



CASTLE PRO-DX VOCIS

Sound Level Meters

Technical Manual

Thank you for buying a Castle product, I am sure you will find both the goods and the service to be of the highest quality but if not, then please feel free to write to me personally and I will ensure that your needs are dealt with immediately.

This manual is designed to show you the operation of the goods you have purchased and a very brief insight into acoustics itself. If you would like to become a competent person in the eyes of the law, then you may like to know more about our Competent Persons training course for the Noise at Work Regulations.

It is my intention for Castle Group Ltd to provide a complete range of Noise and Vibration products and Services of the highest standard. If you would like to know more about any of our other products and services then please telephone on +44(0)1723 584250.

A handwritten signature in black ink, appearing to read 'S Bull', with a horizontal line extending from the end of the signature.

Simon Bull
Managing Director

Copyright

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Precautions

- Only operate the instrument as described in this manual.
- These are precision instruments, protect from shocks and vibrations.
- Take special care with the microphone. The diaphragm is made from a very thin metal and is easily damaged.
- Ambient conditions for the operation of the unit are as follows:-
 - Temperature: -10°C to +50°C
 - Relative Humidity: 25 to 90%
- Protect the unit from extremes of temperature and humidity, direct sunlight and air with a high salt or sulphur content.
- Always turn the unit off after use. Remove the batteries from the instrument when not in use.
- Do not use any solvents or cleaning agents on the instrument. Use only a soft dry cloth or a soft cloth lightly moistened with water when necessary.
- Do not let any conductive objects, such as wire or metal scraps get into the unit.
- Do not try to disassemble the instrument or attempt any repairs as this will invalidate your warranty. Take a note of the condition of the instrument and contact your authorised Castle service station.
- To ensure continued precision performance of your instrument have it checked and serviced at regular intervals.

Contacting Castle Group

This manual contains complete operating instructions for the Castle Pro DX Vocis Meter, read it carefully and you will quickly become familiar with your instrument and its operation.

If you do encounter problems with the operation of your instrument please feel free to contact customer support with your enquiry on: -

Telephone:	+44 (0)1723 584250
Fax:	+44 (0)1723 583728
Website:	www.castlegroup.co.uk
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Technical Specification

Instrument Standards:

<i>GA131I/ GA131C/ GA131M</i>	IEC 61672-1: 2002 Class 1 Group X BS EN 61672-1:2003 Class 1 Group X IEC 60651: 1979 Type 1 + A1: 1993 + A2: 2000 Group X BS EN 60651: 1994 Type 1 Group X IEC 60804: 2000 Type 1 Group X BS EN 60804: 2000 Type 1 Group X IEC 61260: 1993 Class 2 BS EN 61260: 1993 + A1: 2000 Class 2
<i>GA131E</i>	IEC 61672-1: 2002 Class 1 Group X BS EN 61672-1:2003 Class 1 Group X IEC 60651: 1979 Type 1 + A1: 1993 + A2: 2000 Group X BS EN 60651: 1994 Type 1 Group X IEC 60804: 2000 Type 1 Group X
<i>GA231I</i>	IEC 61672-1: 2002 Class 2 Group X BS EN 61672-1:2003 Class 1 Group X IEC 60651: 1979 Type 2 + A1: 1993 + A2: 2000 Group X BS EN 60651: 1994 Type 2 Group X IEC 60804: 2000 Type 2 Group X BS EN 60804: 2000 Type 2 Group X IEC 61260: 1993 Class 2 BS EN 61260: 1993 + A1: 2000 Class 2
<i>GA231E</i>	IEC 61672-1: 2002 Class 2 Group X BS EN 61672-1:2003 Class 1 Group X IEC 60651: 1979 Type 2 + A1: 1993 + A2: 2000 Group X BS EN 60651: 1994 Type 2 Group X IEC 60804: 2000 Type 2 Group X BS EN 60804: 2000 Type 2 Group X

Frequency Weightings:

'A' and 'C' to IEC 61672-1: 2002 Class 1 and IEC 60651: 2001 Type 1

'Z' to IEC 61672-1: 2002 Class 1

Resolution:

All Parameters: 0.1 dB

Warm up time:

≤ 2 minutes

Environmental Stabilization Time:

30 minutes

Level Ranges: SLM Mode Operation

(IEC 60651:1979 / IEC 60804:2000 & IEC 61672-1:2000 where stated):

Display Range	Linear Operating Range (IEC 60804: 2000 4kHz)	Primary Indicator Range (IEC 60651 : 1979 1kHz)	Peak Range (C Weighted) (IEC 60804: 2000) (IEC 60651: 1979) (IEC 61672-1: 2002)
15 - 90 dB	33 - 90 dB	28 - 70 dB	55 - 93 dB
25 - 100 dB	33 - 100 dB	28 - 80 dB	55 - 103 dB
35 - 110 dB	35 - 110 dB	35 - 90 dB	63 - 113 dB
45 - 120 dB	45 - 120 dB	45 - 100 dB	73 - 123 dB
55 - 130 dB	55 - 130 dB	55 - 110 dB	83 - 133 dB
65 - 140 dB	65 - 140 dB	60 - 120 dB	93 - 143 dB

Primary Indicator Range allows for a crest factor of 10 (20dB)

Level Ranges: Full & Third Octave Band Mode Operation

(IEC 60651:1979 / IEC 60804:2000 & IEC 61672-1:2000 where stated):

Display Range	Linear Operating Range (IEC 60804: 2000 4kHz)	Primary Indicator Range (IEC 60651 : 1979 1kHz)	Peak Range (C Weighted) (IEC 60804: 2000) (IEC 60651: 1979) (IEC 61672-1: 2002)
10 - 90 dB	33 - 90 dB	28 - 70 dB	55 - 93 dB
20 - 100 dB	33 - 100 dB	28 - 80 dB	55 - 103 dB
30 - 110 dB	35 - 110 dB	35 - 90 dB	63 - 113 dB
40 - 120 dB	45 - 120 dB	45 - 100 dB	73 - 123 dB
50 - 130 dB	55 - 130 dB	55 - 110 dB	83 - 133 dB
60 - 140 dB	65 - 140 dB	60 - 120 dB	93 - 143 dB

Primary Indicator Range allows for a crest factor of 10 (20dB)

Frequency Range:

Acoustic Characteristics

Microphone	Frequency Range (Hz)
MK250	12.5 to 20,000
ACO 7146	20.0 to 20,000

Electrical Characteristics

1Hz to 20,000Hz

Linear Operating Range (IEC 61672:2002):

Test start point for frequencies > 31.5Hz = 94.0dB on the following display ranges, otherwise 84.0dB:

25 - 100	35 - 110	45 - 120	55 - 130	65 - 140
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Test start point for frequency of 31.5Hz = 84.0dB on the following display ranges, otherwise 74.0dB:

25 - 100	35 - 110	45 - 120	55 - 130	65 - 140
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A Weighted

Display Range (SLM Mode)	Display Range (1/1 or 1/3 Mode)	Frequency (Hz)				
		31.5 (dB)	1000 (dB)	4000 (dB)	8000 (dB)	12,500 (dB)
15 - 90 dB	10 - 90 dB	29 - 53	28 - 90	33 - 90	29 - 90	23 - 89
25 - 100 dB	20 - 100 dB	31 - 63	28 - 100	33 - 100	30 - 100	25 - 99
35 - 110 dB	30 - 110 dB	35 - 73	35 - 110	35 - 110	35 - 110	35 - 109
45 - 120 dB	40 - 120 dB	45 - 83	45 - 120	45 - 120	45 - 120	45 - 119
55 - 130 dB	50 - 130 dB	55 - 93	55 - 130	55 - 130	55 - 130	55 - 129
65 - 140 dB	60 - 140 dB	65 - 103	65 - 140	65 - 140	65 - 140	65 - 139

C Weighted

Display Range (SLM Mode)	Display Range (1/1 or 1/3 Mode)	Frequency (Hz)				
		31.5 (dB)	1000 (dB)	4000 (dB)	8000 (dB)	12,500 (dB)
15 - 90 dB	10 - 90 dB	33 - 90	33 - 90	34 - 90	33 - 90	30 - 87
25 - 100 dB	20 - 100 dB	35 - 100	33 - 100	34 - 100	33 - 100	30 - 97
35 - 110 dB	30 - 110 dB	49 - 110	35 - 110	35 - 110	35 - 110	35 - 107
45 - 120 dB	40 - 120 dB	59 - 120	45 - 120	45 - 120	45 - 120	45 - 117
55 - 130 dB	50 - 130 dB	69 - 130	55 - 130	55 - 130	55 - 130	55 - 127
65 - 140 dB	60 - 140 dB	79 - 140	65 - 140	65 - 140	65 - 140	65 - 137

LIN or 'Z' Weighted

Display Range (SLM Mode)	Display Range (1/1 or 1/3 Mode)	Frequency (Hz)				
		31.5 (dB)	1000 (dB)	4000 (dB)	8000 (dB)	12,500 (dB)
15 - 90 dB	10 - 90 dB	37 - 90	37 - 90	37 - 90	38 - 90	33 - 90
25 - 100 dB	20 - 100 dB	37 - 100	37 - 100	37 - 100	38 - 100	33 - 100
35 - 110 dB	30 - 110 dB	52 - 110	38 - 110	39 - 110	38 - 110	35 - 110
45 - 120 dB	40 - 120 dB	63 - 120	45 - 120	45 - 120	46 - 120	45 - 120
55 - 130 dB	50 - 130 dB	73 - 130	55 - 130	55 - 130	57 - 130	57 - 130
65 - 140 dB	60 - 140 dB	83 - 140	65 - 140	65 - 140	65 - 140	65 - 140

Total Measuring Range:

The difference between the lowest possible measurement on the most sensitive range and the highest level on the least sensitive range at a frequency of 1kHz.

A Weighted	28 - 140
C Weighted	33 - 140
LIN or 'Z' Weighted	37 - 140

Typical Inherent Noise Level:

A combination of Electrical and Microphone Thermal Noise.

MK250 Microphone

Range	'A' Weighting	'C' Weighting	'Z' Weighting
15 - 90	<18dB(A)	< 21dB(C)	< 27dB(Z)
25 - 100	<18dB(A)	< 21dB(C)	< 27dB(Z)

ACO 7146 Microphone

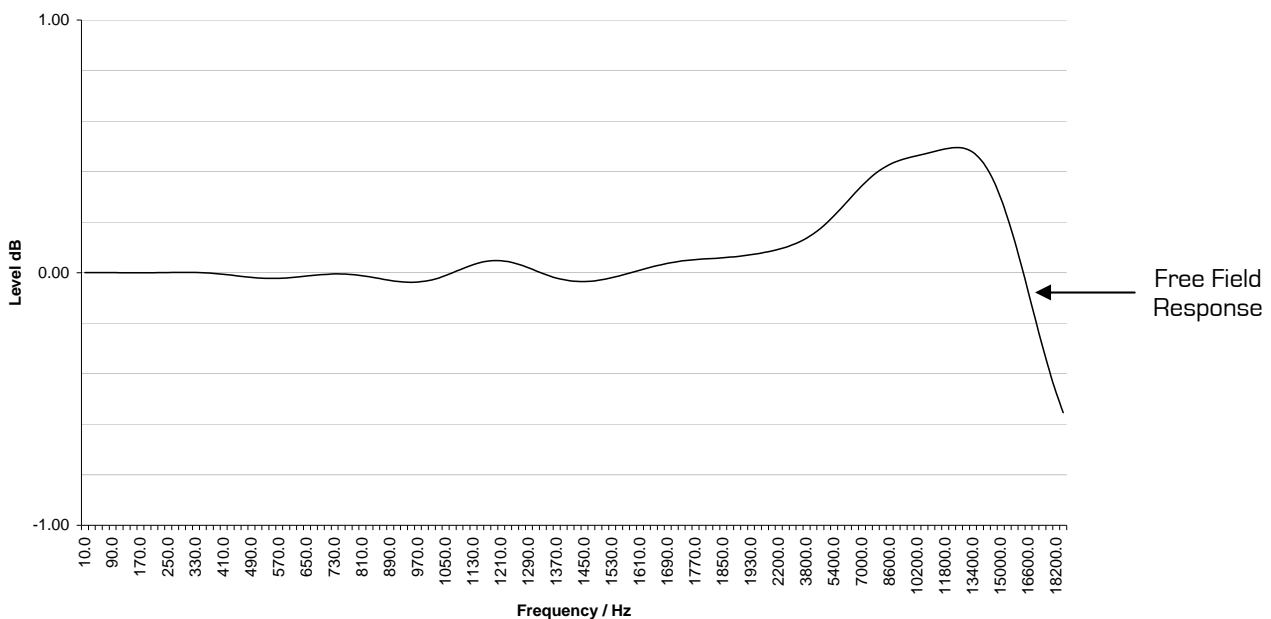
Range	'A' Weighting	'C' Weighting	'Z' Weighting
15 - 90	<18dB(A)	< 21dB(C)	< 27dB(Z)
25 - 100	<18dB(A)	< 21dB(C)	< 27dB(Z)

Microphone:

Microtech Gefell ½" Electret Condenser Microphone Cartridge Type MK250:

Type (MK250)	Specification
Diameter (inch)	0.5 (13.2mm)
Response Type	Free-Field
Polarization (V)	0
Frequency Range (Hz)	3.5 - 20000 (±2dB)
Sensitivity (mV/Pa)	50
Capacitance (pF)	18
Reference Point	Centre of Diaphragm
Max. Sound Pressure Level (dB) For No Damage	146
Temperature Coefficient (dB/°C)	-0.01
Instrument Range	All GA131 Variations

Microtech Gefell Type MK250 Typical Microphone Response:



Microtech Gefell Type MK250 Typical Microphone Response:

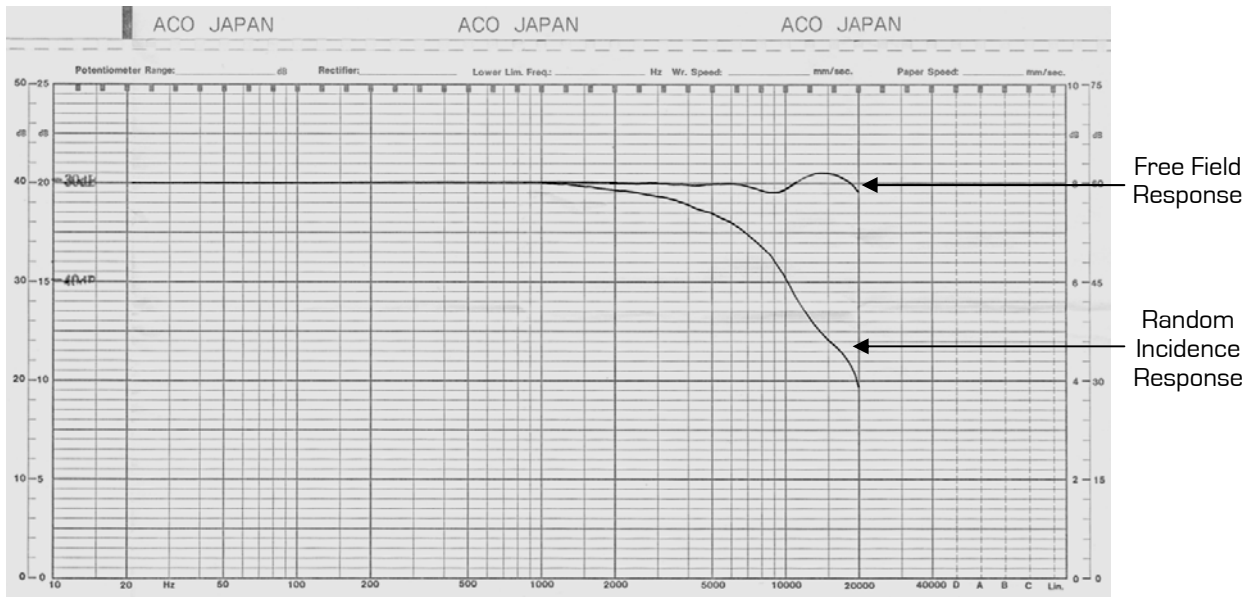
Hz	dB	Hz	dB	Hz	dB
12.5	0.0	1330	0.04	5310	0.13
16	0.0	1410	0.0	5620	0.145
20	0.0	1500	-0.035	5960	0.16
25	0.0	1580	-0.03	6310	0.18
31.5	0.0	1680	0.015	6680	0.21
40	0.0	1780	0.04	7080	0.23
50	0.0	1880	0.055	7500	0.26
63	0.0	2000	0.07	7940	0.3
80	0.0	2110	0.07	8410	0.31
100	0.0	2240	0.07	8910	0.36
125	0.0	2370	0.073	9440	0.39
160	0.0	2510	0.077	10000	0.43
200	0.0	2660	0.08	10600	0.44
250	0.0	2820	0.08	11200	0.45
315	0.0	2990	0.08	11900	0.46
400	0.0	3160	0.085	12600	0.48
500	-0.01	3350	0.09	13300	0.49
630	-0.02	3550	0.09	14100	0.5
800	-0.01	3760	0.09	15000	0.48
1000	-0.035	3980	0.095	15800	0.41
1060	-0.035	4220	0.1	16800	0.27
1120	-0.015	4470	0.11	17800	0.03
1190	0.02	4730	0.11	18800	-0.23
1260	0.05	5010	0.12	20000	-0.55

Microphone:

ACO ½" Electret Condenser Microphone Cartridge Type 7146:

Type (7146)	Specification
Diameter (inch)	0.5 (13.2mm)
Response Type	Free-Field
Polarization (V)	0
Frequency Range (Hz)	20 - 20000 (±2dB)
Sensitivity (mV/Pa)	50
Capacitance (pF)	18
Reference Point	Centre of Diaphragm
Max. Sound Pressure Level (dB) For No Damage	146
Temperature Coefficient (dB/°C)	-0.01
Instrument Range	All GA231 Variations

ACO Type 7146 Typical Microphone Response:



ACO Type 7146 Typical Microphone Response:

Hz	dB
16	0.0
31.5	0.0
63	0.0
125	0.0

Hz	dB
250	0.0
500	0.0
1000	0.0
2000	0.0

Hz	dB
4000	-0.1
8000	-0.7
16000	1.0

Electrical Signal Input:

Electrical signals can be applied to the Pro-DX Vocis range of sound level meters by removing the acoustical microphone and replacing with a dummy microphone having a series capacitor of 18pF ±2%. The BNC termination is then used to interface with a suitable signal generator with an output impedance of 600Ω at 1kHz.

Maximum Peak to Peak Electrical Signal Input For No Damage:

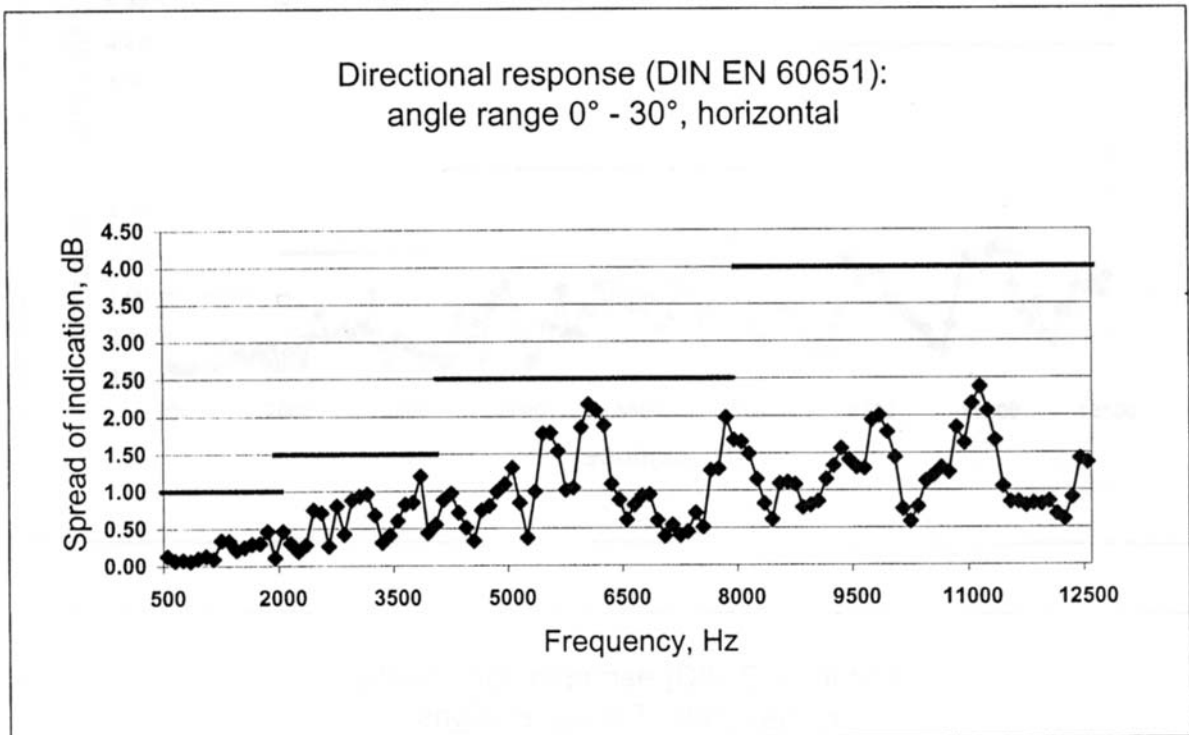
40 Volts

Typical Electrical Self Generated Noise Level:

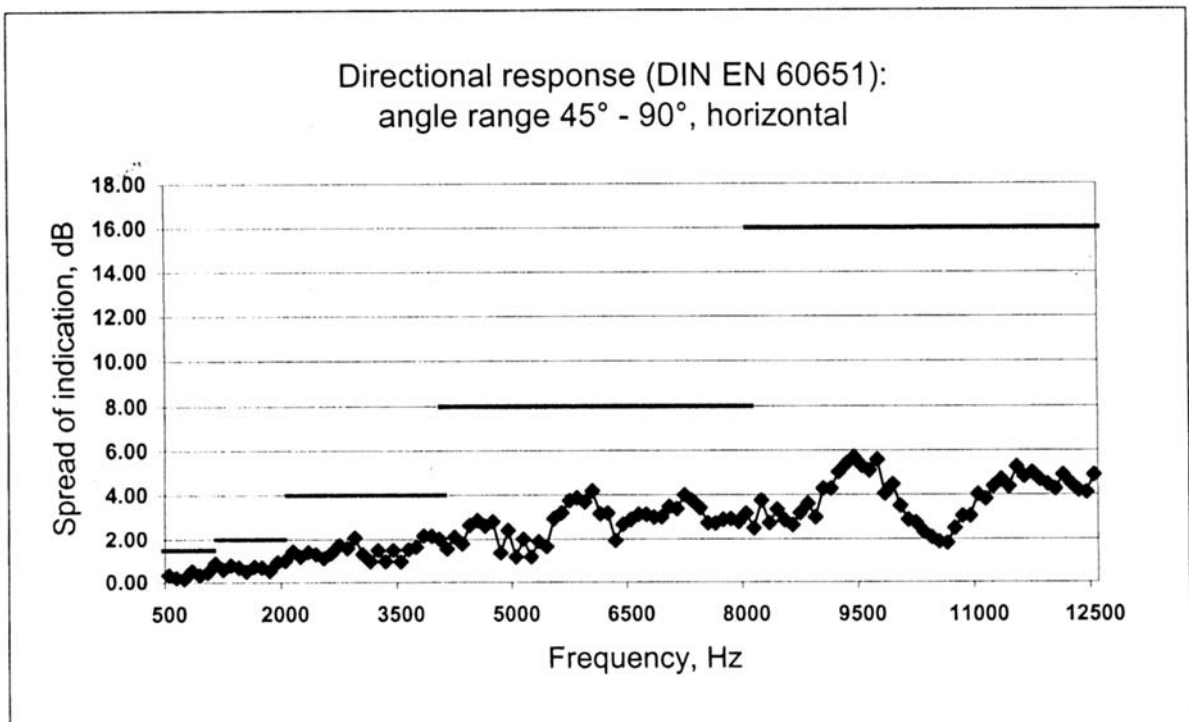
Range	'A' Weighting	'C' Weighting	'Z' Weighting
15 - 90	<18dB(A)	< 21dB(C)	< 27dB(Z)
25 - 100	<18dB(A)	< 21dB(C)	< 27dB(Z)

Case Reflections:

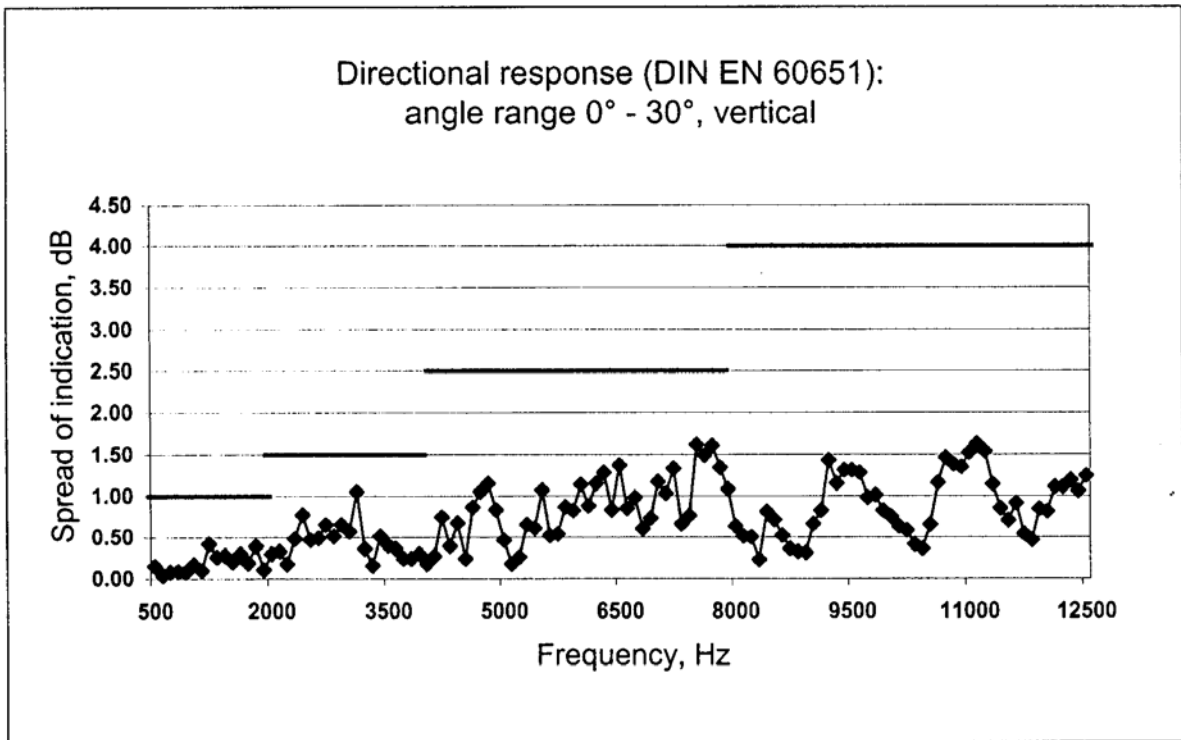
Directional Response, Angle 0° - 30°, Horizontal



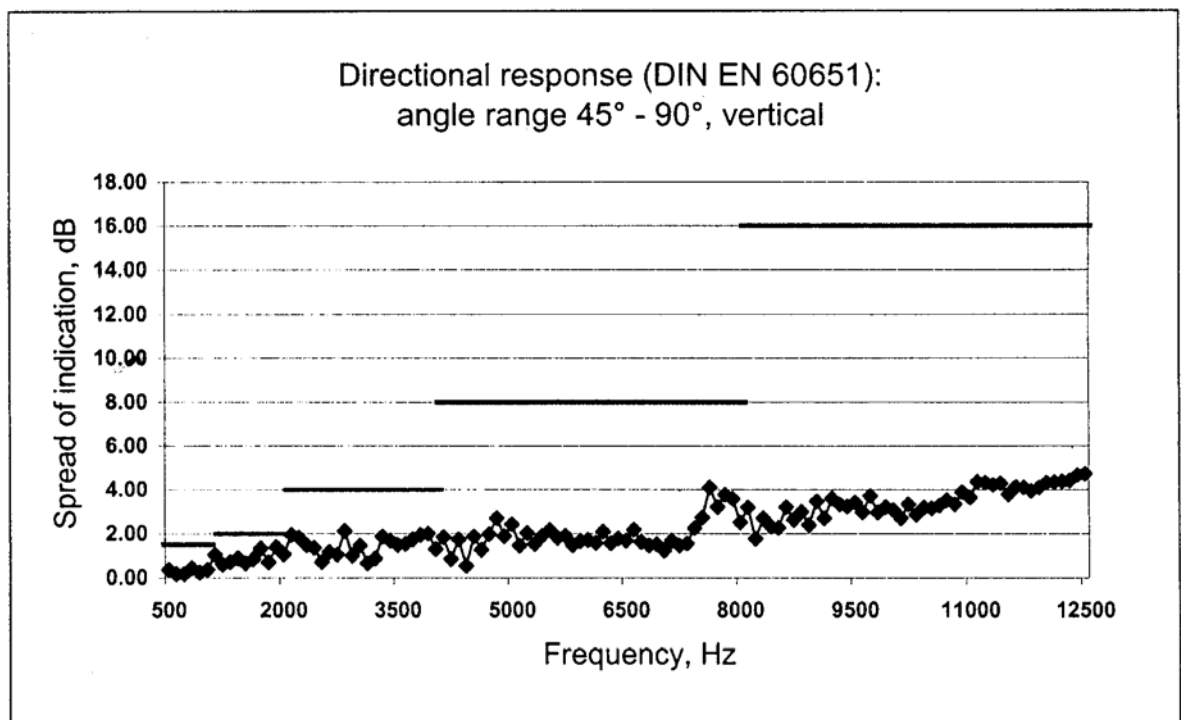
Directional Response, Angle 45° - 90°, Horizontal



Directional Response, Angle 0° - 30°, Vertical



Directional Response, Angle 45° - 90°, Vertical



Case Reflections Only with ACO 7146 microphone fitted:

Absolute error at 1kHz equals -0.4dB

Frequency (Hz)	Error in dB re 1kHz
63	0.3
80	0.5
100	0.3
125	0.4
160	0.4
200	0.4
250	0.3
315	0.6
400	0.8
500	0.3
630	0.2
800	0.2
1000	REF
1250	0.6
1600	0.6
2000	0.1
2500	0.3
3150	0.7
4000	0.5
5000	0.0
6300	-0.1
8000	0.1

Case Reflections Only with MK250 microphone fitted:

Absolute error at 1kHz equals -0.1dB

Frequency (Hz)	Error in dB re 1kHz
63.00	0.0
80.00	0.0
100.00	0.0
125.00	0.0
160.00	0.1
200.00	-0.1
250.00	0.0
315.00	0.4
400.00	0.4
500.00	0.2
630.00	0.0
800.00	-0.1
1000.00	REF
1059.25	-0.5
1122.02	-0.1
1188.50	0.0
1250.00	0.2
1333.52	0.4
1412.54	-0.6
1496.24	0.4
1600.00	0.7
1678.80	0.5
1778.28	0.5
1883.65	0.2
2000.00	0.1
2113.49	-0.9
2238.72	-0.9
2371.37	0.2
2500.00	0.3
2660.73	0.4
2818.38	0.8

Frequency (Hz)	Error in dB re 1kHz
2985.38	0.4
3150.00	-0.4
3349.65	-0.7
3548.13	-0.4
3758.37	0.5
4000.00	-0.4
4216.97	-0.1
4466.84	0.5
4731.51	-0.1
5000.00	-0.5
5308.84	-0.1
5623.41	0.6
5956.62	0.0
6300.00	0.3
6683.44	0.1
7079.46	-0.3
7498.94	-0.6
8000.00	0.3
8413.95	0.4
8912.51	-0.1
9440.61	0.4
10000.00	-0.3
10592.54	0.5
11220.18	-0.3
11885.02	-0.1
12500.00	0.1
13335.21	0.4
14125.38	0.0
14962.36	-0.3
16000.00	-0.4

Normal Operating Mode:

Display Mode = Broadband (SLM)

Class 1 instruments fitted with pre-amplifier type MKDXP and microphone MK250.

Class 2 instruments fitted with pre-amplifier type MKDXPC2 and microphone type ACO 7146.

Pre-amplifier assemblies are clearly labeled with type and unique serial number.

Windshields types KG202 or KG205 may be used and fitted by gently placing the windshield over the microphone which is mounted on the pre-amplifier. Push the windshield down over the microphone and pre-amplifier as far as the groove allows.

See 'Pre-Amplifier and Microphone Removal and Fitting' section for the procedure to attach and remove the pre-amplifier and microphone to either a class 1 or class 2 instrument.

Effect of Fitting Accessories:

GA131C, GA131E, GA131I and GA131M meters fitted with either windscreen or using the microphone extension cable will remain within class 1 tolerances.

Windscreens

90mm Diameter Windscreen (KG202)

Frequency (Hz)	Error in dB re 1kHz
31.5	-0.2
63	-0.2
80	-0.2
100	-0.2
125	-0.1
160	-0.2
200	-0.2
250	-0.1
315	-0.2
400	-0.2
500	-0.3
630	-0.2
800	-0.1
1000	REF
1250	0.0
1600	0.2
2000	0.3
2500	0.3
3150	0.2
4000	-0.4
5000	-0.4
6300	-0.1
8000	-0.8
10000	-0.5
12500	-1.2
16000	-1.6

Absolute error at 1kHz equals +0.2dB

60mm Diameter Windscreen (KG205)

Frequency (Hz)	Error in dB re 1kHz
31.5	-0.2
63	-0.1
80	-0.2
100	-0.1
125	-0.1
160	0.0
200	-0.1
250	-0.1
315	-0.1
400	0.0
500	0.0
630	0.0
800	0.0
1000	REF
1250	0.0
1600	0.3
2000	0.0
2500	0.5
3150	0.4
4000	0.5
5000	-0.1
6300	-0.5
8000	-0.2
10000	-0.5
12500	-0.9
16000	-1.3

Absolute error at 1kHz equals +0.2dB

Extension Cable

ZL1092-01 (1 metre)

Frequency (Hz)	Error in dB re 1kHz
31.5	0.0
63	0.0
80	0.0
100	0.0
125	-0.1
160	0.1
200	-0.1
250	0.0
315	0.0
400	0.1
500	0.1
630	0.1
800	0.1

Frequency (Hz)	Error in dB re 1kHz
1000	REF
1250	-0.1
1600	0.0
2000	0.0
2500	0.1
3150	-0.3
4000	0.1
5000	0.0
6300	0.1
8000	-0.2
10000	-0.1
12500	-0.1
16000	-0.1

Absolute error at 1kHz equals 0.0dB

Typical Actuator to Free Field Correction Factors:

Frequency (Hz)	MK250 Microphone (dB)	ACO 7146 Microphone (dB)
25	0.0	0.0
31.5	0.0	0.0
40	0.0	0.0
50	0.0	0.0
63	0.0	0.0
80	0.0	0.0
100	0.0	0.0
125	0.0	0.0
160	0.0	0.0
200	0.0	0.0
250	0.0	0.0
315	0.0	0.0
400	0.0	0.0
500	0.0	0.0
630	0.0	0.0
800	0.0	0.0
1000	0.0	0.0
1250	0.1	0.0
1600	0.1	0.0
2000	0.2	0.1
2500	0.4	0.3
3200	0.6	0.6
4000	1.0	1.0
5000	1.4	1.5
6300	2.1	2.2
8000	3.1	2.9
10000	4.6	4.2
12500	6.0	6.5
16000	8.5	8.2
20000	10.3	10.0

Adjustment Data Test Frequency

8kHz

Calibration Reference Conditions:

Sound Field:	Free Field
Air Temperature:	23°C (73°F)
Relative Humidity:	50%
Atmospheric Pressure:	101.325kPa
Sound Pressure Level:	94dB
Reference Level Range:	55 – 130 dB (Automatically selected whilst calibrating)
Reference Frequency:	1kHz (Used as Calibration Check Frequency)

The reference direction of incidence for all microphones is perpendicular to the front face (diaphragm surface) of the microphone.

Manufacturers Data:

Uncertainty figures for all manufacturers data are under review at the time of going to print. Please contact Castle Group Ltd for up-to date information.

Measurement Parameters:

All Variations (I, E, C & M)

Lp (SPL), Leq, Lmax, Pmax (Lpeak), Ltm3, Ltm5, LAE, Lmin, 7 user-definable Ln values (pre-set to: L1, L5, L10, L50, L90, L95, L99) plus LAF* for Noise act assessment.

Variations I, C & M

DOSE %, projected DOSE %, user definable criterion (75, 80, 85 or 90), user definable exchange rate (3, 4 or 5), Lex (Lep'd) , projected Lex (Lep'd), 1/1 Octave values in Lp, Leq, Lmax, Lmin. Hearing Protection figures in APL. NR (noise rating).

Vocis M:

1/3 Octave values in Lp, Leq, Lmax, Lmin.

Display:

Electro-Luminescent, White Back-lit LCD panel (160x160 pixels)

Sound Level Meter and Analyzer Display

Numerical: Tabular results on-screen

Bar graph: 1/1 & 1/3 octaves

Refresh Rate ≤ 500mS

Displayed parameter at each update interval is the value at the time of the update interval.

It is recommended that a calculation settling period of 60 seconds is allowed for in any data log file.

Temperature Operating range

-10°C to +50°C

Warning: DO NOT subject the instrument to temperatures greater than 70°C or less than -20°C for any length of time.

Effect of Temperature:

Accuracy better than ± 0.5 dB over the range -10°C to +50°

Storage range: 0% to 90% relative humidity in the absence of condensation

Vibration:

From 20Hz to 1kHz at 1 ms³ no noticeable effect

Humidity:

< 0.5 dB from 25% RH to 90% RH

Effects of Humidity:

Less than 0.5 dB over the range 25% to 90% relative humidity (provided there is no Condensation), relative to the value at 50% relative humidity and 40°C.

Operator presence in Free Field:

No noticeable effect when operator standing more than 2m behind instrument

Overload:

Positive overload warning when the input circuits saturate

Log time Intervals:

User definable in one second intervals (all parameters).

Minimum integrating period equals 1 second.

Maximum potential log size recommended at 67,500 intervals (1/3 octave with Ln's selected)

Timer Function:

A Program Log Timer to give multiple Start-Stop timings.

Time:

Battery backed Real Time clock and calendar

Memory:

2Mb on-board FLASH

2Mb on-board RAM

128Mb min. standard Storage memory (upgradeable to 512mB)

Communication Port:

RS-232: 115200 max. Baud-rate, 8 bit, no parity, bi-directional 9 pin 'D'-sub

Output Socket:

AC Output: Unweighted, 0.953V rms at full scale on each range

Load Impedance > 10K recommended

Short circuit protected

Cable Colours: Red - Signal, Blue - Ground

Batteries:

Internal Backup: CR2032 coin cell

Main: 6 x MN1500 (size AA) alkaline cells

Life: 8 hours continuous use (approx) without backlight

Min Battery Level: 7.5V DC

External Power Supply:

Mains Power (option): 12V DC mains adapter 1.25A, Centre Terminal +12v, Outer Terminal 0V
Powered from nominal AC supply of 230V \pm 10% , 50/60Hz

Min Voltage Level: 11V DC

Max Voltage Level: 18V DC

Processing:

A to D Converter: 24-bit Stereo, 60kHz sampling

DSP: 32-bit 61MHz processor sampling at 60kHz

Controller: 100MHz, 486SX running at 16MHz

Overall Dimensions:

Dimensions: 250mm x 100mm x 50mm (approx.) without microphone assembly

Weight: 870g including microphone assembly and batteries

Accessories:

GA607: Dual Level Class 1 Calibrator

GA505: Portable, Battery Operated, Thermal Printer DPU-414

ZL1083-01: Printer Cable for use with GA505 (1 Metre)

PC007: dBdata Pro Windows Analysis Software (supplied with ZL1103-02)

ZL1103-02: PC to Vocis Download Cable (2 Metres)

KA016: Kit Case for Vocis and Printer (GA505)

KA018: Weatherproof Enclosure

PSU4: Power Supply

ZL1092-01: Microphone Extension Cable (1 Metre)

ZL1092-10: Microphone Extension Cable (10 Metres)

ZL1061-01: AC Output Cable (1 Metre)

MKDXP: Pre Amplifier Assembly (Class 1 GA131 Series)

MKDXPC2: Pre-Amplifier Assembly (Class 2 GA231 Series)

MK75: ACO 7146 Microphone (Class 2)

MK78: Microtech Gefell MK250 Microphone (Class 1)

KG202: Windshield 90mm

KG205: Windshield 60mm

EC Declaration of Conformity:



The CE marking of the Castle Pro DX Vocis Sound Level Meter indicates compliance with the EMC Directive.

Castle Group Ltd declares that the: -

- *Pro DX Vocis GA 131 / GA231 Sound Level Meter*

has in accordance with the following Directive: -

- *89/336/EEC 'The Electromagnetic Compatibility Directive' and associated amending Directives*

been designed and manufactured to the following specification: -

- *EN61326-1:1997 + A1:1998*

meeting the following tests:-

- *Radiated Emissions: EN55022:1995 Class: A*
- *ESD: EN61000-4-2:1995
Levels: $\pm 4kV[C]$, $\pm 8kV[A]$*
- *RF EM Amplitude Mod: EN61000-4-3:1996:
Levels: $3V/m$ & $10V/m$ (Compliance not guaranteed beyond $10V/m$)*

Normal mode of operation is SLM or broadband display mode. No differences in radio frequency emissions are apparent between operating modes of the instrument.

No performance or function degradation is noticeable whilst subject to electrostatic discharge or a.c power frequency and radio frequency fields under any operating mode with the meter. Greatest susceptibility to a.c power frequencies at 180° to source.

Approved cables for use with Castle Pro DX meters to comply with these specifications: -

Cable	Order Code	Length
Printer	ZL1183-01	1m
PC to Vocis	ZL1103-02	2m
Microphone Extension	ZL1092-01	1m
Microphone Extension	ZL1092-10	10m

We hereby declare that the instruments named above have been designed to comply with the relevant sections of the above referenced specifications, and that the above named instruments comply with all essential requirements of the Directive.

EMC tests conducted at the standard test level of 74dB

A Guide to Acoustical Terms and Units

Sound Pressure Level (SPL)

Sound level meters measure acoustic pressure, and by international agreement they are calibrated in decibels (dB). The Sound Pressure Level in decibels is defined as:

$$SPL = 20 \log \frac{P}{P_0}$$

Where: P is the measured **rms** sound pressure
P₀ is the reference **rms** sound pressure.

Note that the decibel is a ratio of two quantities which have dimensions of power, and is not a unit.

The reference sound pressure P₀ is by agreement taken as 20 μPa, which is the minimum audible pressure to a person with 'normal' hearing. The use of a logarithmic scale, such as the decibel permits the wide range of audible sound pressures (approximately 1,000,000 to 1) to be compressed into a scale of 120 units. Hence a faint whisper may be measured as 20dBA where as a chipping hammer of a road workman may produce 105dBA.

Standardised frequency curves

Because the ear is relatively insensitive to very low and very high frequencies, sound level meters have by international agreement weighted frequency responses. Hence different frequency weightings will produce for the same sound source different SPL readings.

Castle sound level meters may have any one of three frequency weightings.

- 'A' weighting, which best expresses the human ears response to loudness is the most commonly used frequency weighting.
- 'C' weighting, this is often used to ascertain the acoustic emissions of machines it has a much broader spectrum than that of the 'A' weighting curve.
- Zero or 'Z' weighting (some times termed un-weighted). It may vary between differing instruments as its characteristics are very dependent on the quality of the microphone and associated pre-amplifier. It is often used in conjunction with octave band filters. A typical Z weighted response would be flat from 20 Hz to 16 KHz.

Time weighting - Fast, Slow, Impulse and Peak

It is important to understand that the SPL is an rms (root mean square) quantity and is therefore averaged within the constraints of an averaging time constant. These time constants are helpfully termed Slow, Fast and Impulse and are sometimes referred to as the time weighting.

The SPL therefore is not only affected by the frequency weighting but by the time weighting of the instrument also. Hence by selecting **Slow** on the sound level meter a sharp rise in

noise will be shown as a gradual rise in the SPL, alternatively a sharp fall in noise will be shown as a gradual decrease in the SPL. By using the **Fast** weighting on the instrument in both of the above scenarios the SPL will rise and fall on a more rapid scale. The **Impulse** response is not as commonly used as the above, it is used in situations of sharp impulsive noises typically a piling operation may require an impulse time weighting. It has a very fast rise time but a very slow exponential fall time.

The **Peak** weighting is very different from Slow, Fast and Impulse weighting in that it is not an rms quantity. It is simply the crest of the sound pressure level and it is shown as the highest Peak achieved within the measuring period. The rise time of the Peak is extremely sharp and it is not uncommon for the Peak to be much higher than the SPL (rms).

Lmax, Lmin, Peak

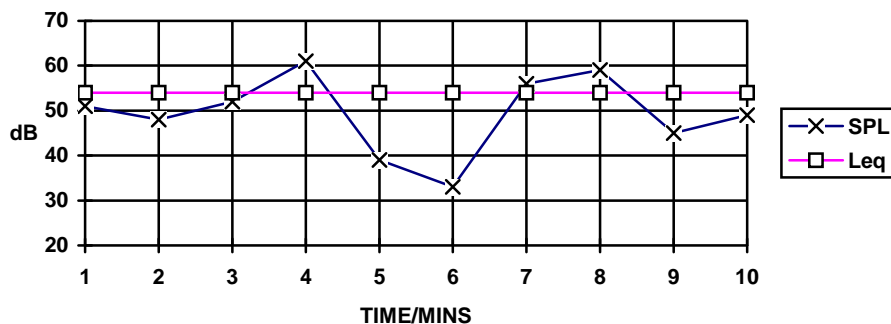
Lmax is the highest rms sound pressure level within the measuring period (with slow, fast or impulse time weighting selected).

Lmin is the lowest rms sound pressure level within the measuring period (with slow or fast time weighting selected).

Peak is the crest (linear) of the sound pressure within the measuring period, not rms.

Leq - Equivalent Continuous Sound Pressure Level

Leq is the constant noise level that would result in the same total sound energy being produced over a given period. It can be measured in either A-Weighted, C-Weighted, or Z-Weighted mode.



Leq can be described mathematically by the following equation:

$$L_{eqT} = 10 \log_{10} \left[\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} \left(\frac{P(t)}{P_0} \right)^2 dt \right]$$

Where: Leq is the equivalent continuous linear-weighted sound pressure level re 20 μPa, determined over a measured time interval TM (sec's).

P(t) is the instantaneous sound pressure of the sound signal.

P₀ is the reference sound pressure of 20 μPa.

When the instantaneous A-weighted sound pressure (P_A) of the sound signal is introduced, then the equivalent continuous A-weighted sound pressure level determined over time interval T_M is as follows:

$$L_{Aeq} = 10 \log_{10} \frac{1}{T_M} \int_0^{T_M} \left[\frac{P_A(t)}{P_o} \right]^2 dt$$

In practice when measuring noise it is possible to take Leq readings with your instrument of short duration i.e. <5 minutes providing all variations of noise emissions are covered. If the measured environment changes greatly, then the longer the Leq reading is taken, the more accurate the measurement.

L_{AE} , Level Exposure (formerly SEL)

This is in effect an Leq normalised to 1 second. It can be used to compare the energy of noise events which have different time duration's. The L_{AE} can be described mathematically as below.

$$L_{AE} = 10 \log_{10} \int_0^{T_M} \left[\frac{P(t)}{P_o} \right]^2 dt$$

Where T_M is measured in seconds.

DOSE

DOSE is a percentage measure of noise exposure similar to L_{ex} , and can be described with the following statement: 100% DOSE = 85dBA for 8 hours

The operation of dose can be mathematically described by the following equation which relates the percentage exposure D to the integrated sound power.

$$D = \frac{100}{T_c} \int_0^T \uparrow \left(\frac{L - L_c}{q} \right) dt$$

Where:

- \uparrow represents the anti-log
- D = Percentage exposure [%].
- T_c = Criterion sound duration (usually 8 hours).
- T = Measurement duration in (hr)
- L = Weighted sound level
- L_c = Criterion level (usually dBA)
- q (Exchange rate parameter, expressed as dB)
 - = $(3/\log 2)$ for an exchange rate of 3 dB (Approx 9.96578)
 - = $(5/\log 2)$ for an exchange rate of 5 dB (Approx 16.61096)

For discrete time intervals at a constant sound level the equation can be rewritten as below:

$$D = \frac{100}{T_c} \sum t_i 10^{\frac{L_i - L_c}{10}}$$

Where:

L_i = Weighted sound pressure level in the i th time interval
 t_i = Time spent in the i th interval (hr)

The dose can be converted to an L_{eq} .

$$L_{eq} = L_c + 10 \cdot \log_{10} \left[\left(\frac{D}{100} \right) \cdot \left(\frac{T_c}{T_M} \right) \right]$$

Where:

L_{eq} = the equivalent continuous sound level, with A-weighting, from the time T_M .
 L_c = Typically 85 dBA in the UK.
 D = indicated dose index (%).
 T_c = reference time base 8 hours.
 T_M = measurement time in hours.

Tables D1, D2 & D3 give examples of how DOSE is related to exposure time and L_{ex} (assuming a criterion of 85 100% DOSE = 85dBA for 8 hours.)

Table D1. Effect of changing SPL

SPL (dBA)	Exposure Time (hours)	Dose (%)	L_{ex} (dBA)
95	8	800	95
91	8	400	91
88	8	200	88
85	8	100	85
82	8	50	82
79	8	25	79

Table D2. Effect of changing exposure time.

SPL (dBA)	Exposure Time (hours)	Dose (%)	L_{ex} (dBA)
85	16	200	85
85	12	150	86.76
85	8	100	85
85	4	50	82
85	2	25	79
85	1	12.5	76

Table D3. Effect of changing SPL and exposure time.

SPL (dBA)	Exposure Time (hours)	Dose (%)	L _{ex} (dBA)
88	4	100	85
85	8	100	85
80	8	31.5	80
82	4	25	79
79	4	12.5	76

Each time the sound level increases by 3dB the DOSE doubles given the same exposure time, similarly if the sound level decreases by 3dB the DOSE will halve for the same exposure time.

Doubling the exposure time doubles the DOSE and halving the exposure time halves the DOSE given the same sound level.

Projected DOSE

DOSE measurements usually require the noise exposure to be measured over a full 8 hour working day. This can be simplified by using Projected DOSE.

Projected DOSE allows the present accumulated DOSE over the elapsed logged time duration to be projected forward to give the predicted 8 hour dose.

For example, if you had been logging for 30 minutes with an accumulated DOSE of 5%, the Projected DOSE would show:

$$5\% \times 8 \text{ hours} / 0.5 \text{ hours} = 80\% \text{ DOSE.}$$

i.e. you would receive an 80% DOSE if you were to stay in this area with the same equivalent level of noise for the full 8 hours.

The following should be taken into consideration when reporting Projected DOSE figures:

1. The Projected DOSE assumes that the current DOSE rate at the time of reading will remain constant, i.e. the sound level does not change over the measurement period compared to the total 8 hour period.
2. The Projected DOSE will be more accurate if the measurement duration is as long as possible.
3. DOSE, and therefore Projected DOSE are measured with 'A' frequency weighting selected.
4. If, say, a 12 hour day is worked the 8 hour Projected DOSE should simply be multiplied by 1.5 (i.e. $12/8$) to calculate what the DOSE would be after 12 hours.

L_{EX} Daily Personal Noise Exposure.

L_{EX} is a measure of exposure that depends not only on the sound pressure level but also on the duration of the noise exposure. It is intended to be used to measure the daily exposure of a worker, and therefore is dependent on shift duration. Unlike DOSE, L_{EX} is displayed as a dB(A) value, and is derived from the equation shown below.

$$L_{EX} = 10 \log_{10} \frac{1}{28800} \int_0^{T_M} \left[\frac{P_A(t)}{P_o} \right]^2 dt$$

Note the similarity between this definition and that of Leq. Since L_{EX} is normalised to 8 hours the L_{EX} would equal the 8 hour Leq of a worker exposed for 8 hours.

Although similar to Leq, L_{EX}, will present a different value to the Leq if the exposure time is greater than or less than 8 hours. See tables, D1, D2, and D3.

The relationship between L_{EX} and DOSE is given by the following equations:

$$L_{EX} = 85 + 10 \cdot \log_{10} [\text{DOSE}/100] \quad (\text{For a criterion level of 85})$$

$$L_{EX} = L_{eq} + 10 \cdot \log_{10} [t/T]$$

Where: t = logging time
 T=8 hours reference (28,800 sec's)

Note that L_{EX} is a logarithmic measurement as opposed to DOSE which is a linear function. Hence DOSE can be added arithmetically but since L_{EX} is logarithmic, values cannot be added arithmetically.

Each time the sound level increases the L_{EX} increases. If the exposure time doubles, say 4 hours to 8 hours, the L_{EX} increases by 3dB.

Glossary of Acoustical Terms

This section describes and defines many terms used in acoustics.

TERM	UNIT OR ABBREVIATION	DEFINITION
Decibels	dB	Ten times the logarithm (to base 10) of the ratio of two mean square values of sound pressure.
Frequency	Hz	The number of cyclical variations per unit time
Octave Bands	Hz	Frequency ranges in which the upper limit of each band is twice the lower limit. Octave bands are identified by their geometric mean frequency or centre frequency.
Sound Power	W	The acoustic power of a sound source expressed in Watts.
Sound Power Level	L_W	<p>The acoustic power radiated from a given sound source as related to a reference power level (typically 10^{-12} W); expressed in decibel as:</p> $L_W = 10 \log_{10} \left(\frac{W}{10^{-12}} \right) dB$ <p>or</p> $L_W = 10 \log_{10} W + 120 dB$ <p>W = acoustic power in Watts. i.e. 1 Watt = 120 dB for L_W</p>
Sound Pressure	P	Fluctuations in air pressure caused by the presence of sound waves.
Sound Pressure Level	SPL	<p>The ratio expressed in decibels of mean - square sound pressure to a reference mean - square pressure which by convention has been selected to be equal to the assumed threshold of hearing.</p> $SPL = 20 \log_{10} \left(\frac{P}{P_0} \right)$ <p>Where: SPL = Sound Pressure Level P = Root Mean Square sound pressure $P_0 = 2 \times 10^{-5} \text{ Nm}^{-2}$ = 20μPa (R M S)</p>
Weighting Network	A - dB(A)	An electronic or digital filter in a sound level meter which approximates under defused conditions the frequency response of the human ear. The A - Weighting network is the one most commonly used.
Equivalent Continuous A -Weighted Sound Pressure Level	L_{AEGT}	The equivalent continuous level which is a measure of the energy content of a sound over a time period. It gives a single figure expressing the equivalent of a varying level. It is an energy average.

TERM	UNIT OR ABBREVIATION	DEFINITION
Equivalent Continuous A-Weighted Sound Pressure Level	L_{AEGT}	The equivalent continuous level which is a measure of the energy content of a sound over a time period. It gives a single figure expressing the equivalent of a varying level. It is an energy average.
Dose	D	Noise dose is a percentage number where: 100% Dose = 85 dB(A) for 8 hours. Note that not only is the sound level important (85 dBA) but also the time a person was exposed (8 hours).
Dose per Hour	DOHR	Designed to show the Dose exposure over each hour.
Projected Dose	Proj D	Projected dose allows the present accumulated dose over the present logged time duration to be projected forward to give the predicted 8 hour dose. This assumes the logged dose rate remains constant over the 8 hour period. A time inhibit on Castle instruments prevents projections being made if the measurement duration is less than five minutes.
Noise Exposure	L_{EX}	<p>Personal noise exposure; usually referred to a daily 8 hour rate. "Exposed" means exposed whilst at work; expressed in dB(A)</p> $L_{EX} = 10 \log_{10} \frac{1}{T_o} \int_0^{T_e} \left[\frac{P_A(t)}{P_o} \right]^2 dt$ <p>Where: T_e = the duration of the person's personal exposure to sound. T_o = 8 hours = 28800 seconds. P_o = 20 μPa P_A = the time - varying value of A weighted instantaneous sound pressure in Pascal's in the undisturbed field in air at atmospheric pressure to which the person is exposed.</p>
Percentile Sound Levels	L_N	The dB(A) level exceeded N% of the time.