RION

Class 2 Sound Level Meter
NL-28

Instruction Manual

Organization of the NL-28 Instruction Manual

There are two types of instruction manuals for Class 2 Sound Level Meter NL-28.

Quick Start Guide

This manual describes the basic handling of Class 2 Sound Level Meter NL-28.

Instruction Manual (this document)

This manual describes the detailed operation of Class 2 Sound Level Meter NL-28, as well as how to connect and handle peripheral devices when using them.
It also describes technical details such as the performance of Class 2 Sound Level Meter NL-28, the structure and characteristics of the microphone, and the effect on measurement when a windscreen is used.

You can download the Instruction Manual from our website:

https://svmanual.rion.co.jp/nl-28/

Organization of This Manual

This manual describes the functions, operation, performance, characteristics, and other technical details of Class 2 Sound Level Meter NL-28. When the measuring system is configured with other equipment, make sure to read the instruction manual of the equipment for how to operate the other equipment.
In addition, safety precautions are described on Page 6 onwards. Please be sure to read them.

The manual consists of the chapters listed below.

- Overview of This Product
  Describes the basic information on this device.
- Terminology and Notation
  Explains notation such as quantifiers and their names.
- Name and Function of Each Part
  Briefly describes the name and function of each key and port.
- Turning on the Power
  Describes how to turn on the power.
- Reading the Display
  Explains the symbols displayed on the screen.
- Menu
  Explains various items that appear on the menu screen of the device.
- Calibration
  Describes how to calibrate the device.
- Measurement
  Provides the basic explanation of measurement.
- Store Operation
  Describes the measurement data stored in the device.
- Connection with Peripheral Devices
  Describes how to connect peripheral devices.
- Specifications
  Lists the technical specifications.
- Microphone
  Describes the microphone structure, principle, and specifications.
- Frequency Weighting
  Describes the frequency weighting used with the device.
- Root-mean-square Circuit and Time Weighting
  Describes the root-mean-square detection circuit and time weighting.

- Measurement Function
  Describes the measurable calculation values (L_{eq}, L_E, L_{max}, L_{Cpeak}).
- Influence of Background Noise
  Describes the effect of background noise and the correction for it.
- Descriptions for IEC 61672-1 (JIS C 1509-1)
  Describes the contents corresponding to the standard.

Safety Precautions / Precautions for Use

Safety precautions

The precautions shown here are intended to help you use the product safely and correctly, and to prevent harm and damage to you and other people. Incidents that could occur as a result of incorrect handling are divided into two categories: “WARNING” and “CAUTION”. Make sure to follow the contents of all these categories because they are serious matters related to safety.

Examples of pictorial indications

Specific prohibitions may be displayed in the illustrations.

	Prohibitions		Instructions

Display	Meaning
⚠ WARNING	Indicates a possibility of death or serious injury due to incorrect handling.
⚠ CAUTION	Indicates a possibility of personal injury or property damage due to incorrect handling.
Important	Failure to observe the precautions indicated by this may result in damage to the device.
Note	Denotes special information that is helpful in utilizing the capabilities of the device but that is not directly related to safety.

- **Handling of the batteries**

⚠WARNING

If electrolyte leaking from the batteries gets into your eyes, rinse with water without rubbing and immediately seek medical attention.
Failing to do so may result in blindness.

If electrolyte leaking from the batteries gets on your skin or clothes, wash it off immediately with water.

- **Handling of this product**

⚠WARNING


Do Not Disassemble

Never disassemble, repair, or modify the product.
Doing so may cause a fire, electric shock, or an accident.


No Wet Hands

Do not connect the USB cable or remove the main unit with wet hands.
Doing so may cause electric shock or injury.


Keep Dry

Do not immerse the main unit in water or splash water on it.
Doing so may cause electric shock or malfunction.

Do not use the device for purposes other than for what it was originally intended.

Keep the product away from heat sources such as fire and stoves.
Failure to do so may cause a fire, electric shock, or malfunction.

Do not use the device if any abnormality such as damage is discovered.
Continuing to use the device regardless of an abnormality may cause electric shock or fire. In such circumstances, please contact your dealer.

Do not use the device if there is something wrong with it, such as it becomes abnormally hot.
Doing so may result in a malfunction or fire.

Do not use or connect to the USB cable in a humid place such as a bathroom or in a place where it may get wet.
Doing so may cause electric shock or malfunction.

Do not use, store, or leave the product in a hot place such as in a place exposed to fire, direct sunlight, or inside a car on a hot day.
Doing so may cause fire, battery breakage, or overheating.

When disposing of the product, do not set it alight.
Doing so may cause a fire or explosion. When disposing of the product, follow the regulations of your country or local municipality.

If there is dust on the USB terminal, wipe it off before connecting the dedicated USB cable.
Failure to do so may result in electric shock, short circuit, or fire.

If there is a problem with the device during use, turn off the power and disconnect the USB cable and remove the batteries.
In such circumstances, please contact your dealer.

Always turn off the power after use.
Turn off the power and remove the batteries if you intend to store the product for a long time without using it. Leaving the batteries inside the device may cause electrolyte to leak. Also, disconnect the USB cable.

Make sure to hold the connector when disconnecting the USB cable.
Do not apply excessive force, such as holding the USB cable and pulling it out.

⚠CAUTION

Do not use or store the product within the reach of children or pets.
Doing so may result in electric shock, injury, or accidental ingestion.

Do not store the device in places in which it will be subject to water, dust, high temperatures, and high humidity, or in direct sunlight. Do not use or store the device in places where it may be adversely affected by salt, sulfur, chemicals, gases, etc.
The operating temperature for this device is -10°C to +50°C and the humidity range is 10% to 90% RH (no condensation).

* In the event of a product defect caused by RION, RION will repair or replace the device.

Precautions for use

- Avoid using and storing the product in places with high temperatures and humidity, or in places exposed to direct sunlight for long periods of time.
- If there is a drastic change in the surrounding temperature, the product may malfunction due to internal condensation.
- As the device is a precision electronic device, avoid using or storing it in locations subject to shock or vibration.
- If you do not intend to use the device for a long time, remove the batteries and store it.
- Do not insert wires, metal pieces, conductive plastics, etc. through any holes or gaps in the product. Doing so may result in a malfunction.
- Do not replace the microphone with one other than the number indicated on the serial number label.
- If you are using the device outdoors and it starts raining, stop taking measurements and keep the device dry. If the device gets wet, wipe it off with a dry cloth and dry it in a well-ventilated environment.
- Make sure that the cover of the battery compartment is securely closed before use. Also, do not open the cover of the battery compartment when the device is wet.
- Make sure the microphone is installed securely before using or storing the device. If there is any looseness, turn off the power, retighten the microphone before using or storing the device.
- To maintain the accuracy of measurements, inspect the device regularly. When using the device for transactions or certification activities, the device needs to be subject to an authorized inspection under the Measurement Act every five years. In such circumstances, please contact your dealer.

[Disclaimer]

- RION shall not be held accountable for the following damages:
  Any damage caused by earthquakes, lightning, wind and floods, fires for which RION is not responsible, actions or accidents by a third party, intentional or negligent misuse by the customer, or use under other abnormal conditions.
- RION shall not be held accountable for the following incidental damages arising from the use or inability to use this product:
  Alteration or loss of recorded content, loss of business profits, or the interruption of business, etc.
- RION shall not be held accountable for any damage caused by not following the contents of this document.

[Cleaning the product]

- To clean the device, use a dry, soft cloth or a cloth wrung out with lukewarm water. Do not use organic solvents such as benzene or alcohol.

[What to do when disposing of the product]

- When disposing of this product or batteries, make sure to consult with your local municipality.

Contents

1

Overview of This Product

- NL-28 is a class 2 sound level meter that complies with the Measurement Act, JIS, and IEC. The measurable frequency range is 20 Hz to 8 kHz.
- It consists of a main unit including a 1/2-inch microphone and a preamplifier. The main unit is equipped with operation keys and an organic EL display.
- There is a function to simultaneously measure the time-weighted sound level, equivalent continuous sound level, sound exposure level, maximum time-weighted sound level, and peak sound level (C-weighting only), and the results are recorded on the main unit.
- The device has a wide linearity range of up to 107 dB, and does not require range switching when measuring.
- Measurement data can be transferred by connecting the USB terminal to a computer.
- The device can be powered by alkaline AA batteries or Ni-MH rechargeable AA batteries, and can operate continuously for approximately 9 hours.

Measurement function

The following values can be measured with the selected frequency weighting and time weighting.

	Name		Frequency weighting	Time weighting
Instantaneous value	Time-weighted sound level	L_p	✓	✓
Calculated values	Equivalent continuous sound level	L_{eq}	✓	–
	Sound exposure level	L_E	✓	–
	Maximum time-weighted sound level	L_{max}	✓	✓
	Peak sound level (C-weighting only)	L_{peak}	✓	–

Device usage environment

Place of use	Indoors or outdoors
Altitude	Up to 2,000 m
Ambient temperature	-10°C to 50°C
Relative humidity	10% to 90% RH (no condensation)
Use in damp locations	Not recommended
Pollution degree of surrounding environment	Pollution degree 2
Dustproof and waterproof performance	Not applicable
Impact resistance	Not applicable

2

Terminology and Notation

Correspondence between the notation of measurement value on Class 2 Sound Level Meter NL-28 and the name of measurement value based on standards

The following table shows the correspondence between the notation of measurable values on this device and the names of measurement values based on standards (IEC 61672-1 and ISO 1996).

- With this device, sound level and sound pressure level are uniformly referred to as sound level without distinguishing them depending on the presence or absence of frequency weighting.
- The measurement value names of L_p and L_{max} are not based on time weighting (F, S).

Notation with NL-28				Measurement value name
Measurement value setting items	Frequency weighting	Time weighting		
		F	S	
L_p Time-weighted sound level	A-weighting	L_{AF}	L_{AS}	A-weighted time-weighted sound level
	C-weighting	L_{CF}	L_{CS}	C-weighted time-weighted sound level
L_{eq} Equivalent continuous sound level	A-weighting	L_{Aeq}		Equivalent continuous A-weighted sound level Time-average A-weighted sound level
	C-weighting	L_{Ceq}		Equivalent continuous C-weighted sound level Time-average C-weighted sound level
L_E Sound exposure level	A-weighting	L_{AE}		A-weighted sound exposure level
	C-weighting	L_{CE}		C-weighted sound exposure level
L_{max} Maximum time-weighted sound level	A-weighting	L_{AFmax}	L_{ASmax}	Maximum A-weighted time-weighted sound level
	C-weighting	L_{CFmax}	L_{CSmax}	Maximum C-weighted time-weighted sound level
L_{peak} Peak sound level	C-weighting	L_{Cpeak}		C-weighted peak sound level

Correspondence between the notation of measurement value on Class 2 Sound Level Meter NL-28 and the quantifiers in each standard

The following table shows the correspondence between the notation of measurable on this device and the quantifiers used in each standard (IEC 61672-1 (JIS C 1509-1) and ISO 1996 (JIS Z 8731)).

- JIS Z 8731 is based on ISO 1996, but some of the quantifiers are different, so the relevant sections are listed separately.
- For the quantifiers of L_p and L_{max}, the time weighting notations (F, S) are omitted.

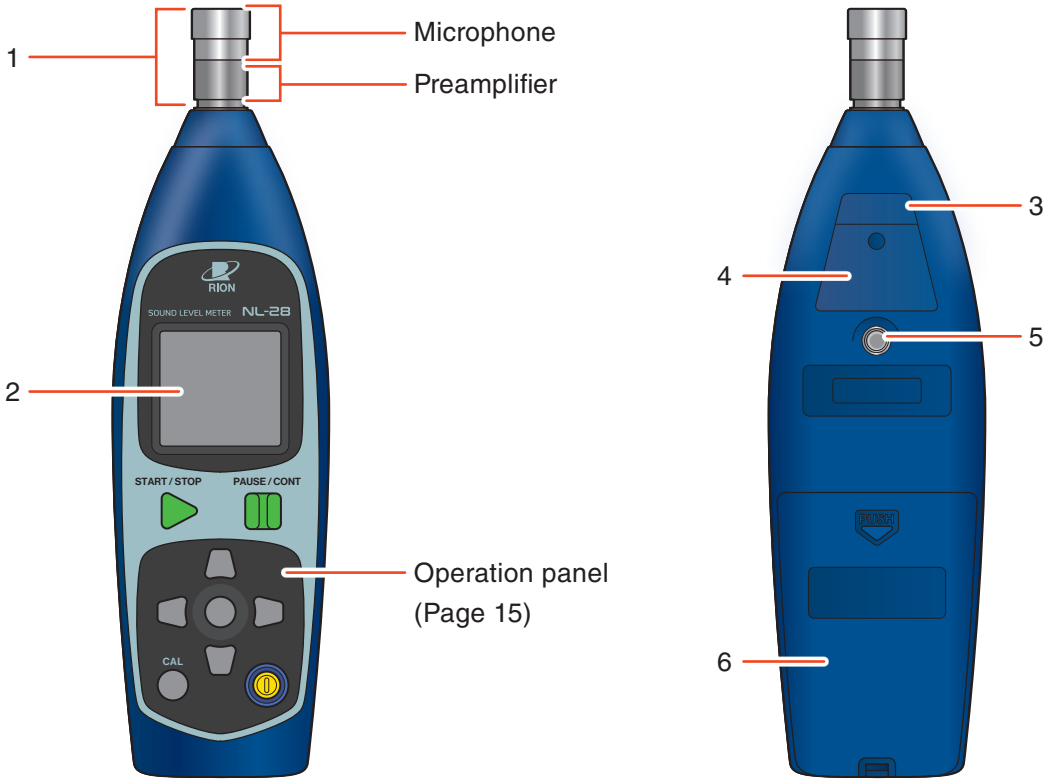
Notation with NL-28			Quantifiers for each standard notation		
Measurement value setting items	**Frequency weighting**	**Quantifier**	**IEC 61672-1 (JIS C 1509-1)**	**ISO 1996**	**JIS Z 8731**
L_p Time-weighted sound level	A-weighting	L_A	L_A	L_{pA}	
	C-weighting	L_C	L_C	-	
L_{eq} Equivalent continuous sound level	A-weighting	L_{Aeq}	$L_{Aeq,T}$	$L_{Aeq,T}$ / L_{Aeq}	
	C-weighting	L_{Ceq}	-	-	
L_E Sound exposure level	A-weighting	L_{AE}	$L_{AE,T}$ / L_{AE}	L_{EA}	$L_{EA,T}$ / L_{EA}
	C-weighting	L_{CE}	L_{CE}	-	
L_{max} Maximum time-weighted sound level	A-weighting	L_{Amax}	L_{Amax}	L_{Amax}	$L_{pA,max}$
	C-weighting	L_{Cmax}	L_{Cmax}	L_{Cmax}	-
L_{peak} Peak sound level	C-weighting	L_{Cpeak}	L_{Cpeak}	-	

3

Name and Function of Each Part

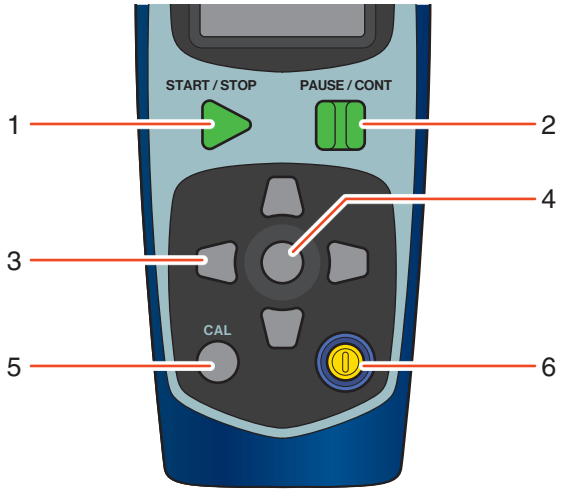
Front

Back



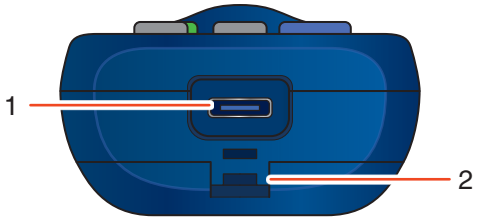
No.	Name	Description
1	Microphone and preamplifier	The microphone can be separated from the main unit, but the preamplifier is fixed to the main unit. Extension cables cannot be used. Attach the windscreen fall prevention rubber and windscreen WS-14 in this order.
2	Organic EL display	The time-weighted sound level is displayed numerically and as a bar graph. This also displays the operating status of the device and sets measurement conditions, warnings and other information.
3	Serial number label	The serial number of the sound level meter main body and that of the microphone are indicated on this label.
4	Nameplate	Shows necessary information such as the model, date of manufacture, and applicable standards of the device.
5	Tripod mounting screw hole	This screw hole can be used to mount the device to a camera tripod.
6	Battery compartment	Install two AA batteries to use the device.

Operation panel



No.	Name	Description
1	START/STOP key	Used when starting or ending measurement. Pressing the START/STOP key with the current screen starts measurement. Press again to end the measurement.
2	PAUSE/CONT key	Used to pause the measurement. Press again to resume. The current state (sound level display) cannot be paused.
3	Direction keys	Used to switch screens and select settings, etc.
4	Center key	Used to configure settings, etc. on the device. Pressing the center key with the current screen displays the menu screen. Pressing this key after changing a setting value saves that setting.
5	CAL key	Used to calibrate the device.
6	POWER key	Press to turn on the power. When the power is on, press and hold for several seconds to turn off the power.

Bottom



No.	Name	Description
1	USB port (Type-C)	A port for connecting a computer. This is for data transfer and operational stability is not guaranteed when powered solely through the USB port. For a reliable connection, it is recommended to insert batteries when using the device in conjunction with a computer.
2	Hand strap attachment part	Attach the hand strap for drop prevention (Page 43).

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Turning on the Power

The device operates on two AA batteries (alkaline batteries or Ni-MH rechargeable batteries).

⚠ WARNING

- If you notice any abnormalities such as excessive heat, smoke, or a burning odor while using the device, immediately remove the batteries, unplug the USB cable connector from the computer, and contact your dealer.
- If you do not intend to use the device for a long time, remove the batteries. Failing to do so may result in battery leakage.

4.1 Inserting the batteries

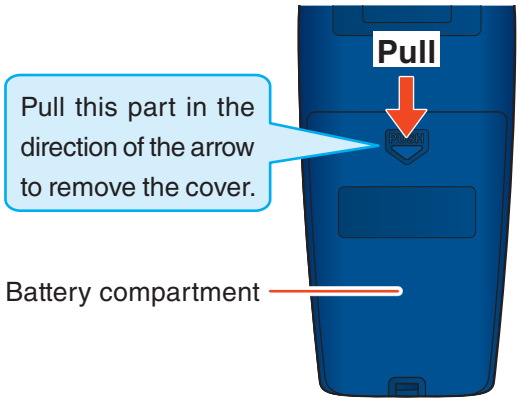
⚠ WARNING

- Make sure to correctly insert the batteries with the polarities of the batteries "+" and "-" matching the marks. If the polarities are incorrect, the batteries may explode or leak. If you do not intend to use the device, remove the batteries to prevent leakage. If electrolyte leaking from the batteries gets on your skin or clothes, wash it off immediately with water.
- Be careful not to injure yourself by pinching or cutting your hand when installing the battery compartment cover.

Important

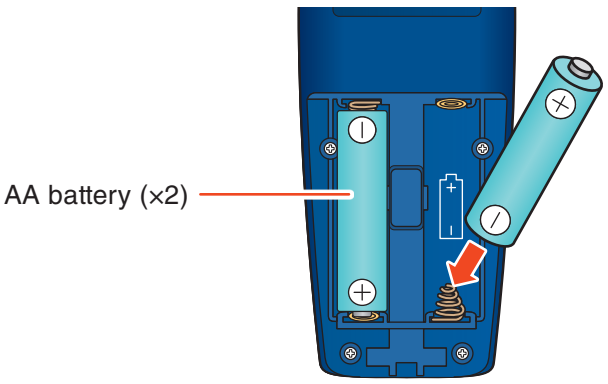
- Insert two new batteries of the same type. Using different types of batteries or mixing old and new batteries may cause a failure.

1 Remove the battery compartment cover.



2 Insert two AA batteries, ensuring that the orientation matches the "+" and "-" marks.

3 Reinstall the cover.



Operating time with batteries

The operating time with batteries will vary depending on the battery manufacturer and type (model), the usage environment of NL-28, and the measurement conditions.
The operating time is approximately as follows.

Battery type	Operating time (at 23°C)
Alkaline battery	Approx. 9 hours
Ni-MH rechargeable battery	Approx. 9 hours

Note

- Make sure to select the corresponding battery type in the [Battery] menu (Page 25).
- The continuous operating time of Ni-MH rechargeable batteries varies depending on the charging state.

4.2 Turning on/off the power

When turning on the power

Press the POWER key.

After the startup screen, the current screen appears.

When turning off the power

Press and hold the POWER key.

Release your finger from the POWER key when the power-off screen appears.

⚠ WARNING

- If the device is to be stored for a long time with the power turned off, remove the batteries. Leaving the batteries inside the device may cause electrolyte to leak. Also, disconnect the USB cable.

Important

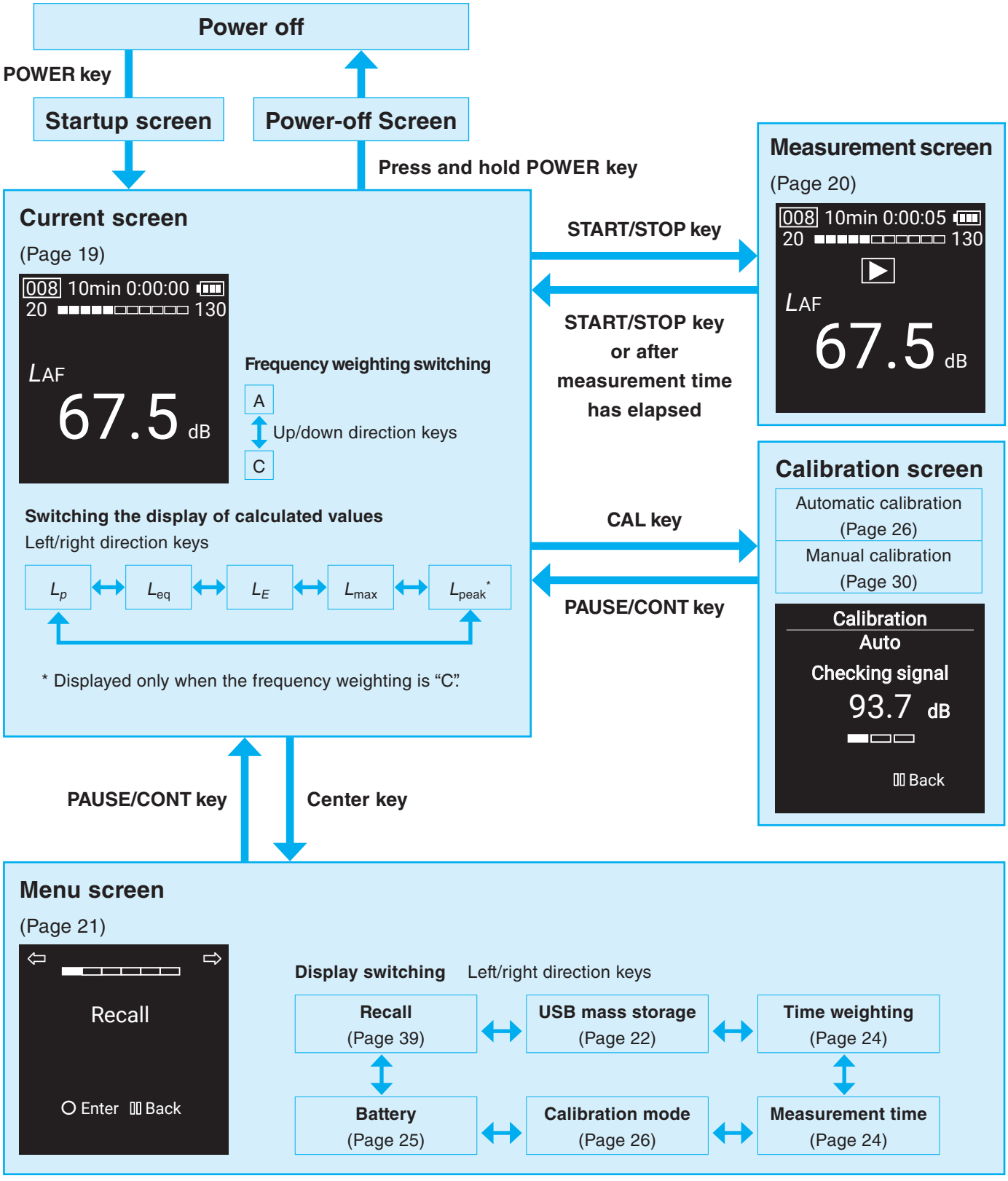
- Always turn off the device using the POWER key. Additionally, when replacing the batteries of the device, wait at least 5 seconds after the screen turns off before proceeding. Failure to follow these steps may result in the device not starting up or displaying incorrect measurements.

Note

- Wait at least 10 seconds after turning off the power of the device before turning it on again.

5 Reading the Display

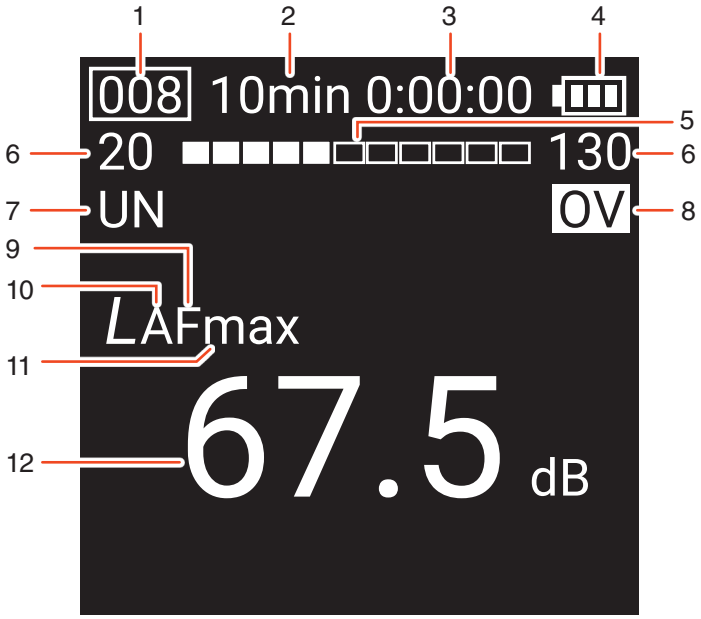
5.1 Screen transition



5.2 Current screen

Note

- While the actual display will not look like the one shown in the figures below, the explanation is based on the assumption that all the text are displayed.

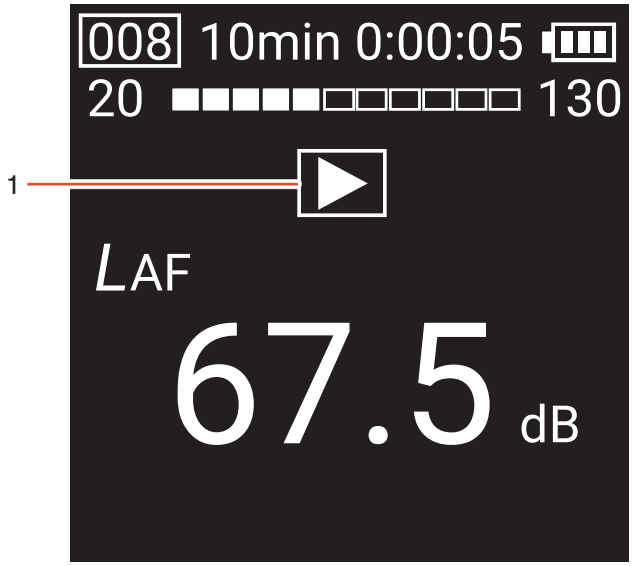


No.	Name	Description
1	Store address	Displays the address of the memory where the data being measured (or the data for the next measurement, if not being measured) will be stored.
2	Measurement time	Displays the measurement time set in “Measurement time”.
3	Measurement elapsed time	During a measurement, the time that has passed since the measurement started is displayed in hours, minutes, and seconds. Otherwise, the measurement time from the previous measurement is shown.
4	Battery level	Displays the power status. As the batteries are used, the remaining level decreases.  Full  Low Replace the batteries. Measurement cannot be taken if it begins to blink. Replace the batteries immediately.
5	Bar graph	Displays the time-weighted sound level L_p as a bar graph (updated every 0.1 s).
6	Bar graph range	Displays the values from the lower limit to the upper limit of the bar graph.
7	Under-range indication	UN When a sound level under-range condition is detected, this indication is shown for at least one second. UN If the calculation contains signal under-range data, this indication is shown. This indication remains on the screen until the next measurement is started.

<table>
<tr><th>No.</th><th>Name</th><th>Description</th></tr>
<tr><td>8</td><td>Overload indication</td><td>
<table>
<tr><td>OV</td><td>When a sound level overload condition is detected, the indication is shown for at least 1 second.</td></tr>
<tr><td>OV</td><td>If the calculation contains signal overload data, this indication is shown. This indication remains on the screen until the next measurement is started.</td></tr>
</table>
</td></tr>
<tr><td>9</td><td>Time weighting</td><td>Displays the set time weighting.
<table>
<tr><td>F</td><td>Fast</td></tr>
<tr><td>S</td><td>Slow</td></tr>
</table>
</td></tr>
<tr><td>10</td><td>Frequency weighting</td><td>Displays the frequency weighting.
<table>
<tr><td>A</td><td>A-weighting</td></tr>
<tr><td>C</td><td>C-weighting</td></tr>
</table>
</td></tr>
<tr><td>11</td><td>Calculated value quantifiers</td><td>Displays the quantifier (L_{eq}, L_E, L_{max}, L_{peak}) for the selected calculated value.</td></tr>
<tr><td>12</td><td>Instantaneous value and calculated value display</td><td>Displays the time-weighted sound level L_p or the calculated value selected with the up/down/left/right direction keys.
The calculated value is the progress of the measurement or the latest calculation result.</td></tr>
</table>

5.3 Measurement screen

Press the START/STOP key to start measurement, and the measurement screen will appear.



<table>
<tr><th>No.</th><th>Name</th><th>Description</th></tr>
<tr><td>1</td><td>Measurement status</td><td>
<table>
<tr><td>▶</td><td>Flashes during measurement.</td></tr>
<tr><td>❚❚</td><td>If the PAUSE/CONT key is pressed during a measurement, the measurement will pause and this will appear.</td></tr>
</table>
</td></tr>
</table>

6 Menu

6.1 Menu screen

Pressing the center key displays the MENU screen when the current screen is active.
Also, pressing the PAUSE/CONT key returns to the current screen.

Use the left/right direction keys to switch the setting item display, and press the center key to display the respective setting screen.

Recall
Displays the measurement data stored in the main unit. (Page 39)

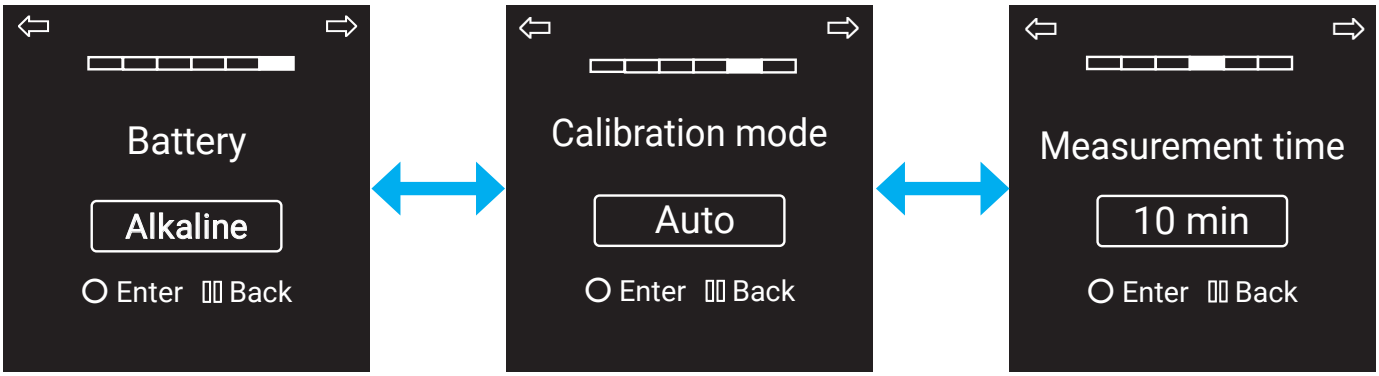
USB mass storage
Connects the device to a computer. (Page 22)

Time weighting
Sets the time weighting. (Page 24)

Battery
Sets the type of batteries used in the device. (Page 25)

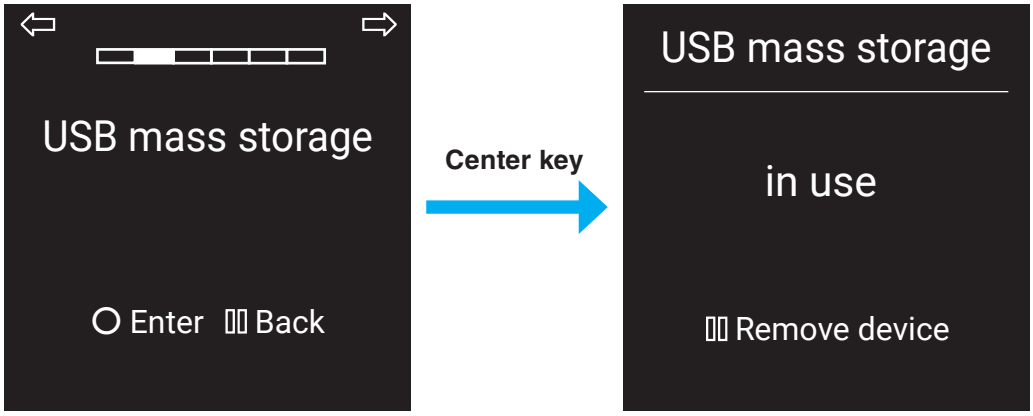
Calibration mode
Sets the calibration method. (Page 26)

Measurement time
Sets the measurement time. (Page 24)

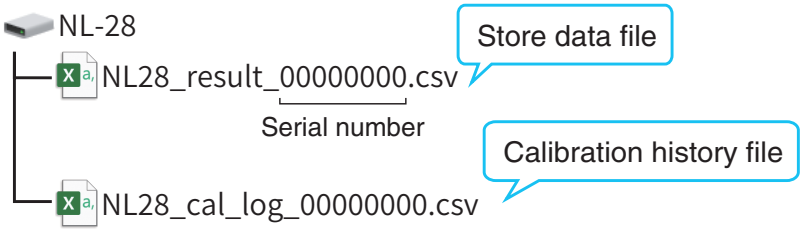


6.2 USB mass storage

This menu is used to connect the device to a computer.
With the device connected to the computer using a USB Type-C cable (Page 43), press the center key when the [USB mass storage] screen is displayed to enable the computer to recognize the device's internal memory as a removable disk.
It is used to check the measurement and calibration history in CSV files and to update the software.
When disconnecting the device from the computer, press the PAUSE/CONT key and wait until "in use" disappears before disconnecting the device.



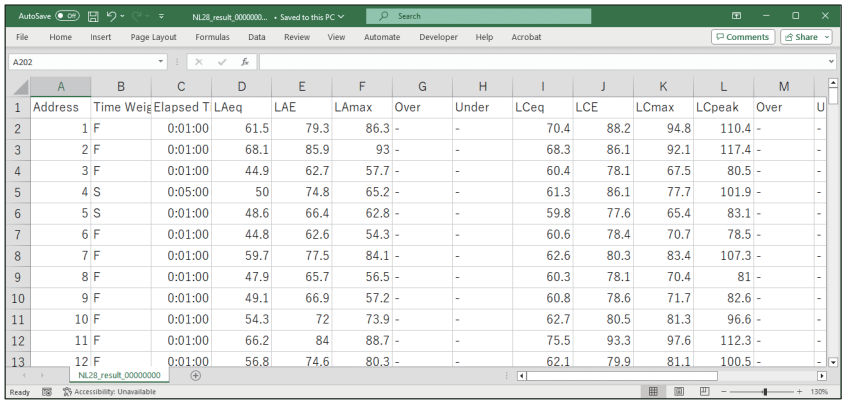
File organization



Note

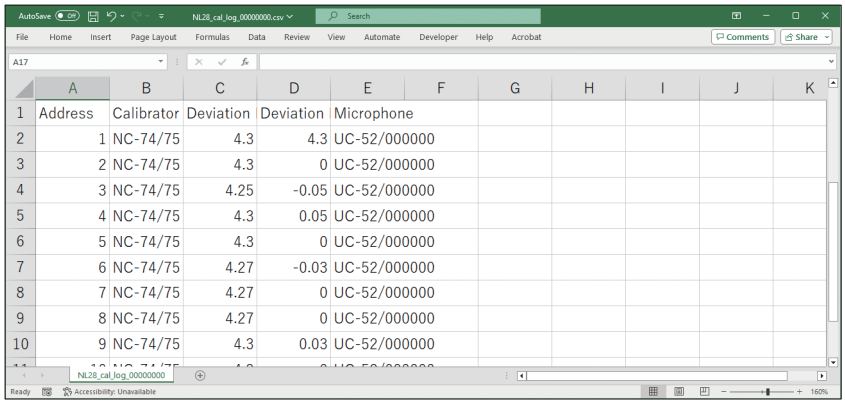
- Up to 200 sets of store data are stored in the store data file, and up to 999 sets of calibration history are stored in the calibration history file.
- The store address is automatically incremented by one for each measurement. Similarly, the address in the calibration history file is automatically incremented by one for each saved calibration result.
- When the number of stored measurement results reaches the upper limit, the address returns to "1", and the address is automatically incremented by one in the same manner. At this point, these stored data are automatically overwritten.
- When the maximum number of stored calibration results is reached, the stored data with address "1" is automatically deleted, and the address number of all data is automatically decremented. Therefore, the data with the largest address always represents the latest calibration result.
- Check the store address on the current screen (before measurement) or on the measurement screen (during measurement).

- **Example of store data screen**



	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Address	Time Weig	Elapsed T	LAeq	LAE	LAmax	Over	Under	LCeq	LCE	LCmax	LCpeak	Over
2	1	F	0:01:00	61.5	79.3	86.3	-	-	70.4	88.2	94.8	110.4	-
3	2	F	0:01:00	68.1	85.9	93	-	-	68.3	86.1	92.1	117.4	-
4	3	F	0:01:00	44.9	62.7	57.7	-	-	60.4	78.1	67.5	80.5	-
5	4	S	0:05:00	50	74.8	65.2	-	-	61.3	86.1	77.7	101.9	-
6	5	S	0:01:00	48.6	66.4	62.8	-	-	59.8	77.6	65.4	83.1	-
7	6	F	0:01:00	44.8	62.6	54.3	-	-	60.6	78.4	70.7	78.5	-
8	7	F	0:01:00	59.7	77.5	84.1	-	-	62.6	80.3	83.4	107.3	-
9	8	F	0:01:00	47.9	65.7	56.5	-	-	60.3	78.1	70.4	81	-
10	9	F	0:01:00	49.1	66.9	57.2	-	-	60.8	78.6	71.7	82.6	-
11	10	F	0:01:00	54.3	72	73.9	-	-	62.7	80.5	81.3	96.6	-
12	11	F	0:01:00	66.2	84	88.7	-	-	75.5	93.3	97.6	112.3	-
13	12	F	0:01:00	56.8	74.6	80.3	-	-	62.1	79.9	81.1	100.5	-

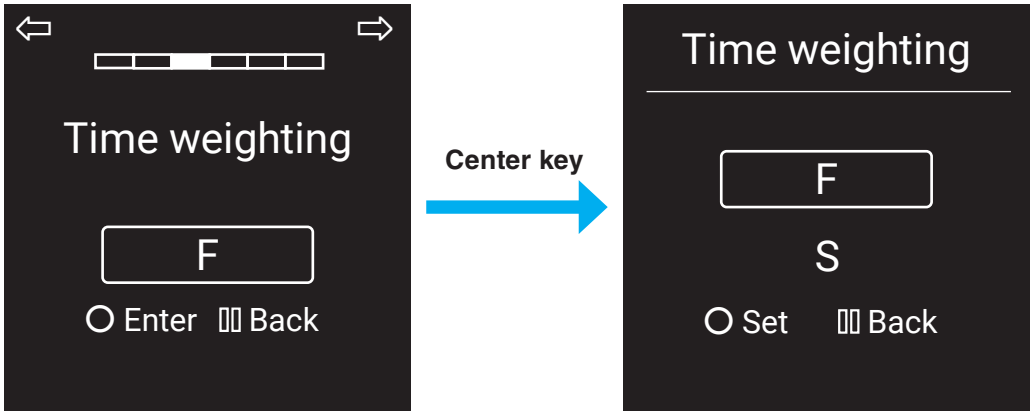
- **Example of calibration history screen**



	A	B	C	D	E	F	G	H	I	J	K
1	Address	Calibrator	Deviation	Deviation	Microphone						
2	1	NC-74/75	4.3	4.3	UC-52/000000						
3	2	NC-74/75	4.3	0	UC-52/000000						
4	3	NC-74/75	4.25	-0.05	UC-52/000000						
5	4	NC-74/75	4.3	0.05	UC-52/000000						
6	5	NC-74/75	4.3	0	UC-52/000000						
7	6	NC-74/75	4.27	-0.03	UC-52/000000						
8	7	NC-74/75	4.27	0	UC-52/000000						
9	8	NC-74/75	4.27	0	UC-52/000000						
10	9	NC-74/75	4.3	0.03	UC-52/000000						

6.3 Time weighting setting

This menu is used to set the time weighting.

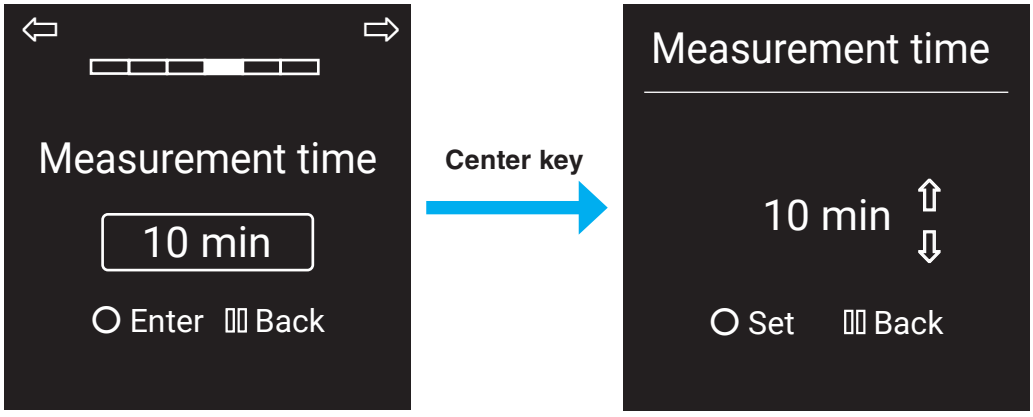


The following items can be set using the up/down direction keys.

Item	Description
F	Sets F (fast). Select this when measuring general noise, especially fluctuating sound. This is usually used for measuring noise levels and sound levels.
S	Sets S (slow). Select this to pick up sounds with little fluctuation or the average values of fluctuating sounds. This is used for measuring noise of Shinkansen, conventional railway, etc.

6.4 Measurement time

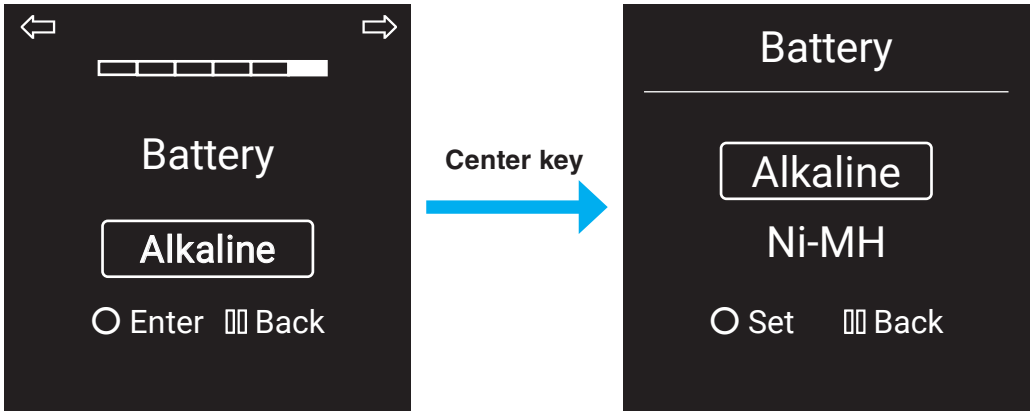
This menu is used to set the measurement time.
Select from “1 min”, “5 min”, “10 min”, and “1 h” using the up/down direction keys.



(min = minutes, h = hours)

6.5 Battery

This menu is used to set the type of batteries used in the device.



The following items can be set using the up/down direction keys.

Item	Description
Alkaline	Select this when using alkaline batteries.
Ni-MH	Select this when using Ni-MH rechargeable batteries.

7 Calibration

Calibration can be automatic or manual.

7.1 Automatic calibration

Insert the microphone of the device into the sound calibrator (NC-75/74).
If necessary, adjust it so that the time-weighted sound level L_p (indicated value) display of the device is equal to the sound level in the coupler of the calibrator.

Note

- When using a calibrator other than NC-75/74, use manual calibration.
- We recommend regularly calibrating the sound calibrator.
- For details on how to calibrate using a sound calibrator, refer to its instruction manual.
- Perform sound calibration with the microphone of this device horizontally inserted all the way into the sound calibrator.

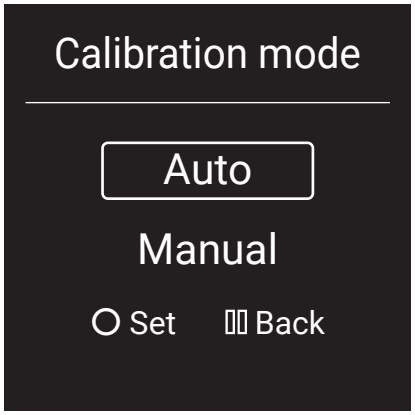
1 **Check that the current screen is displayed, and press the center key.**

The menu screen appears.

2 **Press the left/right direction keys to display the [Calibration mode] screen, and press the center key.**

The [Calibration mode] screen appears.

3 **Select [Auto] using the up/down direction keys, then press the center key.**



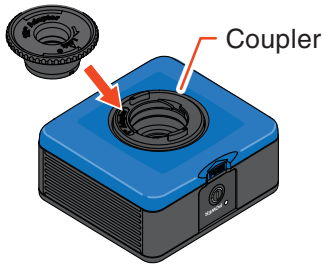
4 **Press the PAUSE/CONT key to return to the current screen.**

5 **Check that the sound calibrator is turned off.**

6 **Attach the 1/2-inch adapter to the sound calibrator.**

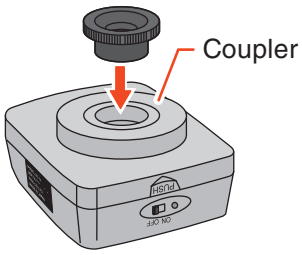
Sound calibrator NC-75

1/2 inch adapter for NC-75



Sound calibrator NC-74

1/2 inch adapter for NC-74

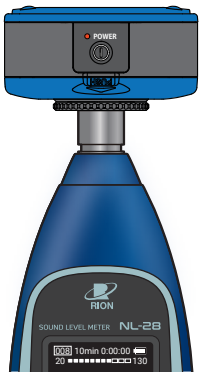


7 **Gently and slowly push the microphone of the device until it hits the back of the coupler.**

Important

- Attach the sound calibrator to the microphone gently and slowly.
- If it is pushed in or pulled out suddenly, the air pressure inside the coupler will change significantly, which may damage the diaphragm of the microphone.
- When attaching or detaching the calibrator, do not rotate the device or the calibrator. Rotating the device or calibrator may loosen or dislodge the microphone and damage the microphone diaphragm.

8 Turn on the sound calibrator.



9 After inserting the microphone, wait briefly and then press the CAL key.

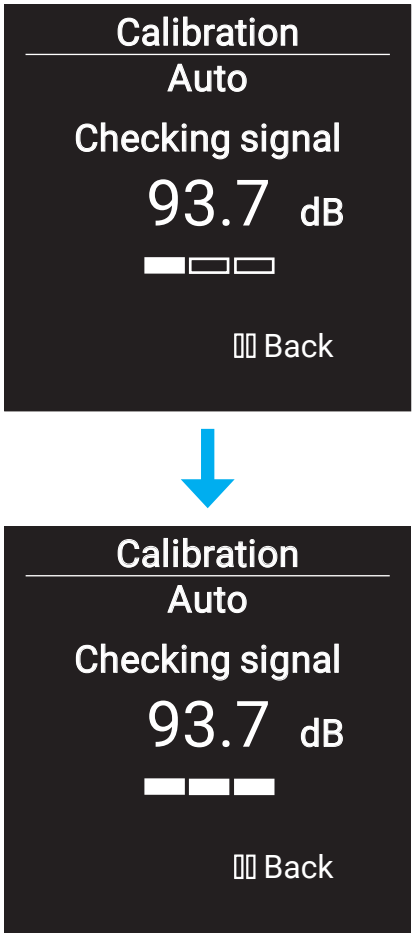
Note

- Accurate calibration cannot be performed immediately after the microphone is inserted because the air pressure inside the calibrator and microphone has changed.
- It takes up to 30 seconds for the air pressure to stabilize and the microphone performance of the device to stabilize. As for the time required for the inside of the calibrator to stabilize, refer to the instruction manual of each sound calibrator.

The [Calibration] screen appears and automatically checks for problems in the calibration environment (such as background noise and calibration signal stability).

The progress of the automatic check is displayed in a bar graph. When the automatic check is completed without any problems, the screen automatically shifts to the screen shown in 10.
If the bar graph does not progress or stops midway, there may be a problem with the calibration environment. Inspect the secure attachment of the sound calibrator and the background noise environment, and then proceed to perform the calibration again.

If you do not wish to calibrate, press the PAUSE/CONT key to return to the current screen.

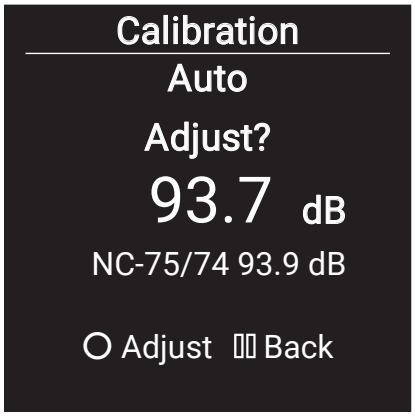


Note

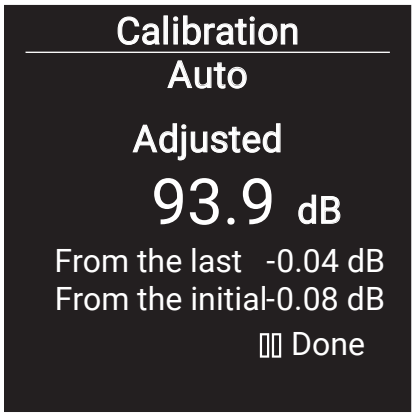
- If the bar graph on the auto-calibration screen does not progress after re-calibration, please contact your dealer.

10 When “Adjust?” appears, press the center key to automatically adjust the indicated value.

If there is no difference between the indicated value and the calibrated value, or if you do not adjust the indicated value, the calibration procedure concludes here. Press the PAUSE/CONT key to return to the current screen.



Once the automatic adjustment is completed, “Adjusted” is displayed, and the calibration history is saved.
“From the last” indicates the difference from the previous calibration value, while “From the initial” shows the difference from the calibration value at the time of manufacture.
If recalibration was performed at the time of inspection, the difference will be from the calibration value at the time of inspection.



11 Press the PAUSE/CONT key to return to the current screen.

12 Turn off the sound calibrator.

13 Gently pull the microphone of the device out of the coupler.

7.2 Manual calibration

For manual calibration, insert the microphone of the device into the sound calibrator (NC-75/74) or the pistonphone (NC-72B/72A).
If necessary, adjust it so that the time-weighted sound level L_p (indicated value) display of the device is equal to the sound level in the coupler of the calibrator.

Note

- We recommend regularly calibrating the sound calibrator and pistonphone.
- For details on how to calibrate using a sound calibrator or pistonphone, refer to the respective instruction manuals.
- Perform sound calibration with the microphone of this device horizontally inserted all the way into the sound calibrator or pistonphone.

1 **Check that the current screen is displayed, and press the center key.**

The menu screen appears.

2 **Press the left/right direction keys to display the [Calibration mode] screen, and press the center key.**

The [Calibration mode] screen appears.

3 **Select [Manual] using the up/down direction keys, then press the center key.**

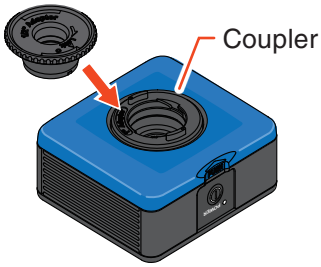
4 **Press the PAUSE/CONT key to return to the current screen.**

5 Check that the sound calibrator or pistonphone is turned off.

6 Attach the 1/2-inch adapter to the sound calibrator or pistonphone coupler.

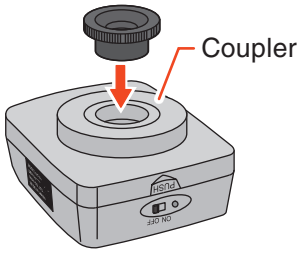
Sound calibrator NC-75

1/2 inch adapter for NC-75

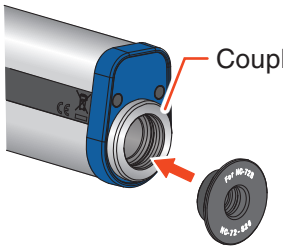


Sound calibrator NC-74

1/2 inch adapter for NC-74

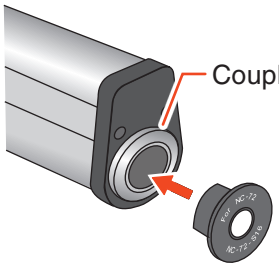


Pistonphone NC-72B



1/2 inch adapter for NC-72B

Pistonphone NC-72A



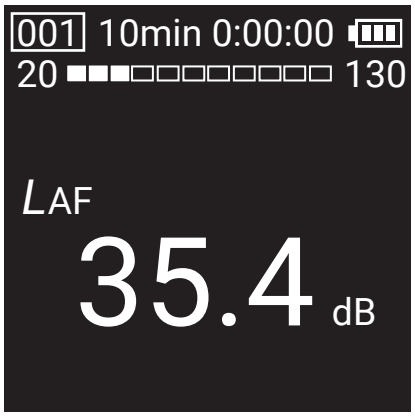
1/2 inch adapter for NC-72A

7 Gently and slowly push the microphone of the device until it hits the back of the coupler.

Important

- Attach the sound calibrator or pistonphone to the microphone gently and slowly.
- If it is pushed in or pulled out suddenly, the air pressure inside the coupler will change significantly, which may damage the diaphragm of the microphone.
- When attaching or detaching the calibrator, do not rotate the device or the calibrator. Rotating the device or calibrator may loosen or dislodge the microphone and damage the microphone diaphragm.

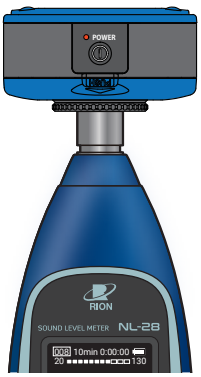
8 After inserting the microphone, wait a short while and then read the indicated value on the device.



Note

- Accurate calibration cannot be performed immediately after the microphone is inserted because the air pressure inside the calibrator and microphone has changed.
  It takes up to 30 seconds for the air pressure to stabilize and the microphone performance of the device to stabilize. As for the time required for the inside of the calibrator to stabilize, refer to the instruction manual of each sound calibrator.

9 Turn on the sound calibrator or pistonphone.



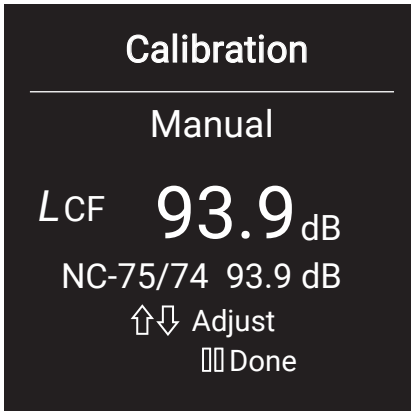
10 Wait until the indicated value on the device settles before reading it.

Check that the sound calibrator (NC-75/74) exceeds the value read in step 8 by 20 dB or more and that the pistonphone (NC-72B/72A) exceeds the read value by 30 dB or more.

Note

- If this difference is less than 20 dB for the sound calibrator (NC-75/74) and less than 30 dB for the pistonphone (NC-72B/72A), the surrounding environment noise will affect the calibration, and you will be unable to calibrate accurately.

11 Press the CAL key and adjust the indicated value if necessary.



- If there is no difference between the indicated value and the calibrated value, or if you do not adjust the indicated value, the calibration procedure concludes here.
- When making adjustments, use the up/down direction keys to ensure that the indicated value matches the calibration value.
- If using the sound calibrator NC-75/74, adjust the indicated value according to the displayed calibration value (NC-75/74: 93.9 dB) on the screen.

Calibrator model	Calibration value
NC-75/74	93.9 dB
NC-72B/72A	See the instruction manual of each product

Note

- Calculate the generated sound pressure level by substituting the following values into the formula provided in the NC-72B/72A operation manual: the specified sound pressure level (nominal value is 114 dB) indicated on the calibration slip supplied with the NC-72B/72A, the amount of correction for differences in microphones (-0.03 dB for NL-28), and the static pressure measured with the supplied barometer.

12 Press the PAUSE/CONT key to save the calibration history, and return to the current screen.

13 Turn off the sound calibrator or pistonphone.

14 Gently pull the microphone of the device out of the coupler.

8 Measurement

This section describes how to check the time-weighted sound level L_p value of the current state and measure the calculated values (L_{eq}, L_E, L_{max}, L_{peak}).

8.1 Checking the current L_p value

Check the time-weighted sound level L_p value in the current screen.

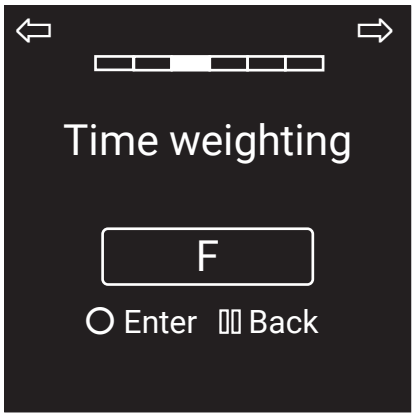
1 **Check that the current screen is displayed.**

2 **Press the center key.**

The menu screen appears.

3 **Press the left/right direction keys to display the [Time weighting] screen, and press the center key.**

The [Time weighting] screen appears.

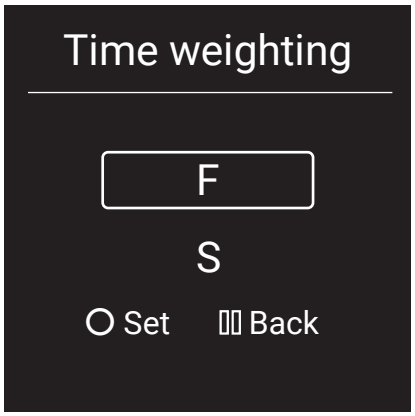


4 Select the time weighting using the up/down direction keys, and press the center key.

When measuring according to a standard such as JIS, set the time weighting according to the corresponding standard.

Item	Description
F	Sets F (fast).
S	Sets S (slow).

For details on each item, refer to Page 24.

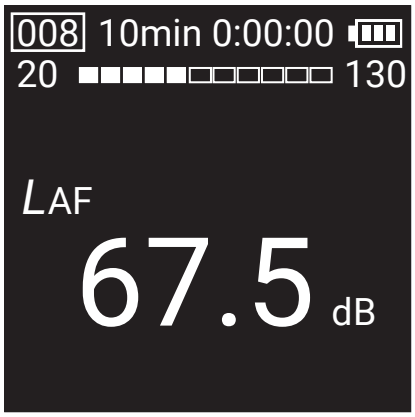


5 Press the PAUSE/CONT key to return to the current screen.

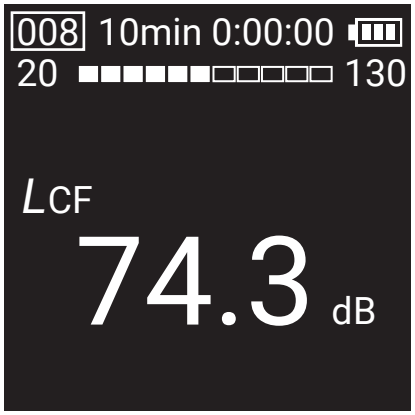
6 Verify the L_p value of the current state.

The current screen displays the time-weighted sound level L_p, with the bar graph updated every 0.1 second and the level values every second.
When an overload signal or under-range signal occurs, [OV] or [UN] appears on the screen (Page 19).
Use the up/down direction keys to check the L_p value for each frequency weighting (A, C).

Item	Description
A	Sets A-weighting. A frequency filter that accounts for the relative loudness perceived by the human ear, and is selected when measuring general environmental noise.
C	Sets C-weighting. A frequency filter is applied that attenuates the low-frequency range equal to or below 31.5 Hz and the high-frequency range equal to or above 8 kHz. In general, C-weighting may be used to reduce low-frequency background noise such as wind noise for frequency analysis, or to measure loud sounds.



Up/down direction keys



8.2 Calculated values measurement

Measure the calculated values (L_{eq}, L_{max}, L_E, L_{peak}).

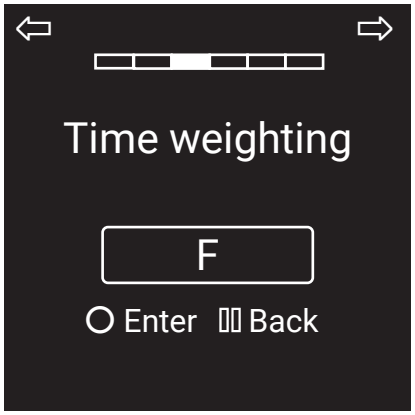
1 **Check that the current screen is displayed.**

2 **Press the center key.**

The menu screen appears.

3 **Press the left/right direction keys to display the [Time weighting] screen, and press the center key.**

The [Time weighting] screen appears.

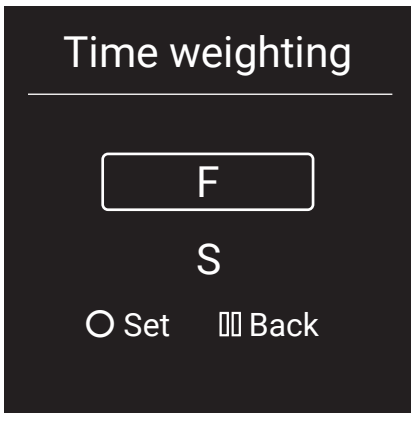


4 **Select the time weighting using the up/down direction keys, and press the center key.**

When measuring according to a standard such as JIS, set the time weighting according to the corresponding standard.

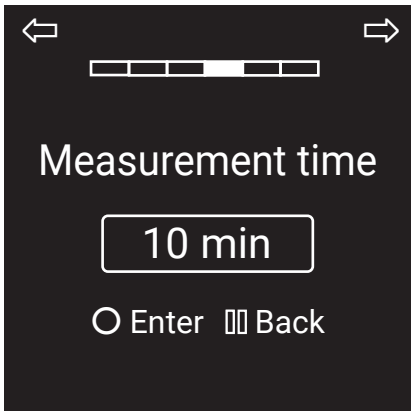
Item	Description
F	Sets F (fast).
S	Sets S (slow).

For details on each item, refer to Page 24.

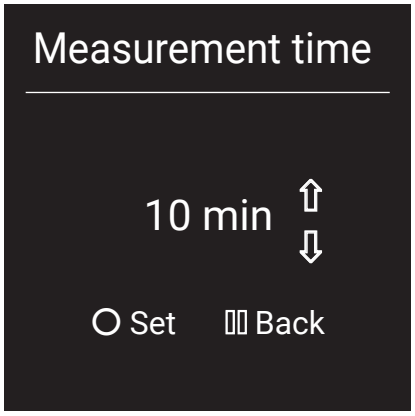


5 **Press the left/right direction keys to display the [Measurement time] screen, and press the center key.**

The [Measurement time] screen appears.



6 **Select the measurement time using the up/down direction keys, and press the center key.**

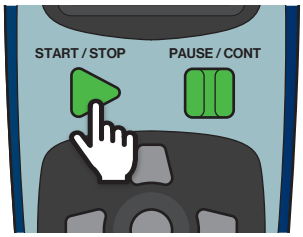


(min = minutes, h = hours)

7 **Press the PAUSE/CONT key to return to the current screen.**

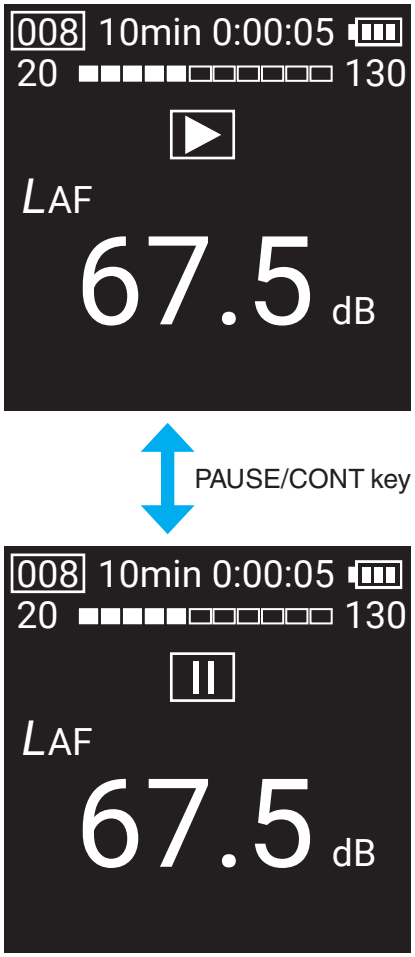
8 Press the START/STOP key to start measuring.

At this point, previous measurement values are cleared.



The time-weighted sound level L_p is displayed in the center of the current screen, with the bar graph updated every 0.1 second and the level values every second.
When an overload signal or under-range signal occurs, [OV] or [UN] appears on the screen (Page 19).
During and after measurement, L_p values and calculations (L_{eq}, L_{max}, L_E, L_{peak} (C-weighting only)) for each frequency weighting (A, C) can be checked by pressing the up/down/left/right direction keys.
When measuring according to a standard such as IEC, set the frequency weighting according to the corresponding standard. For details on each weighting, refer to Page 35.

Press the PAUSE/CONT key to pause the calculation.
[II] is displayed on the screen during pause.
The time-weighted sound level L_p bar graph and the level value display will be updated even during the pause.



9 Measurement ends automatically after the set measurement time has elapsed.

Measurement can be terminated by pressing the START/STOP key even before the set measurement time has elapsed.

Subsequently, on the current screen, you can press the up/down/left/right direction keys to display the calculation values of the latest measurement results.
Data can also be read using the recall function (Page 39) and exported in CSV file format through the USB mass storage function (Page 22).

9 Store Operation

The device automatically saves the measurement data, including calculated values such as equivalent continuous sound level, and measurement conditions such as time weighting, in the main unit.
This section provides details on the saved data.

9.1 Loading the saved data

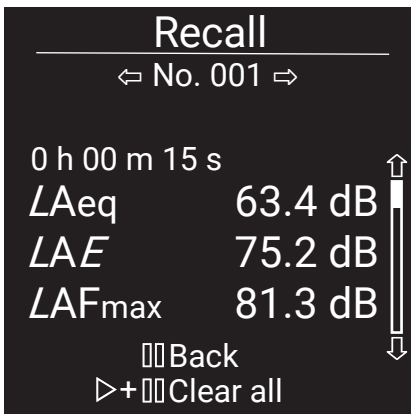
Read the data stored in the main unit.

1 **Check that the current screen is displayed, and press the center key.**

The menu screen appears.

2 **Press the left/right direction keys to display the [Recall] screen, and press the center key.**

Each calculated value is displayed.
Use the up/down direction keys to scroll through the screen, and the left/right key to change the address to be displayed.



9.2 Deleting all the saved data

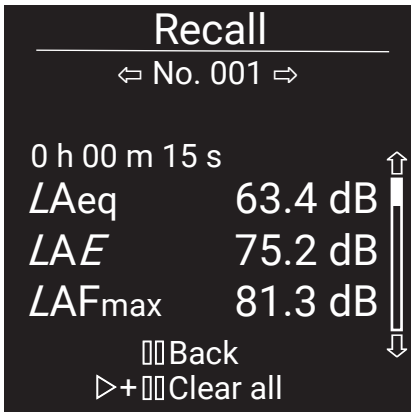
Deletes all data stored in the main unit.
The device does not have a function to individually delete selected data.

1 **Check that the current screen is displayed, and press the center key.**

The menu screen appears.

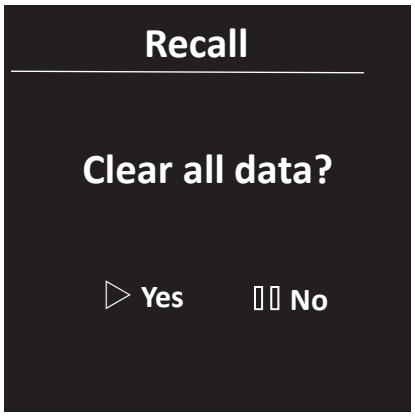
2 **Press the left/right direction keys to display the [Recall] screen, and press the center key.**

Each calculated value is displayed.



3 Press the START/STOP key and PAUSE/CONT key at the same.

The confirmation screen appears.



4 Press the START/STOP key.

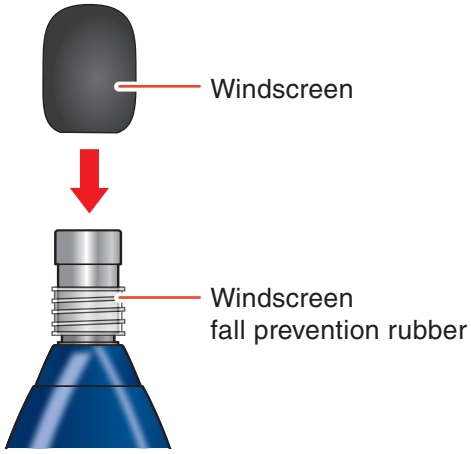
All stored measurement data will be deleted.
If you do not want to delete the data, press the PAUSE/CONT key.

10 Connection with Peripheral Devices

10.1 Attaching the windscreen

When measuring noise outdoors in a windy environment or with a ventilation system present, the wind or air can come into contact with the microphone and generate wind noise, which can affect the measurement results. In such cases, wind/air noise can be reduced by installing the supplied windscreen WS-14 to the microphone.
Attaching the windscreen WS-14 to the microphone will change the sensitivity and frequency response, but the microphone will conform to the standard regardless of whether it is attached or not.
For details on the windscreen characteristics, refer to Page 66.

Attach the windscreen to the microphone.



10.2 Mounting on a tripod

When taking measurements at a fixed point for a long time, mount the device to a camera tripod.

⚠ CAUTION

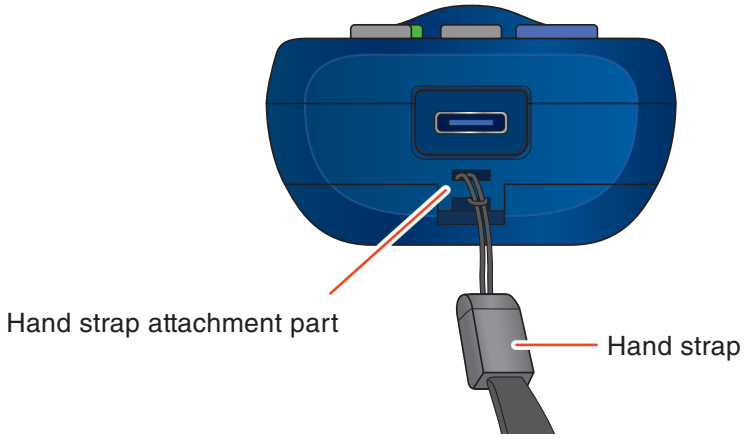
- Be careful not to drop the device when mounting it on a tripod. Also, ensure that the tripod does not fall over.
- When using a tripod, make sure the tripod is stable with the device mounted.
- Do not move the device while it is mounted to the tripod. Doing so may damage the device.

Important

- When mounting the device to a tripod, use the tripod screw to directly fix the device in place.
- Be careful not to tilt the screw when mounting or removing the device from the tripod. Turning with excessive force may damage the screw of the device.

10.3 Attaching the hand strap

When using the device in handheld mode, secure it by attaching the supplied hand strap to prevent any accidental drops. For added security, pass your wrist through the hand strap while using the device.

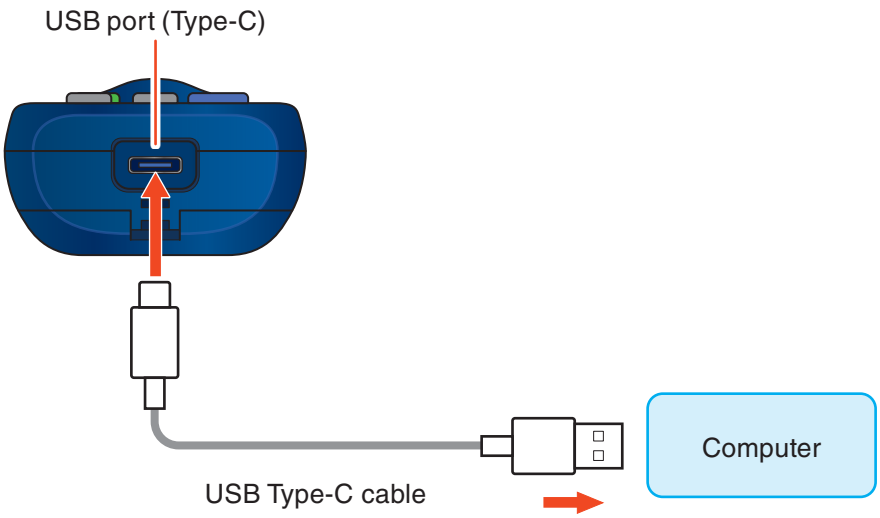


10.4 Computer connection

Connect a computer and the device with a commercially available USB Type-C cable as follows.

1 **Plug the connector of the USB Type-C cable into the USB port of the device and the computer.**

2 **By using the USB mass storage function (Page 22) from the menu, the internal memory of the device is recognized as a removable disk.**



Important

- Power is supplied to the device through the USB port, but this does not guarantee the operation of the device. When connecting the device to a computer, always ensure that the device has batteries installed. Failure to follow these steps may result in the device not starting up or displaying incorrect measurements.

11 Specifications

<table>
<tr><td>Applicable standards</td><td>IEC 61672-1:2013 class 2
JIS C 1509-1:2017 class 2
JIS C 1516:2020 class 2
CE Marking
• EMC Directive Directive 2014/30/EU EN 61326-1:2013
• RoHS Directive Directive 2011/65/EU EN IEC 63000:2018
UKCA Marking, China RoHS, KC Mark</td></tr>
<tr><td>Measurement function</td><td>At the selected time weighting, the following calculation values can all be measured simultaneously at the frequency weighting A and C.
(For L_{peak}, only the C-weighting can be measured.)
<table>
<tr><td>Instantaneous value</td><td>Time-weighted sound level</td><td>L_p</td></tr>
<tr><td>Calculated values</td><td>Equivalent continuous sound level
Sound exposure level
Maximum time-weighted sound level
Peak sound level</td><td>L_{eq}
L_E
L_{max}
L_{peak}</td></tr>
</table></td></tr>
<tr><td>Measurement time</td><td>1 min, 5 min, 10 min, 1 h</td></tr>
<tr><td>Microphone</td><td>
<table>
<tr><td>Model</td><td>UC-52</td></tr>
<tr><td>Sensitivity level (representative value)</td><td>-33 dB (re. 1V/Pa at 1 kHz)</td></tr>
</table></td></tr>
<tr><td>Measurement level range</td><td>
<table>
<tr><td>A-weighting</td><td>30 dB to 137 dB</td></tr>
<tr><td>C-weighting</td><td>36 dB to 137 dB</td></tr>
<tr><td>C-weighted peak sound level</td><td>65 dB to 140 dB</td></tr>
</table></td></tr>
<tr><td>Self-generated noise</td><td>
<table>
<tr><td>A-weighting</td><td>Max. 24 dB (Typical 22 dB)</td></tr>
<tr><td>C-weighting</td><td>Max. 30 dB (Typical 28 dB)</td></tr>
</table></td></tr>
<tr><td>Entire linear operating range</td><td>30 dB to 137 dB (A-weighting, 1 kHz)</td></tr>
<tr><td>Linear operating range</td><td>107 dB (A-weighting, sound level)</td></tr>
<tr><td>Measurement frequency range</td><td>20 Hz to 8 kHz</td></tr>
<tr><td>Standard frequency</td><td>1 kHz</td></tr>
<tr><td>Reference sound pressure level</td><td>94 dB</td></tr>
<tr><td>Frequency weighting</td><td>A-weighting, C-weighting</td></tr>
<tr><td>Time weighting</td><td>F (fast), S (slow)</td></tr>
<tr><td>Calculation interval</td><td>
<table>
<tr><td>L_p, L_{max}, L_{peak}</td><td>20.8 µs (sampling frequency 48 kHz)</td></tr>
<tr><td>L_{eq}, L_E</td><td>1 s</td></tr>
</table></td></tr>
</table>

Calibration

A reference signal is input using sound calibrator NC-75/NC-74 or pistonphone NC-72B/NC-72A, and the signal input sensitivity is adjusted automatically or manually.
Up to 999 calibrations can be managed in the calibration history and saved.

	NC-75 / NC-74	NC-72B / NC-72A
Calibration signal frequency	1 kHz	250 Hz
Calibration signal level	94 dB	See the instruction manual of each product

* With auto-calibration, only the sound calibrator NC-75/74 can be used.

Windscreen

Conforms to IEC 61672-1 class 2, JIS C 1509-1 class 2, and JIS C 1516 class 2, even when a windscreen is attached.

Pause function

Pauses calculation value measurement.
The current state (sound level display) is updated even during pause.

Display

Device	1.5-inch monochrome organic EL display
Resolution	128 × 128
Numeric value update cycle	1 s
Bar graph update cycle	100 ms

Overload indication / under-range indication

OVER is displayed for a signal input that is larger than the upper measurement limit.
UNDER is displayed for a signal input that is smaller than the lower measurement limit.

Manual store

Manually starts or stops measuring and simultaneously calculates L_{eq}, L_E, L_{max} and L_{peak} before recording the results in a file.

Data storage capacity	Internal memory: Can store up to 200 data sets

Language

English

Data recall

Browses stored data.

USB

Internal memory can be recognized by the computer as a removable disk for data transfer.

Power supply

AA battery (×2)

Operating time (23°C, measurement status)	Alkaline battery: Approx. 9 hours Ni-MH rechargeable battery: Approx. 9 hours
Current consumption	135 mA (power supply voltage: 3 V)

Operating temperature and humidity range

Temperature	-10°C to 50°C
Humidity	10% to 90% RH (no condensation)

Dimensions, weight

Approx. 200 mm (H) x 50 mm (W) x 34 mm (D), approx. 160 g (including batteries)

Accessories

Windscreen WS-14	×1
Windscreen fall prevention rubber	×1
Hand strap	×1
USB port cover	×1
Size AA alkaline batteries	×2
Instruction Manual: Quick Start Guide	×1
Supplied Accessories & Inspection Certificate	×1

Optional accessories

Sound calibrator NC-75
Pistonphone NC-72B
Tripod for sound level meter ST-80

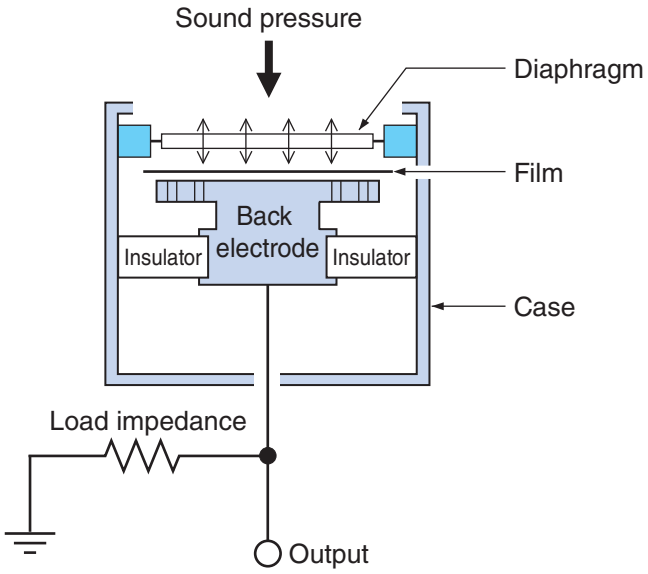
12 Microphone

The Class 2 Sound Level Meter NL-28 is fitted with free-field electret microphone UC-52 that is 1/2 inch in diameter.

12.1 Structure and how it works

As shown in the figure below, in general, an electret condenser microphone used for taking measurements consists of five parts: a diaphragm, film, back electrode, insulator, and case. Usually, a film holding an electric charge is fixed to the back electrode.
When sound pressure is applied to the diaphragm, the distance between the diaphragm and the back electrode changes, and therefore the capacitance formed between them changes. This change in capacitance is output as voltage. The materials and characteristics of each component and their combinations will result in differences in the frequency, temperature, and humidity characteristics, etc. The high-frequency range is determined by the vibration resonant frequency.

Structure of the electret condenser microphone



12.2 Specifications

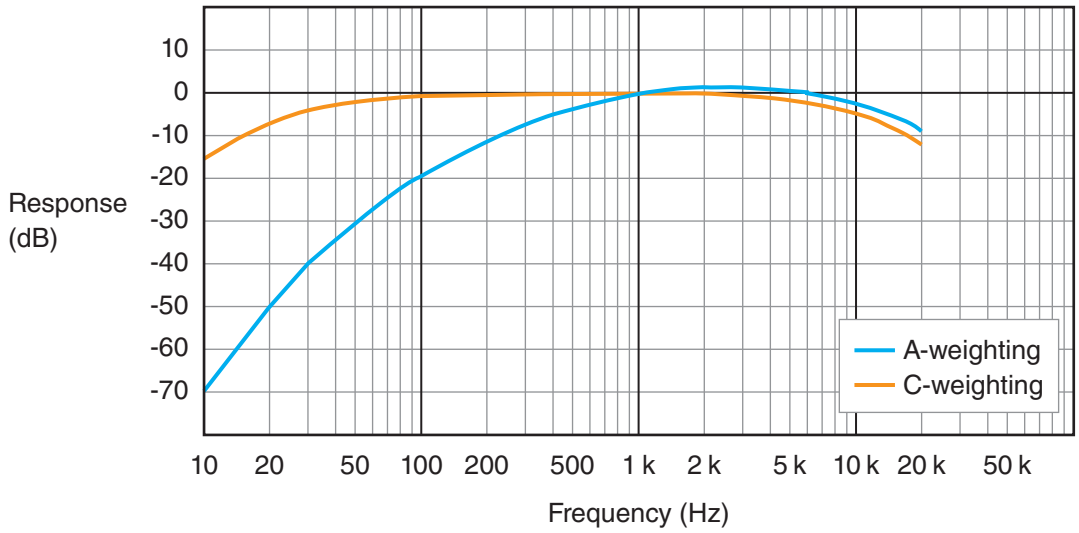
Model	UC-52
Nominal outer diameter	1/2 inches
Sensitivity level (representative value)	-33 dB (re. 1 V/Pa at 1 kHz, standard environmental conditions*)
Frequency response	20 Hz to 8 kHz
Capacitance (representative value)	19 pF
Dimensions	Φ13.2 mm × 12.0 mm
Weight	5.4 g

* Standard environment conditions: temperature = 23°C, humidity = 50% RH, air pressure = 101.325 kPa

13

Frequency Weighting

Frequency weighting A and C of the sound level meter are achieved by frequency weighting circuits with electrical characteristics as shown in the following figure.



Characteristics of frequency weighting circuits

The perceived noise level is not determined by the sound pressure level alone. For example, even with the same sound pressure level, there is a difference in perceived loudness between low and high frequencies. Values measured by A-weighting have been found to be relatively close to the perceived sound level, and A-weighting is used for evaluating general environmental noise (measuring noise level).
C-weighting has an almost flat frequency response, but compared to the wide, flat Z-weighting, it is attenuated in the low frequency range equal to or below 31.5 Hz and in the high frequency range equal to or above 8 kHz. C-weighting is used to measure sound pressure levels excluding the effects of background noise such as wind noise, analyze frequencies, and evaluate impulsive noise.

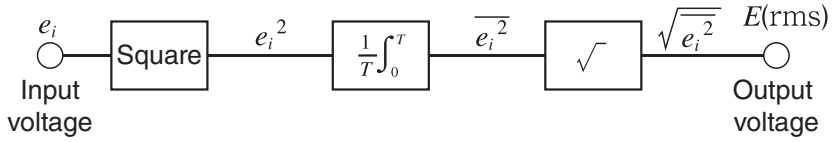
14

Root-mean-square Circuit and Time Weighting

A root-mean-square detection circuit is used to convert the output signal of the microphone preamplifier to a root-mean-square value and calculate the evaluation value (decibel value).

$$E(\mathrm{rms}) = \sqrt{\frac{1}{T}\int_0^T e^2\,\mathrm{dt}}$$

This shows that it can be calculated by squaring the instantaneous voltage (e) of the time waveform up to time (T) and taking the square root of the averaged value.
NL-28 calculates the root-mean-square value using a digital calculation method.



However, the noise level of the sound often fluctuates rapidly, and it is difficult to read the constantly changing values with the aforementioned detection circuit alone. With the sound level meter, the root-mean-square detection circuit can also calculate the exponentially weighted average (exponential average) of the square of the instantaneous voltage. This weighting characteristic is called time weighting and is specified in the “Time constant” section (see the next page).

The main time-weighting characteristics of sound level meters are F (fast) and S (slow). F (fast) narrows the time range of sound pressure that affects averaging, and S (slow) widens it. That is, F (fast) has a greater influence on the result of the current value, while S (slow) has less of an influence on the current result than F (fast).
Thinking of this in terms of measuring noise (sound pressure), F (fast) relatively faithfully follows the phenomenon that the magnitude fluctuates in a short time, whereas S (slow) struggles to follow minor fluctuations, resulting in a large average.

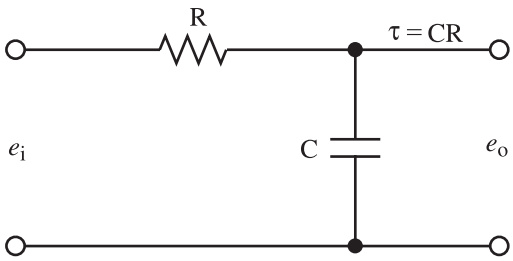
F (fast) is used when measuring general noise, especially fluctuating sound. F (fast) is usually used for measuring noise levels and sound levels unless otherwise stated.

S (slow) is used to pick up sounds with little fluctuation or the average values of fluctuating sounds. Aircraft noise and Shinkansen noise are transient, relatively large fluctuating sounds. Values calculated based on noise events measured by S (slow) are used in the evaluation of aircraft and Shinkansen noise.

Relationship between time weighting and time constant

Time weighting	Time constant	
	Rising characteristics	Falling characteristics
F (fast)	125 ms	125 ms
S (slow)	1 s	1 s

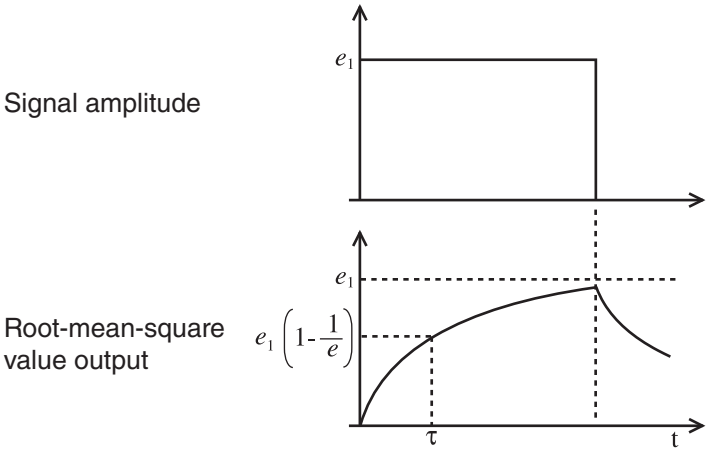
The figure below shows the circuit equivalent to the root-mean-square detection with time weighting. τ is the time constant and τ = CR.



Circuit equivalent to the root-mean-square detection with time weighting

e_i : Input voltage (proportional to the square of sound pressure)
e_o : Output voltage

The response of the root-mean-square detection circuit to a single burst signal is shown in the figure below.



Response to burst signal

e : Base of natural logarithms
τ : Time constant
t : Time
e_1 : Burst signal voltage

15 Measurement Function

15.1 L_{Aeq} (Time-average A-weighted sound level, equivalent continuous A-weighted sound level)

L_{Aeq} (Time-average A-weighted sound level, equivalent continuous A-weighted sound level) indicates the sound level of a continuous stationary sound, which over a given period of time indicates the same total energy as the fluctuating noise. It is defined by the following formula:

$$L_{\mathrm{Aeq},T} = 20 \log_{10} \left\{ \left[\left(\frac{1}{T} \right) \int_{t_1}^{t_2} p_{\mathrm{A}}^{2}(t)\, dt \right]^{1/2} / p_0 \right\}$$

t : Time variable of integration from an arbitrary start time at t_1 to the end of the interval at t_2
T : Time interval $T = t_2 - t_1$
$p_{\mathrm{A}}(t)$: A-weighted instantaneous sound pressure at running time t
p_0 : Reference sound pressure 20 μPa (2 x 10^{-5} N/m^2)

With NL-28, L_{Aeq} is calculated digitally using the following formula:

$$L_{\mathrm{Aeq}} = 20 \log_{10} \left\{ \left(\frac{1}{N} \sum_{i=1}^{N} p_A^{2}(i) \right)^{1/2} / p_0 \right\}$$

N : Number of samples

The sampling cycle of NL-28 is 20.8 μs (48,000 samples per second).

15.2 L_{AE} (A-weighted sound exposure level)

L_{AE} (A-weighted sound exposure level) indicates the noise level of a steady sound with a duration of 1 second, equal to the sum of the energy of the fluctuating or quasi-steady noise generated within a certain time, as well as the energy of single noise. It is defined by the following formula:

$$L_{AE,T} = 10 \log_{10} \left\{ \left[\int_{t_1}^{t_2} p_A^2(t)\, dt \right] / p_0^2 T_0 \right\} = L_{Aeq,T} + 10 \log_{10}(T / T_0)$$

t : Time variable of integration from an arbitrary start time at t_1 to the end of the interval at t_2

T : Time interval $T = t_2 - t_1$

T_0 : Reference time (1 second)

$p_A(t)$: Instantaneous A-weighted sound pressure at running time t

p_0 : Reference sound pressure 20 μPa (2 x 10^{-5} N/m^2)

With NL-28, L_{AE} is calculated digitally using the following formula:

$$L_{AE} = 10 \log_{10} \frac{1}{N_0} \sum_{i=1}^{N} \frac{p_A^2(i)}{p_0^2}$$

N_0 : Number of samples per second

The sampling cycle of NL-28 is 20.8 μs (48,000 samples per second).

15.3 L_{max} (Maximum time-weighted sound level)

The maximum time-weighted sound level within the measurement time can be measured.
NL-28 holds the maximum value after starting measuring for the sound level at each sampling cycle of 20.8 μs (48,000 samples per second). Therefore, the L_{max} value up to that point can be read even while measuring.

15.4 L_{Cpeak} (C-weighted peak sound level)

The maximum absolute value of instantaneous C-weighted sound pressure within the measurement time can be measured.

16

Influence of Background Noise

Background noise refers to the noise in the usage environment when there is no sound that is subject to measurement. As the indicated value of the sound level meter is a mix between the sound to be measured and the background noise, the indicated value may be larger than when only the sound subject to measurement is measured.
If the difference in sound level meter readings with and without the sound subject to measurement is 10 dB or more, the influence of the background noise is almost permissible.
When the difference is less than 10 dB, the level of only sound subject to measurement can be estimated by correcting the indicated value according to the table below.

Correction in relation to influence from background noise

Difference in readings with and without sound subject to measurement	4	5	6	7	8	9
Correction value	-2		-1			

(Unit: dB)

For example, if the noise level measured with a machine operating is 70 dB and the background noise level measured with the machine stopped is 63 dB, the difference is 7 dB.
The correction value for this difference (7 dB) is -1 dB, and so the noise level generated by the machine can be estimated as 70 dB + (-1 dB) = 69 dB.
The method of correcting the amount of influence from background noise is based on the assumption that both the sound subject to measurement and the background noise are stationary sounds/noises. In particular, when the level of the background noise is close to the level of the sound subject to measurement (the difference is 3 dB or less), or when the sound subject to measurement or the background noise fluctuates, correction cannot be performed correctly and so measures such as reducing the background noise are required.

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Descriptions for IEC 61672-1 (JIS C 1509-1)

IEC standard paragraph No.	Description	JIS standard paragraph No. with the same content	Explanation
4	**Reference environment conditions**		Ambient temperature: 23°C Static pressure: 101.325 kPa Relative humidity: 50%
5	**Performance specifications**		
5.1	**General**		
5.1.3	Classification of emissions and immunity	9.2.1 a)	Group X
5.1.4	Configuration and normal operating conditions	9.2.1 b)	Configuration • NL-28 • WS-14 » [Name and Function of Each Part], [Connection with Peripheral Devices]
5.1.5	Conformance class	9.2.1 a)	Class 2
5.1.6	Models of microphone Appropriate procedures for use the sound level meter	9.2.1 c) 9.2.6 b)	UC-52 » [Measurement]
5.1.7	Mounting of microphone	9.2.1 b)	» [Name and Function of Each Part]
5.1.8	Computer software (Component)	9.2.2 j)	Not applicable
5.1.10	All available frequency weighting features	9.2.2 c)	A-weighting, C-weighting
5.1.12	Nominal frequency of the level that can be measured in each level range (1 kHz, A) Instruction of the level range controls and function Recommendation for selecting the optimum level range	9.2.2 e) 9.2.2 f)	30 dB to 137 dB No corresponding function Not applicable
5.1.13	Reference sound pressure level Reference level range Reference direction and position of microphone reference point	9.2.6 a) 9.3 a), b), c)	94 dB Not applicable Reference incident direction and position of reference point (Fig. 1)
5.1.14	Operating of the hold facility and the means for clearing a display that is held	9.2.6 h)	» [Measurement]
5.1.15	Design targets and tolerance limits for electrical performance of electrical signal input equipment	9.3 h)	Capacitance of capacitor: 19 pF Tolerance limit: ±3 pF
5.1.17	Maximum sound pressure level without causing damage to the microphone Maximum input voltage causing damage to the preamplifier	9.3 j)	150 dB 11 Vp-p
5.1.18	Characteristics and operations of each independent channel	9.2.1 e)	Not applicable (1 channel only)
5.1.19	Initial time interval after switching on power	9.2.6 d)	< 90 s

IEC standard paragraph No.	Description	JIS standard paragraph No. with the same content	Explanation
5.2	**Adjustments at the calibration check frequency**		
5.2.1	Model of sound calibrator used for calibration	9.2.4 a)	NC-75/NC-74 (RION) NC-72B/NC-72A (RION)
5.2.3	Calibration procedure, adjustment values	9.2.4 c)	» [Calibration]
5.3	**Corrections to indicated levels**		
5.3.1	**General**		
5.3.1.1	Correction value and expanded uncertainty of measurement	9.2.5 a)	Case reflection » Refer to Table 1 and Fig. 3 Windscreen • Free-field characteristics » Refer to Table 1 and Fig. 4 • Directional characteristics » Refer to Tables 7 and 8, and Figs. 8 and 9 Random incidence response » Refer to Table 10 and Fig. 11 Microphone free-field correction amount » Refer to Table 3
5.3.2	**Reflection and diffraction**		
5.3.2.1	Correction values for reflection and diffraction from case	9.2.5 b)	Refer to Table 1 and Fig. 3
5.3.3	**Windscreen**		
5.3.3.1	Typical correction value for windscreen	9.2.5 c)	Free-field characteristics » Refer to Table 1 and Fig. 4 Directional characteristics » Refer to Tables 7 to 8 and Figs. 8 and 9 Random incidence response » Refer to Table 10 and Fig. 11
5.3.3.2	Data on whether or not a windscreen is attached		Free-field characteristics » Refer to Table 1 and Fig. 4 Directional characteristics » Refer to Tables 5 to 8, and Figs. 6 to 9 Random incidence response » Refer to Tables 9 and 10, and Figs. 10 and 11
5.3.3.3	Data for rotational asymmetry in relation to the microphone shaft		Not applicable
5.3.5	**Correction value used in regular testing**		
5.3.5.1 5.3.5.3	Correction value for multi-frequency sound calibrator	9.2.5 d) 9.3 d)	Refer to Table 3
5.4	**Directional characteristics**		
5.4.5	Detailed table of relative directional characteristics	9.2.2 b)	Refer to Tables 5 to 8

IEC standard paragraph No.	Description	JIS standard paragraph No. with the same content	Explanation
5.5	**Frequency Weighting**		
5.5.5	Table of directional index in relation to random incidence characteristics	9.3 e)	Refer to Tables 9 and 10
5.5.8	Design targets and tolerances for optional frequency weighting	9.2.2 k)	No corresponding function
5.6	**Level linearity**		
5.6.10	Upper and lower limits of linear operating range of noise level	9.3 f)	Refer to Table 4
5.6.11	Starting point for level linearity calculation error testing	9.3 g)	Refer to Table 4
5.7	**Self-generated noise**		
5.7.1	Self-generated noise level (including microphone)	9.3 i)	A-weighting: 24 dB (Typical 22 dB) C-weighting: 30 dB (Typical 28 dB)
5.7.3	Self-generated noise level (when the input terminal of the electrical input device is shorted)	9.3 i)	Dummy microphone (19 pF) Maximum value: Same value as 5.7.1 Typical A-weighting: 21 dB C-weighting: 25 dB
5.7.5	Procedure for measuring fields with low-level sounds	9.2.6 c)	» [Influence of background noise]
5.8	**Time weighting F and S**		
5.8.1	Available time weighting	9.2.2 d)	F (fast), S (slow)
5.11 - 5.12	**Overload indication, under-range indication**		
5.11.1	Behavior of overload indication	9.2.6 j)	» [Reading the display]
5.12.2	Behavior of under-range indication	9.2.6 j)	» [Reading the display]
5.13	**C-weighted peak sound level**		
5.13.1	Level range in which L_{Cpeak} can be measured	9.2.2 i)	Refer to Table 4
5.17	**Threshold**	9.2.6 k)	No corresponding function
5.18	**Display device**		
5.18.1	Display method	9.2.2 g)	» [Reading the display]
5.18.2	Description of the display equipment (monitor)	9.2.2 g)	» [Reading the display]
5.18.3	Description of the displayed measurement value	9.2.2 g) 9.2.2 a)	» [Terminology/Notation]
5.18.4	Update cycle and conditions from the start of taking measurements until the first indicated value is displayed	9.2.2 g)	Update cycle: 1 s
5.18.5	Method for downloading digital data	9.2.6 l)	» [USB mass storage], [Computer connection]
5.19	**Analog or digital output**		
5.19.1	Electrical output terminal	9.2.6 n)	No corresponding function

IEC standard paragraph No.	Description	JIS standard paragraph No. with the same content	Explanation
5.20	**Clock function**		
5.20.1	Procedure for setting integration time and clock time	9.2.6 f)	Integration time » [Measurement time] Clock time » No corresponding function
5.20.2	Minimum and maximum values of integral time	9.2.6 g)	Minimum value: 1 min Maximum value: 1 h
5.21	**Radio frequency emissions and interference with commercial power supply**		
5.21.1	Typical cable lengths and types, characteristics of devices connected by cables	9.2.6 m)	USB cable (1 m)
5.21.2	Operation modes and connected equipment that cause the highest radio frequency emissions	9.3 n)	USB cable (1 m)
5.23	**Power**		
5.23.1	Method to check if the power supply voltage is sufficient	9.2.3 b)	» [Reading the display]
5.23.2	Maximum and minimum operable power supply voltages	9.3 k)	Alkaline batteries : 2.0 V to 3.6 V Ni-MH rechargeable batteries : 2.4 V to 3.6 V
5.23.3	Compatible internal battery models	9.2.3 a)	» [Specifications]
5.23.4	Continuous operating time under normal operating conditions with a fully charged battery	9.2.3 a)	» [Specifications]
5.23.5	How to operate the device by way of an external power supply	9.2.3 c)	Not applicable
5.23.6	Nominal supply voltage and frequency and their respective tolerance limits	9.2.3 d)	Not applicable
6	**Requirements for environmental conditions, static electricity, and radio frequency**		
6.1	**General**		
6.1.2	Time it takes to adapt to changes in environmental conditions	9.3 l)	Temperature change: < 1 h Humidity change: < 1 h Static pressure change: < 5 min
6.2	**Static pressure**		
6.2.2	Measurement method when the static pressure is 65 kPa or more and less than 85 kPa	9.2.6 e)	In that environment, calibrates with Sound Calibrator NC-75/NC-74 or Pistonphone NC-72B/NC-72A and takes measurements.
6.3	**Ambient temperature**		
6.3.2	Components that operate only under specific environmental conditions	9.2.8 a)	None
6.5	**Electrostatic discharge**		
6.5.2	Influence of electrostatic discharge (deterioration or damage to performance/functions)	9.2.8 b)	Measurement values are temporarily affected when there is an electrostatic discharge

IEC standard paragraph No.	Description	JIS standard paragraph No. with the same content	Explanation
6.6	**Power frequency magnetic fields and radio frequency electromagnetic fields**		
6.6.1 6.6.3	Operation mode and connection state where the effects of power frequency magnetic fields and radio frequency electromagnetic fields are maximized	9.3 o)	Refer to Fig. 5 Operation mode: Normal operation Connection type: USB cable (1 m)
6.6.5	Compliance with immunity standards for radio frequency electromagnetic fields above the specified field strengths	9.3 m)	Not applicable
6.6.10	Compliance with immunity standards for radio frequency electromagnetic fields below the specified sound levels	9.2.8 c)	Not applicable
6.7	**Mechanical vibration**	9.2.1 f)	Takes measurements without subjecting the sound level meter to vibration.
7	**Use of accessories**		
7.1	Correction value applied to measurement results when extending the distance between the preamplifier and sound level meter	9.2.7 b)	Not applicable (extension not possible)
7.2	Typical values of the influence of accessory installation on sound level meter performance	9.2.7 a)	Windscreen • Free-field characteristics » Refer to Table 1 and Fig. 4 • Directional characteristics » Refer to Tables 7 and 8, and Figs. 8 and 9 • Random incidence response » Refer to Table 10 and Fig. 11
7.3	Standards to be met when accessories are installed	9.2.1 d)	With windscreen WS-14 attached Complies with IEC 61672-1 class 2 (JIS C 1509-1 class 2)
7.4	How to use a bandpass filter	9.2.7 c)	No corresponding function
7.5	How to connect accessories and how the connection affects the performance of the sound level meter	9.2.7 d)	» [Connection with Peripheral Devices]
9	**Instruction Manual**		
9.2	**Information about operation**		
9.2.1	**General**		
9.2.1 a)	Influence of radio frequency electromagnetic field: Group Performance classification: Class	5.1.3 5.1.5	Refer to 5.1.3 Refer to 5.1.5
9.2.1 b)	Overall configuration, configuration in normal operating state (including windscreen)	5.1.4	Refer to 5.1.4
	How to install the microphone and windscreen	5.1.7	Refer to 5.1.7
9.2.1 c)	Microphone format	5.1.6	Refer to 5.1.6
9.2.1 d)	Compliance with standard when an extension cable is used	7.3	Refer to 7.3

IEC standard paragraph No.	Description	JIS standard paragraph No. with the same content	Explanation
9.2.1 e)	Characteristics and operations of each independent channel	5.1.18	Refer to 5.1.18
9.2.1 f)	Influence of mechanical vibration and how to reduce it	6.7	Refer to 6.7
9.2.2	**Functions**		
9.2.2 a)	Measurable quantity	5.18.3	Refer to 5.18.3
9.2.2 b)	Directional characteristics	5.4.5	Refer to 5.4.5
9.2.2 c)	Frequency weightings that comply with standard	5.1.10 5.5.8	Refer to 5.1.10 Refer to 5.5.8
9.2.2 d)	Available time weighting	5.8.1	Refer to 5.8.1
9.2.2 e)	Upper and lower limits of linear operating range in A-weighted sound level (1 kHz)	5.1.12	Refer to 5.1.12
9.2.2 f)	How to operate the level range switch	5.1.12	Refer to 5.1.12
9.2.2 g)	Description of display equipment (monitor), standard compliance	5.18.1-2-3-4	Refer to 5.18.1-2-3-4
9.2.2 h)	Full linear operating range of A-weighted sound level (1 kHz)		» [Specifications]
9.2.2 i)	Level range in which L_{Cpeak} can be measured	5.13.1	Refer to 5.13.1
9.2.2 j)	Computer software (Component)	5.1.8	Refer to 5.1.8
9.2.2 k)	Design targets and tolerance limits for measurement values for which the standard does not specify performance specifications	5.5.8	Refer to 5.5.8
9.2.3	**Power supply**		
9.2.3 a)	Recommended internal battery model, and continuous operating time under normal operating conditions with a fully charged battery	5.23.3 5.23.4	Refer to 5.23.3 Refer to 5.23.4
9.2.3 b)	How to check the power supply voltage	5.23.1	Refer to 5.23.1
9.2.3 c)	How to operate the device by way of an external power supply	5.23.5	Refer to 5.23.5
9.2.3 d)	Operating conditions and permissible range of commercial AC power supply	5.23.6	Refer to 5.23.6
9.2.4	**Adjustment in calibration check frequency**		
9.2.4 a)	Model of sound calibrator used for calibration	5.2.1	Refer to 5.2.1
9.2.4 b)	Calibration check frequency		» [Specifications]
9.2.4 c)	Calibration procedure, adjustment values	5.2.3	Refer to 5.2.3
9.2.5	**Correction of indicated value**		
9.2.5 a)	Correction value and expanded uncertainty of measurement	5.3.1.1	Refer to 5.3.1.1
9.2.5 b)	Typical values of influence from case-related reflection and diffraction	5.3.2.1	Refer to 5.3.2.1

IEC standard paragraph No.	Description	JIS standard paragraph No. with the same content	Explanation
9.2.5 c)	Typical windscreen influence	5.3.3.1	Refer to 5.3.3.1
9.2.5 d)	Correction value for multi-frequency sound calibrator	5.3.5.1 5.3.5.3	Refer to 5.3.5.1 Refer to 5.3.5.3
9.2.6	**How to operate the sound level meter**		
9.2.6 a)	Reference direction and position of microphone reference point	5.1.13	Refer to 5.1.13
9.2.6 b)	Influence from measurement procedure, case, and operator	5.1.6	Refer to 5.1.6
9.2.6 c)	Procedure for measuring fields with low-level sounds	5.7.5	Refer to 5.7.5
9.2.6 d)	Initial stabilization time (time from turning on the power until you can take measurements)	5.1.19	Refer to 5.1.19
9.2.6 e)	Measurement guidelines and procedures at 65-85 kPa	6.2.2	Refer to 6.2.2
9.2.6 f)	Procedure for setting integration time and clock time	5.20.1	Refer to 5.20.1
9.2.6 g)	Minimum and maximum values of integral time	5.20.2	Refer to 5.20.2
9.2.6 h)	How the level retention function works and how to cancel the retained display	5.1.14	Refer to 5.1.14
9.2.6 i)	Reset function for measurement results, time required from resetting to measurement reinitialization		The measurement results (measurement values, over-display, under-display) are reset by starting to take new measurements. Time required from this operation to reinitialize measuring: < 1 second.
9.2.6 j)	Behavior of overload indication and under-range indication	5.11.1 5.12.2	Refer to 5.11.1 Refer to 5.12.2
9.2.6 k)	Threshold function	5.17	Refer to 5.17
9.2.6 l)	Method for downloading digital data	5.18.5	Refer to 5.18.5
9.2.6 m)	Recommended lengths and types of typical cables	5.21.1	Refer to 5.21.1
9.2.6 n)	Recommended ranges of electrical output terminals	5.19.1	Refer to 5.19.1
9.2.7	**Accessories**		
9.2.7 a)	Typical values of the influence of accessory installation on sound level meter performance	7.2	Refer to 7.2
9.2.7 b)	Correction value applied to measurement results when extending the distance between the preamplifier and sound level meter	7.1	Refer to 7.1
9.2.7 c)	How to use a bandpass filter	7.4	Refer to 7.4
9.2.7 d)	How to connect accessories and how the connection affects the performance of the sound level meter	7.5	Refer to 7.5

IEC standard paragraph No.	Description	JIS standard paragraph No. with the same content	Explanation
9.2.8	**Influence of changes in environmental conditions**		
9.2.8 a)	Components that operate only under specific environmental conditions	6.3.2	Refer to 6.3.2
9.2.8 b)	Influence of electrostatic discharge (deterioration or damage to performance/ functions)	6.5.2	Refer to 6.5.2
9.2.8 c)	Compliance with immunity standard in relation to power frequency magnetic fields and radio frequency electromagnetic fields	6.6.10	Refer to Table 2 and 6.6.10
9.3	**Information about testing**		
9.3 a)	Reference sound pressure level	5.1.13	Refer to 5.1.13
9.3 b)	Reference level range	5.1.13	Refer to 5.1.13
9.3 c)	Microphone reference point	5.1.13	Refer to 5.1.13
9.3 d)	Correction value for multi-frequency sound calibrator	5.3.5.1 5.3.5.3	Refer to 5.3.5.1 Refer to 5.3.5.3
9.3 e)	Directional index in relation to random incidence	5.5.5	Refer to 5.5.5
9.3 f)	Upper and lower limits of linear operating range for A-weighted sound level	5.6.10	Refer to 5.6.10
9.3 g)	Starting point for level linearity calculation error testing	5.6.11	Refer to 5.6.11
9.3 h)	Design targets and tolerance limits for electrical performance of electrical signal input equipment	5.1.15	Refer to 5.1.15
9.3 i)	Maximum self-generated noise level	5.7.1 5.7.3	Refer to 5.7.1 Refer to 5.7.3
9.3 j)	Maximum sound pressure level that the microphone can withstand Maximum voltage the preamplifier can withstand	5.1.17	Refer to 5.1.17
9.3 k)	Maximum and minimum operable power supply voltages	5.23.2	Refer to 5.23.2
9.3 l)	Time it takes to adapt to changes in environmental conditions	6.1.2	Refer to 6.1.2
9.3 m)	Compliance with immunity standards for radio frequency fields above the specified field strengths	6.6.5	Refer to 6.6.5
9.3 n)	Operation modes and connected equipment that cause the highest radio frequency emissions	5.21.2	Refer to 5.21.2
9.3 o)	Operation mode and connection state where the effects of power frequency magnetic fields and radio frequency electromagnetic fields are maximized	6.6.1 6.6.3	Refer to 6.6.1 Refer to 6.6.3

17.1 Free-field characteristics

Table 1. NL-28 free-field characteristics

Without windscreen WS-14 installed

Nominal Frequency (Hz)	Exact Frequency (Hz)	Microphone Free-field Response (dB)		Influence of Case Reflection (dB)		NL-28 Electrical Response (dB)
		UC-52 (NL-28)	Expanded Uncertainty	NL-28	Expanded Uncertainty	
63	**63.096**	**0.0**	**0.3**	**0.0**	**0.15**	**0.0**
80	**79.433**	**0.0**	**0.3**	**0.0**	**0.15**	**0.0**
100	**100.00**	**0.0**	**0.3**	**0.0**	**0.15**	**0.0**
125	**125.89**	**0.0**	**0.3**	**0.0**	**0.15**	**0.0**
160	**158.49**	**0.0**	**0.3**	**0.0**	**0.15**	**0.0**
200	**199.53**	**0.0**	**0.2**	**-0.1**	**0.15**	**0.0**
250	**251.19**	**0.0**	**0.2**	**-0.1**	**0.15**	**0.0**
315	**316.23**	**0.0**	**0.2**	**0.0**	**0.15**	**0.0**
400	**398.11**	**0.0**	**0.2**	**0.1**	**0.15**	**0.0**
500	**501.19**	**0.0**	**0.2**	**0.1**	**0.15**	**0.0**
630	**630.96**	**0.0**	**0.2**	**0.2**	**0.15**	**0.0**
800	**794.33**	**0.0**	**0.2**	**0.2**	**0.15**	**0.0**
1000	**1000.0**	**0.0**	**0.2**	**0.2**	**0.15**	**0.0**
1060	1059.3	0.0	0.3	0.2	0.15	0.0
1120	1122.0	0.0	0.3	0.2	0.15	0.0
1180	1188.5	0.0	0.3	0.2	0.15	0.0
1250	**1258.9**	**0.0**	**0.3**	**0.1**	**0.15**	**0.0**
1320	1333.5	0.0	0.3	0.0	0.15	0.0
1400	1412.5	0.0	0.3	0.0	0.15	0.0
1500	1496.2	0.1	0.3	0.1	0.15	0.0
1600	**1584.9**	**0.1**	**0.3**	**0.0**	**0.15**	**0.0**
1700	1678.8	0.1	0.3	0.1	0.15	0.0
1800	1778.3	0.1	0.3	0.3	0.15	0.0
1900	1883.6	0.1	0.3	0.2	0.15	0.0
2000	**1995.3**	**0.2**	**0.3**	**-0.1**	**0.15**	**0.0**
2120	2113.5	0.2	0.3	-0.4	0.15	0.0
2240	2238.7	0.2	0.3	-0.4	0.15	0.0
2360	2371.4	0.2	0.3	-0.3	0.15	0.0
2500	**2511.9**	**0.3**	**0.3**	**0.0**	**0.15**	**0.0**
2650	2660.7	0.3	0.3	0.0	0.20	0.0
2800	2818.4	0.3	0.3	-0.2	0.20	0.0
3000	2985.4	0.4	0.3	-0.3	0.20	0.0
3150	**3162.3**	**0.4**	**0.3**	**-0.1**	**0.20**	**0.0**
3350	3349.7	0.4	0.3	-0.1	0.20	0.0
3550	3548.1	0.4	0.3	-0.4	0.20	0.0
3750	3758.4	0.4	0.3	-0.5	0.20	0.0

Nominal Frequency (Hz)	Exact Frequency (Hz)	Microphone Free-field Response (dB)		Influence of Case Reflection (dB)		NL-28 Electrical Response (dB)
		UC-52 (NL-28)	Expanded Uncertainty	NL-28	Expanded Uncertainty	
4000	**3981.1**	**0.4**	**0.3**	**-0.2**	**0.20**	**0.0**
4250	4217.0	0.4	0.3	-0.3	0.20	0.0
4500	4466.8	0.4	0.3	-0.3	0.20	0.0
4750	4731.5	0.3	0.3	-0.4	0.20	0.0
5000	**5011.9**	**0.3**	**0.3**	**0.5**	**0.20**	**0.0**
5300	5308.8	0.2	0.3	0.3	0.30	0.0
5600	5623.4	0.2	0.3	-0.1	0.30	0.0
6000	5956.6	0.1	0.3	0.3	0.30	0.0
6300	**6309.6**	**0.0**	**0.3**	**0.1**	**0.30**	**0.0**
6700	6683.4	-0.1	0.3	0.1	0.35	0.0
7100	7079.5	-0.2	0.3	-0.1	0.35	0.0
7500	7498.9	-0.4	0.3	-0.3	0.35	0.0
8000	**7943.3**	**-0.5**	**0.3**	**-0.3**	**0.35**	**0.0**

With windscreen WS-14 installed

Nominal Frequency (Hz)	Exact Frequency (Hz)	Microphone Free-field Response (dB)		Influence of Case Reflection (dB)		Influence of Windscreen (dB)		NL-28 Electrical Response (dB)
		UC-52 (NL-28)	Expanded Uncertainty	NL-28	Expanded Uncertainty	WS-14 Effect	Expanded Uncertainty	
63	**63.096**	**0.0**	**0.3**	**0.0**	**0.15**	**0.0**	**0.10**	**0.0**
80	**79.433**	**0.0**	**0.3**	**0.0**	**0.15**	**0.0**	**0.10**	**0.0**
100	**100.00**	**0.0**	**0.3**	**0.0**	**0.15**	**0.0**	**0.10**	**0.0**
125	**125.89**	**0.0**	**0.3**	**0.0**	**0.15**	**0.0**	**0.10**	**0.0**
160	**158.49**	**0.0**	**0.3**	**0.0**	**0.15**	**0.0**	**0.10**	**0.0**
200	**199.53**	**0.0**	**0.2**	**-0.1**	**0.15**	**0.0**	**0.10**	**0.0**
250	**251.19**	**0.0**	**0.2**	**-0.1**	**0.15**	**0.0**	**0.10**	**0.0**
315	**316.23**	**0.0**	**0.2**	**0.0**	**0.15**	**0.0**	**0.10**	**0.0**
400	**398.11**	**0.0**	**0.2**	**0.1**	**0.15**	**0.0**	**0.10**	**0.0**
500	**501.19**	**0.0**	**0.2**	**0.1**	**0.15**	**0.0**	**0.10**	**0.0**
630	**630.96**	**0.0**	**0.2**	**0.2**	**0.15**	**0.0**	**0.10**	**0.0**
800	**794.33**	**0.0**	**0.2**	**0.2**	**0.15**	**0.0**	**0.10**	**0.0**
1000	**1000.0**	**0.0**	**0.2**	**0.2**	**0.15**	**0.1**	**0.10**	**0.0**
1060	1059.3	0.0	0.3	0.2	0.15	0.1	0.15	0.0
1120	1122.0	0.0	0.3	0.2	0.15	0.1	0.15	0.0
1180	1188.5	0.0	0.3	0.2	0.15	0.1	0.15	0.0
1250	**1258.9**	**0.0**	**0.3**	**0.1**	**0.15**	**0.1**	**0.15**	**0.0**
1320	1333.5	0.0	0.3	0.0	0.15	0.1	0.15	0.0
1400	1412.5	0.0	0.3	0.0	0.15	0.1	0.15	0.0
1500	1496.2	0.1	0.3	0.1	0.15	0.1	0.15	0.0
1600	**1584.9**	**0.1**	**0.3**	**0.0**	**0.15**	**0.1**	**0.15**	**0.0**
1700	1678.8	0.1	0.3	0.1	0.15	0.1	0.15	0.0
1800	1778.3	0.1	0.3	0.3	0.15	0.2	0.15	0.0
1900	1883.6	0.1	0.3	0.2	0.15	0.2	0.15	0.0
2000	**1995.3**	**0.2**	**0.3**	**-0.1**	**0.15**	**0.2**	**0.15**	**0.0**
2120	2113.5	0.2	0.3	-0.4	0.15	0.2	0.15	0.0
2240	2238.7	0.2	0.3	-0.4	0.15	0.2	0.15	0.0
2360	2371.4	0.2	0.3	-0.3	0.15	0.2	0.15	0.0
2500	**2511.9**	**0.3**	**0.3**	**0.0**	**0.15**	**0.2**	**0.15**	**0.0**
2650	2660.7	0.3	0.3	0.0	0.20	0.3	0.15	0.0
2800	2818.4	0.3	0.3	-0.2	0.20	0.3	0.15	0.0
3000	2985.4	0.4	0.3	-0.3	0.20	0.3	0.15	0.0
3150	**3162.3**	**0.4**	**0.3**	**-0.1**	**0.20**	**0.3**	**0.15**	**0.0**
3350	3349.7	0.4	0.3	-0.1	0.20	0.3	0.15	0.0
3550	3548.1	0.4	0.3	-0.4	0.20	0.4	0.15	0.0
3750	3758.4	0.4	0.3	-0.5	0.20	0.4	0.15	0.0
4000	**3981.1**	**0.4**	**0.3**	**-0.2**	**0.20**	**0.4**	**0.15**	**0.0**
4250	4217.0	0.4	0.3	-0.3	0.20	0.4	0.15	0.0
4500	4466.8	0.4	0.3	-0.3	0.20	0.4	0.15	0.0
4750	4731.5	0.3	0.3	-0.4	0.20	0.4	0.15	0.0

Nominal Frequency (Hz)	Exact Frequency (Hz)	Microphone Free-field Response (dB)		Influence of Case Reflection (dB)		Influence of Windscreen (dB)		NL-28 Electrical Response (dB)
		UC-52 (NL-28)	Expanded Uncertainty	NL-28	Expanded Uncertainty	WS-14 Effect	Expanded Uncertainty	
5000	**5011.9**	**0.3**	**0.3**	**0.5**	**0.20**	**0.5**	**0.15**	**0.0**
5300	5308.8	0.2	0.3	0.3	0.30	0.5	0.20	0.0
5600	5623.4	0.2	0.3	-0.1	0.30	0.5	0.20	0.0
6000	5956.6	0.1	0.3	0.3	0.30	0.5	0.20	0.0
6300	**6309.6**	**0.0**	**0.3**	**0.1**	**0.30**	**0.5**	**0.20**	**0.0**
6700	6683.4	-0.1	0.3	0.1	0.35	0.5	0.20	0.0
7100	7079.5	-0.2	0.3	-0.1	0.35	0.6	0.20	0.0
7500	7498.9	-0.4	0.3	-0.3	0.35	0.7	0.20	0.0
8000	**7943.3**	**-0.5**	**0.3**	**-0.3**	**0.35**	**0.8**	**0.20**	**0.0**

17.2 Reference incident direction and position of reference point

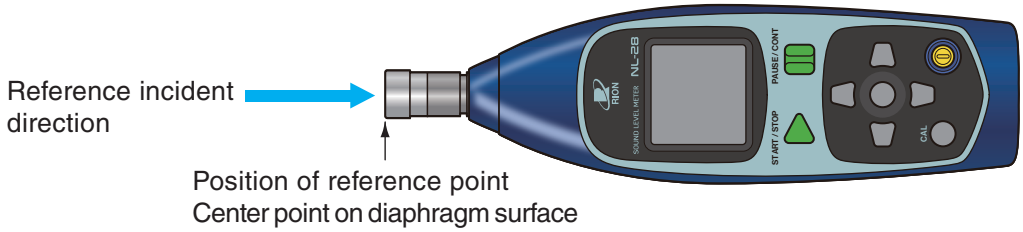

Fig. 1. Reference incident direction and position of reference point

17.3 Microphone frequency response

The frequency response of a free-field microphone is represented by the response to the sound waves from the reference incident direction in a free-field.
Below is an example of the frequency response of microphone UC-52.

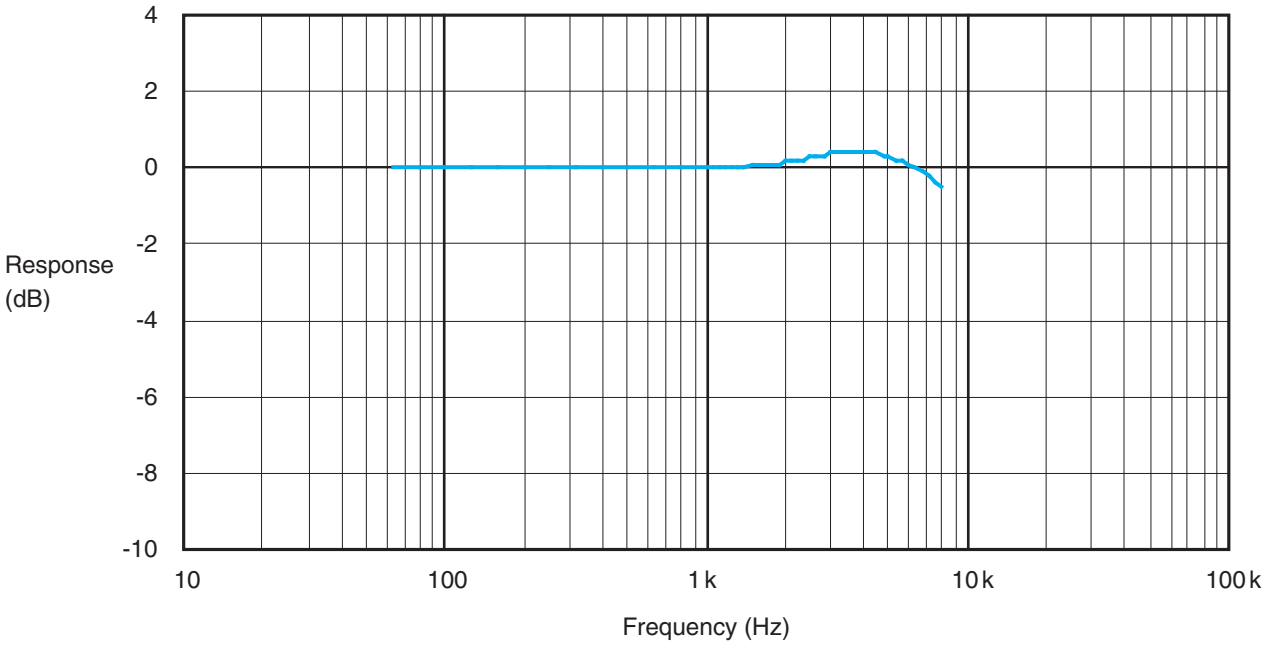

Fig 2. Frequency characteristics of Microphone UC-52 (1 kHz reference)

17.4 Acoustic influence of case

NL-28 is designed to minimize the influence of case-related acoustic reflections on measurements.
The acoustic influence from the case is shown below.

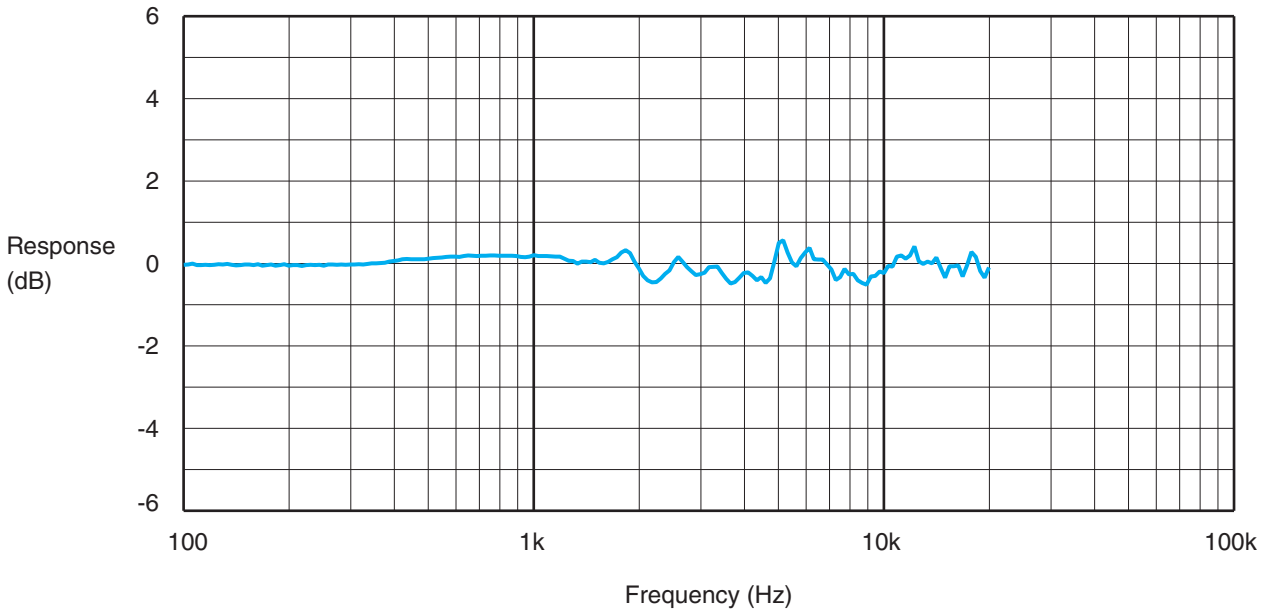

Fig. 3. Acoustic influence of case

17.5 Effects of windscreen WS-14

The effects of wind noise on measurement results can be a problem when taking measurements outdoors in the wind or of a ventilation system. In such cases, attach the included Windscreen WS-14 to the microphone.
The effect of the WS-14 on the free-field characteristics of the sound level meter is within ±1.0 dB up to 20 kHz.

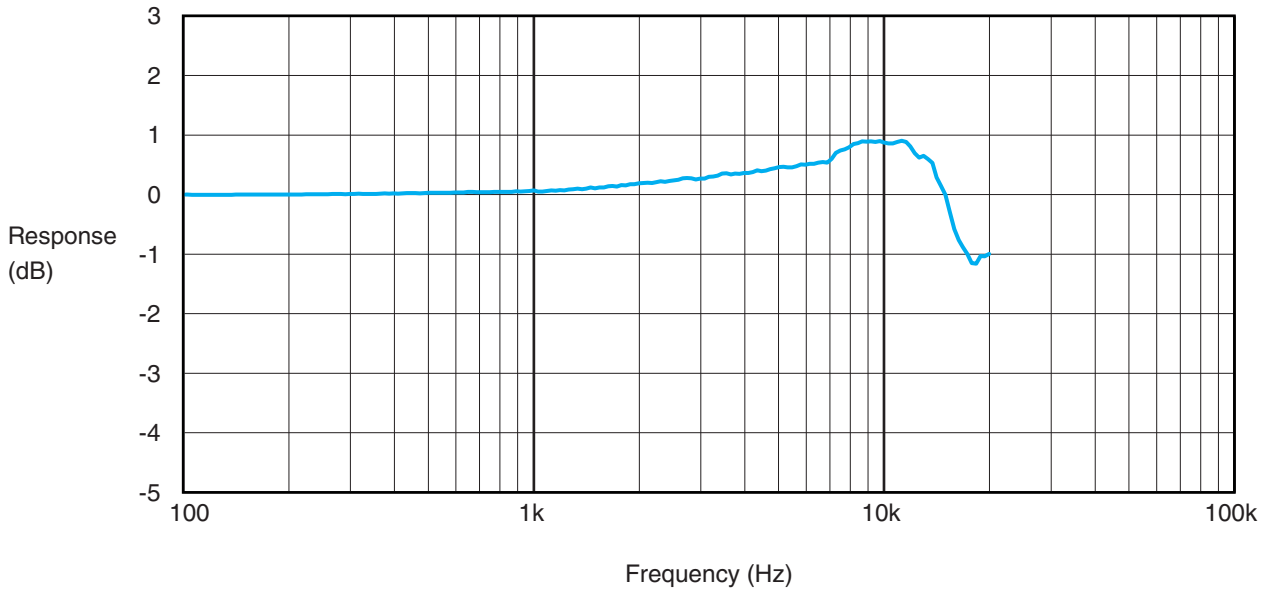

Fig. 4. Windscreen WS-14 frequency response

17.6 Electromagnetic compatibility (EMC)

The following figure shows the immunity test conditions (NL-28 direction, operation mode and connection state) against power frequency magnetic fields and radio frequency electromagnetic fields. Under these conditions, the effects of exposure to power frequency magnetic field and radio frequency electromagnetic field are at their largest. The same applies to the operation mode and connection state in which radio frequency emissions are at their largest.

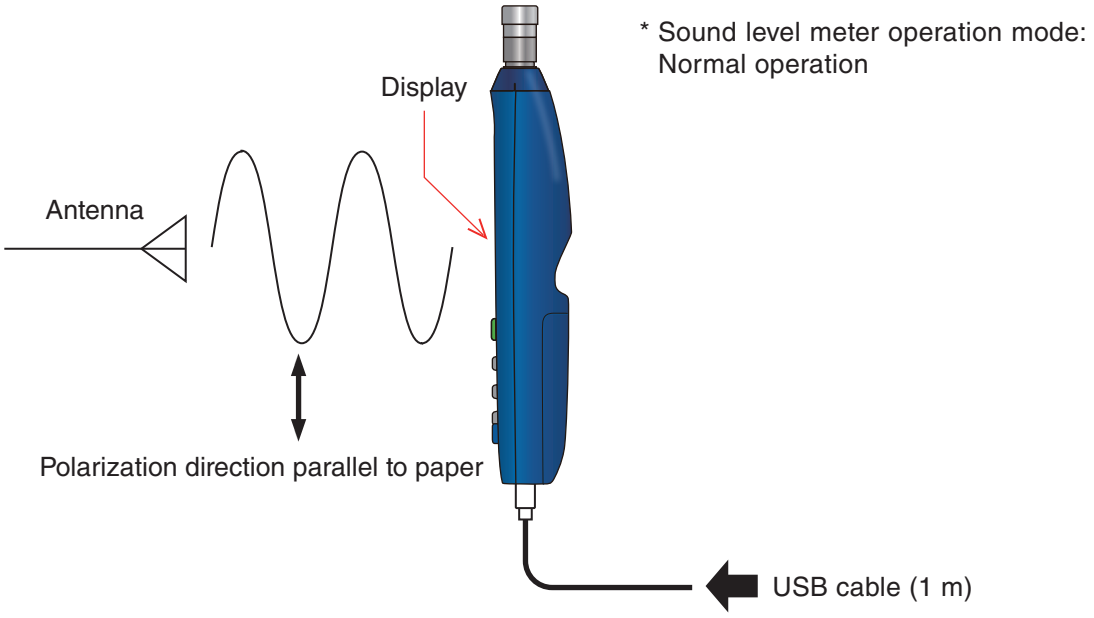

Fig. 5. Immunity test conditions in relation to power frequency magnetic fields and radio frequency electromagnetic fields

Table 2. Compliance with Electromagnetic Compatibility (EMC) Standard

	NL-28
Immunity to power frequency magnetic fields	The specification of IEC 61672-1 class 2 is satisfied
Immunity to radio frequency electromagnetic fields	The specification of IEC 61672-1 class 2 is satisfied
Radio frequency emissions	The specification of IEC 61672-1 class 2 is satisfied
Electrostatic discharge	The specification of IEC 61672-1 class 2 is satisfied

17.7 Microphone free-field correction amount

Table 3. Free-field correction amount for microphones when calibrating sound pressure using a sound calibrator

Nominal frequency (Hz)	Exact frequency (Hz)	UC-52 (NL-28) correction amount (dB)	Expanded uncertainty (dB)
31.5	31.623	0.0	0.20
63	63.096	0.0	0.20
125	125.89	0.0	0.20
250	251.19	0.0	0.20
500	501.19	0.0	0.20
1000	1000.0	0.1	0.20
2000	1995.3	0.3	0.25
4000	3981.1	1.3	0.25
8000	7943.3	3.2	0.30

17.8 Upper and lower limits of linear operating range for sound pressure level

Table 4. Upper and lower limits of linear operating range for sound pressure level

A-weighting

	31.5 Hz	1 kHz	4 kHz	8 kHz
Upper limit	97.0	137.0	137.0	135.0
Start point	94.0	94.0	94.0	94.0
Lower limit	30.0	30.0	30.0	30.0

C-weighting

	31.5 Hz	1 kHz	4 kHz	8 kHz
Upper limit	134.0	137.0	136.0	134.0
Start point	94.0	94.0	94.0	94.0
Lower limit	36.0	36.0	36.0	36.0

Measurement range

	L_A (dB)	L_C (dB)	L_{Cpeak} (dB)
Upper limit	137.0	137.0	140.0
Lower limit	30.0	36.0	65.0

Unit:dB

17.9 Directional characteristics

The directional characteristics of the sound level meter are expressed as the difference between the measurement value of the reference incident direction (0°) and the measurement value of any incident angle θ.
The electret condenser microphone used in NL-28 is a pressure-type microphone, so it is primarily omnidirectional. However, at higher frequencies, it becomes directional due to the effects of structure-related diffraction and dents. The following figures show the directional characteristics of NL-28.

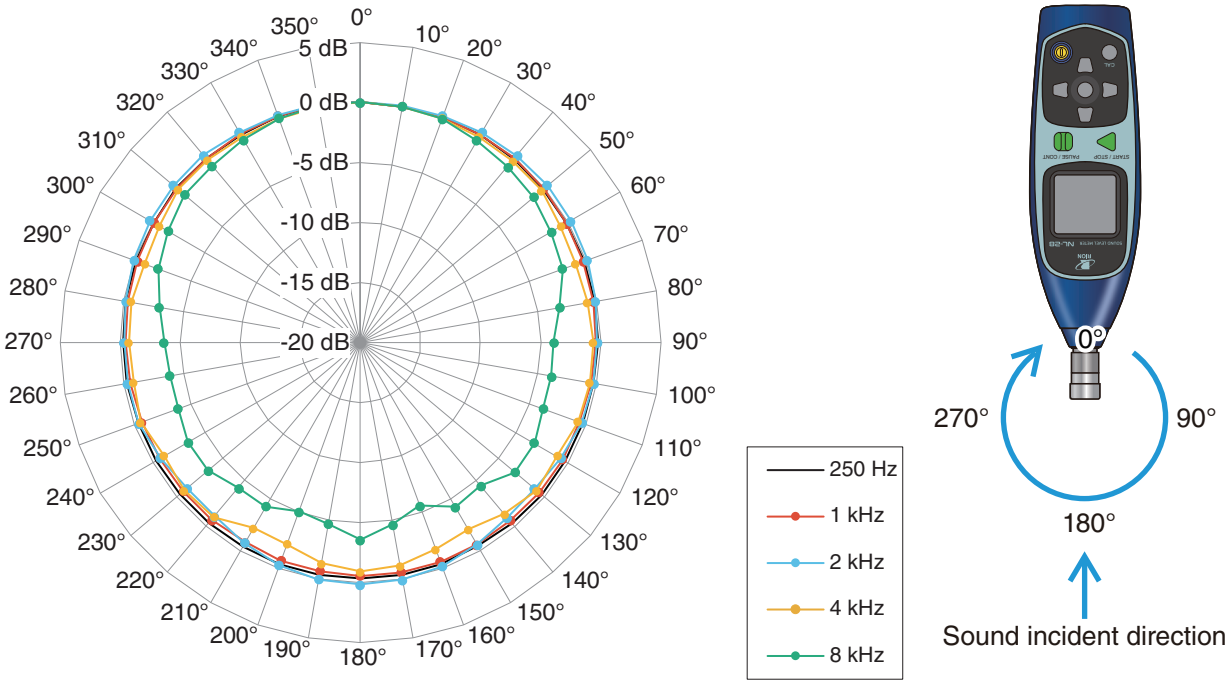

Fig. 6. Directional characteristics of NL-28 (horizontal direction)

Table 5. Directional characteristics of NL-28 (horizontal direction)

Angle (degrees)	Nominal frequency / exact frequency (Hz)							
	250/251.19	315/316.23	400/398.11	500/501.19	630/630.96	800/794.33	1000/1000.0	1250/1258.9
0°	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10°	-0.03	-0.02	-0.02	-0.02	0.00	-0.01	-0.02	-0.01
20°	-0.04	-0.02	-0.02	-0.03	-0.02	-0.02	-0.03	-0.03
30°	-0.03	-0.03	-0.04	-0.03	-0.04	-0.01	0.00	-0.05
40°	-0.07	-0.08	-0.07	-0.09	-0.08	-0.07	-0.04	-0.10
50°	-0.10	-0.09	-0.09	-0.13	-0.12	-0.09	-0.10	-0.14
60°	-0.17	-0.15	-0.16	-0.20	-0.18	-0.15	-0.15	-0.16
70°	-0.18	-0.20	-0.22	-0.25	-0.24	-0.23	-0.25	-0.17
80°	-0.22	-0.23	-0.27	-0.31	-0.29	-0.30	-0.33	-0.18
90°	-0.24	-0.26	-0.29	-0.35	-0.35	-0.37	-0.41	-0.20
100°	-0.25	-0.27	-0.28	-0.37	-0.43	-0.48	-0.46	-0.24
110°	-0.27	-0.32	-0.33	-0.41	-0.48	-0.59	-0.58	-0.40
120°	-0.28	-0.31	-0.33	-0.42	-0.52	-0.63	-0.58	-0.53
130°	-0.30	-0.31	-0.36	-0.44	-0.54	-0.69	-0.58	-0.56
140°	-0.35	-0.37	-0.40	-0.48	-0.55	-0.73	-0.62	-0.56
150°	-0.44	-0.38	-0.40	-0.48	-0.54	-0.70	-0.59	-0.49
160°	-0.38	-0.37	-0.41	-0.48	-0.53	-0.68	-0.55	-0.41
170°	-0.39	-0.41	-0.43	-0.50	-0.52	-0.69	-0.57	-0.37
180°	-0.40	-0.40	-0.43	-0.50	-0.52	-0.67	-0.56	-0.37
190°	-0.38	-0.41	-0.46	-0.51	-0.54	-0.68	-0.67	-0.39
200°	-0.39	-0.39	-0.45	-0.51	-0.55	-0.68	-0.68	-0.45
210°	-0.41	-0.43	-0.49	-0.54	-0.58	-0.75	-0.77	-0.53
220°	-0.36	-0.37	-0.45	-0.50	-0.57	-0.71	-0.74	-0.58
230°	-0.35	-0.31	-0.44	-0.49	-0.56	-0.69	-0.73	-0.58
240°	-0.35	-0.34	-0.41	-0.47	-0.54	-0.65	-0.69	-0.51
250°	-0.28	-0.29	-0.35	-0.39	-0.48	-0.55	-0.60	-0.35
260°	-0.27	-0.30	-0.33	-0.35	-0.44	-0.44	-0.51	-0.19
270°	-0.20	-0.21	-0.27	-0.29	-0.36	-0.36	-0.42	-0.08
280°	-0.13	-0.17	-0.21	-0.24	-0.28	-0.25	-0.28	-0.06
290°	-0.10	-0.14	-0.17	-0.18	-0.22	-0.18	-0.22	-0.06
300°	-0.06	-0.08	-0.13	-0.14	-0.14	-0.10	-0.12	-0.06
310°	-0.01	-0.04	-0.05	-0.05	-0.08	-0.03	-0.02	-0.02
320°	-0.01	-0.02	-0.03	-0.03	-0.05	-0.02	-0.01	0.00
330°	-0.01	0.01	0.01	0.01	-0.02	0.01	0.04	0.03
340°	0.07	0.03	0.04	0.03	-0.01	0.03	0.10	0.07
350°	0.08	0.07	0.08	0.06	0.02	0.05	0.15	0.08

Angle (degrees)	Nominal frequency / exact frequency (Hz)							
	1600/1584.9	**2000/1995.3**	2240/2238.7	**2500/2511.9**	2800/2818.4	**3150/3162.3**	3550/3548.1	**4000/3981.1**
0°	**0.00**	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
10°	**-0.01**	**0.01**	0.00	**-0.05**	0.00	**-0.02**	0.04	**-0.04**
20°	**-0.04**	**0.06**	-0.05	**-0.15**	0.01	**-0.12**	0.08	**-0.12**
30°	**-0.06**	**0.21**	-0.04	**-0.31**	0.09	**-0.26**	0.02	**-0.24**
40°	**-0.17**	**0.32**	0.05	**-0.62**	0.07	**-0.36**	-0.04	**-0.26**
50°	**-0.29**	**0.34**	0.19	**-0.83**	-0.10	**-0.33**	-0.18	**-0.31**
60°	**-0.44**	**0.25**	0.40	**-0.71**	-0.37	**-0.37**	-0.16	**-0.71**
70°	**-0.54**	**0.09**	0.45	**-0.33**	-0.46	**-0.57**	-0.08	**-0.96**
80°	**-0.52**	**-0.14**	0.28	**-0.12**	-0.20	**-0.64**	-0.33	**-0.80**
90°	**-0.37**	**-0.27**	0.18	**-0.39**	-0.05	**-0.28**	-0.44	**-0.64**
100°	**-0.32**	**-0.25**	0.14	**-0.64**	-0.33	**-0.47**	-0.13	**-0.63**
110°	**-0.42**	**-0.37**	0.06	**-0.57**	-0.49	**-0.82**	-0.44	**-0.74**
120°	**-0.52**	**-0.74**	-0.15	**-0.71**	-0.44	**-0.66**	-0.61	**-1.10**
130°	**-0.63**	**-1.07**	-0.51	**-1.18**	-0.77	**-0.83**	-0.58	**-0.84**
140°	**-0.77**	**-0.98**	-0.69	**-1.45**	-1.41	**-1.57**	-1.00	**-1.35**
150°	**-0.77**	**-0.57**	-0.45	**-1.19**	-1.50	**-1.88**	-1.51	**-2.01**
160°	**-0.74**	**-0.14**	-0.01	**-0.58**	-0.98	**-1.34**	-1.20	**-1.67**
170°	**-0.73**	**0.09**	0.26	**-0.14**	-0.55	**-0.84**	-0.71	**-1.11**
180°	**-0.71**	**0.16**	0.36	**-0.01**	-0.38	**-0.61**	-0.50	**-0.91**
190°	**-0.74**	**0.05**	0.25	**-0.19**	-0.57	**-0.90**	-0.83	**-1.34**
200°	**-0.74**	**-0.27**	-0.07	**-0.74**	-1.12	**-1.50**	-1.52	**-2.12**
210°	**-0.82**	**-0.72**	-0.52	**-1.24**	-1.62	**-2.03**	-1.76	**-2.14**
220°	**-0.69**	**-1.09**	-0.69	**-1.60**	-1.31	**-1.51**	-0.99	**-1.05**
230°	**-0.59**	**-1.12**	-0.50	**-1.23**	-0.68	**-0.90**	-0.54	**-0.84**
240°	**-0.50**	**-0.74**	-0.16	**-0.77**	-0.46	**-0.81**	-0.69	**-1.10**
250°	**-0.31**	**-0.35**	0.05	**-0.77**	-0.52	**-0.72**	-0.56	**-0.51**
260°	**-0.26**	**-0.28**	0.11	**-0.87**	-0.38	**-0.36**	-0.16	**-0.78**
270°	**-0.25**	**-0.30**	0.16	**-0.51**	-0.08	**-0.28**	-0.48	**-0.70**
280°	**-0.31**	**-0.13**	0.28	**-0.20**	-0.15	**-0.53**	-0.52	**-0.58**
290°	**-0.34**	**0.08**	0.43	**-0.34**	-0.37	**-0.44**	-0.29	**-0.85**
300°	**-0.26**	**0.27**	0.41	**-0.70**	-0.30	**-0.20**	-0.38	**-0.62**
310°	**-0.10**	**0.38**	0.23	**-0.84**	-0.05	**-0.18**	-0.47	**-0.14**
320°	**-0.05**	**0.34**	0.07	**-0.64**	0.07	**-0.28**	-0.21	**-0.16**
330°	**0.01**	**0.23**	0.02	**-0.33**	0.07	**-0.24**	-0.02	**-0.23**
340°	**0.07**	**0.13**	0.02	**-0.04**	0.04	**-0.10**	-0.02	**-0.15**
350°	**0.11**	**0.10**	0.02	**0.16**	0.02	**0.00**	-0.12	**-0.06**

Angle (degrees)	Nominal frequency / exact frequency (Hz)					
	4500/4466.8	**5000/5011.9**	5600/5623.4	**6300/6309.6**	7100/7079.5	**8000/7943.3**
0°	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
10°	-0.11	**-0.14**	-0.06	**-0.02**	0.05	**-0.04**
20°	-0.16	**-0.38**	-0.16	**-0.09**	0.09	**-0.20**
30°	-0.20	**-0.75**	-0.20	**-0.27**	0.04	**-0.59**
40°	-0.57	**-1.25**	-0.40	**-0.73**	-0.34	**-0.92**
50°	-0.87	**-1.54**	-1.06	**-0.95**	-0.73	**-1.14**
60°	-0.89	**-1.82**	-1.56	**-1.49**	-1.30	**-1.65**
70°	-1.49	**-1.62**	-2.04	**-1.89**	-1.85	**-2.11**
80°	-2.00	**-1.97**	-2.20	**-2.64**	-2.96	**-3.15**
90°	-1.18	**-2.47**	-1.91	**-2.47**	-2.95	**-3.89**
100°	-1.40	**-2.32**	-2.10	**-2.64**	-2.94	**-3.84**
110°	-0.93	**-1.97**	-2.41	**-2.43**	-2.55	**-3.82**
120°	-1.51	**-1.79**	-1.85	**-2.38**	-2.47	**-3.27**
130°	-1.73	**-2.47**	-2.67	**-2.86**	-2.45	**-3.22**
140°	-1.95	**-2.36**	-2.46	**-3.15**	-3.46	**-4.43**
150°	-2.93	**-3.51**	-3.18	**-3.24**	-3.28	**-4.18**
160°	-2.57	**-3.70**	-3.68	**-4.15**	-4.80	**-5.54**
170°	-1.65	**-2.76**	-2.71	**-2.88**	-3.57	**-4.60**
180°	-1.29	**-2.30**	-2.24	**-2.18**	-2.60	**-3.58**
190°	-1.83	**-2.95**	-2.93	**-3.08**	-3.56	**-4.67**
200°	-2.85	**-3.87**	-3.75	**-4.03**	-4.10	**-5.03**
210°	-2.54	**-3.30**	-2.93	**-3.01**	-3.33	**-4.25**
220°	-1.69	**-2.68**	-2.76	**-3.11**	-3.20	**-4.19**
230°	-2.22	**-2.98**	-2.26	**-2.38**	-2.60	**-3.45**
240°	-1.80	**-1.88**	-1.81	**-2.56**	-2.36	**-3.40**
250°	-0.96	**-2.09**	-2.02	**-2.34**	-2.49	**-3.84**
260°	-1.61	**-2.14**	-2.34	**-2.58**	-2.73	**-3.88**
270°	-0.83	**-2.54**	-1.86	**-2.47**	-2.64	**-3.61**
280°	-1.64	**-2.07**	-2.14	**-2.49**	-2.23	**-2.99**
290°	-1.36	**-1.75**	-1.91	**-2.04**	-1.70	**-2.04**
300°	-0.77	**-1.75**	-1.45	**-1.18**	-0.98	**-1.48**
310°	-0.74	**-1.23**	-1.02	**-0.97**	-0.57	**-0.87**
320°	-0.50	**-1.16**	-0.32	**-0.50**	-0.14	**-0.81**
330°	-0.16	**-0.81**	-0.25	**-0.09**	0.16	**-0.52**
340°	0.10	**-0.27**	-0.16	**-0.03**	0.13	**-0.15**
350°	0.25	**0.09**	0.00	**-0.01**	0.06	**0.06**

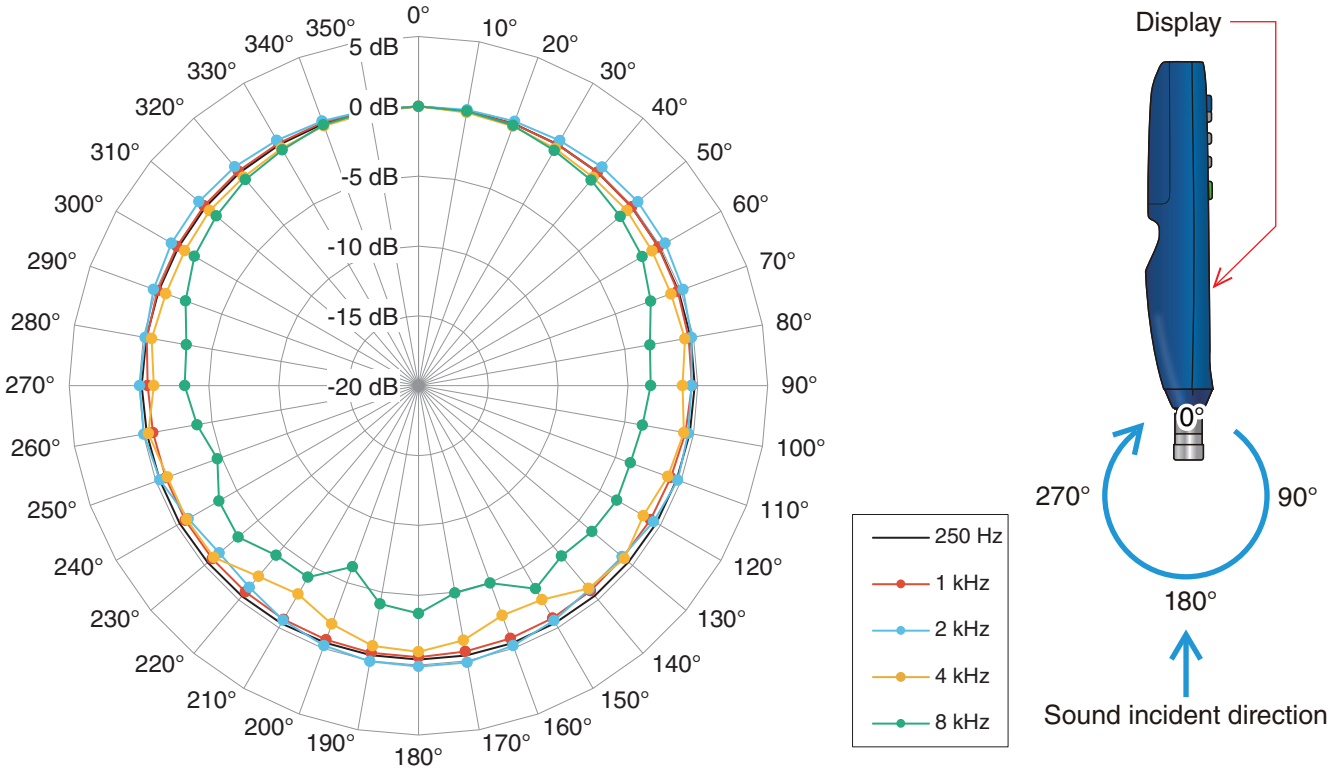

Fig. 7. Directional characteristics of NL-28 (vertical direction)

Table 6. Directional characteristics of NL-28 (vertical direction)

Angle (degrees)	Nominal frequency / exact frequency (Hz)							
	250/251.19	315/316.23	400/398.11	500/501.19	630/630.96	800/794.33	1000/1000.0	1250/1258.9
0°	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10°	-0.03	-0.04	-0.03	-0.04	0.01	0.02	-0.07	-0.03
20°	-0.04	-0.04	-0.04	-0.05	-0.02	0.01	-0.05	0.01
30°	-0.06	-0.07	-0.08	-0.10	-0.05	0.00	-0.08	0.03
40°	-0.07	-0.08	-0.09	-0.11	-0.06	-0.01	-0.05	0.08
50°	-0.09	-0.11	-0.13	-0.16	-0.10	-0.04	-0.08	0.13
60°	-0.14	-0.14	-0.18	-0.22	-0.17	-0.12	-0.15	0.21
70°	-0.19	-0.23	-0.26	-0.27	-0.23	-0.19	-0.24	0.25
80°	-0.20	-0.22	-0.28	-0.30	-0.30	-0.28	-0.36	0.30
90°	-0.22	-0.24	-0.30	-0.35	-0.37	-0.38	-0.42	0.26
100°	-0.28	-0.30	-0.36	-0.41	-0.43	-0.49	-0.60	0.03
110°	-0.34	-0.36	-0.43	-0.48	-0.48	-0.60	-0.79	-0.33
120°	-0.34	-0.39	-0.45	-0.51	-0.51	-0.67	-0.83	-0.64
130°	-0.37	-0.44	-0.48	-0.54	-0.53	-0.73	-0.89	-0.83
140°	-0.37	-0.44	-0.50	-0.55	-0.54	-0.75	-0.84	-0.86
150°	-0.40	-0.44	-0.48	-0.54	-0.52	-0.73	-0.80	-0.78
160°	-0.39	-0.47	-0.49	-0.55	-0.51	-0.70	-0.75	-0.72
170°	-0.39	-0.44	-0.48	-0.53	-0.49	-0.67	-0.68	-0.60
180°	-0.40	-0.42	-0.47	-0.49	-0.52	-0.67	-0.57	-0.52
190°	-0.41	-0.42	-0.47	-0.48	-0.52	-0.68	-0.59	-0.50
200°	-0.44	-0.42	-0.48	-0.51	-0.54	-0.71	-0.66	-0.53
210°	-0.36	-0.41	-0.45	-0.49	-0.53	-0.70	-0.68	-0.57
220°	-0.35	-0.40	-0.45	-0.49	-0.54	-0.72	-0.73	-0.65
230°	-0.32	-0.39	-0.42	-0.48	-0.53	-0.71	-0.74	-0.70
240°	-0.27	-0.34	-0.37	-0.45	-0.50	-0.64	-0.74	-0.62
250°	-0.29	-0.32	-0.35	-0.44	-0.46	-0.58	-0.75	-0.40
260°	-0.26	-0.29	-0.31	-0.40	-0.40	-0.49	-0.70	-0.13
270°	-0.19	-0.24	-0.25	-0.33	-0.33	-0.40	-0.61	0.05
280°	-0.21	-0.19	-0.27	-0.25	-0.28	-0.28	-0.25	0.34
290°	-0.20	-0.20	-0.24	-0.22	-0.21	-0.19	-0.13	0.29
300°	-0.16	-0.11	-0.17	-0.16	-0.15	-0.12	-0.04	0.24
310°	-0.10	-0.08	-0.11	-0.11	-0.08	-0.04	0.03	0.16
320°	-0.08	-0.05	-0.07	-0.05	-0.04	-0.01	0.06	0.12
330°	-0.08	-0.04	-0.07	-0.04	-0.02	0.00	0.03	0.07
340°	-0.05	-0.01	-0.03	0.00	0.00	0.01	0.06	0.05
350°	-0.04	-0.01	-0.01	0.02	0.03	0.02	0.04	0.01

Angle (degrees)	Nominal frequency / exact frequency (Hz)							
	1600/1584.9	**2000/1995.3**	2240/2238.7	**2500/2511.9**	2800/2818.4	**3150/3162.3**	3550/3548.1	**4000/3981.1**
0°	**0.00**	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
10°	**-0.03**	**0.05**	-0.05	**-0.09**	0.04	**0.01**	-0.06	**-0.13**
20°	**-0.05**	**0.14**	-0.05	**-0.20**	0.12	**-0.06**	-0.05	**-0.23**
30°	**-0.12**	**0.27**	-0.04	**-0.45**	0.16	**-0.17**	-0.04	**-0.40**
40°	**-0.14**	**0.44**	0.02	**-0.75**	0.15	**-0.22**	-0.15	**-0.54**
50°	**-0.22**	**0.50**	0.23	**-0.92**	-0.05	**-0.19**	-0.22	**-0.51**
60°	**-0.27**	**0.39**	0.48	**-0.78**	-0.49	**-0.12**	-0.25	**-0.69**
70°	**-0.28**	**0.15**	0.48	**-0.35**	-0.77	**-0.42**	-0.19	**-0.77**
80°	**-0.11**	**-0.15**	0.27	**-0.12**	-0.35	**-0.74**	-0.26	**-0.63**
90°	**0.10**	**-0.45**	0.21	**-0.36**	-0.06	**-0.79**	-0.40	**-1.09**
100°	**0.13**	**-0.39**	0.22	**-0.93**	-0.17	**-0.45**	-0.61	**-0.71**
110°	**-0.06**	**-0.25**	0.10	**-0.78**	-0.48	**-0.52**	-0.64	**-1.00**
120°	**-0.25**	**-0.55**	-0.09	**-0.72**	-0.59	**-0.43**	-0.39	**-1.41**
130°	**-0.49**	**-0.96**	-0.42	**-1.12**	-0.89	**-0.86**	-0.17	**-0.77**
140°	**-0.66**	**-0.98**	-0.63	**-1.49**	-1.46	**-1.73**	-0.84	**-1.06**
150°	**-0.72**	**-0.60**	-0.40	**-1.27**	-1.62	**-2.21**	-1.88	**-2.31**
160°	**-0.78**	**-0.21**	-0.04	**-0.61**	-1.18	**-1.81**	-1.77	**-2.50**
170°	**-0.69**	**0.12**	0.32	**-0.09**	-0.56	**-0.96**	-0.91	**-1.50**
180°	**-0.75**	**0.10**	0.42	**-0.08**	-0.44	**-0.66**	-0.33	**-0.95**
190°	**-0.75**	**0.02**	0.35	**-0.10**	-0.55	**-0.81**	-0.41	**-1.09**
200°	**-0.79**	**-0.20**	0.08	**-0.39**	-1.05	**-1.39**	-0.97	**-1.85**
210°	**-0.75**	**-0.63**	-0.38	**-1.14**	-1.75	**-2.03**	-1.58	**-2.78**
220°	**-0.75**	**-1.17**	-0.83	**-1.75**	-1.91	**-1.90**	-1.30	**-2.19**
230°	**-0.74**	**-1.38**	-0.82	**-1.69**	-1.13	**-1.07**	-0.59	**-0.89**
240°	**-0.64**	**-0.96**	-0.33	**-0.99**	-0.28	**-0.52**	-0.34	**-0.85**
250°	**-0.56**	**-0.31**	0.08	**-0.53**	-0.24	**-0.77**	-0.35	**-0.89**
260°	**-0.43**	**-0.05**	0.37	**-0.54**	-0.39	**-0.47**	0.06	**-0.37**
270°	**-0.43**	**-0.04**	0.37	**-0.26**	-0.27	**-0.28**	0.00	**-1.05**
280°	**-0.13**	**-0.13**	0.33	**-0.17**	-0.37	**-0.65**	-0.29	**-0.61**
290°	**-0.30**	**0.17**	0.54	**-0.40**	-0.79	**-0.32**	-0.21	**-0.75**
300°	**-0.29**	**0.41**	0.53	**-0.83**	-0.51	**-0.03**	-0.27	**-0.67**
310°	**-0.24**	**0.52**	0.29	**-0.97**	-0.06	**-0.10**	-0.25	**-0.49**
320°	**-0.16**	**0.46**	0.07	**-0.80**	0.13	**-0.13**	-0.17	**-0.52**
330°	**-0.13**	**0.29**	0.01	**-0.50**	0.14	**-0.08**	-0.06	**-0.38**
340°	**-0.06**	**0.16**	0.00	**-0.25**	0.10	**0.03**	-0.07	**-0.22**
350°	**-0.05**	**0.07**	0.01	**-0.14**	0.02	**0.10**	-0.08	**-0.12**

Angle (degrees)	Nominal frequency / exact frequency (Hz)					
	4500/4466.8	**5000/5011.9**	5600/5623.4	**6300/6309.6**	7100/7079.5	**8000/7943.3**
0°	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
10°	-0.05	**-0.16**	-0.11	**0.04**	-0.01	**-0.05**
20°	-0.05	**-0.51**	-0.27	**0.03**	-0.01	**-0.17**
30°	-0.07	**-0.98**	-0.43	**-0.12**	-0.17	**-0.56**
40°	-0.18	**-1.27**	-0.50	**-0.72**	-0.37	**-0.78**
50°	-0.80	**-1.04**	-1.13	**-1.33**	-0.52	**-1.15**
60°	-1.09	**-1.25**	-1.38	**-1.69**	-1.27	**-1.52**
70°	-1.28	**-1.82**	-1.43	**-1.90**	-1.97	**-2.32**
80°	-1.26	**-2.22**	-1.84	**-2.04**	-2.21	**-3.18**
90°	-1.24	**-2.46**	-2.60	**-2.86**	-2.35	**-3.38**
100°	-1.11	**-1.91**	-2.16	**-2.50**	-2.74	**-3.73**
110°	-1.26	**-2.08**	-2.31	**-2.57**	-2.83	**-3.86**
120°	-1.85	**-2.30**	-1.89	**-2.73**	-2.73	**-3.60**
130°	-1.56	**-2.70**	-2.46	**-2.62**	-2.86	**-3.78**
140°	-1.21	**-1.86**	-2.14	**-2.65**	-3.13	**-4.07**
150°	-2.63	**-3.16**	-2.45	**-2.59**	-2.41	**-3.23**
160°	-2.99	**-4.12**	-3.83	**-4.40**	-4.40	**-4.97**
170°	-1.81	**-2.93**	-2.84	**-3.07**	-3.75	**-4.93**
180°	-1.64	**-2.36**	-2.19	**-2.23**	-2.55	**-3.70**
190°	-1.79	**-2.55**	-2.37	**-2.60**	-2.97	**-4.15**
200°	-2.74	**-3.65**	-3.77	**-4.39**	-5.21	**-6.20**
210°	-3.75	**-4.16**	-3.96	**-3.88**	-3.61	**-4.17**
220°	-2.23	**-2.44**	-1.92	**-2.37**	-3.03	**-4.16**
230°	-1.47	**-2.30**	-2.64	**-3.06**	-2.90	**-3.15**
240°	-1.81	**-2.05**	-1.77	**-1.93**	-2.39	**-3.51**
250°	-1.13	**-1.68**	-2.04	**-2.53**	-2.92	**-4.69**
260°	-1.46	**-2.17**	-2.34	**-3.60**	-4.11	**-3.90**
270°	-1.70	**-2.97**	-3.22	**-3.34**	-2.11	**-3.26**
280°	-1.37	**-2.27**	-1.91	**-2.02**	-2.20	**-3.14**
290°	-1.39	**-1.87**	-1.50	**-1.88**	-1.96	**-2.27**
300°	-1.20	**-1.29**	-1.45	**-1.67**	-1.26	**-1.47**
310°	-0.91	**-1.09**	-1.20	**-1.31**	-0.51	**-1.10**
320°	-0.29	**-1.31**	-0.57	**-0.70**	-0.36	**-0.74**
330°	-0.18	**-1.03**	-0.50	**-0.10**	-0.17	**-0.52**
340°	-0.16	**-0.56**	-0.34	**0.05**	0.00	**-0.12**
350°	-0.17	**-0.21**	-0.18	**0.06**	0.00	**0.00**

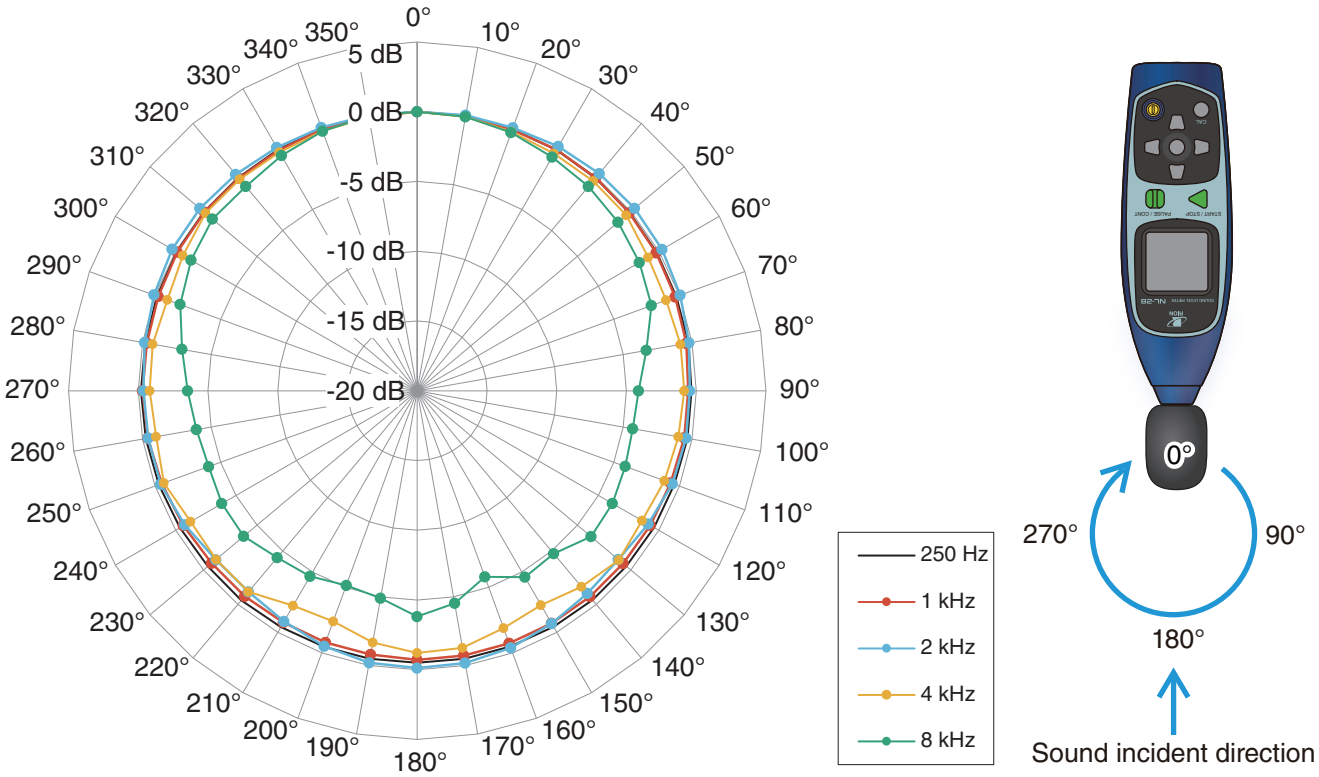

Fig. 8. Directional characteristics of NL-28 with WS-14 attached (horizontal direction)

Table 7. Directional characteristics of NL-28 with WS-14 attached (horizontal direction)

Angle (degrees)	Nominal frequency / exact frequency (Hz)							
	250/251.19	315/316.23	400/398.11	500/501.19	630/630.96	800/794.33	1000/1000.0	1250/1258.9
0°	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10°	-0.01	0.00	0.00	0.00	-0.01	0.01	0.00	-0.02
20°	-0.06	-0.05	-0.05	-0.05	-0.04	-0.04	-0.08	-0.06
30°	-0.06	-0.04	-0.05	-0.06	-0.07	-0.03	-0.03	-0.08
40°	-0.10	-0.08	-0.09	-0.11	-0.11	-0.08	-0.08	-0.11
50°	-0.14	-0.13	-0.14	-0.17	-0.16	-0.13	-0.15	-0.14
60°	-0.16	-0.17	-0.18	-0.22	-0.21	-0.18	-0.22	-0.16
70°	-0.23	-0.22	-0.24	-0.31	-0.29	-0.28	-0.32	-0.16
80°	-0.26	-0.27	-0.30	-0.35	-0.36	-0.36	-0.41	-0.13
90°	-0.34	-0.33	-0.38	-0.44	-0.45	-0.50	-0.57	-0.18
100°	-0.33	-0.34	-0.38	-0.47	-0.48	-0.58	-0.56	-0.26
110°	-0.39	-0.39	-0.44	-0.51	-0.54	-0.69	-0.67	-0.43
120°	-0.40	-0.40	-0.44	-0.54	-0.58	-0.75	-0.71	-0.58
130°	-0.44	-0.45	-0.49	-0.59	-0.61	-0.81	-0.74	-0.68
140°	-0.42	-0.44	-0.49	-0.59	-0.61	-0.80	-0.73	-0.66
150°	-0.47	-0.50	-0.54	-0.60	-0.63	-0.83	-0.74	-0.62
160°	-0.48	-0.51	-0.57	-0.63	-0.63	-0.82	-0.74	-0.56
170°	-0.49	-0.50	-0.53	-0.61	-0.62	-0.80	-0.73	-0.52
180°	-0.50	-0.54	-0.57	-0.63	-0.62	-0.79	-0.71	-0.52
190°	-0.48	-0.52	-0.56	-0.62	-0.62	-0.79	-0.79	-0.54
200°	-0.46	-0.51	-0.54	-0.61	-0.62	-0.80	-0.79	-0.58
210°	-0.45	-0.49	-0.56	-0.61	-0.63	-0.82	-0.82	-0.63
220°	-0.39	-0.45	-0.50	-0.57	-0.62	-0.80	-0.77	-0.63
230°	-0.40	-0.45	-0.53	-0.58	-0.62	-0.80	-0.77	-0.63
240°	-0.35	-0.39	-0.45	-0.51	-0.57	-0.72	-0.65	-0.49
250°	-0.28	-0.31	-0.37	-0.42	-0.49	-0.59	-0.51	-0.29
260°	-0.24	-0.28	-0.32	-0.38	-0.43	-0.50	-0.40	-0.12
270°	-0.19	-0.23	-0.27	-0.31	-0.35	-0.38	-0.31	-0.04
280°	-0.19	-0.21	-0.25	-0.28	-0.27	-0.28	-0.31	-0.06
290°	-0.15	-0.18	-0.22	-0.22	-0.20	-0.20	-0.25	-0.08
300°	-0.09	-0.12	-0.14	-0.14	-0.12	-0.10	-0.13	-0.07
310°	-0.05	-0.08	-0.10	-0.10	-0.09	-0.06	-0.08	-0.05
320°	-0.07	-0.07	-0.10	-0.09	-0.06	-0.06	-0.12	-0.07
330°	-0.04	-0.06	-0.06	-0.05	-0.03	-0.04	-0.10	-0.04
340°	-0.01	-0.04	-0.03	-0.02	0.00	0.00	-0.05	0.00
350°	0.01	-0.01	-0.01	0.00	0.02	0.03	-0.04	0.02

Angle (degrees)	Nominal frequency / exact frequency (Hz)							
	1600/1584.9	**2000/1995.3**	2240/2238.7	**2500/2511.9**	2800/2818.4	**3150/3162.3**	3550/3548.1	**4000/3981.1**
0°	**0.00**	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
10°	**-0.01**	**0.07**	-0.02	*0.02*	0.03	**-0.04**	0.00	**-0.06**
20°	**-0.09**	**0.07**	-0.06	**-0.13**	-0.01	**-0.17**	0.05	**-0.24**
30°	**-0.11**	**0.23**	-0.10	**-0.31**	0.01	**-0.32**	-0.09	**-0.37**
40°	**-0.22**	**0.32**	-0.03	**-0.56**	-0.05	**-0.41**	-0.24	**-0.37**
50°	**-0.35**	**0.35**	0.12	**-0.76**	-0.26	**-0.45**	-0.41	**-0.44**
60°	**-0.46**	**0.28**	0.31	**-0.64**	-0.52	**-0.53**	-0.43	**-0.87**
70°	**-0.55**	**0.06**	0.30	**-0.34**	-0.62	**-0.80**	-0.44	**-1.01**
80°	**-0.49**	**-0.21**	0.14	**-0.22**	-0.32	**-0.80**	-0.72	**-0.84**
90°	**-0.48**	**-0.46**	-0.03	**-0.52**	-0.33	**-0.58**	-0.62	**-0.86**
100°	**-0.46**	**-0.43**	0.00	**-0.81**	-0.60	**-0.76**	-0.36	**-1.00**
110°	**-0.58**	**-0.52**	-0.11	**-0.76**	-0.76	**-1.11**	-0.77	**-1.14**
120°	**-0.71**	**-0.87**	-0.33	**-0.92**	-0.73	**-0.97**	-0.87	**-1.38**
130°	**-0.87**	**-1.18**	-0.73	**-1.38**	-1.11	**-1.23**	-0.85	**-1.12**
140°	**-0.87**	**-1.03**	-0.83	**-1.68**	-1.65	**-1.89**	-1.39	**-1.67**
150°	**-0.97**	**-0.72**	-0.54	**-1.31**	-1.63	**-2.18**	-1.78	**-2.26**
160°	**-0.89**	**-0.39**	-0.16	**-0.81**	-1.15	**-1.64**	-1.43	**-1.89**
170°	**-0.84**	**-0.17**	0.12	**-0.43**	-0.71	**-1.06**	-0.88	**-1.28**
180°	**-0.87**	**-0.12**	0.19	**-0.29**	-0.59	**-0.93**	-0.75	**-1.20**
190°	**-0.85**	**-0.20**	0.02	**-0.50**	-0.82	**-1.16**	-1.16	**-1.67**
200°	**-0.86**	**-0.50**	-0.28	**-1.05**	-1.34	**-1.75**	-1.82	**-2.40**
210°	**-0.89**	**-0.91**	-0.70	**-1.61**	-1.77	**-2.16**	-1.93	**-2.20**
220°	**-0.76**	**-1.19**	-0.84	**-1.79**	-1.50	**-1.63**	-1.20	**-1.19**
230°	**-0.74**	**-1.15**	-0.59	**-1.20**	-0.94	**-1.12**	-0.82	**-1.18**
240°	**-0.54**	**-0.76**	-0.23	**-0.90**	-0.79	**-0.98**	-0.97	**-1.25**
250°	**-0.31**	**-0.42**	-0.01	**-0.93**	-0.82	**-0.85**	-0.78	**-0.67**
260°	**-0.22**	**-0.41**	0.07	**-0.95**	-0.61	**-0.49**	-0.41	**-0.99**
270°	**-0.25**	**-0.37**	0.09	**-0.55**	-0.31	**-0.48**	-0.79	**-0.82**
280°	**-0.31**	**-0.16**	0.15	**-0.38**	-0.37	**-0.68**	-0.76	**-0.74**
290°	**-0.40**	**0.09**	0.32	**-0.53**	-0.59	**-0.56**	-0.47	**-0.93**
300°	**-0.29**	**0.29**	0.32	**-0.79**	-0.48	**-0.34**	-0.61	**-0.60**
310°	**-0.20**	**0.34**	0.14	**-0.85**	-0.23	**-0.35**	-0.55	**-0.19**
320°	**-0.18**	**0.24**	-0.01	**-0.66**	-0.09	**-0.39**	-0.15	**-0.20**
330°	**-0.10**	**0.13**	-0.06	**-0.41**	-0.03	**-0.29**	0.03	**-0.26**
340°	**-0.02**	**0.08**	-0.04	**-0.17**	0.00	**-0.12**	0.00	**-0.17**
350°	**0.02**	**0.07**	-0.04	**-0.07**	0.02	**0.04**	-0.02	**-0.08**

Angle (degrees)	Nominal frequency / exact frequency (Hz)					
	4500/4466.8	**5000/5011.9**	5600/5623.4	**6300/6309.6**	7100/7079.5	**8000/7943.3**
0°	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
10°	0.08	**-0.04**	0.00	**-0.05**	-0.01	**-0.06**
20°	-0.23	**-0.41**	-0.16	**-0.04**	0.05	**-0.31**
30°	-0.15	**-0.74**	-0.19	**-0.25**	0.02	**-0.67**
40°	-0.53	**-1.18**	-0.42	**-0.73**	-0.28	**-0.89**
50°	-0.86	**-1.52**	-1.15	**-0.89**	-0.70	**-1.20**
60°	-0.93	**-1.71**	-1.61	**-1.54**	-1.22	**-1.60**
70°	-1.70	**-1.63**	-2.22	**-1.97**	-1.91	**-2.13**
80°	-1.91	**-2.34**	-2.15	**-3.08**	-2.68	**-3.33**
90°	-1.41	**-2.70**	-2.19	**-2.40**	-3.17	**-4.13**
100°	-1.88	**-2.72**	-2.42	**-2.76**	-3.30	**-4.31**
110°	-1.45	**-2.20**	-2.61	**-2.57**	-2.86	**-4.14**
120°	-2.24	**-2.28**	-2.11	**-2.53**	-2.78	**-3.84**
130°	-2.37	**-2.96**	-3.01	**-3.11**	-2.90	**-3.73**
140°	-2.46	**-2.80**	-2.64	**-3.27**	-3.63	**-4.77**
150°	-3.44	**-4.00**	-3.59	**-3.52**	-3.76	**-4.56**
160°	-2.83	**-3.91**	-3.88	**-4.22**	-4.89	**-5.80**
170°	-1.90	**-2.92**	-2.78	**-2.76**	-3.37	**-4.52**
180°	-1.68	**-2.57**	-2.45	**-2.31**	-2.78	**-3.81**
190°	-2.11	**-3.20**	-3.23	**-3.32**	-3.79	**-4.90**
200°	-3.24	**-4.12**	-4.04	**-4.11**	-4.15	**-5.16**
210°	-2.96	**-3.46**	-3.17	**-3.18**	-3.43	**-4.63**
220°	-2.11	**-3.01**	-3.14	**-3.33**	-3.20	**-4.38**
230°	-2.71	**-3.17**	-2.45	**-2.49**	-2.74	**-3.75**
240°	-2.08	**-2.18**	-2.20	**-2.73**	-2.50	**-3.82**
250°	-1.23	**-2.38**	-2.29	**-2.69**	-2.72	**-4.08**
260°	-1.82	**-2.20**	-2.85	**-2.84**	-2.81	**-3.92**
270°	-1.07	**-2.84**	-2.03	**-2.78**	-2.62	**-3.55**
280°	-1.84	**-2.18**	-2.37	**-2.60**	-2.18	**-2.88**
290°	-1.49	**-1.87**	-1.97	**-2.08**	-1.67	**-1.92**
300°	-0.81	**-1.69**	-1.53	**-1.14**	-0.92	**-1.28**
310°	-0.83	**-1.21**	-0.98	**-0.99**	-0.56	**-0.84**
320°	-0.65	**-1.14**	-0.38	**-0.49**	-0.17	**-0.88**
330°	-0.35	**-0.79**	-0.32	**-0.10**	0.15	**-0.53**
340°	-0.08	**-0.33**	-0.23	**-0.06**	0.07	**-0.19**
350°	-0.01	**-0.07**	-0.12	**-0.06**	-0.01	**0.00**

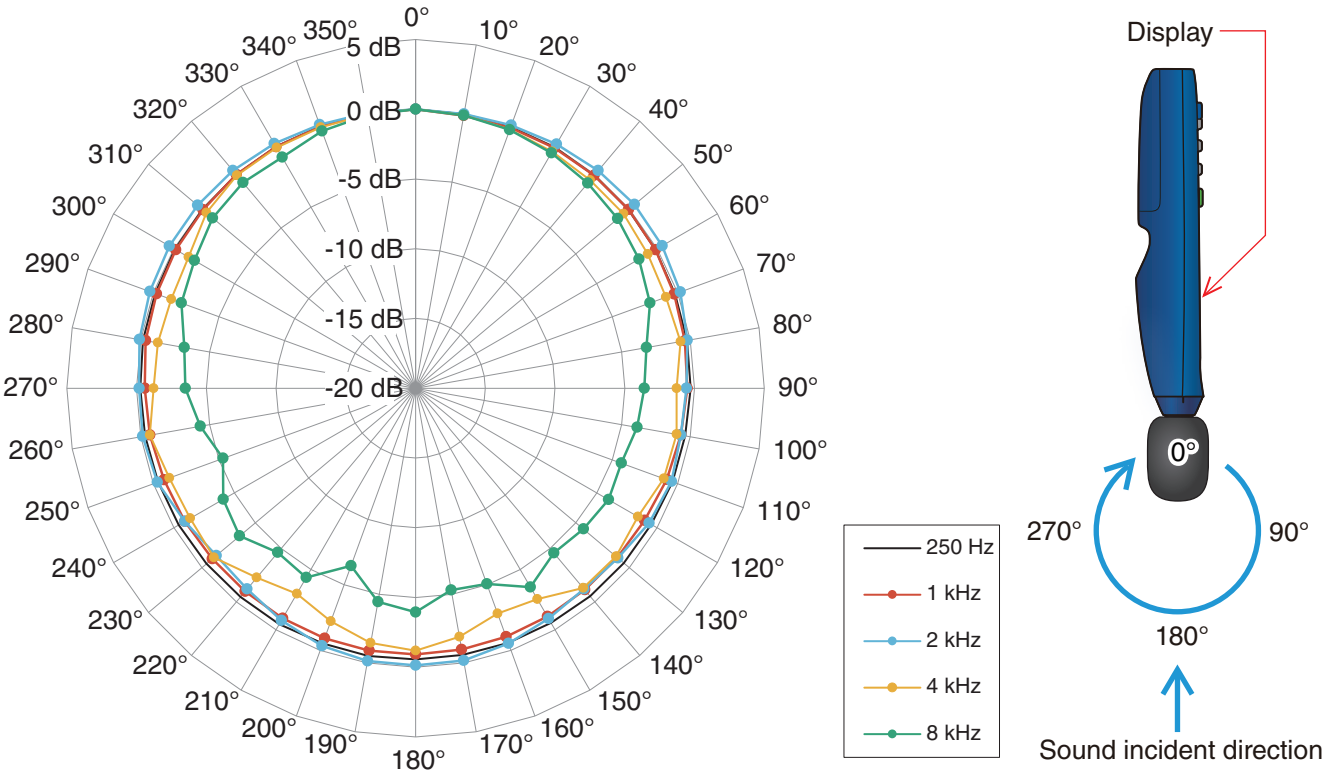

Fig. 9. Directional characteristics of NL-28 with WS-14 attached (vertical direction)

Table 8. Directional characteristics of NL-28 with WS-14 attached (vertical direction)

Angle (degrees)	Nominal frequency / exact frequency (Hz)							
	250/251.19	315/316.23	400/398.11	500/501.19	630/630.96	800/794.33	1000/1000.0	1250/1258.9
0°	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10°	-0.06	-0.06	-0.05	-0.06	-0.01	-0.03	-0.16	-0.06
20°	-0.07	-0.06	-0.06	-0.07	-0.02	-0.03	-0.12	-0.04
30°	-0.06	-0.07	-0.07	-0.08	-0.04	-0.02	-0.10	-0.01
40°	-0.08	-0.08	-0.10	-0.10	-0.07	-0.05	-0.08	0.05
50°	-0.08	-0.12	-0.13	-0.14	-0.11	-0.07	-0.08	0.13
60°	-0.15	-0.16	-0.19	-0.20	-0.17	-0.15	-0.14	0.21
70°	-0.20	-0.21	-0.25	-0.28	-0.23	-0.22	-0.26	0.30
80°	-0.24	-0.27	-0.31	-0.35	-0.32	-0.34	-0.39	0.34
90°	-0.28	-0.32	-0.38	-0.42	-0.39	-0.44	-0.51	0.31
100°	-0.37	-0.39	-0.45	-0.49	-0.51	-0.61	-0.69	0.10
110°	-0.40	-0.43	-0.49	-0.56	-0.56	-0.71	-0.85	-0.26
120°	-0.49	-0.51	-0.58	-0.65	-0.63	-0.86	-1.04	-0.64
130°	-0.51	-0.55	-0.65	-0.66	-0.65	-0.90	-1.12	-0.87
140°	-0.54	-0.59	-0.67	-0.70	-0.67	-0.95	-1.13	-0.95
150°	-0.57	-0.62	-0.69	-0.73	-0.68	-0.95	-1.11	-0.92
160°	-0.58	-0.61	-0.67	-0.72	-0.66	-0.91	-1.04	-0.84
170°	-0.58	-0.59	-0.65	-0.70	-0.65	-0.89	-0.98	-0.75
180°	-0.56	-0.56	-0.58	-0.63	-0.65	-0.92	-0.92	-0.58
190°	-0.50	-0.54	-0.59	-0.58	-0.58	-0.92	-0.89	-0.60
200°	-0.52	-0.54	-0.59	-0.58	-0.57	-0.94	-0.92	-0.63
210°	-0.47	-0.52	-0.56	-0.55	-0.55	-0.93	-0.94	-0.67
220°	-0.47	-0.51	-0.56	-0.56	-0.55	-0.94	-0.98	-0.71
230°	-0.43	-0.49	-0.53	-0.54	-0.53	-0.93	-0.97	-0.73
240°	-0.39	-0.43	-0.47	-0.52	-0.49	-0.83	-0.90	-0.63
250°	-0.35	-0.40	-0.40	-0.49	-0.45	-0.73	-0.80	-0.41
260°	-0.30	-0.33	-0.34	-0.44	-0.40	-0.60	-0.65	-0.22
270°	-0.26	-0.28	-0.27	-0.42	-0.34	-0.49	-0.58	-0.05
280°	-0.16	-0.18	-0.15	-0.31	-0.28	-0.36	-0.35	0.01
290°	-0.13	-0.16	-0.12	-0.27	-0.23	-0.28	-0.24	-0.05
300°	-0.08	-0.11	-0.06	-0.21	-0.17	-0.18	-0.14	-0.11
310°	-0.06	-0.07	-0.03	-0.15	-0.13	-0.12	-0.10	-0.13
320°	-0.01	-0.05	0.00	-0.10	-0.09	-0.06	-0.01	-0.08
330°	0.00	-0.02	0.03	-0.05	-0.04	-0.02	-0.01	-0.07
340°	-0.01	-0.02	0.02	-0.04	-0.03	-0.02	-0.04	-0.05
350°	-0.01	-0.01	0.01	-0.02	-0.01	-0.01	-0.04	-0.04

Angle (degrees)	Nominal frequency / exact frequency (Hz)							
	1600/1584.9	**2000/1995.3**	2240/2238.7	**2500/2511.9**	2800/2818.4	**3150/3162.3**	3550/3548.1	**4000/3981.1**
0°	**0.00**	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
10°	**-0.12**	**-0.04**	-0.04	**-0.14**	0.02	**-0.04**	0.07	**-0.11**
20°	**-0.14**	**0.06**	-0.05	**-0.24**	0.08	**-0.11**	0.01	**-0.26**
30°	**-0.15**	**0.21**	-0.09	**-0.48**	0.10	**-0.19**	-0.08	**-0.40**
40°	**-0.19**	**0.37**	-0.05	**-0.78**	0.06	**-0.23**	-0.21	**-0.53**
50°	**-0.21**	**0.48**	0.12	**-1.03**	-0.16	**-0.17**	-0.36	**-0.53**
60°	**-0.26**	**0.42**	0.35	**-0.96**	-0.60	**-0.16**	-0.37	**-0.78**
70°	**-0.24**	**0.20**	0.38	**-0.59**	-0.89	**-0.51**	-0.25	**-0.90**
80°	**-0.10**	**-0.21**	0.13	**-0.35**	-0.54	**-0.92**	-0.48	**-0.71**
90°	**0.04**	**-0.57**	-0.03	**-0.63**	-0.26	**-0.87**	-0.73	**-1.28**
100°	**0.02**	**-0.68**	0.00	**-1.25**	-0.48	**-0.57**	-0.80	**-0.99**
110°	**-0.19**	**-0.46**	-0.09	**-1.18**	-0.83	**-0.74**	-0.79	**-1.06**
120°	**-0.53**	**-0.66**	-0.26	**-0.92**	-0.90	**-0.92**	-0.80	**-1.59**
130°	**-0.71**	**-1.06**	-0.60	**-1.24**	-1.00	**-1.05**	-0.44	**-1.24**
140°	**-0.86**	**-1.20**	-0.89	**-1.73**	-1.63	**-1.90**	-0.96	**-1.31**
150°	**-0.96**	**-0.93**	-0.80	**-1.56**	-1.98	**-2.55**	-1.98	**-2.53**
160°	**-0.95**	**-0.52**	-0.40	**-0.99**	-1.60	**-2.18**	-2.01	**-2.81**
170°	**-0.87**	**-0.18**	0.03	**-0.39**	-0.98	**-1.39**	-1.19	**-1.91**
180°	**-0.85**	**-0.13**	0.22	**-0.22**	-0.69	**-1.12**	-0.58	**-1.18**
190°	**-0.81**	**-0.15**	0.07	**-0.28**	-0.79	**-1.22**	-0.83	**-1.45**
200°	**-0.84**	**-0.35**	-0.21	**-0.61**	-1.23	**-1.79**	-1.38	**-2.22**
210°	**-0.78**	**-0.77**	-0.68	**-1.39**	-1.89	**-2.39**	-1.94	**-2.99**
220°	**-0.81**	**-1.20**	-1.09	**-1.86**	-1.98	**-2.22**	-1.62	**-2.28**
230°	**-0.82**	**-1.34**	-1.01	**-1.68**	-1.23	**-1.36**	-0.88	**-1.11**
240°	**-0.79**	**-0.89**	-0.52	**-1.00**	-0.56	**-0.89**	-0.68	**-1.34**
250°	**-0.70**	**-0.31**	-0.09	**-0.62**	-0.51	**-1.08**	-0.68	**-1.21**
260°	**-0.57**	**-0.13**	0.20	**-0.70**	-0.52	**-0.76**	-0.22	**-0.65**
270°	**-0.51**	**-0.18**	0.18	**-0.45**	-0.42	**-0.56**	-0.31	**-1.23**
280°	**-0.40**	**0.09**	0.23	**-0.23**	-0.32	**-0.57**	-0.50	**-1.23**
290°	**-0.43**	**0.28**	0.39	**-0.41**	-0.52	**-0.63**	-0.52	**-1.36**
300°	**-0.30**	**0.39**	0.38	**-0.68**	-0.42	**-0.53**	-0.61	**-1.20**
310°	**-0.18**	**0.40**	0.14	**-0.78**	-0.20	**-0.55**	-0.63	**-0.42**
320°	**-0.06**	**0.37**	-0.04	**-0.54**	-0.04	**-0.52**	-0.44	**-0.07**
330°	**0.01**	**0.25**	-0.11	**-0.25**	-0.03	**-0.38**	-0.17	**-0.09**
340°	**0.01**	**0.11**	-0.08	**-0.10**	-0.05	**-0.19**	0.03	**-0.09**
350°	**-0.01**	**0.03**	-0.05	**-0.02**	-0.03	**-0.07**	0.05	**-0.07**

Angle (degrees)	Nominal frequency / exact frequency (Hz)					
	4500/4466.8	**5000/5011.9**	5600/5623.4	**6300/6309.6**	7100/7079.5	**8000/7943.3**
0°	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**
10°	-0.30	**-0.26**	-0.14	**-0.01**	-0.05	**-0.13**
20°	-0.27	**-0.50**	-0.27	**0.01**	-0.07	**-0.29**
30°	-0.16	**-0.82**	-0.44	**-0.13**	-0.09	**-0.51**
40°	-0.28	**-1.21**	-0.71	**-0.45**	-0.29	**-0.81**
50°	-0.68	**-1.22**	-1.11	**-1.18**	-0.55	**-1.09**
60°	-1.08	**-1.32**	-1.39	**-1.76**	-1.10	**-1.50**
70°	-1.49	**-1.79**	-1.63	**-1.90**	-1.86	**-2.12**
80°	-1.60	**-2.40**	-2.00	**-2.13**	-2.26	**-3.20**
90°	-1.58	**-2.88**	-2.91	**-2.99**	-2.35	**-3.59**
100°	-1.52	**-2.40**	-2.33	**-2.61**	-2.86	**-3.87**
110°	-1.70	**-2.49**	-2.73	**-2.76**	-2.98	**-4.29**
120°	-2.45	**-2.53**	-2.40	**-3.18**	-3.04	**-4.03**
130°	-2.35	**-3.28**	-2.88	**-2.69**	-3.14	**-4.29**
140°	-1.76	**-2.29**	-2.71	**-3.09**	-3.40	**-4.57**
150°	-2.99	**-3.28**	-2.68	**-2.62**	-2.67	**-3.54**
160°	-3.53	**-4.53**	-4.27	**-4.50**	-4.45	**-5.07**
170°	-2.30	**-3.35**	-3.25	**-3.46**	-4.07	**-5.30**
180°	-1.92	**-2.63**	-2.32	**-2.41**	-2.86	**-3.94**
190°	-2.09	**-2.85**	-2.70	**-2.90**	-3.42	**-4.45**
200°	-3.06	**-3.89**	-4.02	**-4.58**	-5.56	**-6.46**
210°	-4.03	**-4.36**	-4.09	**-3.85**	-3.69	**-4.33**
220°	-2.53	**-2.65**	-2.31	**-2.55**	-3.46	**-4.63**
230°	-1.88	**-2.60**	-3.01	**-3.28**	-3.09	**-3.52**
240°	-2.21	**-2.42**	-2.12	**-2.20**	-2.89	**-4.08**
250°	-1.44	**-2.06**	-2.39	**-2.78**	-3.38	**-5.30**
260°	-1.81	**-2.43**	-2.75	**-4.03**	-4.47	**-4.33**
270°	-2.03	**-3.30**	-3.51	**-3.40**	-2.28	**-3.49**
280°	-2.08	**-2.65**	-2.24	**-2.28**	-2.62	**-3.17**
290°	-1.78	**-1.60**	-1.75	**-2.03**	-1.85	**-2.14**
300°	-0.60	**-1.48**	-1.39	**-1.75**	-1.18	**-1.69**
310°	-0.48	**-1.45**	-1.25	**-0.77**	-0.76	**-1.01**
320°	-0.42	**-0.93**	-0.44	**-0.71**	-0.51	**-0.75**
330°	-0.28	**-0.46**	-0.13	**-0.43**	-0.09	**-0.88**
340°	-0.23	**-0.24**	-0.18	**-0.20**	0.06	**-0.39**
350°	-0.09	**-0.03**	-0.06	**-0.07**	-0.01	**-0.12**

17.10 Random incidence response

The random incidence response represents the random incidence sensitivity level in a diffuse field minus the free-field sensitivity level in the free-field.
The high-frequency response is lower in a diffuse field than in a free-field.

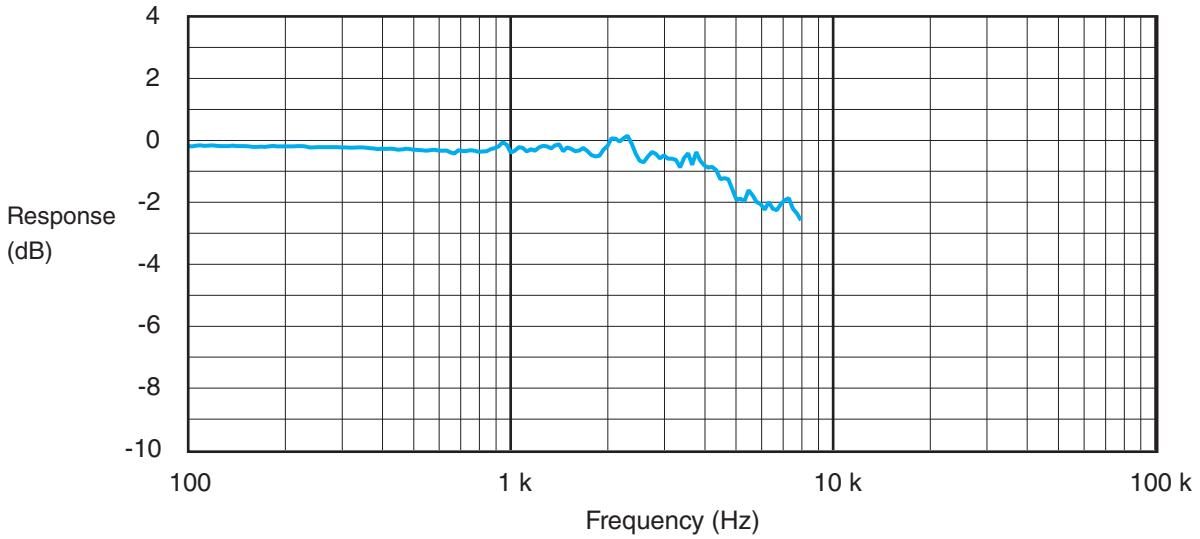

Fig. 10. NL-28 random incidence response

Table 9. NL-28 random incidence response

Nominal frequency (Hz)	Exact frequency (Hz)	Random incidence response (dB)
63	**63.096**	**-0.2**
80	**79.433**	**-0.2**
100	**100.00**	**-0.2**
125	**125.89**	**-0.2**
160	**158.49**	**-0.2**
200	**199.53**	**-0.2**
250	**251.19**	**-0.2**
315	**316.23**	**-0.2**
400	**398.11**	**-0.3**
500	**501.19**	**-0.3**
630	**630.96**	**-0.3**
800	**794.33**	**-0.4**
1000	**1000.0**	**-0.4**
1060	1059.3	-0.2
1120	1122.0	-0.4
1180	1188.5	-0.3
1250	**1258.9**	**-0.2**
1320	1333.5	-0.3
1400	1412.5	-0.1
1500	1496.2	-0.2
1600	**1584.9**	**-0.3**
1700	1678.8	-0.2
1800	1778.3	-0.5
1900	1883.6	-0.5
2000	**1995.3**	**-0.2**

Nominal frequency (Hz)	Exact frequency (Hz)	Random incidence response (dB)
2120	2113.5	0.1
2240	2238.7	0.1
2360	2371.4	-0.1
2500	**2511.9**	**-0.7**
2650	2660.7	-0.5
2800	2818.4	-0.4
3000	2985.4	-0.5
3150	**3162.3**	**-0.6**
3350	3349.7	-0.9
3550	3548.1	-0.4
3750	3758.4	-0.4
4000	**3981.1**	**-0.8**
4250	4217.0	-0.9
4500	4466.8	-1.3
4750	4731.5	-1.3
5000	**5011.9**	**-1.9**
5300	5308.8	-2.0
5600	5623.4	-1.8
6000	5956.6	-2.1
6300	**6309.6**	**-2.0**
6700	6683.4	-2.3
7100	7079.5	-1.9
7500	7498.9	-2.2
8000	**7943.3**	**-2.6**

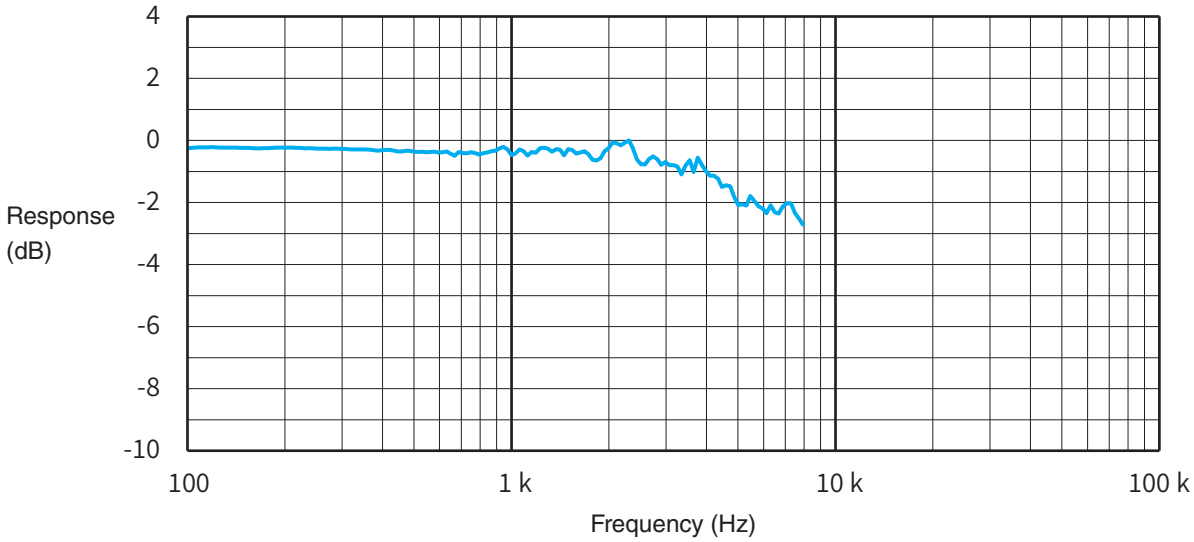

Fig. 11. Random incidence response of NL-28 with WS-14 attached

Table 10. Random incidence response of NL-28 with WS-14 attached

Nominal frequency (Hz)	Exact frequency (Hz)	Random incidence response of with WS-14 attached (dB)
63	**63.096**	**-0.2**
80	**79.433**	**-0.2**
100	**100.00**	**-0.2**
125	**125.89**	**-0.2**
160	**158.49**	**-0.2**
200	**199.53**	**-0.2**
250	**251.19**	**-0.3**
315	**316.23**	**-0.3**
400	**398.11**	**-0.3**
500	**501.19**	**-0.4**
630	**630.96**	**-0.4**
800	**794.33**	**-0.5**
1000	**1000.0**	**-0.5**
1060	1059.3	-0.3
1120	1122.0	-0.5
1180	1188.5	-0.4
1250	**1258.9**	**-0.2**
1320	1333.5	-0.4
1400	1412.5	-0.3
1500	1496.2	-0.3
1600	**1584.9**	**-0.4**
1700	1678.8	-0.3
1800	1778.3	-0.6
1900	1883.6	-0.6
2000	**1995.3**	**-0.2**

Nominal frequency (Hz)	Exact frequency (Hz)	Random incidence response of with WS-14 attached (dB)
2120	2113.5	-0.1
2240	2238.7	-0.1
2360	2371.4	-0.2
2500	**2511.9**	**-0.8**
2650	2660.7	-0.6
2800	2818.4	-0.6
3000	2985.4	-0.7
3150	**3162.3**	**-0.8**
3350	3349.7	-1.1
3550	3548.1	-0.6
3750	3758.4	-0.6
4000	**3981.1**	**-1.0**
4250	4217.0	-1.1
4500	4466.8	-1.5
4750	4731.5	-1.5
5000	**5011.9**	**-2.1**
5300	5308.8	-2.1
5600	5623.4	-2.0
6000	5956.6	-2.2
6300	**6309.6**	**-2.1**
6700	6683.4	-2.4
7100	7079.5	-2.0
7500	7498.9	-2.3
8000	**7943.3**	**-2.7**

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