Instruction Manual

Pistonphone Type 42AA / 42AA-S1

G.R.A.S.
SOUND & VIBRATION

Skovlytoften 33, 2840 Holte, Denmark
www.gras.dk gras@gras.dk

LI0125

Revision History

Any feedback or questions about this document are welcome at **gras@gras.dk**.

Revision	Date	Description
1	1 February 2010	First publication
2	4 July 2013	Section 3.1 “Shipment and transport” added

Before shipment, remove the batteries and wrap separately. Assure cautious handling during transport. Remove the battery as soon as it is discharged or if the 42AA is stored for a prolonged period of time. Leakage from the batteries may otherwise destroy the electronic components.

Note: unless individually specified, the term “Pistonphone” throughout this document refers to both types, i.e. Type 42AA and Type 42AA-S1.

Trademarks

Product names mentioned in this document may be trademarks or registered trademarks of their respective companies and are hereby acknowledged.

CONTENTS

1. General Description

The G.R.A.S. Pistonphone (Fig. 1.1) is a battery-operated, precision sound source for accurate and reliable calibration of measurement microphones, sound level meters and other sound measuring equipment.

- Type 42AA includes barometer type ZC0002K.
- Type 42AA-S1 includes barometer type RA0168.

Otherwise, there is no difference between the two types.

1.1 Operating Frequency

The Pistonphone type 42AA and type 42AA-S1 operates at a frequency of 250Hz.

1.2 Calibration Level

With a microphone inserted in the Pistonhone's coupler and the Pistonphone and switched on, the nominal calibration level is:

- 114 dB [1] re. 20 µPa
- 105.4 dBA re. 20 µPa (with A-weighting applied)

At a static ambient pressure of 1013 hPa, no further correction factors need be applied. An individual calibration chart is delivered with each Pistonphone.

Fig. 1.1 Pistonphone

The Pistonphone is an extremely stable laboratory-standard sound source which can also be used for field calibrations - it retains its high accuracy even under hostile environmental conditions.

The Pistonphone complies with all the requirements of IEC Standard 942 (1988) Sound Calibrators Class 1 when corrected with barometer ZC0002K as well as Class 0 when corrected with barometer RA0168. Type 42AA includes ZC0002K and Type 42AA-S1 includes RA0168.

* True centre frequency of a 250 Hz ⅓-octave band filter

[1] 114 dB is equivalent to 10 Pa

The Pistonphone works on the principle of two reciprocating pistons actuated by a precision-machined cam disc with a sinusoidal profile. The rotation speed of the cam disc is controlled to within 0.5% via a tachometer signal in a feed-back loop.

The operating procedure is straight forward, simply fit the microphone into the coupler of the Pistonphone and switch on. The Pistonphone will now produce a constant sound pressure level on the diaphragm of the microphone.

The Pistonphone is normally delivered with a coupler for calibrating ½-inch microphones. Adapters for calibrating ¼-inch and ⅛-inch microphones are included. A coupler (RA0023) for calibrating 1-inch microphones is also available.

2. Theory

2.1 Principle

The Pistonphone works on the principle of a pair of similar opposing, reciprocating pistons (Fig. 2.1) actuated by a precision-machined cam disc with a sinusoidal (SHM) profile. The cam disc is mounted on the shaft of a small electric motor. The profile of the cam disc is such that the pistons follow a sinusoidal movement at a frequency equal to four times the speed of rotation. This results in a corresponding sinusodial variation in the effective volume of the closed coupler and, consequently, an acoustic signal within it. The RMS pressure, *P* (in pascals), of this acoustic signal is given by:

$$P = \gamma \cdot P_0 \cdot \frac{2A_p \cdot S}{V \cdot \sqrt{2}} \qquad (1)$$

Where :

- γ is the ratio of specific heats for the gas in the coupler (for air this is 1.402 at 20 °C and 1 atm.)
- P_0 is the ambient pressure in pascals (Pa)
- A_p is the cross-sectional area of one piston in square metres (m^2)
- S is the stroke length of the pistons in metres (m)
- V is the coupler volume in cubic metres (m^3)

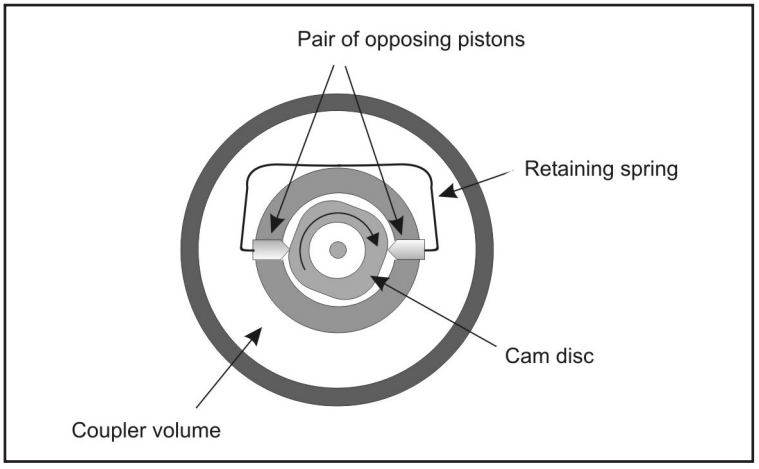

Fig. 2.1 Principle of the Pistonphone

A_p and S are determined by the physical dimensions of the pistons and the cam disc; the ambient pressure refers, in most cases, to the barometric pressure of the atmosphere.

2.2 Volume Corrections

The volume of the coupler is defined partly by the dimensions of the coupler itself and partly the effective load volume of the microphone. The effective load volume of the microphone is sum of the equivalent volume and the front cavity volume. The front cavity volume of the microphone is the volume between the microphone's diaphragm and the protection grid plus the volume contained in the slits of the protection grid.

The equivalent volume of the microphone is the apparent volume of the microphone behind the diaphragm. Since the diaphragm is not perfectly stiff, it will be deflected slightly by a sound pressure. This slight deflection of the diaphragm can be considered as equivalent to a small volume and, as such, should be added to the sum of the grid and coupler volumes. Since the grid and equivalent volumes can vary slightly from one type of microphone to another, the total volume of the coupler will, accordingly, also vary slightly.

A change in the total volume of the coupler will cause a change in the sound pressure level generated within the coupler. A change in the sound pressure level ΔP, in decibels, for a change in coupler volume ΔV is given by:

$$\Delta P = 20 \cdot Log \cdot \left(\frac{V}{V + \Delta V} \right) \qquad (2)$$

Where:

V = 15540mm^3, including the effective load volume of 40AG

ΔV is the equivalent volume correction

The Pistonphone is calibrated using a G.R.A.S. ½-inch Microphone Type 40AG. Since all G.R.A.S. ½-inch microphones have the same grid volume, the only correction necessary when calibrating the various types is the correction for the various equivalent volumes*.

Table 2.1 shows the equivalent volumes of G.R.A.S. ½-inch microphones and the corresponding Pistonphone corrections.

G.R.A.S. Mic. Type	Equiv-volume correction (mm^3)	Correction (decibels)
40AC	–20	0.011
40AD	20	–0.011
40AE	25	–0.014
40AF	30	–0.017
40AN	25	–0.014
40AP	25	–0.014
40AQ	15	–0.008
40AR	25	–0.014
40AU	–137	0.077

Table 2.1 Corrections for G.R.A.S. ½-inch microphones re. the G.R.A.S. Microphone Type 40AG

The equivalent volume uncertainty is ±7mm^3. The correction uncertainty is ±0.004 dB.

No equivalent volume correction is needed for calibration of ¼-inch microphones (G.R.A.S. type 40BD, 40BE, 40BF, 40BP) using the adaptor RA0049, nor 1-inch microphone (G.R.A.S. type 40EN) using the adaptor RA0023.

When calibrating 1/8-inch microphones (G.R.A.S. type 40DD, 40DP) using the adaptor RA0069 the equivalent volume correction is +19mm^3 and requires a correction -0.011 dB.

* The G.R.A.S. Microphone Type 40AG is equivalent to the Brüel & Kjær Type 4134 and the volume correction for these are 0 dB. As a matter of interest, the volume correction for a G.R.A.S. Type 40AU and a Brüel & Kjær Type 4180 is 0.077 dB.

2.3 Static-pressure Corrections

The Pistonphone is factory adjusted to give a nominal sound pressure level of 114 dB re. 20 µPa. This nominal value is valid for the following ambient reference conditions:

- Temperature 23° C
- Static pressure 1013 hPa
- Relative humidity 50 %

For other static pressures, the nominal Pistonphone level will have to be corrected. The correction ΔP, in decibels, is given by the following equation:

$$\Delta P = 20 \cdot Log \cdot \left(\frac{P_a}{P_r} \right) \qquad (3)$$

Where:

P_a = measured static ambient pressure (hPa)

P_r = reference static pressure (1013 hPa)

The corrections for ambient static pressure are shown in Fig. 2.2 (see also Appendix A.1 for an extended pressure range). These values should be applied to the nominal Pistonphone level.

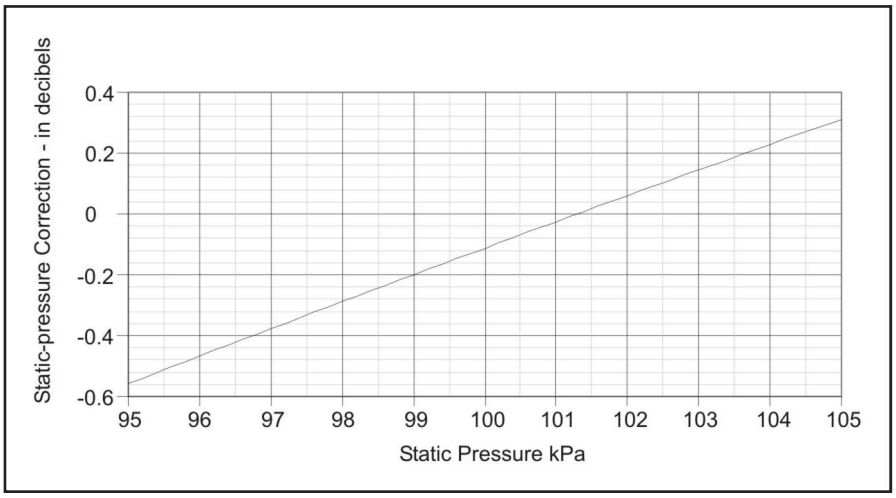

Fig. 2.2 Corrections for static ambient pressure

2.3.1 Barometer

The Pistonphone is delivered with a small barometer as a standard accessory for use when applying static-pressure corrections.

- Type 42AA is delivered with barometer ZC0002K
- Type 42AA-S1 is delivered with barometer RA0168

Analogue Barometer ZC0002K (Fig. 2.3)

This barometer has the static-pressure corrections printed directly on its scale.

Digital Barometer RA0168 (Fig. 2.4)

This has an LCD which can display (via a toggle button) either the static-pressure correction (e.g. –0.13 dB) or the ambient static pressure (e.g. 997 hPa). It runs on standard 9 V battery which can be accessed by removing the back plate which is held in place by four screws.

Fig. 2.3 Barometer ZC0002K

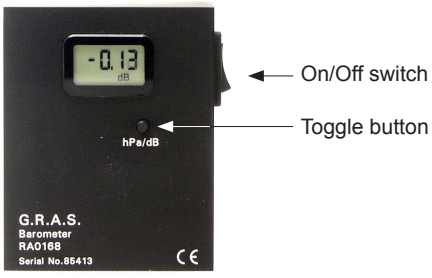

Fig. 2.4 Barometer RA0168

3. Handling and Operation

3.1 Shipment and Transport

Before any major shipment where rough handling is to be expected, remove the batteries to protect connectors and other internal parts from accidental damage.

Before shipment, remove the batteries and wrap separately.
Assure cautious handling during transport.

3.2 Batteries

The Pistonphone runs on four 1.5 V batteries (type AA [LR6]). To install or replace the batteries, remove the lid of the battery compartment which is held in place by the screw shown in Fig. 3.1. Slide the lid in the direction shown after removing the screw. Insert four new batteries observing the correct polarity as indicated on the figure inside the battery compartment.The Pistonphone can operate continuously for about 20 hours on a new set of batteries.

Remove the battery as soon as it is discharged or if the 42AA is stored for a prolonged period of time. Leakage from the batteries may otherwise destroy the electronic components.

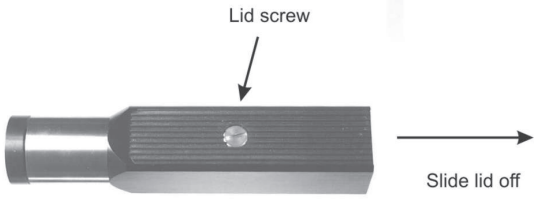

Fig. 3.1 Access to batteries

3.3 Calibrating Microphones

3.3.1 Microphone Size

The Pistonphone is normally delivered ready to calibrate ½-inch microphones. For ¼-inch and ⅛-inch microphones, special adapters are included and for 1-inch microphones, a 1-inch coupler (available from G.R.A.S.) has to be fitted. Each case is described in the following sections.

3.3.2 ½-inch Microphones

To calibrate a ½-inch measurement microphone, first loosen the microphone retention collar as shown in Fig. 3.2. Then insert the microphone into the ½-inch coupler[1] as shown in Fig. 3.3. Make sure that the microphone is all the way in, then tighten the microphone retention ring so that the microphone is held firmly in place.

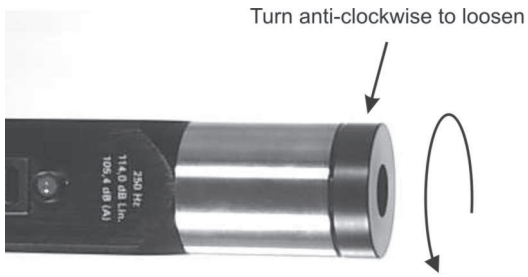

Fig. 3.2 Loosening the microphone retention collar

[1] The ½-inch coupler is individual calibrated with the pistonphone, and these must be considered as a pair

Fig. 3.3 ½-inch microphone inserted in the coupler

Switch the Pistonphone on via the on/off (**I/0**) button. The LED above the on/off button is a dual-colour LED for showing red or green. The LED shows green if the Pistonphone is operating properly at the specified frequency. If the LED shows red or flashing red, the Pistonphone is not operating at the specified frequency and the batteries should be changed (see section 3.2).

Wait approximately for 15 seconds for the static pressure in both the Pistonphone and the microphone to stabilise, and for the microphone itself to stabilise within the coupler.

The static pressure within the coupler volume is equalised via an air-equalisation tube located under the cap which protects the pistons and retention spring shown in Fig. 2.1.

With the Pistonphone switched on, the microphone is subjected to a sound pressure level L_C given as the sum of the Pistonphone's nominal sound pressure level L_N (found on the pistonphone's calibration chart as "Sound Pressure Level"), the static pressure correction L_B and the volume correction L_V, i.e.:

$$L_C = L_N + L_B + L_V \qquad (4)$$

3.3.3 ¼-inch Microphones

To calibrate a ¼-inch measurement microphone, first loosen the microphone retention collar as shown in Fig. 3.2. Then insert the ¼-inch microphone adapter (RA0049) into the ½-inch coupler as shown on Fig. 3.4. Make sure that the adapter is all the way in, then tighten the microphone retention collar so that the adapter is held firmly in place. Insert the ¼-inch microphone into the ¼-inch adapter.

Switch the Pistonphone on via the on/off (**I/0**) button. The LED above the on/off button is a dual-colour LED for showing red or green. The LED shows green if the Pistonphone is operating properly at the specified frequency. If the LED shows red or flashing red, the Pistonphone is not operating at the specified frequency and the batteries should be changed (see section 3.2).

Fig. 3.4 ¼-inch microphone adapter inserted in the coupler

Wait approximately for 15 seconds for the static pressure in both the Pistonphone and the microphone to stabilise, and for the microphone itself to stabilise within the coupler.

The static pressure within the coupler volume is equalised via an air-equalisation tube located under the cap which protects the pistons and retention spring shown in Fig. 2.1.

With the Pistonphone switched on, the microphone is subjected to a sound pressure level L_C given as the sum of the Pistonphone's nominal sound pressure level L_N (found on the pistonphone's calibration chart as "Sound Pressure Level"), the static pressure correction L_B and the volume correction L_V, i.e.:

$$L_C = L_N + L_B + L_V \qquad (5)$$

3.3.4 ⅛-inch Microphones

To calibrate a ⅛-inch measurement microphone, first loosen the microphone retention collar as shown in Fig. 3.2. Then insert the ⅛-inch microphone adapter (RA0069) into the ½-inch coupler as shown on Fig. 3.4. Make sure that the adapter is all the way in, then tighten the microphone retention collar so that the adapter is held firmly in place. Insert the ⅛-inch microphone into the ⅛-inch adapter.

Switch the Pistonphone on via the on/off (**I/0**) button. The LED above the on/off button is a dual-colour LED for showing red or green. The LED shows green if the Pistonphone is operating properly at the specified frequency. If the LED shows red or flashing red, the Pistonphone is not operating at the specified frequency and the batteries should be changed (see section 3.2).

Wait approximately for 15 seconds for the static pressure in both the Pistonphone and the microphone to stabilise, and for the microphone itself to stabilise within the coupler.

The static pressure within the coupler volume is equalised via an air-equalisation tube located under the cap which protects the pistons and retention spring shown in Fig. 2.1.

With the Pistonphone switched on, the microphone is subjected to a sound pressure level L_C given as the sum of the Pistonphone's nominal sound pressure level L_N (found on the pistonphone's calibration chart as "Sound Pressure Level"), the static pressure correction L_B and the volume correction L_V, i.e.:

$$L_C = L_N + L_B + L_V \qquad (6)$$

Fig. 3.5 ⅛-inch microphone adapter inserted in the coupler

3.3.5 1-inch Microphones

To calibrate a 1-inch measurement microphone, the standard ½-inch coupler has to be replaced by the optional 1-inch coupler[1] (RA0023), see Fig. 3.6. Unscrew the ½-inch coupler from the Pistonphone body. The pistons and retention spring shown in Fig. 2.1 are protected so there is no risk of accidentally damaging these parts when removing the coupler. Screw the 1-inch coupler (RA0023) onto the Pistonphone body. Then insert the 1-inch microphone into the 1-inch coupler. Make sure that the microphone is all the way in.

Switch the Pistonphone on via the on/off (**I/0**) button. The LED above the on/off button is a dual-colour LED for showing red or green. The LED shows green if the Pistonphone is operating properly at the specified frequency. If the LED shows red or flashing red, the Pistonphone is not operating at the specified frequency and the batteries should be changed (see section 3.2).

Wait approximately for 15 seconds for the static pressure in both the Pistonphone and the microphone to stabilise, and for the microphone itself to stabilise within the coupler.

The static pressure within the coupler volume is equalised via an air-equalisation tube located under the cap which protects the pistons and retention spring shown in Fig. 2.1.

With the Pistonphone switched on, the microphone is subjected to a sound pressure level L_C given as the sum of the Pistonphone's nominal sound pressure level L_N (found on the pistonphone's calibration chart as "Sound Pressure Level"), the static pressure correction L_B and the volume correction L_V, i.e.:

$$L_C = L_N + L_B + L_V \qquad (7)$$

Fig. 3.6 1-inch and ½-inch couplers

[1] The 1-inch coupler is individual calibrated with the pistonphone, and these must be considered as a pair.

3.4 Calculation of Microphone Sensitivity

The sensitivity of a microphone under test can be calculated via a measurement of the microphone's output voltage. If the measured output voltage is V_o, and the sound pressure level in the Pistonphone's coupler is L_C (decibels), the microphone sensitivity S is given by:

$$S = \frac{V_o}{20\,\mu Pa \cdot 10^{L_C/20}} \qquad (8)$$

The value $20\,\mu Pa$ is the standard reference sound pressure. The result here includes the loading effect of the preamplifier's input impedance as well as the gain or attenuation within the preamplifier. To measure the "Open Circuit Sensitivity" of the microphone (i.e. when the microphone's output is not affected by the load of a preamplifier), a special preamplifier, for example the G.R.A.S. Type 26AG (which has insert voltage calibration capability), should be used.

4. Specifications

Sound pressure level:

Nominal: 114 dB re. 20 µPa

Individually calibrated and valid for the following ambient reference conditions:-

Pressure: 1013 hPa

Temperature: 23 °C

Humidity: 50 % RH

Calibration accuracy:

Absolute:	1/2” mic.:	±0.09 dB at reference condition
	1” mic.:	±0.2 dB at reference condition
When corrected for ambient pressure:	1/2” mic.:	±0.1 dB
	1” mic.:	±0.2 dB

Frequency:

250 Hz ±0.5 %

Distortion:

<1.5 %

Nominal effective coupler volume:

15540 mm^3 (including effective load volume of microphone type 40AG or type 40EN)

Temperature range:

– 10 °C to +55 °C (batteries permitting)

Batteries:

Four standard LR6-AA alkaline cells

Dimensions:

Length:	175 mm (6.89 in)
Width:	35 mm (1.38 in)
Height:	35 mm (1.38 in)
Weight:	325 g (0.7 lbs)

[1] Applies only to Pistonphones fitted with a 1-inch microphone coupler RA0023

Accessories included:

Adapter for ¼-inch microphones:	RA0049
Adapter for ⅛-inch microphones:	RA0069
Barometer:	ZC0002K (type 12AA)
Barometer:	RA0168 (type 12AA-S1)
Coupler for ½-inch microphones:	RA0048
Four LR6-AA alkaline cells:	EL0001

Accessories available:

Adapter for Outdoor Microphone System [1]:-	
Type 41AM:	RA0009
Type 41CN:	RA0041
Adapter for Environmental Microphone [1]:-	
Type 41AL:	RA0010
Coupler for 1-inch microphones:	RA0023
Two-port calibration coupler:	RA0024 (see Fig. 4.1)
Octopus coupler (½-inch mics.):	RA0072

Fig. 4.1 Two-port Coupler RA0024 shown here with the two phase-matched microphones of an intensity probe

[1] Applies only to Pistonphones fitted with a 1-inch microphone coupler RA0023

A Appendix

A.1 Corrections for Static Ambient Pressure

Fig. A.1 shows the correction curve for ambient static-pressures over an extended range.

A.2 Corrections for Humidity

For highly-precise calibrations in accordance with IEC Standard 942 Class 0, it will be necessary to correct for the influence of air humidity. The influence of air humidity depends on both air temperature and barometric pressure.

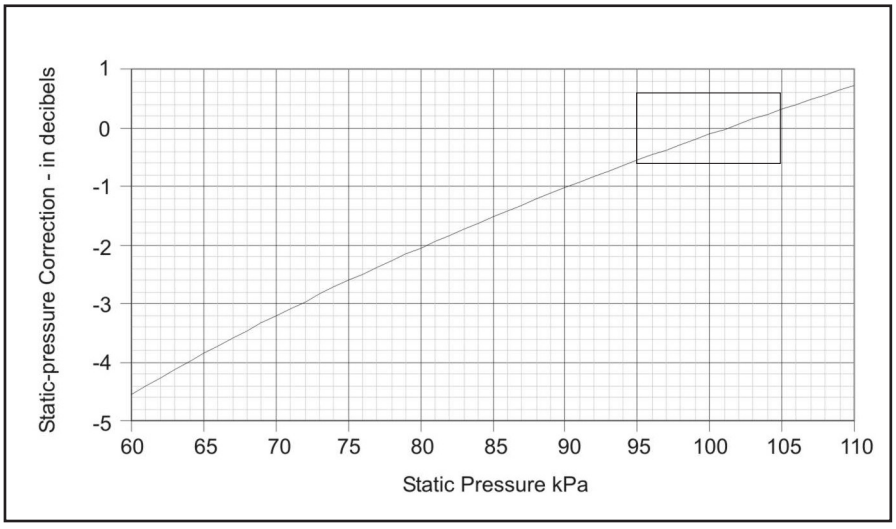

Fig. A.1 Corrections for static ambient pressure; the small rectangle outlines the range covered by Fig. 2.2

A.2 Corrections for Humidity

For highly-precise calibrations in accordance with IEC Standard 942 Class 0, it will be necessary to correct for the influence of air humidity. The influence of air humidity depends on both air temperature and barometric pressure.

$$\Delta L_H = \frac{P_r}{P_a} \cdot C - 0.0064\,dB \qquad (9)$$

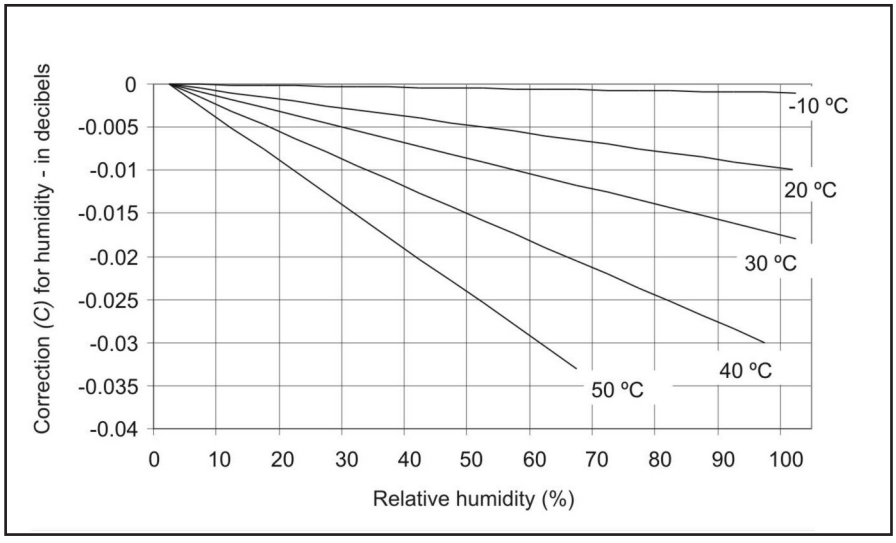

Fig. A.2 Corrections for humidity at different temperatures

Manufactured to conform with:

CE marking directive:
93/68/EEC

WEEE directive:
2002/96/EC

RoHS directive:
2002/95/EC