GRAS
An Axiometrix Solutions Brand

Instruction Manual

GRAS 42AC/42AC-S2 Pistonphone

Revision History

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

Revision	Date	Description
1	June 2012	Version June 2012
2	4 July 2013	Section 3.1 “Shipment and transport” added
3	17 February 2023	Remove hydrophone support

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 42AC 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 42AC / 42AC-S2.

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1. General Description

The GRAS Pistonphone Type 42AC (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 42AC includes ½″ microphone coupler.
- Type 42AC-S2 includes 1″ microphone coupler.

Otherwise, there is no difference between the two types.

1.1 Operating Frequency

The Pistonphone type 42AC and type 42AC-S2 operate 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:

- 134 dB [1] re. 20 µPa
- 125.4 dBA re. 20µPa (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.

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.

Fig. 1.1 Pistonphone Type 42AC

The Pistonphone complies with all the requirements of IEC Standard 942 (1988) Sound Calibrators Class 1 when corrected with barometer ZC0003K.

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.

[1] 134 dB is equivalent to 100 Pa

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 Type 42AC is delivered with a ½″ coupler[1] (RA0048) for calibrating 1/2″ microphones directly. The Type 42AC-S2 is delivered with a 1″ coupler[1] (RA0023) for calibrating 1″ microphones directly. Adaptors for calibrating ¼″ and ½″ microphones are included.

[1] The coupler is individually calibrated with the pistonphone, and these must be considered as a pair

2. Theory

2.1 Principle

The Pistonphone works on the principle of two pairs 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:

$$P = \gamma \cdot P_0 \cdot \frac{4A_p \cdot S}{V \cdot \sqrt{2}} \qquad (1)$$

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)

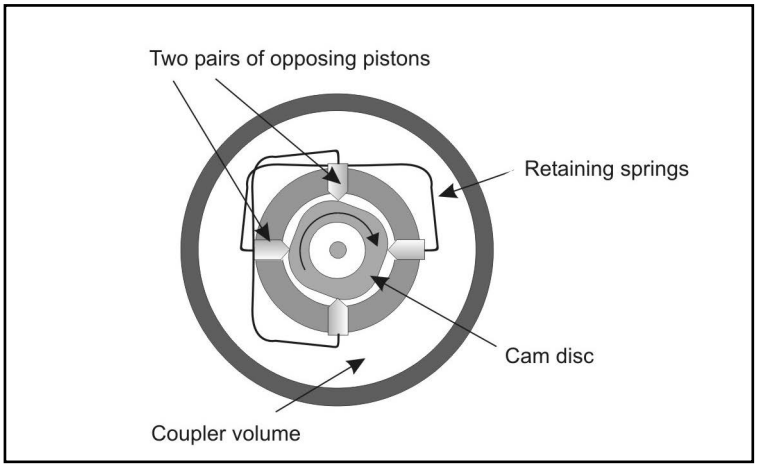

Fig. 2.1 Principle of the Pistonphone

Ap 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 = 12530mm^3, including the effective load volume of 40AG

ΔV is the equivalent volume correction

The Pistonphone is calibrated using a GRAS ½″ Microphone Type 40AG. Since all GRAS ½″ 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 GRAS ½″ microphones and the corresponding Pistonphone corrections.

GRAS Mic. Type	Equiv-volume correction (mm^3)	Correction (decibels)
40AC	−20	0.014
40AD	20	−0.014
40AE	25	−0.017
40AF	30	−0.021
40AN	25	−0.017
40AP	25	−0.017
40AQ	15	−0.010
40AR	25	−0.017
40AU	−137	0.095

Table 2.1 Corrections for GRAS ½″ microphones re. the GRAS Microphone Type 40AG

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

No equivalent volume correction is needed for calibration of ¼″ microphones (GRAS type 40BD, 40BE, 40BF, 40BP) using the adaptor RA0049, nor 1″ microphone (GRAS type 40EN) using the adaptor RA0023.

When calibrating 1/8″ microphones (GRAS type 40DD, 40DP) using the adaptor RA0069 the equivalent volume correction is +19mm^3 and requires a correction +0.013 dB

2.3 Static-pressure Corrections

The Pistonphone is factory adjusted to give a nominal sound pressure level of 134 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:

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

* The GRAS 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 GRAS Type 40AU and a Brüel & Kjær Type 4180 is 0.095 dB.

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.

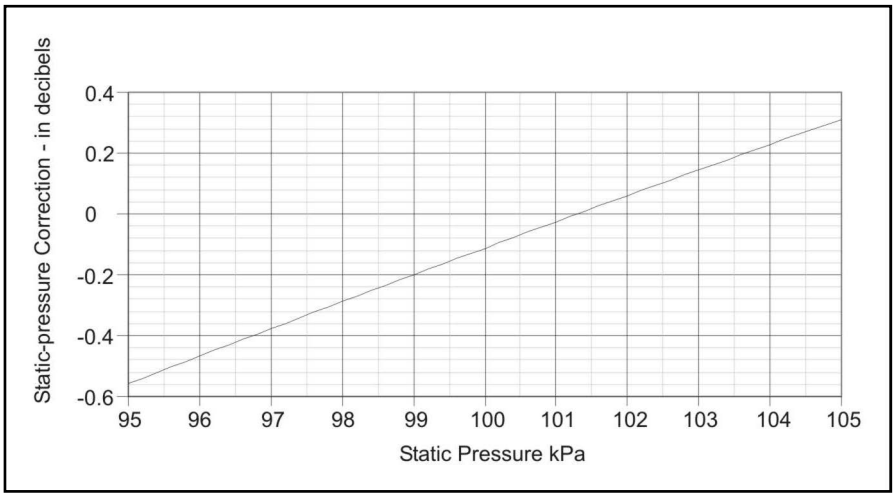

Fig. 2.2 Corrections for static ambient pressure

2.3.1 Barometer

The Pistonphone is delivered with a small barometer (ZC0003K) as a standard accessory for use when applying static-pressure corrections

Analogue Barometer ZC0003K (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 ZC0003K

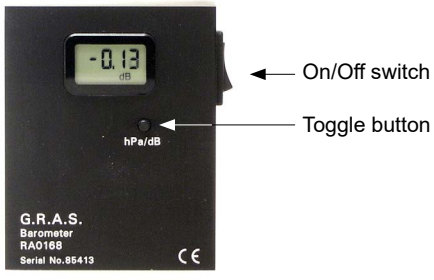

Fig. 2.4 Barometer RA0168

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 first 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 42AC is stored for a prolonged period of time. Leakage from the batteries may otherwise destroy the electronic components.

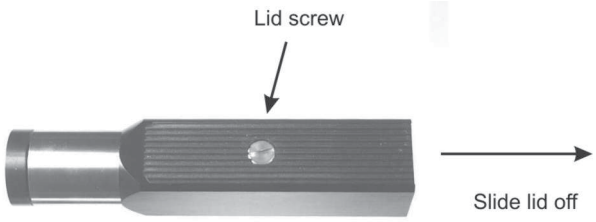

Fig. 3.1 Access to batteries

3.3 Calibrating Microphones

3.3.1 Microphone Size

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

3.3.2 ½″ Microphones

To calibrate a ½″ measurement microphone, first loosen the microphone retention collar as shown in Fig. 3.2. Then insert the microphone into the ½″ 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.

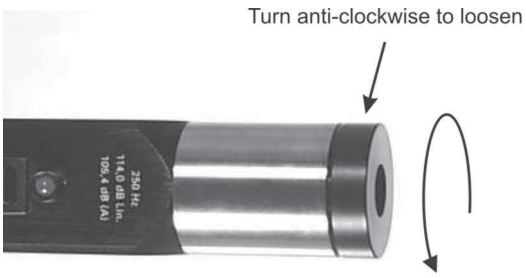

Fig. 3.2 Loosening the microphone retention collar

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

Fig. 3.3 ½″ 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, the static pressure correction LB and the volume correction LV, i.e.:

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

3.3.3 ¼″ Microphones

To calibrate a ¼″ measurement microphone, first loosen the microphone retention collar as shown in Fig. 3.2. Then insert the ¼″ microphone adapter (RA0049) into the ½″ 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″ microphone into the ¼″ 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″ 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, 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″ Microphones

To calibrate a ⅛″ measurement microphone, first loosen the microphone retention collar as shown in Fig. 3.2. Then insert the ⅛″ microphone adapter (RA0069) into the ½″ coupler as shown on Fig. 3.5. 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″ microphone into the ⅛″ 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, 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″ microphone adapter inserted in the coupler

3.3.5 1″ Microphones

To calibrate a 1″ measurement microphone, the standard ½″ coupler has to be replaced by the optional 1″ coupler[1] (RA0023), see Fig. 3.6. Unscrew the ½″ 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″ coupler (RA0023) onto the Pistonphone body. Then insert the 1″ microphone into the 1″ 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, 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″ and ½″ couplers

[1] The 1″ 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 LC (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 µP*a 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 GRAS Type 26AG (which has insert voltage calibration capability), should be used.

4. Specifications

Sound pressure level:

Nominal:	134 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.:	±0.14 dB at reference condition
	1″ mic.:	±0.2 dB at reference condition
When corrected for ambient pressure:	1/2″ mic.:	±0.14 dB
	1″ mic.:	±0.2 dB

Frequency:

250 Hz ±0.5 %

Distortion:

Max 2 %

Nominal effective coupler volume:

12530 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)

Accessories included:

Adapter for ¼″ microphones:	RA0049
Adapter for ⅛″ microphones:	RA0069
Barometer:	ZC0003K
Coupler for ½″ microphones [1]:	RA0048
Coupler for 1″ microphones [2]:	RA0023
Four LR6-AA alkaline cells:	EL0001

[1] Applies only for 42AC
[2] Applies only for 42AC-S2

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″ microphones:	RA0023
Coupler for ½″ microphones:	RA0048
Digital precision barometer:	RA0168
Two-port high-pressure calibration coupler:	RA0042 (see Fig. 4.1)
Octopus coupler (½″ mics.):	RA0072

Fig. 4.1 Two-port Coupler RA0042 shown here with the two phase-matched microphones of an intensity probe

[1] Applies only to Pistonphones fitted with a 1″ 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.

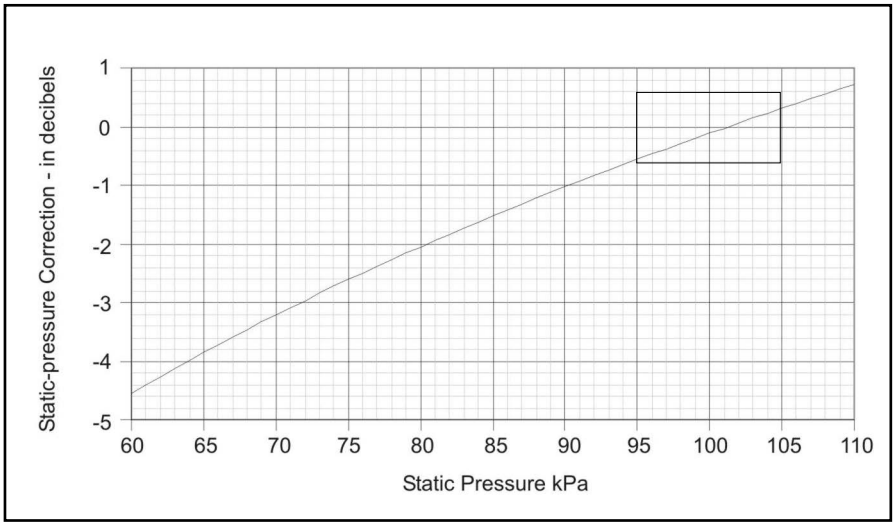

Fig. A.1 Corrections for static ambient pressure; the small rectangle outlines the range covered by Fig. 2.2

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.

The curves in Fig. A.2 show corrections (*C)* which account for the effects of both temperature and humidity when the ambient pressure equals the reference pressure P_r (101.3 kPa).

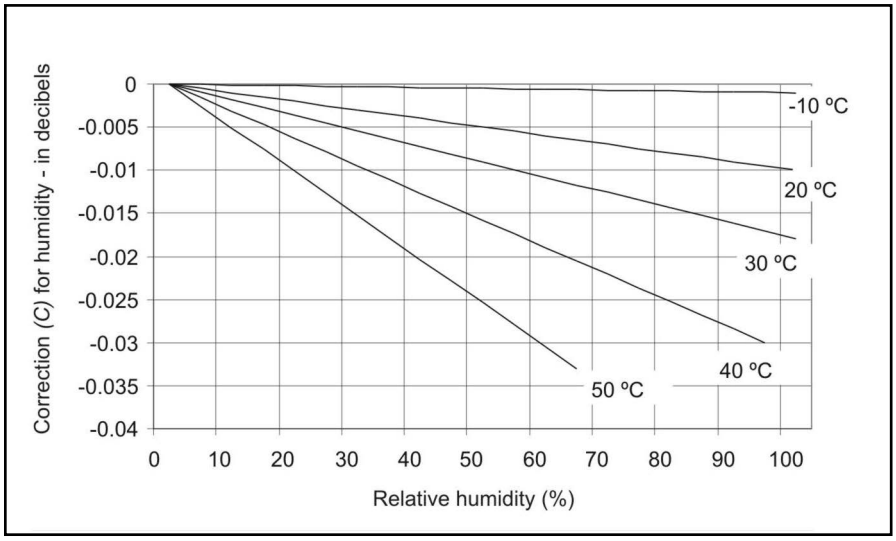

Fig. A.2 Corrections for temperature humidity

The value *(C)* together with the actual value of the barometric pressure P_A are used as follows to calculate the actual correction humidity:

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

The correction ΔL_H has to be added to the other correction factors in equations 4, 5, 6 and 7.

Manufactured to conform with:

CE marking directive: 93/68/EEC

WEEE directive: 2002/96/EC

RoHS directive: 2002/95/EC

GRAS Sound & Vibration continually strives to improve the quality of our products for our customers; therefore, the specifications and accessories are subject to change.