

Vaisala CARBOCAP® Carbon Dioxide Transmitter GMT221:

GMT221 in Cold Storage Applications

Carbon dioxide is a safe and non-flammable refrigerant, which has been used since the early days of refrigeration. Despite the high pressures needed when using CO₂ as a refrigerant, it has recently become more popular in this application. Carbon dioxide is one of the environmentally friendly refrigerants and has replaced the restricted CFC, HCFC and HFC refrigerants, which have been found to be harmful to the ozone layer and contributing to climate change as greenhouse gases. Carbon dioxide is often used beside ammonia in the secondary refrigerant cycle or, in some cold making applications, even preferred in the primary cycle. The brand name for CO₂ in cold making is R744.

CO₂ in cold making

Because CO₂ is an odorless and colorless gas, the leak of a refrigerating agent cannot be detected without an appropriate sensor. Although CO₂ is a non-toxic substance, in poorly ventilated spaces the CO₂ concentration can reach dangerous levels. Being heavier than air, CO₂ replaces oxygen at the floor level. A Finnish guideline for maximum allowed concentration of CO₂ is 5000 ppmCO₂ (0.5% CO₂). Short term exposure to high CO₂ levels can cause hyperventilation. Longer term or repeated exposure leads to agitated breathing, headache, and minor metabolic disorders. Levels of 30 000...50 000 ppmCO₂ (3...5% CO₂)

leads to headaches and respiratory problems, whereas mortal danger occurs at levels higher than 50 000 ppmCO₂ (5% CO₂).

At all places where CO₂ gas or CO₂ ice is used, produced, shipped or stored, the levels of CO₂ can rise dangerously high and the environment must be monitored with an appropriate sensor.

The GMT221 in harsh environments

The Vaisala CARBOCAP® Carbon Dioxide Transmitter GMT221 is designed for harsh and humid environments. The housing of the transmitter is watertight (IP65/NEMA4) and the materials have been chosen for harsh environments, keeping in mind especially the corrosion resistance of the transmitter probe and body. Extensive qualification testing has been done to the transmitter.

Extended operating temperature range of the GMT221

Cold duration tests

The operating temperature range for the GMT221 is specified from -20°C to +60°C. However, the transmitter has been tested at temperatures down to -40°C. The long-term stability of the transmitter has been tested:

- at a constant temperature of -40°C
- at a rapidly changing temperature ranging from -40°C to +70°C

In addition, the temperature dependency of the transmitter reading has been modelled down to -30°C. These tests allow the use of the transmitter at temperatures below -20°C, even as low as down to -40°C. However, the housing material (ABS plastic) might become stiffer at cold conditions.

Temperature dependency between –30°C and –20°C

The GMT221 has been calibrated at factory to the environmental conditions of 25°C and 1013 hPa. Since all gases are compressible, the reading of the GMT221 needs to be compensated at conditions deviating largely from these conditions. The required compensation follows roughly the ideal gas law ($pV=nRT$), although the temperature dependency of the GMT221 consists also of temperature dependencies of the electronic and optical components of the transmitter. For achieving the most accurate CO₂ measurement, the internal compensation function of the GMT221 should be used (*please see the GMT220 Series Carbon Dioxide Transmitter User's Guide for details of the internal temperature and pressure compensations*).

The internal temperature compensation function of the GMT221 is valid down to temperatures of –20°C only. Since in many cold storage applications the transmitters are used in temperatures below –20°C, the need for supplement correction of the reading must be considered.

To give an idea of the temperature dependency of the GMT221 at 0.5%CO₂ see *Table 1*. Approximate errors without internal compensation (as a factory default MF_TEMP 25) and with internal compensation applied (MF_TEMP X, where X is the prevailing ambient temperature) are given.

Ambient temperature	Error with factory default MF_TEMP 25	Error with user set value MF_TEMP X
25°C	negligible	negligible
-20°C	+10% of reading	very small
-30°C	+17% of reading	+9% of reading

Table 1. Temperature dependency induced typical error in reading with and without internal compensations (at 0.5%CO₂)

Correcting the reading at temperatures below –20°C

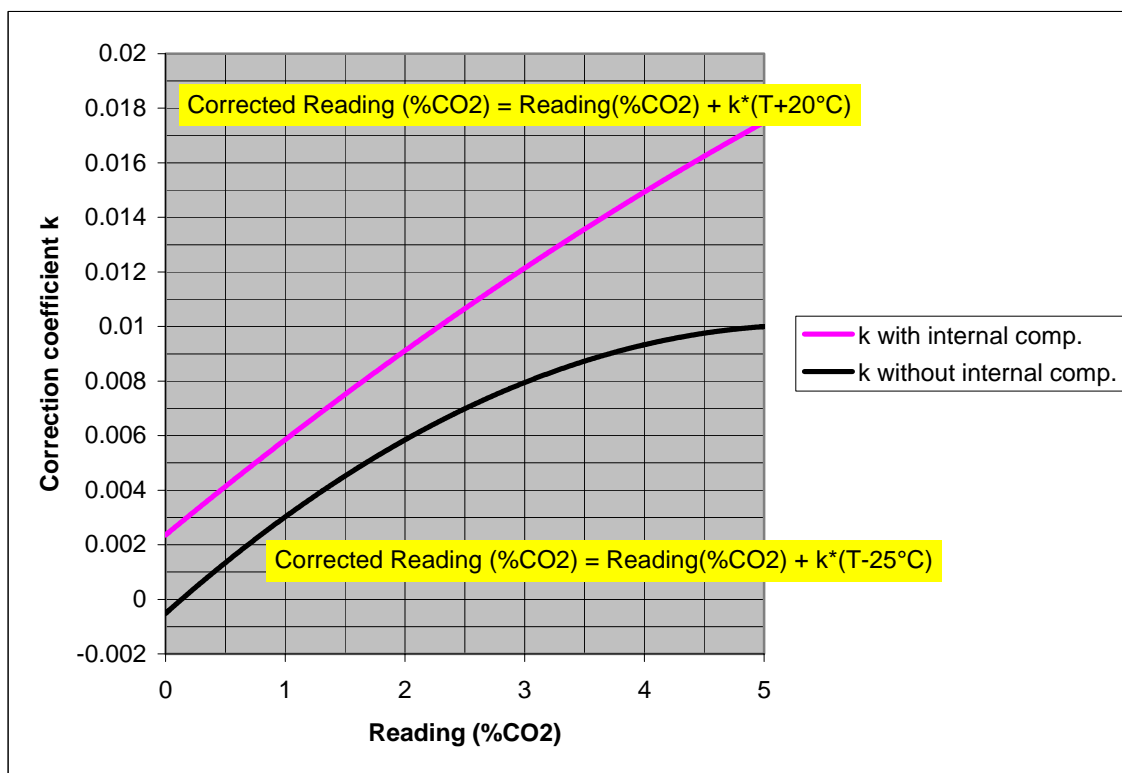
To correct the GMT221 reading at temperatures below –20°C, a supplementary compensation can be applied. *Graph 1* below illustrates the temperature correction formulas of the GMT221 at temperatures below –20°C as internal compensation is applied (MF_TEMP is set to the prevailing ambient temperature) and as internal compensation is not applied (MF_TEMP is set to 25°C). The correction coefficient should be approximated from the curves of *Graph 1*, according to the measured reading of the GMT221 transmitter. Compensation can be then calculated from the appropriate formula, which is

$$\text{Corrected Reading (\%CO}_2\text{)} = \text{Reading (\%CO}_2\text{)} + k \cdot (T + 20^\circ\text{C})$$

when the internal compensation is applied. And

$$\text{Corrected Reading (\%CO}_2\text{)} = \text{Reading (\%CO}_2\text{)} + k \cdot (T - 25^\circ\text{C})$$

when the internal compensation is not applied. In the formulas above, the reading is the CO₂ concentration given by the transmitter (note: 10 000ppmCO₂ = 1%CO₂), k is the correction coefficient given by *Graph 1*, and T is the prevailing ambient temperature.



Graph 1. The temperature correction formulas for the GMT221 at temperatures $T(^{\circ}\text{C})$ below -20°C .

Installing the GMT221

The measurement of CO₂ in a cold storage is typically conducted for the safety of the personnel working in the area. In this type of a safety application, the CO₂ transmitter should be installed as close as possible to potential leakage points for early detection. Transmitters should be placed in all human occupied spaces such as the compressor room, the valve center, and each cold space. Also the geometry of the area to be monitored should be considered, taking into account the air flow and ventilation in the space. Carbon dioxide is heavier than air, which means that the transmitters should in most cases be installed near the floor. The number of transmitters taken into use should be based on a thorough risk assessment of the monitored area.

An alarming system should be built as secure as possible. Alarms should be given in addition for rising CO₂ levels,

also in case of malfunctions such as loss of system power, loss of signal, or a communications error. In a complete safety system, also the routine calibration of CO₂ and other sensors should be well planned.

The GMT221 has a wide variety of options in measurement ranges. Also, there are several probe cable lengths for remote installation of the probe. The interchangeable probes allow for easy field maintenance of the transmitter, since the probes can be conveniently replaced with newly calibrated ones.

Note: If the installation of the transmitter is made at temperatures below -20°C , extra care should be taken when handling the transmitter enclosure. This is due to the stiffening of the transmitter housing material (ABS plastic).