질량 표준 실험실에서 이산화탄소 농도의 영향
Effect of CO_2 Concentration in a Mass Laboratory

*#이우갑, 이용재, 정진완
*#W. G. Lee(woogab@kriss.re.kr), Y. J. Lee, J. W. Chung
한국표준과학연구원 질량힘센터

Key words : Mass standards, Air density, Buoyancy artefact

1. Introduction

Precision mass measurements made in air require the correction of air buoyancy effects. If a mass m_2 is compared to a standard mass m_1 in air by weighing, the mass equilibrium equation is expressed by

$$m_2(1-\rho/d_2)-m_1(1-\rho/d_1)=\delta m(1-\rho/d_s)$$

where δm is the mass difference between and m_2 and m_2, and ρ the air density, d the density of respective weight including the sensitivity weight. In the air buoyancy corrections, national mass standard laboratories use the following equation of air density recommended by the Consultative Committee for Mass and related quantities (CCM).[1]

$$\rho=[3.48349+1.44(X_{CO2}-0.0004)]*10^{-3}/\frac{p}{ZT}(1-0.378X_V)$$

where, XCO2 is the molar fraction of carbon dioxide, Xv the molar fraction of water vapor, p the air pressure, T temperature, Z the compressibility factor. It is assumed that the molar mass of dry air is constant except for local variability of the mole fraction of carbon dioxide.

The laboratories at the KRISS of length, mass and electricity are subject to the air flow pathes of an air conditioner having the space of 730 cubic meters. In the mass laboratory the variations of CO2 concentration of air have been checked when carrying out high precision mass calibrations. The objects of this paper are to understand the practical difference of CO2 concentrations between the normal air and the spot air of the mass laboratory and to evaluate the uncertainty for the variations of CO2 concentrations of the mass laboratory with its effect on the measurements.

2. Experimental Conditions

The total space of air flow is estimated as730m^3 which include 699 m^3 for the laboratory rooms and 31 m^3 for duct parts of air flow paths. For convenience, the space is assumed as an air container. The rooms are air-conditioned by supply air flow rate of 29,000 m^3/h. Parts of the input flow are mixed with atmospheric air from outside. The maximum inlet flow rate is about 1,300 m^3/h in spring and autumn and 520m m^3/h in winter and summer. The mass laboratory has been maintained at the condition of 20 ± 0.5 ℃ and 40 ± 5 %RH.

The CO2 concentration of the mass laboratory was measured with a CO2 analyzer (Horiba PIC-2000) having a range of 0 to 500 ppm, readability of 0.5 % full scale. Its span drift is 1 % for 24 hours of full scale within a temperature drift of 5 ℃, having also response time of 1.2 seconds and sample gas flow rate of 0.5 L/min.

The CO2 analyzer was calibrated using reference gases of pure nitrogen and 505 ppm CO2. The measurement uncertainty is estimated to be 5 ppm considering the repeatability and span drift., sof

3. Results and Discussions

The CO2 concentration of the laboratory

received the effects of breath and the change of atmospheric CO2 concentration. The CO2 concentration in working days as shown in Fig. 1 shows that the concentration increases rapidly in the morning (8:00 – 12:00), decreases in the lunch time (12:00-13:00), increases and reaches a maximum value in the afternoon, and decreases after the office hour in December. It also shows that it takes about 12 hours for the CO2 concentration to reach an equilibrium state with that of the ambient air.

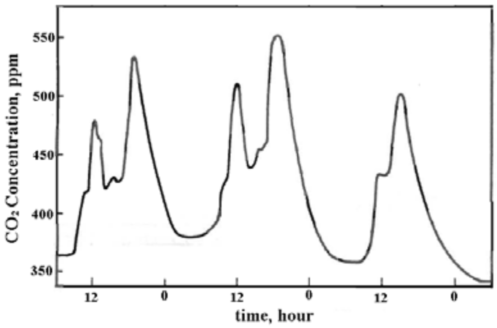
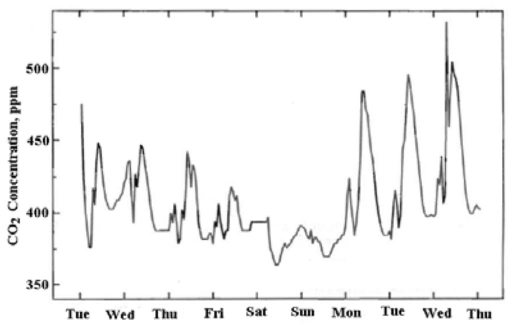


Fig. 1 Daliy trend of CO2 concentration in the mass laboratory of KRISS.

The average high and low concentration depends on the month due to the air-conditioning status which controls the mixing quantities of ambient air from outside.

The week day trend is shown in Fig. 2

Fig. 2 Weekday trend of CO2 concentration



In calibration of a stainless steel kilogram standard of 125 cm3 volume using a national prototype kilogram of 46 cm3 volume, their volume difference is about 80 cm3 which yields an air buoyancy correction.

The density of air is calculated by the Equation 1. Cases of CO2 measurement uncertainties are considered. The first case is that air tight chamber is used for weighing, where the uncertainty is 5 ppm. The second case is where daily drift of 50 ppm is not considered. And the last case of 100 ppm is the case when the international average value is used without measurement. The first and second cases result in the uncertainty of mass measurement of 2 microgram, while the last case results in 4 microgram. The uncertainty of 4 microgram is significant for precision measurement between a prototype kilogram and a stainless steel kilogram.

4. Conclusions

The CO2 concentration of the mass laboratory of KRISS was monitored by a CO2 analyzer.

The CO2 concentration was found to be not constant during a day and showed also seasonal change.

Without the measurement of CO2, the mass measurement between a prototype kilogram and a stainless steel kilogram resulted in an uncertainty of 4 microgram at most.

REFERENCES

1. Giacomo, P., “Equation for the determination of the density of moist air”, Metrologia, Vol. 18, 33, 1974.
2. Picard, A., Davis, R., Glaser, M. and Fujii, K., “Revised formula for the density of moist air,” Metrologia, Vol. 45, No. 2, pp. 149-155, 2008.