1 AEROSOL PARTICLE MEASUREMENTS

RAF uses a modified TSI, Inc. Model 3760 condensation nucleus counter to measure the concentration of particulates in the atmosphere larger than about 0.01 μm diameter. Individual inlets have been designed for each research aircraft that provide approximately isokinetic flow at research airspeeds. The CN counter is often used as a stand-alone instrument, but it also can be placed downstream of various instruments, such as a counterflow virtual impactor or differential mobility analyzer. It is useful at altitudes up to about 11km. It operates by condensing n-butyl alcohol on the particles as they pass through a cooling/condenser tube where supersaturation of a few hundred percent is produced. The particles grow large enough to be seen by a laser-diode optical detector, and the pulses from tat detector are counted to obtain an estimate of the total concentration of aerosol particles. The counter does not resolve particle concentration by size; the lower size limit of the TSI 3760 is about XXX μm, and all particles above that size enter the measurement of the total concentration.

If large concentrations are encountered, two or more particles may be present in the viewing volume at once and will produce only a single pulse from the photodetector. This "coincidence" error, which increases from about 0.6% at a total concentration of $10^3/cm^3$to about 6% at $10^4\mathrm{cm}^{-3}$; a correction for these effects of coincidence is applied, but for concentrations above about $2 \times 10^4\,\mathrm{cm}^{-3}$ effects of coincidence become large enough that the correction introduces significant uncertainty in the measurements.

The variables associated with these measurements of condensation-nucleus concentrations are discussed in the remainder of this section.

CN Counter Inlet Pressure (mbar): PCN

PCN is the absolute pressure inside the inlet tube of the instrument, as measured by a Heise Model 623 pressure sensor. The measurement is used to correct the sample flow rates (FCN and XICN) that are used to obtain measurements of concentration.

CN Counter Inlet Temperature ($°C$): TEMP1, TEMP2, CNTEMP

TEMP1, TEMP2 or CNTEMP is the output from a temperature sensor mounted on the outside of the sampling tube immediately ahead of the counter. The measurement, an approximation to the temperature of the air passing through the tube, is used to correct the sample flow rates (FCN and XICN).

Raw CN Counter Sample Flow Rate (slpm): FCN

Corrected CN Counter Sample Flow Rate (vlpm): FCNC

FCN is the raw sample flow rate in standard liters per minute (slpm) measured with a Sierra 830 Mass Flow meter. The flow meter measures the flow rate that would apply under "standard" conditions; i.e., pressure of 1013.25 and temperature of $0°C$. FCNC is the sample flow rate in vlpm (volumetric liters per minute) corrected for pressure and temperature.

PCN = pressure at the inlet to the CN counter (mb)
TEMP1 = temperature at the inlet of the sample tube ($°C$)
P_{ref} = standard reference pressure, 1013.25 mb
T_{ref} = standard reference temperature, 293.26 K

$$\text{FCNC} = \{\text{FCN}\}\frac{P_{ref}}{\{\text{PCN}\}}\frac{(\{\text{TEMP1}\} + T_0)}{T_{ref}}$$

Raw CN Isokinetic Side Flow Rate (slpm): XICN
Corrected CN Isokinetic Side Flow Rate (vlpm): XICNC
XICN is the raw isokinetic side flow rate in standard liters per minute (slpm) measured with a Sierra 830 Mass Flow meter, and XICNC is that flow corrected for pressure and temperature to be the true volumetric flow. For isokinetic sampling, the flow rate at the inlet entrance needs to equal the true airspeed, and for proper operation the flow rate through the CN counter should be at least 1.2 vlpm. A side flow of filtered air is added so both of these conditions can be met.

PCN = pressure at the inlet to the CN counter (mb)
TEMP1 = temperature at the inlet of the sample tube ($°C$)
P_r = standard reference pressure, 1013.25 mb
T_r = 293.26 K

$$\text{XICNC} = \{\text{XICN}\}\frac{P_r}{\{\text{PCN}\}}\frac{(\{\text{TEMP1}\} + T_0)}{T_r}$$

TSI CN Counter Output (counts per sample interval); CNTS
CNTS is the raw output count from the TSI, Inc. 3760 condensation cncleus counter. The project-dependent sample rate may be chosen in the range from 1–50 Hz. In some unusual cases the counts are divided by a selected power of two to keep the counter from overflowing; see the project documentation.

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Condensation Nucleus (CN) Concentration (cm^{-3}): CONCN
CONCN is the corrected concentration of condensation nuclei, calculated with consideration of the sample rate and corrected for losses caused by coincidence:

CNTS = counts per second from the CN counter
ΔT = interval between recorded samples
D = scale factor (normally 1)
FCNC = corrected sample flow rate (cm^3/s)
T_{vv} = time each particle is in the view volume = $4.167\times 10-6$ s

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$$\mathrm{A} = \frac{\{\mathrm{CNTS}\}}{\{\mathrm{FCNC}\}\Delta\mathrm{T}}\,\mathrm{D}$$

$$\mathrm{CONCN} = \mathrm{A}\,e^{AT_{vv}\{\mathrm{FCNC}\}} \tag{1}$$

See the introduction to this section for comments regarding the range of validity of the coincidence correction in Eq. (1).