C-52
SAMPLE CHAMBER

instruction/service manual

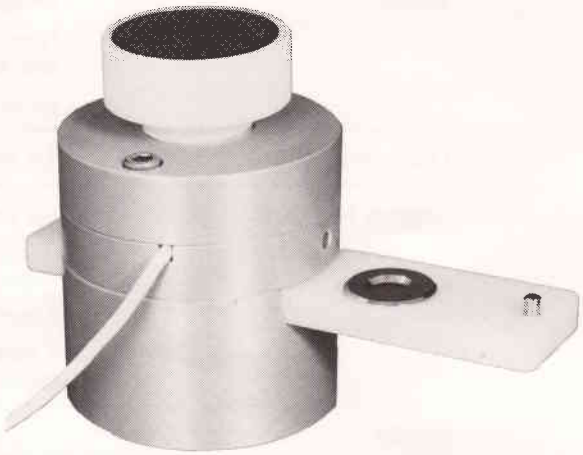
M-2740

WESCOR

contents

SECTION 1
INTRODUCTION

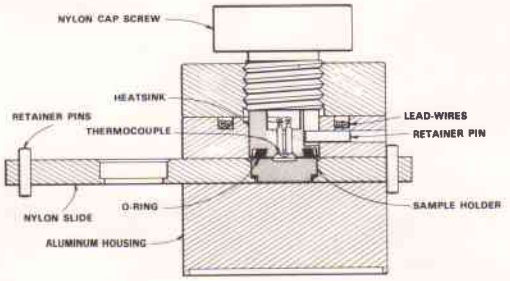
The Wescor C-52 Sample Chamber measures water potential of small samples in the laboratory or in the field without requiring a constant temperature bath. A thermocouple transducer in an internal chamber functions either as a psychrometer (wet bulb depression method) or as a hygrometer (dew point depression method), depending upon the type of readout equipment employed. Researchers have reported exceptional ease and accuracy using these instruments.



The instrument is precision machined from the finest materials and expertly assembled to assure accuracy and precise operation. Each unit is individually performance-tested before leaving the factory. The psychrometric output for a 0.55 molal NaCl solution (-25 bars) is recorded and furnished with each sample chamber.

An all-metal thermocouple mount provides direct thermal contact between the thermocouple and the upper heat sink. This and the solid aluminum housing give rapid temperature equilibration and reduced zero offset error.

An integral copper-constantan thermocouple sensor allows accurate ambient temperature measurements for correction of psychrometric readings or for Π_V correction when needed.



APPLICATIONS

Measuring matric water potential in soil, wood or other materials.

Measuring total water potential of plant or animal tissue.

Measuring relative vapor pressure of solvents such as alcohol, acetone, carbon tetrachloride, etc.

Can be used as a micro osmometer (10 microliter samples) to do rapid accurate sampling without the risk of measurement artifacts that may accompany the freezing point depression method.

MODEL C-52 SAMPLE CHAMBER SPECIFICATIONS

SIZE	Approximately 57 mm diameter by 75 mm height.
WEIGHT	Approximately 0.40 kg.
FINISH	Anodized aluminum body. Nickel-chromium plated thermocouple mount and sample holders. White delrin slide and sealing knob.
LEAD LENGTH	1.5 m
SAMPLE HOLDERS	Six holders furnished (two of each size). 9.5mm diameter x 2.5 mm deep for soil or other large samples. 7 mm diameter x 1.25 mm deep for leaves, etc. 7 mm diameter x 1.25 mm deep for saturated filter paper discs.
RANGE	0 to -70 Bars nominally.
CALIBRATION	Standard solutions.
SAMPLE TIME	30 seconds to several minutes, depending upon the time required for sample to reach vapor equilibrium.
PRECISION	2% ± 0.1 Bar.

SECTION 2
CONNECTING TO METER

The C-52 Sample Chamber has a single, three conductor cable with an aluminized mylar shield and drain wire. The black, the red and the bare wire are copper. The blue wire is constantan. The black conductor is attached to the chromel side of the psychrometer junction and must be connected to the negative input terminal of the measurement instrument. The red wire is attached to the constantan side of the psychrometer and must be connected to the positive input terminal. The blue conductor is soldered to the red wire just above the psychrometer junction forming a thermocouple junction for the measurement of temperature. The blue wire must be connected to the constantan input terminal of the readout instrument for temperature measurements. Specific instructions for connecting the sample chamber to Wescor readout instruments are given below.

WESCOR HR-33T MICROVOLTMETER

The HR-33T Microvoltmeter allows measurements to be made with either the hygrometric (dew point depression) or the psychrometric (wet bulb depression) method. The HR-33T also allows ambient temperature to be read directly from the meter in degrees Celsius.

The colors of the binding posts on the HR-33T match the colors of the insulation on the lead wires from the C-52 Sample Chamber. Each lead should be connected to the corresponding binding post. The bare lead (shield) should be connected to the green binding post (case ground) or left unconnected, whichever results in lower noise pickup. HR-33T Microvoltmeters manufactured after February 1979 (S.N. 1606* and above) do not require any disconnecting of leads to switch from temperature measurements to water potential measurements.

The operation of the HR-33T is explained in the instruction manual for that instrument.

OTHER METERS

The C-52 can be used with almost any meter which has the capability of providing the appropriate cooling current and which has sufficient amplifier sensitivity to measure the low signals from the psychrometer junction. The information given in the first paragraph of this section will enable you to make the proper connections to other meters.

An excellent datalogger is available from Wescor for automated measurements.

SUREFAST CONNECTORS

A Wescor SUREFAST™ connector is now available as an option on all Wescor psychrometer transducers and readout instruments. This simplifies transducer connection, eliminates connection errors and reduces thermal errors. Check the catalog or contact Wescor for ordering information.

HR-33T Microvoltmeters with serial numbers above 1769* have SUREFAST™ receptacles. SUREFAST™ receptacles have also been added to some older HR-33T Microvoltmeters. If the sample chamber has a SUREFAST™ cable connector (C-52-SF), it can be attached to these units through the SUREFAST™ receptacle. The binding posts are also available on all HR-33T Microvoltmeters to allow sample chambers without the connector option to be used. All other Wescor psychrometer readout instruments or the Wescor switchbox require sensors with SUREFAST connectors.

*Last four digits

SECTION 3
SAMPLE LOADING

Sample holders of three different sizes (two of each size) are supplied with each sample chamber to accommodate various materials. The sample may be loaded into the holder before or after the holder is installed in the slide. Care must be taken to be sure that part of the sample or other foreign matter is not spilled on the lip of the sample holder or on the slide as this may contaminate the thermocouple and chamber. Use a lint free tissue to clean the sample holder if necessary. After inserting the slide, the chamber is sealed to the holder by tightening the knob on top of the chamber. Be sure to release the tightening screw by at least ½ turn when removing the sample.

Correct loading procedure is very important to ensure accuracy and to avoid contamination within the instrument. For solution sampling, filter paper discs can be cut with a standard ¼ inch paper punch. (Sample discs are available from Wescor - catalog number SS-033). After saturating the disc with the test solution, place it in the center of the shallow sample holder. Take care not to touch the outer periphery of the sample holder with the wet disc, as this will contaminate the thermocouple mount. Insert the sample into the chamber as soon as possible and firmly tighten the sealing knob.

When soil or similar samples are being measured, fill the appropriate size sample holder to about 1/16 inch from the top. Before inserting any sample be sure that the level of the sample is below the top of the sample holder and that the top surface of the sample holder is clean.

Incorrect readings will result if the thermocouple chamber or the thermocouple is allowed to become contaminated with foreign material. Care should always be exercised to guard against contamination through improper sample loading or insertion. Contaminating soil, fingerprints or other substances should not be allowed to collect on the sample holder or the sample slide. See SECTION 4 for methods of checking for contamination and for cleaning the thermocouple and chamber.

IMPORTANT

In order to achieve meaningful results, the thermocouple mount, the thermocouple and the chamber must be clean and free from excessive temperature gradients. To check for these conditions see **SECTION 4.**

SECTION 4
CALIBRATION

Each C-52 Sample Chamber is calibrated for one value of water potential (approximately -25 bars) at the factory. The psychrometric curve is included with the instrument. The instrument can be more precisely calibrated by measuring the water potential of known samples.

The water potential of NaCl solutions at various temperatures are given in Table I. Standard NaCl solutions are available from Wescor. Standard solutions may be prepared using pure distilled water and reagent grade NaCl. A one molal solution is made up from 58.44 grams of NaCl and 1000 grams of water. From Table I, this corresponds to -46.4 bars at 25 degrees Celsius. The table can be used to determine the water potential for solutions of any molality within the range of the instrument.

Basic calibration of the instrument involves measurement of the output as a function of water potential in the chamber. There is less chance for error if the calibration conditions are, as nearly as possible, the potentials between 0 and approximately 0.47 microvolts per bar at 25 degrees Celsius using the psychrometer method. The hygrometric dew point output is also linear and is approximately 0.75 microvolts per bar. If the cooling coeffecient Π_V is properly set (see HR-33T manual) for the ambient temperature, the hygrometric output is independent of temperature. Details of the measurement procedures are contained in the manuals for the readout and control instruments.

The calibration curves of **Figure 2** represent typical performance of the model C-52 Sample Chamber. They were constructed from data obtained in carefully controlled tests at Wescor, Inc. Most users will wish to determine the actual calibration of their individual instruments. Using the curves of **Figure 2**, one can establish the relative difference between the individual instrument and the typical performance, if any. A single calibration at room temperature can serve this purpose adequately, since variations from typical can be expected to be small, and the same relationship will apply for the entire family of curves. However, the same procedure will apply whether one wishes to do a single calibration or reconstruct the entire family of calibration curves for the instrument.

The psychrometric output is a function of the ambient temperature. The C-52 Sample Chamber contains an internal thermocouple for temperature measurement. The temprature correction factor is given by:

$$\text{CORRECTED READING} = \frac{\text{READING}}{(.325 + .027T)}$$

where T is in degrees Celsius.

Error in calibration may also result from rapid ambient temperature changes which might occur in field use. Additional suggestions and information regarding field use and calibration of the instrumenmt are contained in **SECTION 5**.

The Wescor HR-33T Microvoltmeter is designed to maintain the thermocouple at the dew point depression temperature during measurement of water potential. Instructions for water potential measurements in the hygrometric dew point mode are detailed in the HR-33T manual.

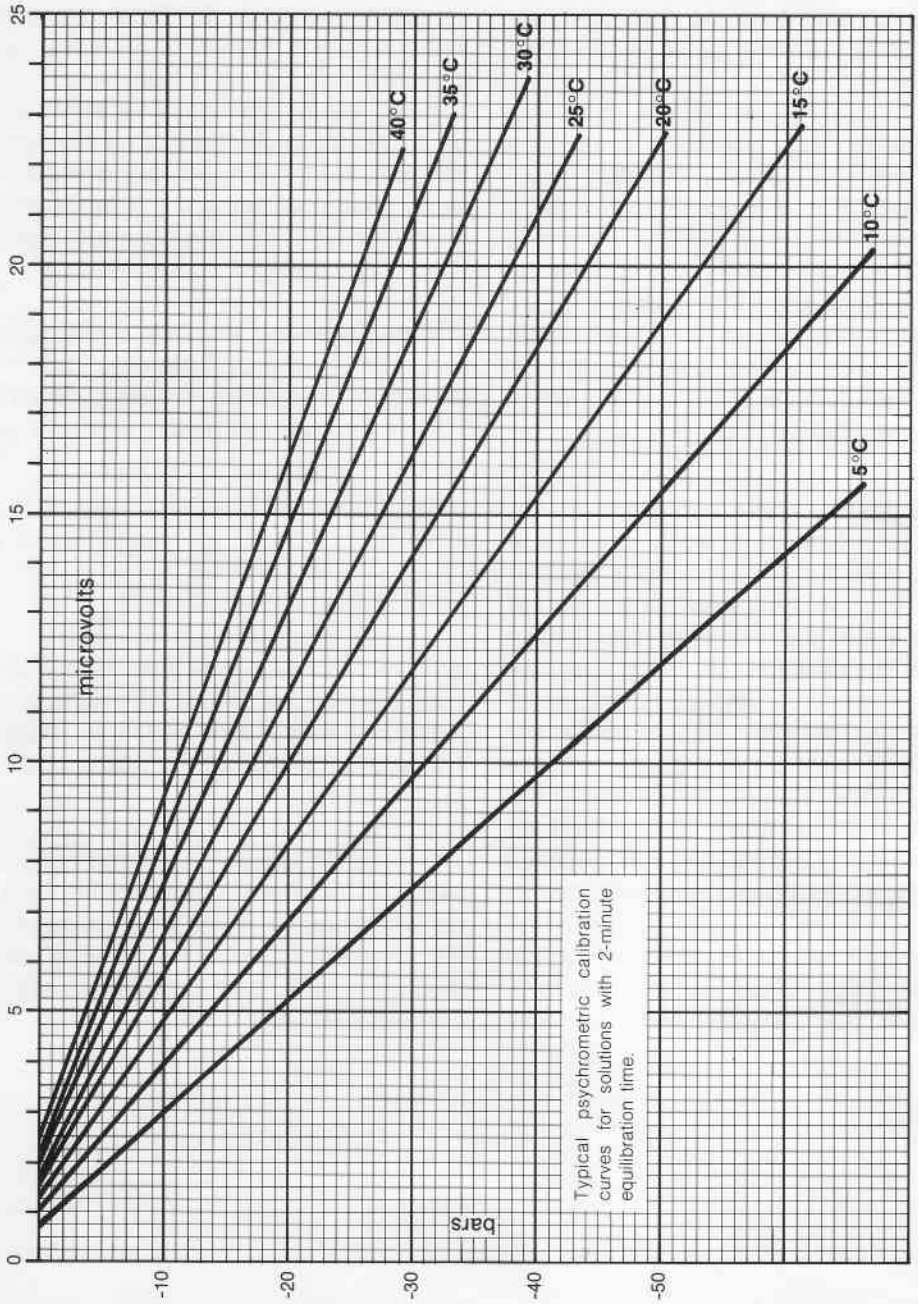

microvolts
bars
40°C
35°C
30°C
25°C
20°C
15°C
10°C
5°C
0
5
10
15
20
25
-10
-20
-30
-40
-50
Typical psychrometric calibration curves for solutions with 2-minute equilibration time.

FIGURE 2

SECTION 5
CONTAMINATION CHECKS & CLEANING

Even with due caution, contamination will result from use. It is good practice to periodically check the thermocouple and the thermocouple chamber to make sure that they are clean. Simple and reliable procedures have been worked out to accomplish this.

CHECKING FOR CONTAMINATION

Three methods are given below to determine the presence of contamination.

METHOD 1

Record the psychrometric (wet bulb) output using a sample disc saturated with a solution of NaCl or another known sample. The presence of contamination can be indicated by the rate at which the psychrometric reading returns to zero following the plateau and by the sharpness of the plateau. FIGURE 3 shows the difference in the microvoltmeter output for a clean and for a contaminated psychrometer. A 0.55 molal NaCl solution was used in this example. If the output returns to ambient slowly after an indefinite plateau the sample chamber should be cleaned.

METHOD 2

Place an empty shallow sample holder in the chamber and seal. After thermal equilibrium is achieved, release the seal and slide the sample holder out and in a few times (without sealing the chamber), noting the reaction on the 10 microvolt scale of the meter. Next, place a filter paper disc saturated with pure water in the sample holder and slide it out and in as was done before. If there is any contamination on the thermocouple, water will condense on it as the sample is inserted, causing the thermocouple to heat (negative reading on the meter). As the sample is drawn out of the chamber, a positive reading will result due to evaporation from the thermocouple. If the thermocouple is clean, there will be no difference between the reaction with the water sample and without it. The thermocouple can be considered to be sufficiently clean for accurate measurements if the difference does not exceed 5 microvolts.

METHOD 3

Insert an empty sample holder, seal the chamber and allow adequate time for thermal equilibration. Thermal equilibration is achieved when there is less than 4 uv difference between the INPUT SHORT mode and the SHORT mode. After equilibration, insert a sample of pure water (drinking water is adequate in most areas) on a filter paper disc and seal the chamber. After a 25 second equilibration, take a reading using a 5 second cooling time. If the reading is 2.5 microvolts or less using the psychrometer (wet bulb) method the chamber is sufficiently clean.

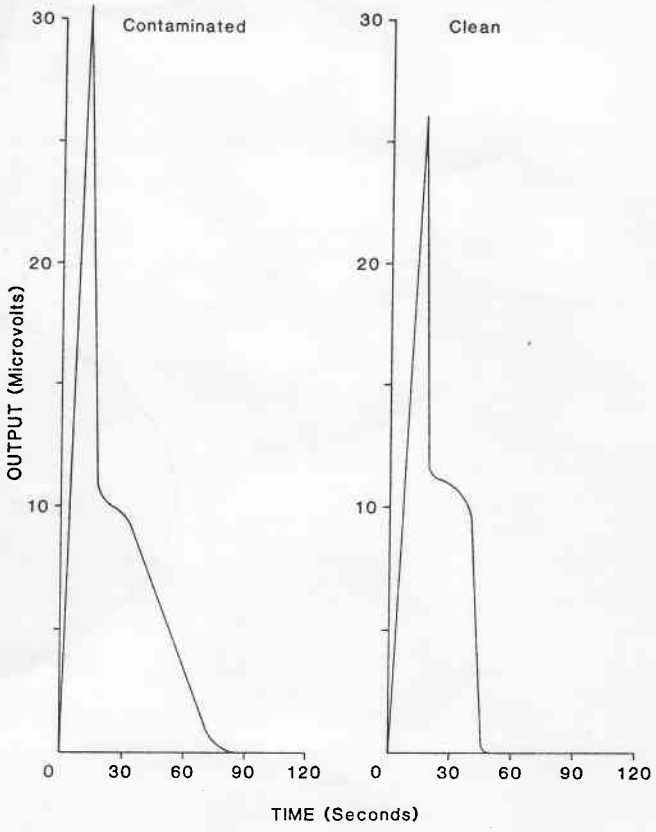
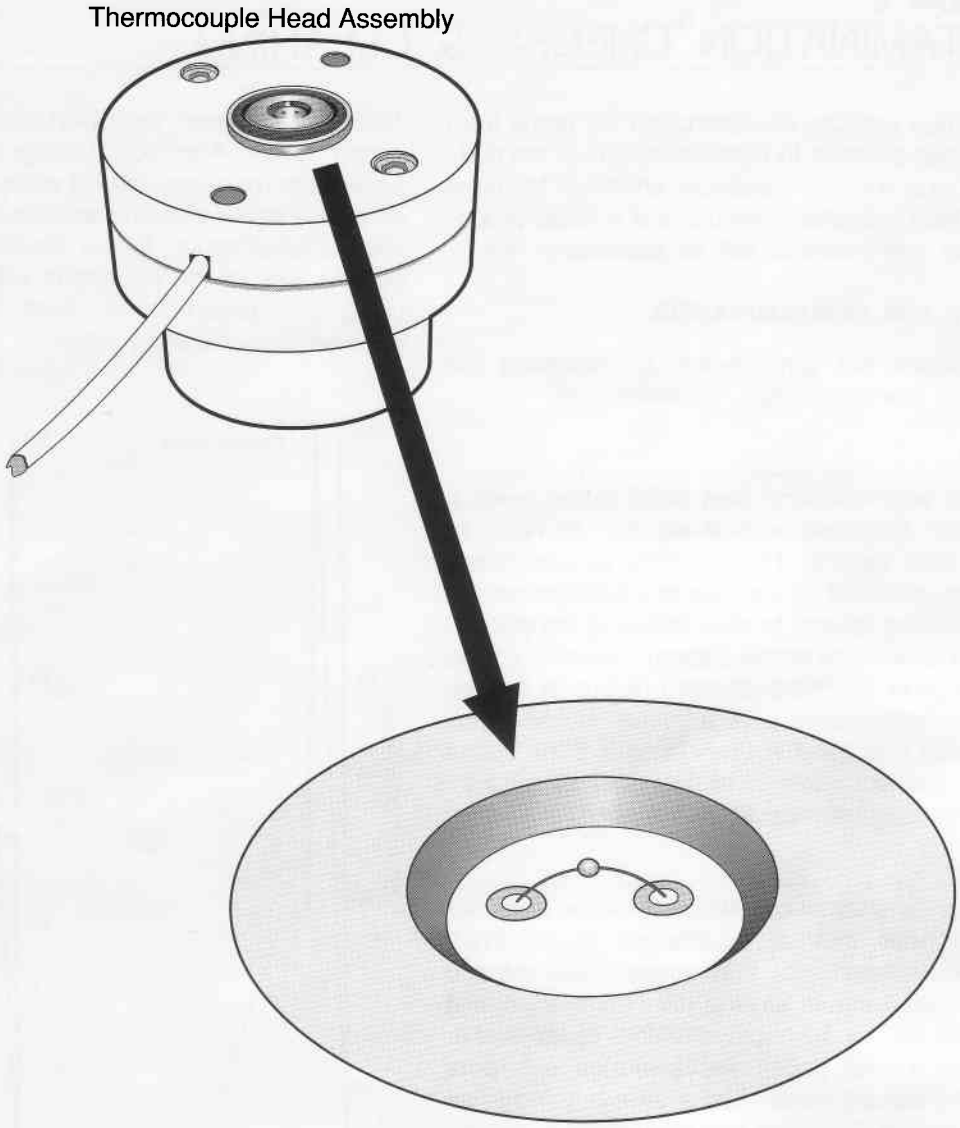


FIGURE 3
Output From a Contaminated Psychrometer
and
Output From a Clean Psychrometer



Caution!

The thermocouple is constructed of very fine wire and is therefore liable to be damaged if contacted by any object. Never touch the thermocouple while cleaning.

FIGURE 4

Enlarged view of Thermocouple and Mount

CLEANING THERMOCOUPLE AND CHAMBER

If the contamination tests indicate that cleaning is necessary, proceed as follows:

IMPORTANT

The thermocouple (**FIGURE 4**) *is constructed of very fine wire and will be damaged if touched by an object. Never touch the thermocouple while cleaning.*

Remove the two allen head screws visible on the upper side of the instrument and carefully separate the top and bottom halves of the sample chamber. The thermocouple chamber itself is at the center of the nickel plated core.

In the following outlined procedure, always apply liquid sparingly and carefully, to avoid penetration of liquids into the chamber assembly.

1. Using a dropper, release cleaning solution (10% ammonium hydroxide, reagent grade acetone, or a mild detergent solution) onto the central depression of the thermocouple mount as shown in **FIGURE 5**. The surface of the mount inside the O-ring and the top of the O-ring should be covered by the solution. Avoid filling the O-ring groove with solution.

2. Hold the top of the chamber in your hand with a relaxed but firm grip. Using a smooth, rapid motion, pull the chamber straight down and away from the droplet of liquid. Inertial forces will pull the liquid away from the face of the thermocouple mount. A waste container placed on the floor below will catch the liquid.

IMPORTANT

Do not allow any residual droplets of cleaning solution to evaporate from the thermocouple mount as this will cause the dissolved material to be redeposited on the thermocouple.

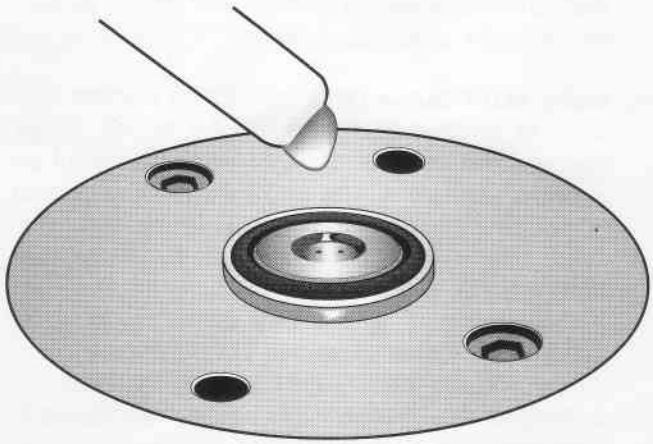


FIGURE 5
Applying Cleaning Solution to Thermocouple and Mount

3. Immediately after step 2, apply a droplet of purified water* to the central portion of the mount to dilute any residue of the cleaning solution. The purified water should cover the same area covered by the cleaning solution. Shake off the liquid as in the previous step. Repeat this procedure with purified water at least five more times. Do not allow the tip of the dropper to come in contact with the droplet on the thermocouple mount, as this may contaminate the water in the dropper and subsequently the container from which it is taken. *Pure water that has a resistivity of 1 MEGOHM per cc or better must be used for rinsing.*

4. Using **BLOW CLEAN** (Wescor catalog number SS-026), or another source of *CLEAN* dry air, purge any residual droplets of liquid from the mount as shown in FIGURE 6. The **BLOW CLEAN** can should sit flat on the work surface as shown in the figure. If the can is tilted, liquid propellant may be discharged. The propellant will contaminate the thermocouple mount and is very difficult to remove. The nozzle should be aimed perpendicular to the mount surface and should be kept at least ¼" away from the thermocouple to avoid damaging it. This operation should be done in one short burst of 1 to 3 seconds duration. The purpose is to blow away the remaining droplets, not to dry them out.

5. Visually inspect the thermocouple mount for any residual particles or other contamination. If foreign material is visible on the thermocouple mount and it does not respond to repeated washing and rinsing, a wooden swab stick or a toothpick may be used to scour the surface and help remove the material. If it is necessary to remove material that is near the thermocouple, it is recommeneded that this procedure be performed under a microscope.

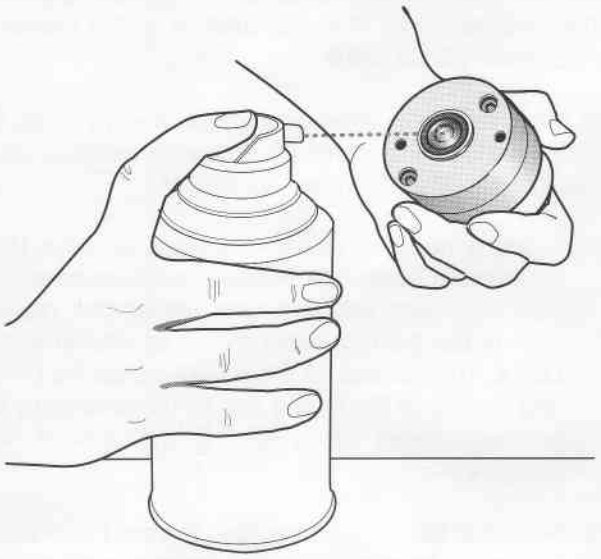


FIGURE 6
Removing Excess Water With Blow Clean

SEVERE OR STUBBORN CONTAMINATION

Ordinarily, a single cleaning using the procedure described above will fully renew sample chamber performance. A severely contaminated chamber may require that the procedure be repeated a number of times before a satisfactory clean test is obtained. If the thermocouple itself becomes contaminated with a substance which cannot be removed easily, such as the oily material which results from incorrect use of

*Use only de-ionized water (1 megohm or better) that has been stored in a covered container for the cleaning operation.

BLOW CLEAN (expelling liquid propellant), an unacceptable clean test may result even though no trace of foreign substance is visible on the thermocouple mount. If repeated cleanings fail to produce a satisfactory clean test, and if the thermocouple mount shows no trace of foreign materials, an additional solvent such as acetone (reagent grade), applied before the cleaning solution, may prove helpful. Caustic or highly acetic solutions should be avoided, however, since these could possibly damage the plated surfaces or the thermocouple itself.

If the thermocouple mount should accidentally become contaminated with sample residues, it may become necessary to remove the O-ring in order to effect a thorough cleaning. This should not be undertaken unless abolutely necessary, since there is considerable risk of damaging the thermocouple unless great care is exercised. The O-ring can be lifted from its groove in much the same way as a tire is removed from a rim, by carefully working a rounded, narrow tool point under the O-ring. Be careful not to injure the surface of the O-ring or scratch the thermocouple mount during this operation.

Wash the O-ring in cleaning solution and rinse thoroughly with distilled water. Replace the O-ring, and repeat the normal cleaning procedure described above.

If the O-ring is damaged, replace only with a factory-supplied part.

SECTION 6
ADDITIONAL OPERATING NOTES

SAMPLE LOADING

The sample holder can be removed from the slide to insert samples or for cleaning. However, if the temperature of the holder is changed by handling, this will increase the equilibration time. This may be avoided by carefully loading the sample holder while it is in the slide.

The slide has positions for two sample holders. For normal measurements, only one holder should be placed in the slide. The open space will allow any water left on the thermocouple to completely evaporate while the next sample is being loaded.

READINGS BELOW -60 BARS

The second position for a holder on the slide is useful for making water potential measurements below (dryer than) -60 bars where it is impossible to condense water onto the thermocouple from the sample by Peltier cooling. Basically, the technique involves insertion of a shallow sample holder containing a filter paper disc saturated with pure water. The thermocouple is cooled to coat the thermocouple with condensed water. The sample holder with water is removed and the sample is then inserted and sealed. The temperature depression of the thermocouple due to the evaporation of water in the environment of the sample is then read from the meter in the conventional manner. Extra care must be taken in preparing and handling the sample to avoid temperature gradients and error due to evaporation or absorption of water by the sample while it is in the ready position. Water potential measurements of samples to -3000 bars have been reported using this technique.

EQUILIBRATION TIME

After inserting and sealing the sample to be measured in the chamber, a period of time must be allowed for equilibration of temperature and vapor pressure within the chamber. The time necessary depends on the temperature differential between the sample and the chamber, the water potential of the sample and the physical nature of the sample. Equilibration time for many liquid samples may be as short as a few seconds. Soil and other bulky samples may require 15 minutes or more to fully equilibrate due to the mass of the sample and the fact that it may be necessary to handle the holder in order to fill it. For samples with a large component due to matric potential, vapor pressure equilibrium may take much longer than temperature equilibrium. Vapor pressure equilibrium is indicated when successive readings show no change in water potential.

Leaf samples may be obtained with a standard ¼ inch paper punch. Prepare the leaf by first swabbing the upper surface with pure water, then blot. Punch a disc from the leaf and place it in the sample holder and seal the sample chamber. Total water potential measurements of this type may require equilibration of 15 minutes or more. If the osmotic potential is of interest, the leaf can be frozen and pressed onto a filter paper disc until the disc is saturated. The saturated disc is measured as with any other solution.

The necessary time for equilibration of any sample can best be judged through experience with similar samples. If necessary, trial readings on the sample being measured can be used to determine if equilibration has been reached. To do this, repeat the measurement without opening the sample chamber. When the same result can be obtained repetitively it may be assumed that vapor pressure equilibrium has occurred. It is important that consistent equilibration times be used in any series of related measurements.

TEMPERATURE ENVIRONMENT

The aluminum housing of the sample chamber psychrometer serves as a thermal sink to reduce temperature qradients within the chamber and the attendant errors which can result. This design has proven to be very effective in laboratory environments and gives good performance in more rigorous field environments as well. Nevertheless, it should be recognized that temperature gradients around the instrument are not conducive to good results, and a few simple precautions taken to help stabilize the temperature environment, such as avoidance of drafts and direct solar radiation, will be amply repaid with better results.

THERMOCOUPLE COOLING TIME

Thermocouple cooling time does not appreciably affect the reading from the psychrometer if sufficient time is allowed to effect condensation upon the junction. Nevertheless, for best accuracy, one should endeavor to use a consistent cooling period from measurement to measurement, and in any case, use the same cooling period for measuring samples as is used in calibrating the instrument for the same range.

SUGGESTED COOLING TIMES ARE:

0 to -5 bars	2-5 seconds
-5 to -25 bars	8-12 seconds
below -25 bars	15 seconds or more

OTHER PROCEDURES

Many techniques and procedures have been developed by individuals for the use of their C-52 Sample Chambers. Your personal experience will be extremely valuable. Develop your own methods which work for you. Be sure to read the manual and be aware of the precautions given.

TABLE I

WATER POTENTIALS OF NaCl SOLUTIONS AT TEMPERATURES BETWEEN 0-40°C

(Lang, 1967)

Temperature Molality	0°C	5°C	10°C	15°C	20°C	25°C	30°C	35°C	40°C
0.05	-2.14	-2.18	-2.22	-2.26	-2.30	-2.34	-2.38	-2.42	-2.45
0.1	-4.23	-4.31	-4.39	-4.47	-4.54	-4.62	-4.70	-4.77	-4.85
0.2	-8.36	-8.52	-8.68	-8.84	-9.00	-9.15	-9.30	-9.46	-9.61
0.3	-12.47	-12.72	-12.97	-13.21	-13.44	-13.68	-13.91	-14.15	-14.37
0.4	-16.58	-16.93	-17.27	-17.59	-17.91	-18.23	-18.55	-18.86	-19.17
0.5	-20.70	-21.15	-21.58	-22.00	-22.41	-22.81	-23.22	-23.62	-24.02
0.6	-24.84	-25.39	-25.93	-26.44	-26.94	-27.44	-27.94	-28.43	-28.91
0.7	-29.01	-29.67	-30.30	-30.91	-31.51	-32.10	-32.70	-33.28	-33.85
0.8	-33.20	-33.98	-34.72	-35.43	-36.12	-36.82	-37.51	-38.18	-38.85
0.9	-37.43	-38.32	-39.17	-39.98	-40.79	-41.58	-42.27	-43.14	-43.90
1.0	-41.69	-42.70	-43.66	-44.59	-45.50	-46.40	-47.29	-48.15	-49.01
1.1	-45.99	-47.13	-48.20	-49.24	-50.26	-51.27	-52.26	-53.22	-54.18
1.2	-50.32	-51.60	-52.78	-53.94	-55.07	-56.20	-57.30	-58.35	-59.41
1.3	-54.70	-56.11	-57.42	-58.69	-59.94	-61.19	-62.39	-63.54	-64.71
1.4	-59.12	-60.68	-62.10	-63.50	-64.87	-66.23	-67.54	-68.80	-70.06
1.5	-63.59	-65.29	-66.84	-68.37	-69.86	-71.34	-72.76	-74.11	-75.48
1.6	-68.11	-69.96	-71.63	-73.30	-74.91	-76.52	-78.05	-79.50	-81.07
1.7	-72.60	-74.60	-76.40	-78.20	-80.00	-81.70	-83.30	-84.90	-86.50
1.8	-77.30	-79.40	-81.30	-83.30	-85.20	-87.00	-88.80	-90.40	-92.10
1.9	-81.90	-84.30	-86.30	-88.40	-90.40	-92.40	-94.30	-96.00	-97.80
2.0	-86.70	-89.20	-91.30	-93.60	-95.70	-97.80	-99.80	-101.60	-103.50

WATER POTENTIAL (BARS)

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