YSI Conductivity Calibrator Solutions

YSI Conductivity Calibrator Solutions are secondary standard solutions for the calibration of conductivity cells together with conductance meters. The solutions are provided in two ranges of accuracy. The YSI 3161, 3163, and 3165 solutions are made to close tolerances and intended primarily for use in laboratory applications where other factors which strongly influence conductivity can also be tightly controlled or accurately measured. The YSI 3160, 3167, 3168, and 3169 solutions are made to less exacting tolerances and are intended mainly for use in field applications where other factors are less subject to close control or measurement.

YSI Conductivity Calibrator Solution

YSI Number	Size	Conductivity in μSiemens at 25°C	Tolerances at 25°C
3160	8 x 1 US Pt	1,413	±1.0%
3161	1 US Quart	1,000	±0.50%
3163	1 US Quart	10,000	±0.25%
3165	1 US Quart	100,000	±0.25%
3167	8 x 1 US Pt	1,000	±1.0%
3168	8 x 1 US Pt	10,000	±1.0%
3169	8 x 1 US Pt	50,000	±1.0%

Units of Measure

Resistance = Ohms = Ω Conductance = siemens = s = mho
1 US Gallon = 3.785L 1 US Quart = 0.9462L
Conductance = 1/Resistance = Ω^{-1}
1 S/m = 0.01 mhos/cm = 10,000 μSiemens/cm
1,000,000 μSiemens = 1,000 mmhos = 1 mho
Solution Conductivity = Conductance x Cell Constant = 1/Resistivity

Directions for Use

Clean and rinse the cells before calibration, then season them in the Calibrator Solution. Minimize evaporation of the Calibrator Solution when calibrating; use a narrow-necked vessel or cover the vessel with plastic kitchen wrap. Avoid carrying contaminants in with cells being calibrated - the effect of this is cumulative. Do not introduce anything into the original container of Calibrator Solution, as this may inoculate the solution with microbes. Heavily platinized cells, or cells of complex geometry may require more than two minutes to achieve stable readings. Check the calibration of the bath or thermometer. At high conductance, contact resistance between the meter and probe can be a source of error. Make this connection as solid as possible. Do not get grease on electrode surfaces. It is very important that the electrodes be thoroughly wetted before use. See conductivity cell instructions.

Temperature has a large effect on conductivity. Calibration should be performed as close as practical to 25°C, preferably with a water bath to control temperature. If room temperature is stable and between 20°C and 30°C, the calibrator may be thermally equilibrated with the room, and then the temperature may be measured at the moment of calibration to an accuracy of ±0.1°C, or as precisely as possible. Electrically compensated readings may be taken on instruments so equipped. This may be less accurate because the temperature coefficient of the compensator may not match that of the solution, the circuitry of the compensator may introduce additional sources of electrical error, and because of the uncertainty in the temperature measurement. If the compensator is adjustable, set it to 1.9%/°C for YSI 3161 or 3163, and for 3160, 3167 and 3168 solutions; and to 1.8%/°C for YSI 3165 and 3169 solutions. To minimize compensator errors, calibrate at a temperature as close as possible to 25.00°C.

Dip Cells: Select a glass or plastic container several inches taller than the working part of the cell and at least two inches greater in diameter. Clean and dry this container, then fill it with calibrator solution to a depth at least two inches greater than the working part of the cell. Rinse the cell by pouring a little calibrator solution into and over it. Connect the cell to the conductance meter and immerse the cell in the calibrator solution. For approximately two minutes, stir the solution intermittently with the cell and move the cell up and down to force liquid through it. Take care to purge the cell of bubbles. Position the cell in the approximate center of the calibrator solution, and at least one inch from any wall or from the surface of the solution. Record the temperature reading and record (or adjust) the conductance meter reading.

Flow Cells: Purge the cell by passing ten to twenty times its own volume of Conductivity Calibrator Solution through it. (The volume of any connecting tubing or fittings must be considered part of the cell volume for this operation). When the cell temperature is stable, record the temperature and record or adjust the conductance meter reading. Micro cells may give high readings if the solution is completely stagnant-maintain some flow of solution through the cell during calibration, preferably the same rate of flow that would be used to measure an unknown solution.

Fill Cells: Fill and empty the cell at least three times with the Conductivity Calibrator Solution. When the cell temperature is stable (allow at least two minutes), record the temperature and record or adjust the conductance meter reading. When calibration is complete, rinse and store the cell in distilled water or in a dilute solution of HCl or KCl. Used Conductivity Calibrator Solution must be regarded as contaminated and should not be returned to its original container.

Calculations

If the calibration was performed at 25.00°C or is ostensibly corrected to 25.00°C, the meter reading for the calibration solution should have been the nominal 25.00°C value of 1,000, 1,413, 10,000, 50,000 or 100,000 μSiemens/cm. Adjustable meters can be trimmed to agree exactly with the nominal value of the calibrator solution. If the meter is not adjustable, or is to be used with several different probes, calculate a cell constant or a correction factor as follows:

$$\text{Cell Constant} = \frac{\text{Actual Calibrator Solution Conductivity}}{\text{Conductance Meter Reading}}$$

Conductivity readings on unknown solutions with this cell and meter may then be taken according to:

Solution Conductivity = (Conductance Meter Reading) x (Cell Constant)

For meters which presume a cell constant (not necessarily a round number) and give a reading in conductivity, it is more practical to calculate a correction factor by the formula:

$$\text{Correction Factor} = F = \frac{\text{Actual Calibrator Solution Conductivity}}{\text{Conductivity Meter Reading}}$$

Unknown solution readings are then corrected by:

Correct Conductivity = (F) x (Meter Reading)

Note that the meter calibration is a factor in all these readings. Unless meters are accurately calibrated, different cal Constants or correction factors will be obtained from the same cell and solution with different meters, or even on different ranges of the same meter. For independent calibration of conductance meters, use the YSI 3166 Conductance and Resistance Calibrator Set. If meters are not independently calibrated, the cell constant or correction factor calibrated above will apply only to the very cell, meter, range and mode (for meters which read in both ohms and Siemens or mhos) used in the calibration. Calibrate each cell in each range and each mode for best results.

When calibrating without temperature compensation at a temperature other than 25.00°C, you must factor into the equations given above the Calibrator Solution conductivity *at the temperature of calibration* instead of the nominal 25.00°C value. See the discussion of **Temperature Effects**, below.

Apart from errors due to conductance meter calibration, cell constants may vary slightly with conductivity and with cell history. Calibration should therefore be undertaken with a Calibrator Solution as near in value as possible to the value of the unknown solutions to be measured. For unknowns of very low conductivity use the 1,000 μSiemens/cm Calibrator Solutions.

Calibrator values lower than 1,000 μSiemens/cm would be unstable and are not well documented. Recalibrate at six-month intervals, or following any visible change in cell condition. Cell fouling, cleaning or replatinization may have a substantial effect on cell constants, as will any mechanical bending or displacement of the electrodes.

Temperature Effects

The conductivity of the Calibrator Solutions at various temperatures may be calculated from the following equation:

$$\text{Conductivity} = (\text{Conductivity at } 25.00°C) \times (A + Bt + Ct^2)$$

where t = temperature in °C (ITPS68)

Conductivity at 25.00°C	A	B	C
1,000 μSiemens/cm	0.5407	0.0173	0.000043
1,413 μSiemens/cm	0.5413	0.0173	0.000043
10,000 μSiemens/cm	0.5538	0.0168	0.000042
50,000 μSiemens/cm	0.5666	0.0163	0.000041
100,000 μSiemens/cm	0.5825	0.0157	0.000040

The conductivity may be obtained by using the following table for the YSI 3160 to 3165 solutions:

TEMP	3160	3161	3163	3165
20°C	1277 μSiemens/cm	904 μSiemens/cm	9,066 μSiemens/cm	91,260 μSiemens/cm
21°C	1304 μSiemens/cm	923 μSiemens/cm	9,251 μSiemens/cm	92,980 μSiemens/cm
22°C	1331 μSiemens/cm	942 μSiemens/cm	9,437 μSiemens/cm	94,730 μSiemens/cm
23°C	1358 μSiemens/cm	961 μSiemens/cm	9,624 μSiemens/cm	96,480 μSiemens/cm
24°C	1386 μSiemens/cm	981 μSiemens/cm	9,812 μSiemens/cm	98,230 μSiemens/cm
25°C	1413 μSiemens/cm	1,000 μSiemens/cm	10,000 μSiemens/cm	100,000 μSiemens/cm
26°C	1441 μSiemens/cm	1,020 μSiemens/cm	10,190 μSiemens/cm	101,800 μSiemens/cm
27°C	1468 μSiemens/cm	1,039 μSiemens/cm	10,380 μSiemens/cm	103,600 μSiemens/cm
28°C	1496 μSiemens/cm	1,059 μSiemens/cm	10,570 μSiemens/cm	105,400 μSiemens/cm
29°C	1524 μSiemens/cm	1,079 μSiemens/cm	10,760 μSiemens/cm	107,100 μSiemens/cm
30°C	1552 μSiemens/cm	1,098 μSiemens/cm	10,960 μSiemens/cm	109,000 μSiemens/cm

Numerical Examples
It is desired to measure the conductivity of groundwater which is expected to be in a range between 3,000 and 8,000 μSiemens at 25°C. A 10,000 μSiemens/cm Calibrator Solution is selected for this example. About 900 ml of solution is poured into a clean and dry 1,000 ml Erlenmeyer flask. The flask and its contents are equilibrated to room temperature. A dip cell is connected to a conductance meter. The cell is rinsed with a small quantity of Calibrator Solution, which is then discarded. The cell is immersed in the Calibrator Solution in the flask. After two minutes of stirring, the solution temperature is measured with a ±0.1°C thermometer and found to be 22.1°C. From the equation, the conductivity of the Calibrator Solution is then calculated as follows:

Using the YSI 3163 Calibrator Solution

Calibration Solution Conductivity = $10{,}000 \times [0.5538 + (0.0168)(22.1) + (0.000042)(22.1)^2] = 9{,}456$ μSiemens/cm

The tolerance of the Calibrator Solution at this temperature is ±0.35%. The conductance meter reading is 9,200 μSiemens. Therefore, the cell constant is calculated as follows:

$$\text{Cell Constant} = \frac{9{,}456 \text{ μSiemens/cm}}{9{,}200 \text{ μSiemens/cm}} = 1.028 \pm 0.0036/\text{cm}$$

When a groundwater specimen yields a meter reading of 4,000 μSiemens the actual conductivity is:

Specimen Conductivity = 4,000 μSiemens x 1.028/cm = 4,112±14 μSiemens/cm

There is an additional error depending on the uncertainty in the measurement of the temperature. In general, this error is approximately an additional ±0.2% for each 0.1°C uncertainty in the temperature. In the example, if it is assumed that the temperature is 22.1±0.1°C, then the cell constant is 1.028±0.0057/cm.

Storage
Store below 30°C (86°F) to minimize the likelihood of error due to evaporation of water or to microbial growth. Do not freeze; the bottle may break. If a container does freeze, thaw it completely and mix the contents before removing any solution. Discard if expiration date is past, or if color, turbidity, or visible microbial growth develops. Solutions that have been opened are not secure against microbial invasion, and must be discarded within one month of opening.

Safety
These solutions are nonflammable, unreactive and are believed to be of a very low order of toxicity. However, swallowing large amounts of potassium salts may lead to cardiac arrhythmias. If swallowed, induce vomiting. If splashed in the eye, rinse the eye thoroughly with clean water. Although precautions have been taken to exclude microorganisms from these products, they are not sold as medically sterile.

Metrology
This solution is referenced to a primary reference solution in a constant temperature bath in which the temperature is uniform, stable and controlled. A conductivity cell, constructed of platinum and chemically resistant glass, similar in design to that used by Jones and Bradshaw (J.Am.Chem.Soc.55,1780-1800[1933]), is connected by four wires (to avoid lead resistance effects) to a 4 ½ digit conductance meter of established stability and linearity. The cell constant is chosen so as to keep the measured conductance between approximately 1,000 and 10,000 μSiemens to minimize error due to shunt or series impedance's. The cell and meter are only transfer standards; the primary reference solution is the fundamental reference.

Primary reference solutions are prepared according to the recommendation (IR No. 56-1981) of the Organization Internationale de Metrologie Legale (OIML). The OIML recommendation is the recognized international reference. This recommendation is substantially consistent with ASTM Standard Test Method D1125-77.

Potassium chloride (NIST SRM 999, National Institute of Standards and Technology) is dried for five hours at 500°C after which the purity is at least 99.98%. Taking the potassium chloride as 100%, on the basis that the impurities are salts of similar conductivity, a specified mass (corrected to vacuo) is dissolved in distilled, deionized water to yield 1,000.00 grams of solution (corrected to vacuo). The initial conductivity of the distilled water equilibrated to atmospheric CO_2, approximately 1.3 μSiemens/cm, is then added to the value tabulated below to obtain the assigned conductivity of the primary reference solution.

gKCl per Kg Solution	Conductivity at 25.00°C
71.1352	111,310 μSiemens/cm
7.41913	12,852 μSiemens/cm
0.745263	1,408.3 μSiemens/cm

The primary reference solution nearest in conductivity to each YSI Conductivity Calibrator Solution is used to inspect that solution. This solution will be within stated tolerances at both the beginning and the end of the shelf life interval.

Warranty
All YSI products are warranted for one year or until the expiration date against defects in materials and workmanship when used for their intended purpose and maintained according to instructions. Contact your dealer for warranty service.

Limitation of Warranty
This Warranty does not apply to YSI product damage or failure caused by (i) failure to install, operate or use the product in accordance with YSI's written instructions, (ii) abuse or misuse of the product, (iii) failure to maintain the product in accordance with YSI's written instructions or standard industry procedure, (iv) any improper repairs to the product, (v) use by you of defective or improper components or parts in servicing or repairing the product, or (vi) modification of the product in any way not expressly authorized by YSI.
This warranty is in lieu of all other warranties, expressed or implied, including any warranty of merchantability or fitness for a particular purpose. YSI's liability under this warranty is limited to repair or replacement of the product, and this shall be your sole and exclusive remedy for any defective product covered by this warranty. In no event shall YSI be liable for any special, indirect, incidental or consequential damages resulting from any defective product covered by this warranty.