

Standard Operating Procedure for the
Determination of Conductivity
CCAL 11A.0

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1.0 Scope and Application

- 1.1 Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This number depends on the total concentration of ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valence, and their actual and relative concentrations affect conductivity. The practical range of determination is 0 μ S – 3 S.

2.0 Summary of Method

- 2.1 Conductivity is determined with a YSI 3200 temperature-correcting meter. The meter is calibrated with a single point calibration. The samples are measured using a glass probe with thermistor. A consistency standard is analyzed once each analysis batch to monitor instrument drift over time.

3.0 Definitions

- 3.1 DI water: Water that has been through a deionization system to produce water similar to ASTM Type I reagent with 16.7 Mohms resistivity (ASTM) (Reference 16.3).
- 3.2 Method Detection Limit (MDL): The minimum concentration of an analyte that can be measured and reported with 99% confidence, based on a one-sided 99% confidence interval (t -value at a significance level of 0.01 and $n-1$ degrees of freedom) from at least seven repeated measurements of a low concentration standard measured within an analysis run.

$$\text{MDL} = ts$$

Where,

t = Student's t value at a significance level of 0.01 and $n-1$ degrees of freedom

s = standard deviation of at least seven repeated measurements of a low level standard

4.0 Interferences

- 4.1 Electrolytic conductivity (unlike metallic conductivity) increases with temperature at a rate approximately 2% per degree C. Significant errors can result from inaccurate temperature measurements. Although the YSI model 3200 meter compensates for variability in temperature, samples are still allowed to warm to at least 15° C to minimize temperature effect.
- 4.2 Sources of contamination include dust, carryover and salts from hands. The probe must be washed thoroughly between samples and gloves should be worn during the procedure.
- 4.3 Air bubbles trapped inside the probe will result in erratic measurements. Shake the probe to remove trapped bubbles before each measurement.

5.0 Safety

- 5.1 The toxicity or carcinogenicity of each reagent has not been precisely determined; however, each chemical should be regarded as a potential health hazard. Exposure to these chemicals should be reduced to the lowest possible level. Cautions are included for known extremely hazardous materials.

6.0 Equipment and Supplies

Note: *Brand names, suppliers and part numbers are for illustrative purposes only. No endorsement is implied. Equivalent performance may be achieved using apparatus and materials other than those specified here, but demonstration of equivalent performance that meets the requirements of this method is the responsibility of the laboratory.*

- 6.1 YSI 3200 Conductivity Instrument
- 6.2 YSI 3256 Glass probe with thermistor
- 6.3 Nitrile gloves

7.0 Reagents and Standards

- 7.1 Preparation of Standards

7.1.1 *Demal's Solution (KCl Standard Solution):*

Dissolve 745.6 mg anhydrous KCl into 1000 mL of DI water at 25°C. The resulting 0.0100 N KCl standard reference solution has a specific conductance of 1413 $\mu\text{S}/\text{cm}$ at 25°C and is satisfactory for most waters when using a cell constant between 1 and 2.

8.0 Sample Handling and Storage

- 8.1 Unfiltered samples are stored at 4°C in the dark. Samples are analyzed within 72 hours to ensure sample integrity.

9.0 Quality Control

- 9.1 Preparation of stock standards is recorded on worksheets and documented by weight of standard added to a given flask before dilution to volume with DI water. All records of certification are kept on file at CCAL Laboratory.
- 9.2 Blank: DI water run before the calibration.
- 9.3 Quality Control Check Sample: Run once per analysis batch.
- 9.4 Method Detection Limit (MDL): Established for each analyte. Based on a one-sided 99% confidence interval (t-value) from at least seven repeated measurements of a low concentration standard. The t-distribution value is multiplied by the standard deviation of the population (n-1) to obtain the MDL.
- 9.5 Analytical Duplicate: Separate analysis from the same sample aliquot. Run a minimum of once every analysis set.

10.0 Calibration and Standardization

- 10.1 Balances: calibrated yearly by external vendor.
- 10.2 Pipette delivery checked by weight to within 2% of theoretical weight of aliquot volume.

11.0 Procedure

11.1 Calibration

- 11.1.1 Refer to the YSI model 3200 Operations Manual to properly configure the instrument. This will include calculating and storing the cell constant. Temperature compensation should be set to "natural". The instrument will need to be reconfigured each time a new cell is necessary.
- 11.1.2 At least 1 hour before initiating conductivity analysis fill the glass electrode chamber in the conductivity probe with fresh DI water. The electrode should always be immersed with DI water when not in use. This keeps the electrode hydrated and provides for more stable response.
- 11.1.3 Press the power switch and allow the conductivity meter to warm up and equilibrate for at least 15 minutes.
- 11.1.4 Rinse the probe with DI water and shake-out any excess. Be careful not to insert anything in the electrode chamber that would cause any of the black platinum coating from the electrode to chip-off.
- 11.1.5 Fill the probe with fresh DI water. Temperature of the DI water should be $\geq 15^{\circ}$ C. Make sure that the sample does not sit long enough for the sample temperature to change appreciably, as the specific conductance measurement is a function of temperature.
- 11.1.6 Allow the instrument to equilibrate (generally 1 - 2 minutes) before recording the readout on the data sheet. The instrument automatically sets the range for the analysis. All analyses are performed in conductance mode. Be certain to correctly record the proper unit magnitude (μ S/cm, mS/cm, S/cm). Readings should be recorded to the nearest tenth of a unit for the μ S/cm scale, to the nearest unit for the mS/cm and S/cm scales. The reading for DI water should be approximately 0.4 -0.7 μ S/cm. Rinse probe and shake dry.
- 11.1.7 Analyze the Demal's solution by first rinsing the electrode chamber with enough solution to completely rinse the electrodes and discarding the rinse. Then fill the electrode chamber with solution, allow the instrument to equilibrate (1 - 2 minutes) and record the measurement. Keep a record of analyzed values for the Demal's over time. Large deviations show that the meter is not functioning or the solution has deteriorated. At 25°C the standard reference solution has a specific conductance of 1,413 μ S/cm. The temperature of the Demal's should be $\geq 15^{\circ}$ C. Make sure that the sample does not sit long enough for the sample temperature to change appreciably, as the specific conductance measurement is a function of temperature. Rinse probe with DIW and shake dry.

- 11.1.8 The instrument is now calibrated and ready to perform sample analysis.
- 11.2 Sample Testing Procedure
- 11.2.1 Rinse the electrode chamber three times with DI water and shake-out any excess after the last rinse.
- 11.2.2 Rinse the electrode chamber with enough sample to completely rinse the electrodes and discard the rinse. Then fill the electrode chamber with sample, allow the instrument to equilibrate (1 - 2 minutes) and record the measurement. Temperature of the sample should be $\geq 15^{\circ}$ C. Make sure that the sample does not sit long enough for the sample temperature to change appreciably, as the specific conductance measurement is a function of temperature. The instrument automatically sets the range for the analysis. Be certain to correctly record the proper unit magnitude (μ S/cm, mS/cm, S/cm). Readings should be recorded to the nearest tenth of a unit for the μ S/cm scale, to the nearest unit for the mS/cm and S/cm scales.
- 11.2.3 Repeat steps 1 and 2 for all samples.
- 11.3 System Notes
- 11.3.1 Although the YSI model 3200 meter compensates for variability in temperature, samples are still allowed to warm to at least 15° C to minimize temperature effect.
- 11.3.2 If there is a shift in order of magnitude in response between two samples, the meter is allowed to stabilize with the new sample, the sample is discarded and poured fresh for determination.

12.0 Data Analysis and Calculations

- 12.1 YSI model 3200 data are direct reading and require no calculation.

13.0 Method Performance

- 13.1 This method was validated through inter-laboratory studies. The CCAL participates in the USGS Standard Reference Water QA program.

14.0 Pollution Prevention

- 14.1 The chemicals used in this method pose little threat to the environment when properly managed.
- 14.2 All standards and reagents should be prepared in volumes consistent with laboratory use to minimize the volume of disposable waste.
- 14.3 For further information on pollution prevention consult *Less is better: Laboratory Chemical Management for Waste Reduction*, available from the American Chemical Society's Department of Government Relations and Science Policy, 1155 16th Street NW, Washington D.C. 20036, (202) 872-4477.

15.0 Waste Management

- 15.1 It is the laboratory's responsibility to comply with all federal, state and local regulations governing waste management, and to protect the environment by minimizing and controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is required.
- 15.2 For further information on waste management, consult "The Waste Management Manual for Laboratory Personnel", and "Less is Better: Laboratory Chemical Management for Waste Reduction", both available from the American Chemical Society's Department of Government Relations and Science Policy, 1155 16th Street NW, Washington DC, 20036.

16.0 References

- 16.1 Standard Methods For The Examination of Water and Wastewater, Method 2510-Conductivity. American Public Health Association. 21st Edition, 2005.
- 16.2 Code of Federal Regulations. Protection of Environment. Section 40, Appendix B to Part 136. Definition and procedure for the determination of the method detection limit. Revision 1.11. Revised July 1, 1990. Office of the Federal Register, National Archives and Records.
- 16.3 ASTM. American Society for Testing and Materials. Standard Specifications for Reagent Water. D1193-77 (Reapproved 1983). Annual Book of ASTM Standards, Vol. 11.01. ASTM: Philadelphia, PA, 1991.

- 16.4 YSI 3200 Conductivity Instrument Manual. YSI Environmental, YSI Incorporated.

17.0 Tables, Diagrams, Flowcharts, and Validation Data

- 17.1 pH, Alkalinity and Conductivity Data Sheet

