FRASER
Anti-Static Techniques

OPERATING INSTRUCTIONS

MODEL L40

LIQUID CONDUCTIVITY METER

Contents

1. Introduction

The Importance of Liquid Conductivity Measurement

The motion of low conductivity liquids, such as fuels and solvents, can result in the generation of hazardous levels of static electricity.

Stirring, pouring and flow through metal or plastic pipes are all examples of industrial operations which can produce an electrostatic ignition hazard.

These operations and others are covered in various Standards (British Standard 5958 Parts 1 and 2, and the CENELEC PD CLC/TR 50404). In these documents, a number of references are made to liquid conductivity and the importance of liquid conductivity measurement in hazard control is emphasised.

It is essential when dealing with flammable fuels and solvents of conductivity below 500 $pS.m^{-1}$ to consider measures to combat electrostatic ignition hazards. Such measures should not be necessary with relatively conductive liquids (above 500 $pS.m^{-1}$) In all cases, once a value for the conductivity has been established, the recommendations in the above documents should be followed.

2. Theory of Operation

The Model L40 Liquid Conductivity Meter is specifically designed to aid in the evaluation and control of electrostatic hazards, although it will find applications in all processes where quantification of the electrical conductivity of liquids is important.

Low conductivity liquids do not strictly obey Ohm's Law and to obtain reproducible results the conditions of measurement should be controlled. Most importantly, the liquid sample should be uncharged at the time of the measurement. If it has been charged, adequate time should be allowed for relaxation and for the establishment of ionic equilibrium; this may take several seconds for non-polar solvents. (Note: The resultant conductivity is sometimes referred to as the 'rest conductivity' meaning that the liquid is electrically at rest, although not necessarily motionless). These requirements also impose limits on the applied voltage, electrode spacing and the duration of the test.

The Model L40 Liquid Conductivity Meter consists of a metering cell coupled to a precision electrometer and a DC bias voltage supply. The metering cell consists of two concentric cylindrical electrodes between which the liquid sample is placed.

With the 'read' switch fully depressed the outer electrode of the cell is taken to +5 volts DC and assuming Ohmic conditions apply:

$$V = IR$$

Where V is the applied voltage, I is the resultant current and R is the sample resistance. For the case of two concentric cylindrical electrodes and a linear, isotropic, homogeneous sample, the electrical resistance is given by:

$$R = \frac{1}{2\pi l\sigma} \ln \frac{r_a}{r_b}$$

In this equation, l is the (inner) cylinder height, σ is the sample conductivity and r_a and r_b are the outer and inner electrode-sample interface radii. Therefore we have:

$$\sigma = \frac{1}{2\pi lV} ln \frac{r_a}{r_b} . i$$

The dimensions of the metering cell and the applied bias voltage are fixed thus allowing the conductivity of the sample to be displayed directly on the digital panel meter of the instrument.

3. Sample preparation for low-conductivity liquids

Care should be taken when handling low conductivity samples (less than 100 pS.m-^{1}) since small amounts of contaminants can have a large effect on the conductivity value. Any sampling vessels or equipment used to transport the sample to the metering cell should be extremely clean.

4. Cleaning the cell

In order to thoroughly clean the metering cell it is necessary to rinse the inside of the cell with a low conductivity solvent such as fresh AR-grade toluene or heptane.

After the cell has been cleaned in the above manner, it should be checked by measuring the conductivity of a sample of AR grade n-heptane as detailed in the following section. If the result is greater than 5 pS.m^{-1}, the cleaning procedure should be repeated.

Should the result be greater than 5 pS.m^{-1} for a second time it is necessary to check for a zero (+/-0.1) reading with the cell dry. Failure to obtain a zero reading indicates that the cell may be severely contaminated and require servicing. This is unlikely to occur under normal conditions.

5. Measurement procedure

With the power off, set up the instrument by connecting the leads from the cell base to the rear panel of the electrometer. Note that one of the cables from the cell base has a 4mm plug to threaded connector (TNC) and the other has a bayonet to bayonet (BNC).

Place the lid on the cell and switch on power. The instrument will run off internal rechargeable batteries but mains charging can be applied at any time during operation by connecting the mains lead and applying power. When mains power is connected, the red CHARGE light will illuminate. The instrument can be charged using 110-240 V mains supply without any adjustment. Full battery charge can be achieved by switching off the instrument on the front panel of the electrometer and keeping mains power applied overnight.

To make a measurement perform the following steps:

1. Switch on the electrometer using the red **POWER** switch and allow a few seconds for the circuit to initialise. The digital display will indicate **Initialising** followed by an advancing series of dots. Once the initialisation sequence is complete, the display will read:

   0.0 x 1 Z (+/-0.1)

   This indicates that the instrument has performed a self-zeroing operation.

2. Carefully fill the metering cell with the sample under test. The volume between the inner and outer cylinders should be carefully filled until the liquid just starts to overflow into the central hollow.

3. Place the cap on the cell and allow up to 20 seconds for any charge on the liquid to relax. Depress the **READ** switch and keep it pressed.
   The display will read:

   - . - x 1

5. Measurement Procedure

The instrument will now begin to auto range and the display may show the exponent (ie. **10^2**, **10^3** etc) increasing or decreasing until the correct range is obtained. Once the correct range is reached a further zero check may be initiated and then after a few seconds the liquid conductivity reading will be displayed. *Note: Because on start up the instrument performs self-zeroing on the most sensitive range there may be some fluctuation in the reading due to external pick-up.*

For conductivity values below 1000 $pS.m^{-1}$ the instrument display uses non-exponent notation eg. 5.0 $pS.m^{-1}$ reads **5.0 x 1** and 500 $pS.m^{-1}$ reads **500 x 1**. For values of 1000 $pS.m^{-1}$ and above the exponent is shown e.g. 5000 $pS.m^{-1}$ reads **5.0 x 10^3**.

4. Note the reading, release the READ switch and if required measure the temperature of the sample with a clean thermometer. Once the READ switch is released the display returns to -.- x 1.

5. The liquid sample can be disposed of by disconnecting and emptying the contents. The cell should be thoroughly cleaned prior to performing a measurement on a new sample.

6. Standby Mode

In order to preserve battery life, the instrument will enter STANDBY mode if left with the power on and not used for 1 minute. In this mode, the microprocessor is put into a low-power condition and the display is blanked. STANDBY mode is indicated by the orange LED blinking every 5 seconds. Pressing and holding the READ switch immediately re-enables the measurement.

7. Interpretation of Results

Liquid conductivity is an important parameter, which should be taken into account when assessing the electrostatic hazard associated with any particular liquid handling process. This is because liquid conductivity is inversely related to the time it takes for charge on the liquid to flow away to earth when it is in contact with conducting earthed plant.

A low conductivity implies a long charge relaxation time, which in turn leads to a higher risk of producing an electrostatic discharge. This relationship may be expressed as:

$$\tau = \frac{\varepsilon_o \varepsilon_r}{\sigma}$$

Where τ is the charge relaxation time (time for charge to decay to 0.37 of its initial value), $\varepsilon_o = 9 \times 10^{-12}$ F.m^{-1}, ε_r = dielectric constant of liquid (1.5-3.0 for hydrocarbons) and σ = liquid conductivity (S.m^{-1}). Note 1 pS.m^{-1} = 10^{-12} S.m^{-1}.

As a useful general rule, with liquid flow through conducting and earth-bonded pipes to conducting, earthed tanks, a liquid with a conductivity greater than 500 pS.m^{-1} is not expected to produce an electrostatic hazard. With liquids of conductivity up to 500 pS.m^{-1} electrostatic hazards can arise particularly in processes where there is limited contact with earth such as plastic pipes and tanks. In either case, unless the conductivity can be raised above these thresholds (e.g. by use of anti-static additives), additional precautions may have to be taken.

Specialist information and advice on all aspects of electrostatics may be obtained from:

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7. Interpretation of Results

Further information can also be found in the European Code of Practice and other international Standards. An appropriate document for reference is PD CLC/TR 50404:2003 'Electrostatics – Code of practice for the avoidance of hazards due to static electricity' (CENELEC – European Union Committee for Electrotechnical Standardization).

It is important to note that this equipment is not certified flameproof or intrinsically safe for use in the presence of sensitive flammable atmospheres. Although it is unlikely to produce an ignition hazard, it should not be used in an environment where flammable concentrations of gas, vapour or dust clouds are present.

8. Specification

Metering cell volume:	36 ml
Cell constant:	3.5 (conductivity = 3.5/sample resistance)
Electrode spacing:	10 ± 0.8 mm
Bias voltage:	5 V DC
Total measurement range:	0.1 pS.m^{-1} – 1.0 x 108 pS.m^{-1}
Power supply:	Internal rechargeable battery cells and mains 110-240 V, 50-60 Hz
Time for full battery charge:	16 hours (overnight)
Low battery:	Indication on digital display
Extras:	Spare metering cell (not included in basic kit) Low-volume metering cell (not included in basic kit)

For more information about static and to view the full range of our products, please visit **www.fraser-antistatic.com**

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