Visit to Adelaide Airport

[Insulation Testing article]

A visit to Adelaide airport to inspect Ansett□s aircraft maintenance facility is being planned. This will be a "walk and talk" type of visit and by necessity of schedules the visit cannot start until 9.00 PM. This would be preceded by drinks perhaps in the airport club from 7.30 PM.

We need to know firm numbers for this visit so if you are interested in attending could you please contact Adrian Richards at TQEH with expressions of interest by 24 June 1998.

Annual General Meeting

The AGM will be held on Tuesday 18 August 1998 at the Repatriation General Hospital. More details will be provided in the next newsletter but mark this date in your diary.

Nominations are also being called for the positions of President, Secretary, and 2 councillors.

A nomination form is at the end of this newsletter. Nominations must be with the secretary by Friday 17 July 1998.

The following article is from Mark Littlejohn of Electrolab Medical. Mark may be contacted on

(02) 9681 6770 regarding any aspects of this article and on test equipment that is now available.

Insulation Testing

What is meant by insulation testing? What are we testing and how do we do it?. There are properties other than resistance determining the insulation value of a material. These are dielectric strength, tracking, permittivity and loss tangent.

Resistivity: I am sure none of us need an introduction to a resistor. There is volume resistivity and surface resistivity. These are affected by moisture, and the nature of the material used as an insulator.

Dielectric Strength: This is the property of an insulating material that enables it to withstand electric stress without failure. It is usually expressed in terms of the minimum electric stress (ie. potential difference per unit distance) that will cause failure or breakdown of the dielectric under specified conditions, e.g. shape of electrodes, temperature and method of application of test voltage.

Tracking: Leakage along the surface of a solid insulating material, may lead to carbonisation of the organic materials and conduction along the carbonised path. This will increase the leakage current leading to a degenerative process.

Permittivity: This property is specific to a material under given conditions of temperature, frequency, moisture content, etc. When two or more dielectrics are in series and an electric stress is applied across them, the voltage gradient across them is inversely proportional to its permittivity. This is particularly important when air spaces exist, as the permittivity is always higher than that of air. Hence, air will have the higher stress.

Dielectric Loss: A capacitor with a perfect dielectric material between its electrodes and with a sinusoidal waveform applied, takes a pure capacitive current I=wCV with a leading phase angle of **90^o.** In a practical sense, conduction and hysteresis effects are present, the phase angle is less than **90^o** by a normally small angle & .The power factor is approximately given by tan& and is called the loss tangent. The power loss is a close approximation to $P=V^2 2\pi$ fCtan&. The loss tangent varies with frequency and temperature, particularly when moisture is present, in which case the permittivity also rises with temperature. This is often the basic cause of electrical breakdown in an insulator under AC stress, especially if it is thick, as the losses cause internal temperature rises with a consequential increase in the dielectric loss. This action becomes cumulative and results in thermal instability and finally breakdown (and possibly tracking as above).

This effect has been demonstrated in insulation used on a particular electrosurgical accessory with open circuit voltages as low as 600V.

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<u>Air as a Dielectric</u>

Air is the most important gas used for insulating purposes having the unique features of being universality and immediately available at no cost. The resistivity of air can be considered as infinite under normal conditions when there is no ionisation. There is no measurable dielectric loss, negligible tans and a permittivity of unity. in an airgap, the voltage gradient is greatest at the electrode surfaces. For plane gaps all exhibit a minimum breakdown voltage known as the Paschen minimum. This occurs at a given value of the product Pd of absolute gas pressure and gap length. For air this minimum occurs at Pd~6(torr-mm). At this point the voltage is approximately 33OVdc. This is a minimum and will increase with either an increase or decrease in pressure.

The breakdown voltage is therefore a non-linear function of its length. The shape of the electrode affects the voltage gradient in a particular area and a concentration will occur at sharp edges or points. The higher the permittivity the lower the voltage at which flashover is likely to occur.

If the breakdown voltage is exceeded, then an arc will be produced. An arc consists of a column of ionised gas ie. gas in which the molecules have lost one or more electrons, leaving positive ions. The electrons are attracted to the positive contact and move towards it very rapidly, the ions are attracted to the negative contact but as they comprise almost all the mass of the molecule, move relatively slowly. The electron movement thus constitutes the current flow. The current will tend to flow in a narrow path as the "magnetic pinch" effect means the parallel lines of conduction will act on each other and have mutual attraction, drawing them together.

Once the arc has started and a voltage gradient is maintained along it, the rapidly moving electrons collide with molecules of the gas and dislodge further electrons by collision. More and more current can thus flow and the resistance of the arc drops with increasing current so that the voltage across it drops only slightly (-dV/di).

If the current were to drop such that there is not sufficient electrons to maintain the ionisation process then the arc changes to a glow discharge and dies out. Ionisation is accompanied by the emission of heat and light.

Ionisation effects can occur in the insulation material itself, leading to breakdown of the long hydrocarbon chains (in the heatshrink type insulation), allowing conduction and tracking to occur. This means that insulation that can withstand >20kV for ***1*** minute may break down at a lesser voltage over a period of time. The time taken will be an exponential function of the voltage.

This would imply, therefore, that the insulation of an electrosurgery accessory will breakdown after a period of time.

Insulation breakdown can be due to the effects of moisture and temperature cycling in sterilising autoclaves, cuts, nicks, abrasion and electrical stress.

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Insulation Breakdown

The in-service testing of the insulation is therefore concerned with determining the breakdown voltage of the insulation. Leakage currents due to capacitance result from the design and would not be expected to vary markedly in use. Resistance testing is really only of use when looking for tracking over or through the insulation as the resistance of air, or indeed most of the insulation of interest would be unable to conduct sufficient current to cause significant injury without some failure of the insulation being present. Low voltage resistance measurement would not therefore be a good indicator of insulation quality. The breakdown voltage can be affected by quite a number of factors, and the resistance is practically indeterminate as it is negative ***(-dV/di).***

Negative resistance is an important property as it is the basis of simple oscillators. The spark gap itself can be used in a tuned tank circuit to produce a RF wave. It has also been the basis of spark gap diathermy used for coagulation. A current charges a capacitance (stray capacitance or otherwise) until the break over voltage is reached. The capacitance rapidly discharges and the dielectric again becomes an insulator. The effective series resistance in the charging and discharging circuit (the energy dissipated as light and heat), the capacitance and the break over voltage will affect the frequency. The measurement we are making is in fact determining the average current drawn by such an oscillator.

Note that the human body if insulated from earth has a significant capacitance. This capacitance can be charged to quite a high voltage by a current low enough not to be noticed. However, when the break over voltage is reached and the capacitance is discharged the effective series resistance may be quite low and the discharge current quite high. This current could easily be high enough to notice.

When using high voltage testing ensure that leads, etc are kept short and stray capacitance, etc is minimised. Never charge large value capacitors, as their discharge current could be lethal.

MEETING CALENDAR

Please mark the following dates in your diary. Technical meetings will be held in the 3rd week of the month. Where no date is set , this will be advised as soon as possible as will the topic of the meeting.

June 23 June J&J Monitoring and Dr John Russell

July

Tuesday 18th August 1998 Annual General Meeting

November 15th - 19th 1998 Conference , Tasmania

Tuesday 1st December 1998 Christmas Dinner

CONFERENCE CALENDAR

2nd -8th August 1998 Third World Congress on Biomechanics , Hokkaido University , Japan

29th October -1st November 1998 20th Annual International Conference of the IEEE Engineering in Medicine and Biology Conference-Biomedical Engineering Towards Year 2000 and Beyond , Hongkong. http://www.ee.cuhk.edu.hk/embs98.html

15th - 19th November 1998 EPSM98 "Relevance Beyond Rationalism" Hobart , Tasmania

Information on the above are available from the editor or president.

E.& O.E.

NOMINATION FOR COUNCIL POSITION 1998/2000

I ....nominate ....
for the position of

President/Secretary/Councillor (circle one) for the term 1998/2000.

Signed ....nominator.

....seconder.

....nominee.

Please have nominations with secretary by COB Friday 17 July 1998.