MATELECT
ACPD Depth Probe
TYPE MAT-3

INSTRUCTION MANUAL

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ACPD DEPTH PROBE MAT-3

This product has been designed to the highest standard in both electronic and mechanical design, with careful attention to stability, reliability and electrical safety.

The MAT-3 handheld probe is designed exclusively for use with the CGM series of crack growth monitors that have established themselves as the world's best selling laboratory ACPD equipment by far. Matelect produce a range of other peripherals to support the CGM series of instruments and have also built up many years of experience in the ACPD technique. Please contact us should you ever require further information or assistance.

This manual applies to the MAT-3 hand held probe. Other manuals can be obtained from Matelect at the address given below.

IMPORTANT

Please read these instructions carefully before you use the instrument. Please pay particular attention to the section that follows on the method of use.

Please note that there are no user serviceable parts within the MAT-3 probe. Never attempt to open the probe as this will void any warranty. Please contact Matelect should you ever experience any difficulties.

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OVERVIEW

Matprobes are accessories that enable the Crack Growth Monitor (CGM) user to obtain crack depth data in the field without the need to provide permanent contact to a specimen. Spring loaded pins are utilised to form some or all of the contacts necessary for operation. The probes are designed to be used as handheld devices although it is possible to incorporate them into other apparatus to maintain fixed geometries (e.g. for use on a production line).

It is important to note that the CGM series of crack growth monitors have been primarily designed for accurate ACPD monitoring in controlled laboratory conditions. Crack growth resolutions of the order of tens of microns can be achieved by careful experimentation in such environments. Unfortunately use of the Matprobes to measure depth can never achieve such results and tens of millimetres is the usually accepted standard.

This instruction book applies to the Matprobe 3 (order code MAT-3)

QUICK GUIDE TO MATPROBE-3 USE

The following procedure has been designed to allow rapid measurement of crack depth using the CGM7 and MAT-3 handheld probe combination. The accuracy of this method is restricted to ±0.5 mm, which is sufficient for most fieldwork needs. No prior calibration is required.

Those requiring higher accuracies must follow the procedures outlined in the main section of this handbook. These procedures require a degree of calibration.

For Ferrous Materials (e.g. Plain Carbon Steel)

1. Power up the CGM-7 and connect the MAT-3 probe. Abrade and clean the specimen.
2. Set the current to 0.5 Amps, frequency to 10 kHz, mode to Polar, Offset to Off, and Filter to None.
3. Apply the probe by pressing down on a non cracked region - record the reading as 'B'
4. Apply the probe across the crack - record the reading as 'A'
5. Perform the following calculation (A-B)/B which will give you the crack depth in cm.

For Non Ferrous Materials (e.g. Aluminium)

1. Follow above procedure except set frequency to 30 kHz

Notes

The readings obtained are independent of set current and set gain so users can vary these if the signal is too low to give good accuracy or too high and being clipped.

Make sure specimen surface is bright and corrosion free - good electrical contact is a prerequisite of correct ACPD measurement.

Obtain multiple readings to increase the reliability of your measurements.

Please read the main text of this handbook and the instruction manual of the CGM7 to obtain further details on particular points of usage. Contact Matelect for advice and clarification on any aspects of ACPD measurement.

GENERAL DESCRIPTION

The MAT-3 handheld probe is an advanced crack depth measurement probe which is made up of an outer aluminium tube body and two PTFE inserts containing, a high precision pre-amplifier circuit as well as a detachable probe head that contains all the necessary contacts to pass both the current and pick up the resultant ACPD voltage signals.
Four spring-loaded pins form the contacts. Figure 1 shows the basic configuration of the MAT-3 handheld probe. The outer pins form the current contacts, whilst the inner pins are used to pick up the resultant PD voltage signals. A single lead attaches to the top of the probe that carries both the current to the probe head and delivers the resultant PD signal to the CGM unit for processing, the lead finally separates into two leads at the CGM end for attachment to the relevant sockets. All leads are terminated in standard CGM-7 Lemo connectors, if the user is using the unit with a CGM-5R or earlier unit then they must use the relevant adaptors provided by Matelect on request.

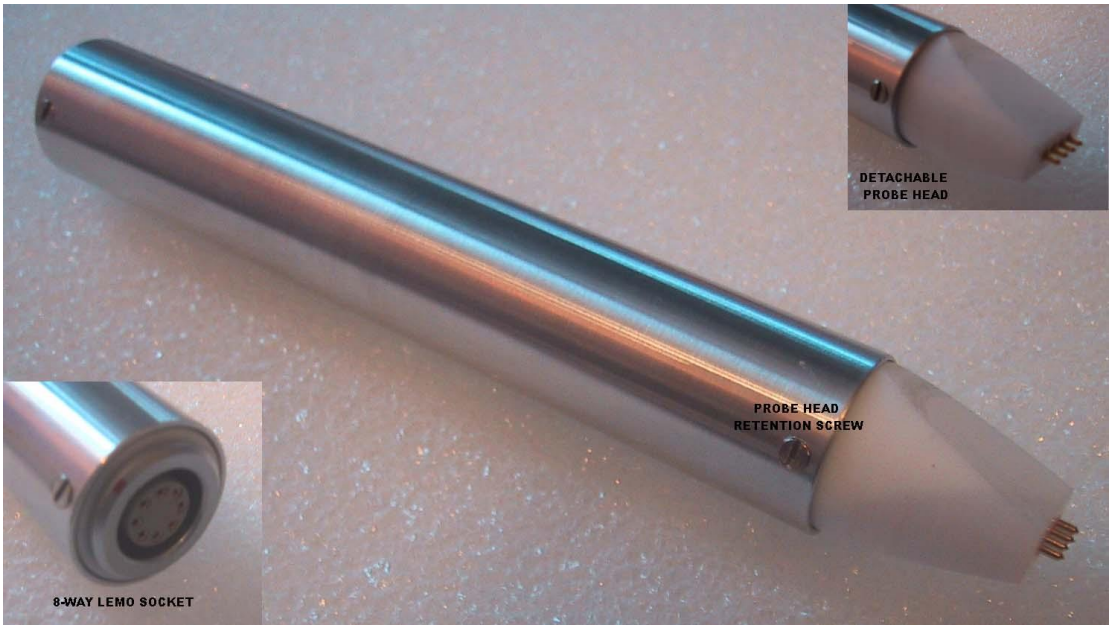

Figure 1 - Basic configuration of the Matprobe-2

The MAT-3 handheld probe is equipped with a number of unique features. It's detachable head allows users to design and implement their own designs for specific situations. The built in pre-amplifier reduces pick-up and the effect of lead movement, resulting in a more stable reading. Should customers wish to produce their own probe heads they are welcome to contact Matelect for help and advice on this matter.

PRINCIPLE OF OPERATION

Figure 2 illustrates the principle of operation of the MAT-3 handheld probe. The current contacts pass the AC current from the CGM through the specimen, the voltage drop (ACPD) across the surface of the specimen is measured using the central pins. The value of the ACPD will obviously be dependent upon a number of factors such as the test material's resistivity, magnetic permeability, the current, gain, offset and the frequency setting of the CGM, and the presence of a defect such as a crack.

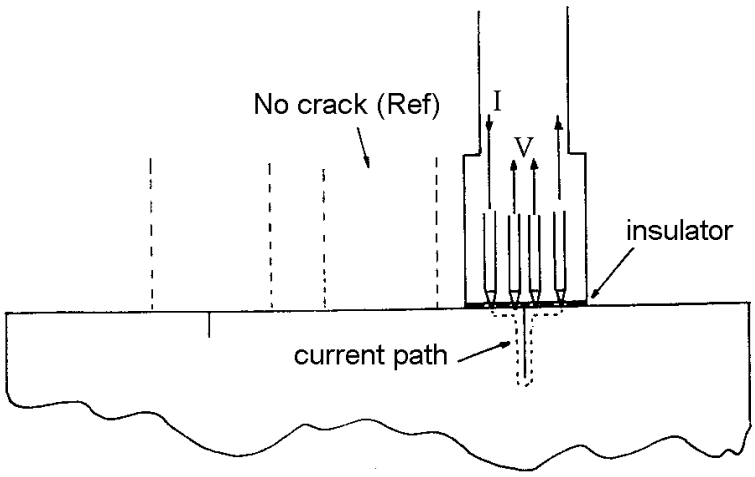

Figure 2 - Principle of Operation

In order to obtain a meaningful value of crack depth it is necessary to obtain both a value of the ACPD on a non-cracked area and the value over a crack. If we assume that the AC current is largely confined to the surface of the specimen, then the ACPD measured will be proportional to the path length between the probes. Cracks act to increase the path length and a simple subtraction of the two results obtained will yield a value proportional to the crack depth.

This simple approach can be extended to give a theoretical value of the crack depth in true units. Referring to figure 3, if we assume that the spacing between the probes is 'L' mm and the depth of the crack is 'd' mm then by the treatment shown,

$$d = L\frac{(A - B)}{2B} \qquad \textit{(Equation 1)}$$

This method has the added advantage of compensating for different materials and for changes in the material properties due to variation in temperature, since (A-B) is effectively normalised by the division by B.

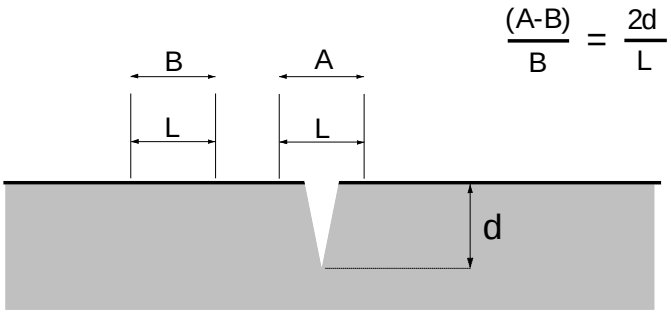

Figure 3 - Crack Depth Calculation

Whilst the last method is the one recommended, it does not, unfortunately, lead to an absolute value of crack depth. This is primarily due to a phenomenon known as pick-up. Pick-up (PU) is a term used to describe a voltage induced in the leads carrying the ACPD signal by the action of the AC current flowing through the current carrying leads and the specimen itself. The actual ACPD voltage measured is therefore not a pure specimen signal but a resultant of the true ACPD and the PU.

Complete removal of PU is not easily achieved, although the Matprobes have been designed to minimise PU. Additionally PU varies with the frequency of the AC current used and with the geometry of the measuring system. Assuming measurements are made at the same frequency, then it is important to maintain the test geometry. In the case of the MAT-3 handheld probe this restriction has been removed since the position of the current leads, with respect to the voltage leads, is always kept constant. Complete freedom of movement is thus possible. The MAT-3 handheld probe is therefore considerably easier to use than traditional two pin probes.

The treatment of the PU problem is complicated and will not be discussed in detail here. Importantly, even if the PU is constant, the crack depth calculation will yield a value that depends on the strength of the PU. Consequently the calculated depth varies with the frequency of the AC current. In the case of the MAT-3 handheld probe, this variation has been found to be reasonably linear when plotted on a log scale.

Fortunately the user can still make adequate crack depth measurements as both theory and experiment indicate that the calculation yields a value that is approximately linear with actual depth for any particular frequency of AC current. A crack will therefore register half the value of another crack that is twice as long.

In consideration of the above it is clear that for absolute crack depth determination a method of calibration is needed. This can most easily be achieved by making a series of saw cuts within specimens of similar type and geometry, to predetermined depths. The actual depths can then be related to the calculated depths via use of the Matprobes.

METHOD OF USE

1. Connect the MAT-3 handheld probe to the current and voltage sockets of the crack growth monitor, the Lemo connector goes to the current output socket and the black Lemo connector goes to the signal input socket, the other end of the cable should be connected to the top of the probe. Switch the instrument on and set the current to about 0.5 Amps. Select a suitable frequency (depending on the specimen material). Steels usually yield adequate signals between 0.3 and 10 kHz. Non-magnetic materials require higher frequencies. Remember increasing the GAIN setting on the CGM can boost low signals. It is useful to note that this is better than increasing the frequency since PU rises with frequency.

2. Make sure any oxide or surface deposits have been cleaned from the areas where electrical contact is to be made. Use abrasive paper as necessary to clean the surface.

3. Place the MAT-3 handheld probe on the specimen on a non-cracked area and push down until the probe body is in contact with the specimen surface. Indication of a reliable contact is given when the current display on the CGM-7 has stopped adjusting and is within 1mA of the user set current. Additionally the user should wait until a steady reading on the LCD is obtained. Note down the reading. Follow the same procedure for the cracked region, making sure that the voltage contact correctly straddles the crack. Perform the calculation of equation 1 (page 6) where L is 3.2mm. A suitable configuration for the probe and leads is shown in figure 4.

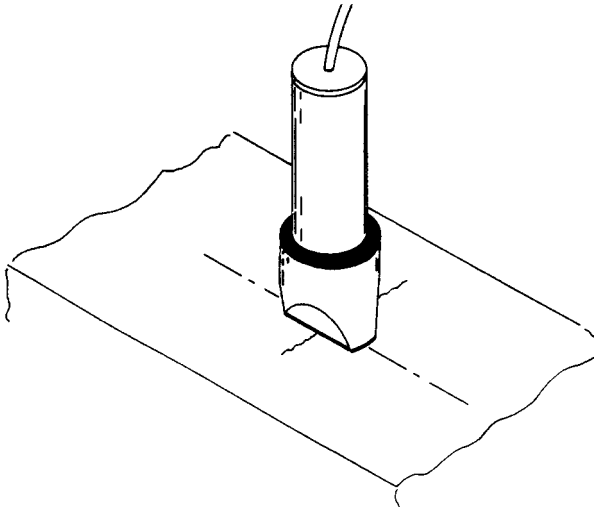

Figure 4 - Suggested measurement configuration

4. Use the method above to obtain a set of results for a series of standard saw cut cracks. The values obtained can be plotted as a graph and will act as the calibration for measurements on real cracks.

PRECAUTIONS IN USE

The reliability of the results obtained will depend on the mode of use of the Matprobe. The elimination of error due to the PU effect greatly simplifies the use of the MAT-3 handheld probe and increases the reliability of the results. Edge effects can sometimes be a problem and the user should note that readings of crack depth taken very near the edge of a specimen can sometimes be subject to error.

The following additional precautions should be observed.

Keep the probe pins and the surface of the specimen clean and free from deposits during use. This ensures that the contact resistance between pin and specimen is kept to a minimum. Contact resistance can sometimes affect the signal value if it approaches too closely the input impedance of the CGM.

If the pins have worn tips or damage has occurred to any part of the probe or leads please do not attempt to open the probe or perform repairs. The probe has not been designed to be dismantled easily. All Matprobes are warranted for 1 year and a comprehensive repair/renewal service is provided at minimum cost after expiry of the warranty. Please contact Matelect for details. The replacement of probe pins however can be done by the customer again please contact Matelect for further advice.

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