ACFM Inspection Procedure

for U31 and QFMu

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Document: TSC/MCS/1523
Date: 04 March 2003
Issue: 1.1 (2)
Revision: 1

Document Revision Approval Sheet

6 Mill Square, Featherstone Road, Wolverton Mill,
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KEYWORDS:

Controlled Copy: Yes No

TITLE:

ACFM Inspection Procedure for U31 ACFM Instrument and QFMu

Document: TSC/MCS/1523

1.1 (2)	MCS	MCL	MCL	update for 3.2b - new probe change procedure	04 March 2003
1.0 (1)	MCS	MCL	MCL		26 April 2002
Issue(Rev)	Initiated by	Checked by	Approved by		Date

Issued Document Revisions

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Introduction

Overview

This document describes the inspection procedure to be used with the U31 Underwater ACFM instrument for manual inspection with standard probes. These probes are designed to be deployed by diver, with data collected and sent to a controlling PC. An example system is shown below.

This procedure has been written for use with version 3.x of the QFMu inspection software on a PC running Windows 9x / ME / 2000 / XP or NT. To check the version of software in use, select the "About..." option in the "Help" pull-down menu in QFMu.

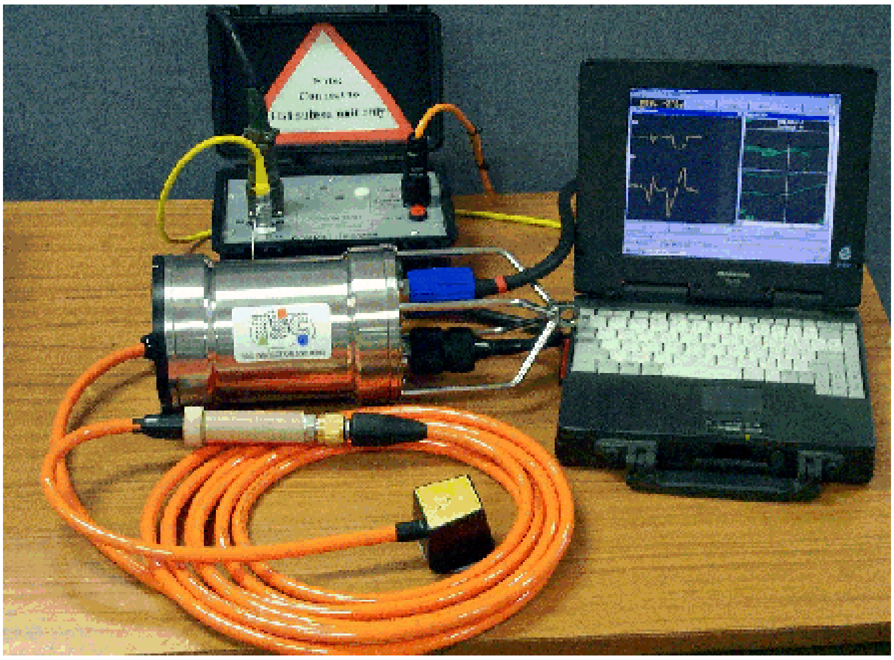

Figure 1. U31 instrument with Topside Unit, Weld Probe and laptop PC

Introduction to ACFM

The A.C. field measurement (ACFM) technique was developed from the A.C. potential drop (ACPD) technique which has been used for crack sizing and crack growth monitoring. ACPD has been used underwater even though electrical contact has to be maintained between the probe and the component being inspected. The ACFM technique is simpler in operation as it depends on the measurement of the near-surface magnetic fields rather than the surface electric fields, thus requiring no electrical contact. Theoretical work carried out at the Wolfson NDE Centre in the Mechanical Engineering Department of University College London determined the relationship linking these two fields. Thus existing models of electric fields around cracks can be used to size cracks using magnetic field measurements. This non-contacting sizing capability relies on the use of unidirectional input current in the region under inspection, similar to that required for the

ACPD technique. For the ACFM technique, the input current is induced into the specimen thus making the system fully non-contacting.

In single probe ACFM operation the Crack Microgauge passes two signals to the ACFM crack detection and sizing software (QFMu). The first is the magnetic field strength measured in the direction parallel to the crack edge (Bx) and the second is the magnetic field strength measured in a plane perpendicular to the surface of the metal (Bz). The software (QFMu) then displays these signals in three forms; the Bx and Bz traces separately against a timebase, a dual digital meter display, and a polar plot display in which one component is plotted against the other. This latter form is known as a butterfly plot because of the characteristic trace produced by a defect.

For more information, refer to TSC's introductory literature.

The ability to size surface breaking cracks without cleaning the weld region down to bare metal offers significant potential benefits over existing techniques such as magnetic particle inspection, ACPD and eddy currents. As well as allowing crack depth estimates to be made (for ferritic materials), the use of a unidirectional input current provides further practical benefits. Firstly, the decay in strength of the input field with probe height is relatively small so that variations in signal with probe lift-off are reduced. Secondly, the current flow is arranged normal to a weld toe or other material discontinuity so that there is no perturbation in current direction and hence no signal from the interface due to a change in material property. A final benefit is that the technique requires no calibration for sizing. Techniques requiring calibration rely on the measurement of signal strength on a standard notched sample. For weld inspection the standard block is invariably of different material to that at the crack location leading to errors in interpretation.

Description of Hardware

The ACFM Probes

Each probe contains a sensor coil pair consisting of a Bx coil and a Bz coil wound concentrically. A field induction solenoid is housed in the top of the probe body.

Standard weld probes (type 293) should be used for all inspections where access and local geometry allows. If the chord-to-brace angle is too small to allow access of the standard probe, a tight access weld probe should be used (type 312). It is important that a tight access probe is not used in geometries with a chord-brace angle of more than 90^{o} because this results in a lower detection sensitivity compared to a standard probe. The tight access probe relies on the proximity of both chord and brace to induce a strong uniform field across the weld. A pencil probe (type 303) should only be used for inspecting ground out regions or other geometries where a weld probe cannot gain access.

Miniature pencil probes are also available for very restrictive geometries (type 291 with right angle cable entry, type 292 with straight cable entry). These probes are inevitably more prone to probe rock and lift-off than other types of probe, and should only be used when absolutely necessary.

Note that the type number for a particular probe is included on the label. If there is any doubt about a particular probe, refer to T.S.C.

Other special probes, including probes for detecting and sizing small defects, can be made to order if required by TSC.

Topside Unit

The Topside Unit acts as the interface between the software running on the controlling computer and the subsea unit. It contains a microprocessor that handles the conversion in serial communications between RS232 from the computer and RS485 to the subsea unit. It also supplies power to the subsea unit and provides a 110V output to power the computer.

Under no circumstances must the Topside Unit be connected to any device (e.g. computer) which is powered from another source, unless that source also has RCD protection.

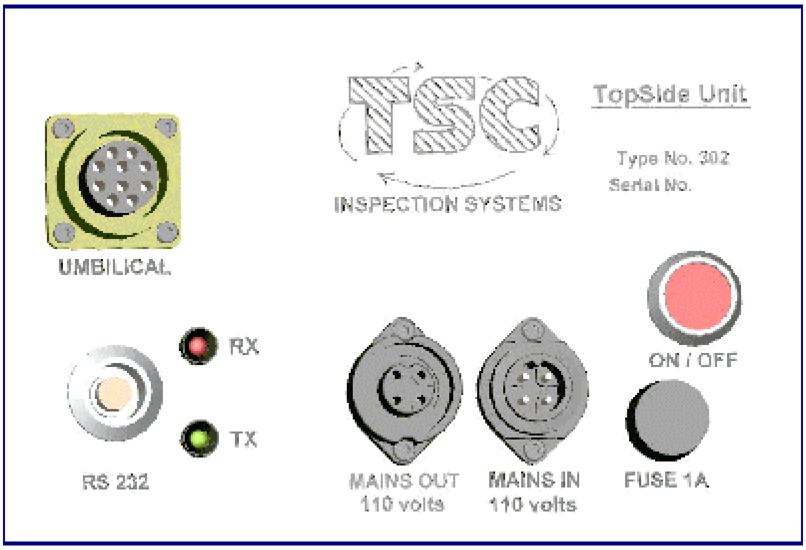

Figure 2. Layout of front of topside unit

The topside unit is housed in a case that is IP54 rated and the unit can withstand rain from above when stored or in use providing that all connectors or blanking plugs are used. The front panel has the following features:

- On/Off button which turns power on to the internal electronics and microprocessor. When switched on, mains power is also routed to the Mains Out socket and DC power is sent to the Umbilical connector. Thus, if the subsea unit is connected via the umbilical, this is powered up at the same time.
- Mains in - 4-way panel-mounted plug for connection to 110V AC supply. Connection to mains power must be through the in-line RCD supplied with the system.
- Mains Out - 4-way panel-mounted socket for output of 110V AC supply to computer. The computer should be connected to this socket rather than to a separate mains connection to maintain protection from the RCD.
- Umbilical socket - 12-way Amphenol socket used to connect an umbilical cable to the subsea unit. The umbilical takes DC power to the subsea unit and carries RS485 communication lines between the topside unit and the subsea unit.
- RS232 socket - 6-way Lemo socket used to connect the RS232 serial communications cable to the associated computer running the QFMu software. The other end of this cable is a 9-way 'D' connector which plugs into the serial port (Com1:) on the computer.
- TX - Green led which flashes when the topside unit sends data to the subsea unit.
- RX - Red led which flashes when the topside unit receives data from the subsea unit.

Sub-Sea Unit

The subsea unit houses the electronic instrumentation which generates the field signals for the probes and samples and digitises the raw ACFM signals detected by the probes.

The subsea unit has just two connectors. One, labelled Umbilical, is an 8-way Wet-Con plug for connection of the umbilical cable from the topside unit; the other is a 16-way socket for connection of a probe. Both connections should made prior to the subsea unit being put underwater. The probe can be disconnected underwater to allow a different one to be used, but **the probe socket power must be turned off, using a button in the software, while the change is made**.

All connectors must be cleaned with fresh water at the end of a shift and should be lubricated using silicon spray.

Figure 3. U31 Subsea bottle

Routine Maintenance and Handling

Before carrying out any of the following maintenance, *Switch off Mains Power at Topside Unit*

Connectors

1. Clean subsea unit with fresh water after each dive while probe and umbilical are still connected.
2. Always keep connectors covered when not in use to avoid contamination - do not allow to 'dry out' by long exposure to heat and sunshine!
3. Lightly lubricate the connector pins with silicon spray on the rubber part only.
4. Check cleanliness of contacts.
5. Use warm soapy water with cotton buds to clean female Wetcon connectors.
6. Before each dive, visually check the connectors, particularly with regard to splits or mechanical damage.

Subsea Unit and Umbilical

1. There are no user serviceable parts in the subsea bottle. Opening the bottle will invalidate the warranty. Always use 110V AC supply to topside unit.
2. The system must never be used without RCD protection.
3. The umbilical is a special cable and must not be substituted or shortened.

Handling of unit

1. Never use the umbilical to lift the subsea unit. A separate lift line should be used and attached to the lifting eye on the top of the unit.
2. Never put strain on the probe or connectors. Always use "tie wraps" to provide strain release in case of accidental tension being applied to the cables.
3. Avoid bending the connectors where they are attached to the bottle.
4. If the umbilical is damaged, refrain from using the unit.

***** IF IN DOUBT, REFER TO MANUFACTURER *****

Annual Maintenance

It is recommended that the unit is returned to the manufacturer annually for a routine check and issue of new Certificate of Conformance. It is also recommended that the connectors are replaced at this time if they show signs of degradation.

Manufacturers Contacts

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Inspection Requirements

Introduction

This procedure has been developed to enable underwater ACFM inspection to be carried out. Although it has been developed primarily for the inspection of uncoated tubular welded connections, additional procedures have been included for other situations including coated structures, ground-out regions, and structures containing plate to plate welds or stiffeners. For inspection using special-purpose probes or of any geometries not covered in this document, please refer to TSC.

This procedure should only be used once the operator/supervisor is fully familiar with the following documents:

1. QFMu Software User Manual Level 1.
2. U31 User Manual (TSC Doc. No. 1522).
3. An Introduction to Underwater ACFM. Document MCL/0581 Revision 1.008, 10 April 1992.

Note: QFMu User Manual Level 1 is intended for use by Level 1 (Inspectors) in order to collect, store and analyse data. The QFMu User Manual Level 2 is intended for use by Level 2 (Supervisors) allowing them to change the parameters of the probe set-up and instrument control and to overwrite data files.

Personnel Required

ACFM Operator — Experienced operator holding a CSWIP ACFM Level1 certificate or a Lloyds ACFM certificate. Access to a CSWIP Level 2 is required if complex welds or interpretation difficulties are encountered. If there is no Level 2 on site then reference may be made to ACFM supervisory staff within TSC (see "Manufacturers Contacts" on page 6).

Probe Operator — For subsea operation, a diver qualified to CSWIP 3.1U who has received training on probe handling and scanning procedures and for whom the TSC Probe Operators check list has been completed.

Whenever remote probe operators are used, continuous audio communication is required to enable the ACFM operator to lead the inspection and for the probe operator to be able to report back on any local factors influencing the inspection.

In addition, if an inspection is carried out with divers then a diver helmet-mounted camera system must be used to enable the ACFM operator to supervise the subsea inspection site.

Operators holding certification from other recognised Qualification / Certification schemes than the above may be considered suitably qualified, however they should contact the qualification body responsible for the inspection site for official approval.

Equipment Requirements

The following equipment list is not an exhaustive list of equipment that may be needed for a particular job but does highlight essential and recommended equipment that will be needed as a minimum.

- U31 Crack Microgauge including Subsea Bottle, Topside Unit
- Test Umbilical
- Main Umbilical (150m), 1 or 2 off depending on requirements
- 240V to 110V transformer (optional depending on local supply)
- Topside Unit power cable
- RS232 Serial Communications cable
- ACFM Probes – Weld probe (type 293) plus other types selected according to geometry and use
- Transit Case
- Marker Pencils / chalk (Box) or magnetic arrows
- Ruler / Measuring Tape
- Function Check Block of the same material type as that to be inspected.
- Laptop portable PC with 3.5" Floppy Disk Drive (A:) and RS232 comms port on 9-pin 'D' connector, running Windows (9x, ME, 2000, XP or NT) and QFMu Software v3.x installed on hard disk.
- Spare Computer Battery and Charger
- Probe File Disk for all ACFM Probes*
- Box of Formatted Floppy Disks or other storage media appropriate to the computer
- U31 User Manual
- QFMu Vn3.x Software Manuals Level 1 and 2
- TSC ACFM Report Sheets

*N.B. The TSC issued probe files delivered with the probes are set up for use on ferritic steels. If they are to be used on another material they may need to be modified to ensure that the signal levels obtained are correctly displayed on the screen. The procedure for doing this is described in the Level 2 Software User Manual.

Inspection Considerations

Probe Deployment Considerations

Cleaning

The surface must be cleaned sufficiently to allow smooth probe travel and to allow features such as grinds or seam welds to be seen. This requires removal of marine fouling and flaking paint or corrosion for which use of a wire brush, hand scraper or water jet is normally sufficient. It should be noted that cleaning to bright metal is not required.

However in some locations, particularly in warmer waters, marine growth can be hard and thick. In such cases it will be necessary to use grit blast cleaning.

The system operator shall confirm that the surface condition is acceptable prior to carrying out the inspection, using information supplied by the diver and the divers video camera.

General Considerations - All Welds

The following notes on probe deployment describe how to inspect welded components for fatigue cracks where it is assumed that defects will closely follow the weld line. The technique relies on recognition of the signal from a probe scan along the length of a defect, so an ACFM probe is always scanned along a line parallel to the weld. For this reason, defects that lie at an angle of more than about 25^{o} to the weld may not be detected. If inspection for transverse defects is required, refer to the procedure in section "Transverse Cracks" on page 14.

Standard weld probes should be used for all welds where access allows. A pencil probe should only be used for inspecting ground out regions or other geometries where a weld probe cannot gain access.

The recommended scanning speed is about 10mm per second. The standard probe scans a width of approximately 20mm. Scans should always be made along both weld toes and, if wider than 20mm, the weld cap should also be covered by making a number of passes sufficient to cover the weld cap width taking into account the coverage of the probe.

Finding the Plane of a Crack

If a defect indication is found during a weld toe scan, repeat the scan 10mm away from the toe in the relevant plate and in the first interbead root on the weld cap to confirm the crack identification and to identify whether the crack indication is due to interbead cracking. If the indication in the parent plate is of similar amplitude to that of the weld toe, it is likely to be due to Seam Welds, Surface Grinding or Work Hardening. Note that a seam weld may have been ground off and so not visible. Conduct another scan 20mm from the weld toe to confirm this observation. If the indication during the bead scan is larger than that observed during the weld toe scan, the defect must be in a weld cap. Repeat in the adjacent roots until the defect indication is greatest. The root giving the greatest signal is the root containing the defect. Note that interbead cracking often jumps between beads, which will result in a sudden drop in the signal from one bead coinciding with a sudden rise in the adjacent bead.

Cracking into Parent Plate

In some geometries, especially tubular intersections, long defects that start growing along a weld toe can deviate into the parent plate. This will show itself as a sudden drop in Bx with no corresponding Bz peak or trough. In this case, scans should be made on the parent plate, along the expected defect line, to find the defect's end.

Through Cracking

Where the crack depth calculated is greater than the plate thickness this indicates that cracking may be completely through the weld and so the diver should be asked to look for further evidence of this. Such evidence may be visual crack opening or, if the back face is accessible (e.g. on flat plates), crack-like indications there.

Circumferential Welds - No Ground Out Regions

Where the length of weld to be inspected is greater than 400mm the weld should be marked up into smaller lengths which overlap. (Longer scans tend to be more difficult for the diver to perform, therefore increasing the chance of probe lift off etc.). The measurements from a datum to the four cardinal clock positions should be recorded. The location of any features that affect probe movement or probe signal should be reported (e.g. the position of a seam weld that joins the weld under inspection, or the presence of weld spatter).

When a crack is located it should be re-scanned in more detail by scanning the defect area plus 30mm before and after each end at a slower scan rate. The crack tips should be located and marked and surface breaking crack length reported to the ACFM operator. The circumferential distance from a datum (e.g. 12 o'clock position) to one end of the crack should also be noted.

If the weld is to be ground out to remove the defect the estimated depth using ACFM should be the depth to which the first grind is made. Before grinding takes place the defect plus 30mm either side should be scanned with a Pencil probe for later comparison. After grinding the grind should be re-inspected with the same Pencil probe to ensure the defect has been removed (the pencil probe type selected for the pre-grind scan should therefore be chosen to fit into the subsequent ground area).

Inspecting Ground Out Areas

Welds that have been ground to remove defects require the use of a Pencil probe. A pencil probe is necessarily easier to tilt or rock than a weld probe and so extra care must be taken during a scan to ensure that this does not happen. The first scan with the probe should be with the probe axis perpendicular to the root of the grind. The weld should be scanned such that at least 30mm either end of the ground out region is scanned. If a defect signal is found two further scans should be performed to determine whereabouts around the grind the defect is located:

a) Probe axis at $+30^{o}$ angle from the normal to the root of the grind.

b) Probe axis at -30^{o} angle from the normal to the root of the grind.

The maximum signal perturbation should be used to determine crack depth and should also indicate the location of the defect in the ground out channel.

The ground out region of the weld should be marked at suitable intervals (e.g. 20mm) which should be called to the ACFM operator as the probe scan passes each mark. A measurement of length from a suitable datum (e.g. 12 o'clock position) to the weld grind marks should be made and also reported to the ACFM operator.

Where the geometry of the grind start or finish is sharp this may obscure small defects. The ACFM operator will advise whether further grinding is required to smooth off the edges of the grind to give good probe movement and signals at the grind start.

Inspection During Grinding

If a detected defect is to be removed by grinding, a scan of the defect using a pencil probe must be made prior to any grinding. This provides a baseline for comparison, removing the effects of variations in sensitivity between different probes. The whole of the grinding process should be monitored with the same probe.

Between grinding passes, the defect should be rescanned. Particular note should be made of the position of the defect in the grind profile, to ensure that the grind follows the defect even if the defect curves away from the expected direction.

The ACFM operator should note changes in the ACFM signal between grinding passes, such as changes in length, or splitting into two or more separate cracks. An apparent increase in length or depth may indicate a sub-surface or branching crack.

If MPI is being used in addition to ACFM, care must be taken when comparing the results for sizing purposes. Refer to the section "Length Sizing With ACFM" on page 24 for the procedure to be followed in this case.

Inspecting Flat Plate Welded Supports/Stiffeners

Full geometry detail is required by the ACFM operator before scanning can commence. As with tubular components, the standard weld probe should always be used where geometry allows and other probe types only used where necessary.

The use of a uniform input field, which allows defect sizing, means that the standard weld probe picks up strong signals from sharp geometry changes such as plate edges, corners and rat-holes. This edge effect occurs when a probe is used within a certain distance of the edge, the distance being roughly equal to the width of the main part of the probe body. Thus a standard weld probe will pick-up edge signals when the mid-point of the probe is within about 50mm of the edge. A pencil probe also experiences edge effects, but to a much lesser degree. Mini/micro pencil probes can be used up to about 10mm from an edge.

The presence of an edge does not preclude the use of standard probes but signal interpretation is not so easy. The effect of an edge is to superimpose a general slope in probe readings that will increase in gradient as the plate edge is approached. For detection, this has the effect of separating the signal from either end of a defect on the butterfly plot so that the loop formed is not closed. Where cracks are located within 50mm of a plate edge the depth of the defect should be calculated using an estimate of what the background Bx would have been at the centre of the defect, as shown below.

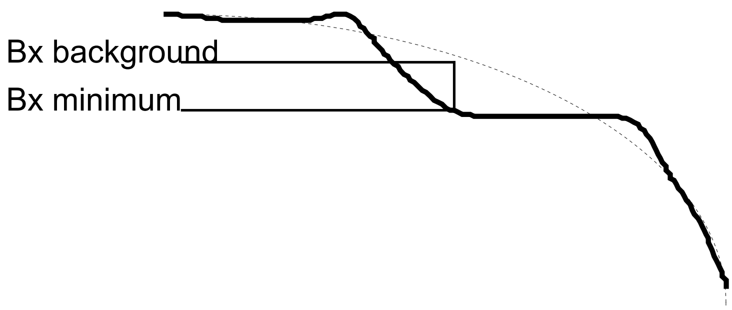


Figure 4. Bx background and minimum values to be used near a plate edge.

If there is not too much curvature in the signal, this background Bx is best estimated as an average of the Bx values either side of the defect.

Instead of clock position marking, the weld to be inspected needs to be marked off in suitable linear intervals (maximum 100mm).

Rat-holes and plate ends

On rat-hole specimens with full welds (as shown in Figure 5), the mini pencil probe should be used if the weld lengths involved are all short.

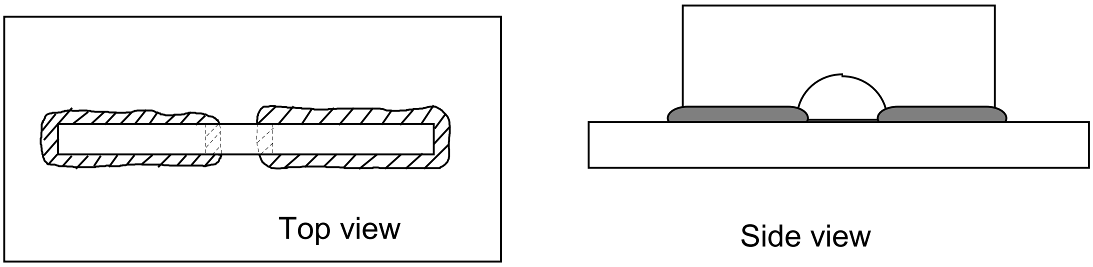


Figure 5. Views of rat-hole with complete welds (welds shown hatched)

The probe should be first used to detect longitudinal defects in a series of 6 scans as indicated in Figure 6. The scan directions are such that the probe is always moving in the 'C' direction so that a defect will be indicated by a clockwise going loop in the butterfly plot. Note that when the probe leaves or approaches a weld, a change in the Bx level is seen. There is no significant associated change in Bz however, so the signal should not be confused with a defect signal.

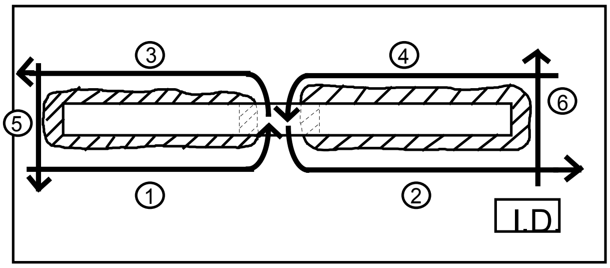


Figure 6. Detection scans 1 to 6 for rat-hole specimen with complete welds

With any scan, a defect lying wholly along the scan path will give a complete loop. However a defect leaving the scan path will give a lop-sided loop because one or both of the defect ends may not be covered. A defect leaving the scan path will show a sudden return in Bx to the background level but no accompanying Bz peak or trough.

Scan 1, for instance, starts on the parent plate about 25mm from the corner of the weld. A defect running into the parent plate from the weld toe (marked as A in Figure 7) will thus give a complete loop as shown, while a defect that follows the weld toe round the corner (marked as B) will give a lop-sided loop.

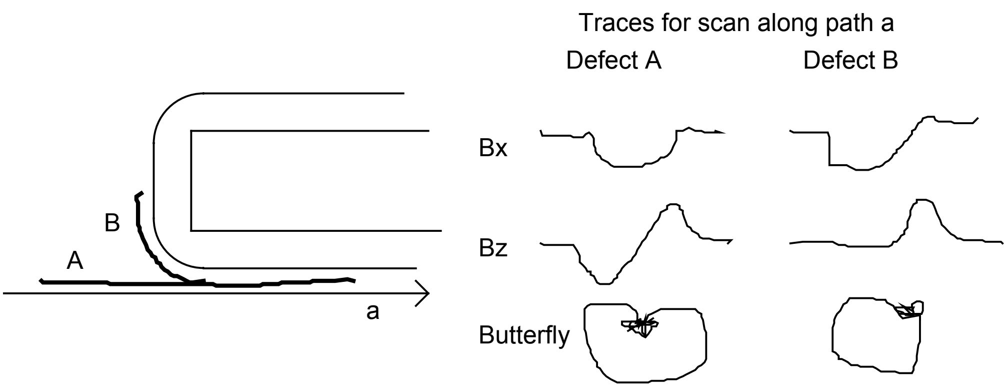


Figure 7. Comparison of signals from a defect that follows weld to one that leaves weld

Similarly, the end of scan 1 in Figure 6 follows the weld toe round to the mid-point of the rat hole, so a defect following the weld toe will give a complete loop, while a defect continuing into the parent plate will give a lop sided loop. In either case, a later scan should be taken along the suspected line of the defect to confirm the defect and to size it.

Scan 5 (or 6) will give a complete loop for a defect running into the parent plate. For a defect running around both corners, only a dip in Bx will be seen coinciding with the extent of the weld. In this case, the defect ends will be seen in scans 1 and 3 (or 2 and 4). Again a scan around the weld corner must be made later to confirm the defect. When no defect is present, scans 5 and 6 show a low peak in Bx. This produces a dent in the trough produced by a defect as shown in Figure 8.

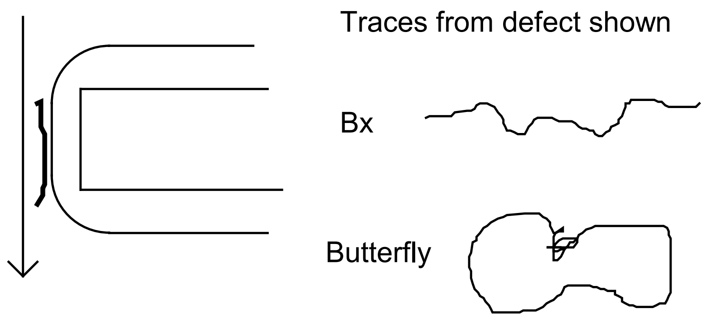


Figure 8. Signal from a short defect at a free plate end

Finally, scans should be made as shown below in Figure 9 to detect defects growing into the parent plate from the rat-hole welds. On specimens with large rat-holes, the scans can be combined into two scans (i.e. join 7 and 8 together, and 9 and 10). For smaller rat-holes, the right-angled mini pencil probe should be used. The scans should be continued into the parent plate until the traces become flat - i.e. about 25mm if no defect is present. Four scans will be necessary for specimens with very small rat-holes where there is insufficient room for the probe to pass through, but scans 7 and 8 (and 9 and 10) should be combined on one page by pausing the scan between lifting the probe from the surface at the end of scan 7, and putting the probe down at the start of scan 8.

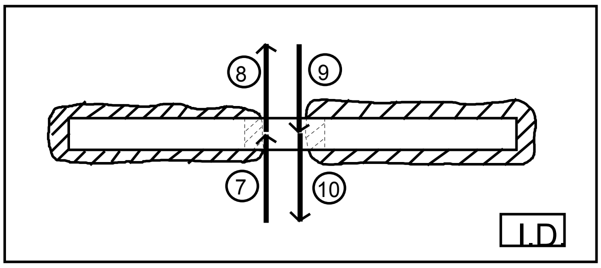


Figure 9. Detection scans 7 to 10 for rat-hole specimen with complete welds

Having completed all the detection scans, positions and lengths should be measured with the same probe, and then defects should be sized with the standard weld probe if possible. Defects inside the rat-hole can be sized with the mini pencil probe. The procedure to be followed is therefore:

1. Use the standard weld probe or mini pencil probe to do 10 scans as described above.
2. If defects suspected to run away from scan line, carry out additional detection scans as described above.
3. Measure the position and length of all defects found in steps 1 and 2.

4. Change to the standard probe, if necessary, and scan over all defects found and measure their depths.

For rat-holes and plate ends with incomplete welds, a similar procedure should be followed, but no scans should be made where no weld exists (e.g. scans 5 - 10 above).

Transverse Cracks

If the geometry or conditions are such that it is suspected that the weld may contain transverse defects, the following probe deployment procedure should be carried out for detection. In order to obtain a signal from a transverse defect, the input field must run perpendicular to the defect, so to detect a transverse defect the ACFM probe must be turned around by 90^{o} as shown in Figure 10. The standard weld probe should be used for flat or cylindrical butt welds; for T-butt welds where deployment of this probe is not possible, a pencil probe should be used.

The normal probe scan path to produce a butterfly plot loop would then be across the weld cap, however for detection this would have to be repeated every 10mm or so along the weld resulting in a slow detection process. Instead of this the probe should be scanned along the centre of the weld cap as shown in Figure 10.

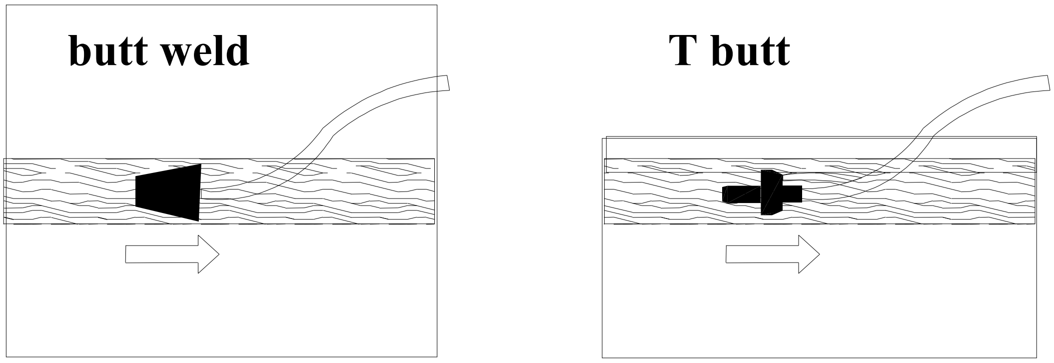


Figure 10 . Probe orientations and scan directions for initial detection of transverse defects across weld caps

Since the scans are not along the expected line of a defect, a transverse defect will not produce a loop in the butterfly plot. Instead, the possible presence of a defect is indicated by a dip in the Bx signal. The Bz signal may show a peak or a dip if the scan passes nearer to one end of the defect than the other, but will show nothing if the scan passes over the middle of the defect. The dip in Bx will be about 20mm across - this width is determined mainly by the probe input field geometry rather than the defect size. The depth of the dip is determined by the defect depth.

Since probe rock and lift-off changes will inevitably be more severe when the probe is scanned along the weld cap, the presence of a dip in Bx is not enough on its own to indicate the presence of a defect. In order to confirm a defect-like indication, a scan should be made across the weld cap along the line through the dip found in Bx (i.e. along the line of the suspected defect) as shown in Figure 11.

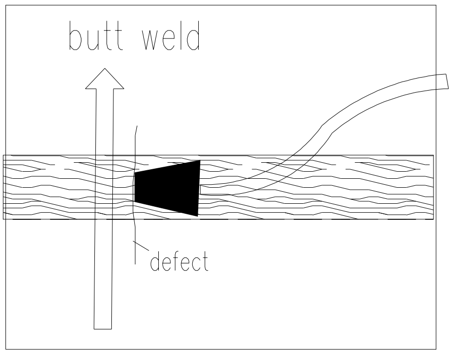


Figure 11. Probe orientation and scan direction for confirming detection of transverse defects across weld caps

The probe should still be oriented as before, and the scan should start and finish at least 25mm from the weld toes to ensure that both defect ends will be covered. In this way, a defect will produce a loop on the butterfly plot as for conventional weld toe defects. Note, however, that since any material property change associated with the weld now runs across the scan direction, signals may be seen in both Bx and Bz due to the weld (this is similar to scanning across a seam weld in conventional deployment). Since these weld signals may produce confusing loops in the butterfly plot, a scan must also be made across the weld cap away from the suspected defect for comparison.

Material Features

Coating Thickness

With the ACFM technique, it is possible to detect defects through 5mm or more of non-conducting coating. The signal strength obtained is obviously smaller than for an inspection with no coating but sizing estimates can still be obtained by entering an estimate of the coating thickness in the QFMu sizing procedure using the box labelled "Extra lift off". The look up tables presently implemented do not support extra lift-offs greater than 3 to 5mm (dependent on probe type) - refer to TSC for sizing through thicker coatings. Note that, because of the use of a unidirectional input field, the ACFM signals are relatively insensitive to lift-off and so the thickness need only be estimated to the nearest millimetre. For the same reason, the ACFM technique is relatively insensitive to changes in coating thickness (or changes in lift off) and in any case, only the Bx signal is affected so no confusion with a possible defect signal can occur. It should be borne in mind that the reduction in Bx and especially Bz amplitudes due to coatings will result in smaller butterfly loops than otherwise expected for a given defect size. To compensate for this, a new probe file should be made through a non-conducting layer of the same thickness on a standard function check sample.

Magnetic State

It must be ensured that the surface being inspected is in an unmagnetised state. Therefore the procedure followed with any previous magnetic technique deployed (particularly MPI inspection) must include demagnetisation of the surface. This is because areas of remnant magnetisation, particularly where the leg of an MPI yoke was sited, can produce loops in the butterfly plot which may be confused with a defect signal.

If magnetisation of the structure is unavoidable (e.g. d.c. magnets used to attach an ROV), the magnetised area must be at least 500 mm away from the weld to be inspected.

Surface Grinding or Work Hardening

It has been noted in a number of instances, especially on Duplex, that areas of surface grinding or work hardening etc. which produce localised changes in material properties can result in strong signals in both Bx and Bz which may be confused with a defect signal. Areas of grinding should be reported by the probe operator at the time of scanning and recorded by the ACFM operator.

If a defect signal is suspected in a region of grinding or possible work hardening, further scans should be taken parallel to but away from the weld toe. The signal from a defect (especially Bz) will drop off quickly away from the defect, so that a scan away from the weld toe will be much flatter. The rate at which the signal drops off will depend on the length and depth of the crack, but a significant difference in amplitude should be seen 20mm away if the signal is due to a defect. If there is no significant change in signal amplitude 20mm away from the weld toe, the signal is likely to be due to the effects of the grinding. A further scan 40mm away should be made to confirm the trend. To assist later signal interpretation, marker lines should be added on the display at the start and end of the ground area.

If an edge effect probe is available, and geometry allows its deployment, a scan with this probe will produce a much flatter signal from grinding marks than from a defect.

Seam Welds

Seam welds running across the line of scanning also produce strong signals in Bx and Bz which can sometimes be confused with a defect signal. As for grinding marks above, if a defect is suspected at or near a seam weld, further scans should be made away from but parallel to the suspected defect line to confirm the defect. The signal from the seam weld will persist at roughly the same amplitude, whereas a defect signal will exhibit a much reduced amplitude. Again, an edge effect probe, if available, can be used to emphasise any defect signal.

Inspecting materials other than ferritic steel

The probe file associated with a given probe contains information used to produce accurate sizing estimates, and scaling information to match the screen display limits to the signal levels produced by the probe on a reasonable size defect. By default, these scales are set so that a 50mm long by 5mm deep notch in ferritic steel produces a loop on the butterfly plot that is roughly centred on the screen, fills about 50% of the height of the plot (i.e. Bx amplitude) and more than fills the width (Bz amplitude).

If a probe is to be used on other materials, such as Duplex, aluminium, stainless steel, etc. the scaling may not be correct so that the display may be more or less sensitive resulting in the possibility of getting more spurious indications or missing small defects respectively. Also, the depth sizing will not be accurate. In order to avoid this a new probe file must be used for the material in question. In the first instance contact TSC to see if a relevant probe file is available. If not, refer to the QFMu v3.x Level 2 Software Manual.

Duplex

Duplex is known to be more susceptible than other materials to spurious signals caused by material differences arising from grinding, heat treatment etc. In some cases it is possible for these signals to produce butterfly plot loops similar to those produced by a defect. For this reason defect signals should be confirmed by taking extra probe scans adjacent and parallel to the suspected defect as described in “Surface Grinding or Work Hardening” on page 16.

Inspection Reporting

Reporting Requirements

ACFM results are backed up onto floppy disks, or other media, which contain the raw inspection data. These will only be useful to the client if backed up with data sheets filled in correctly. This section deals with the information required and production of these data sheets.

The data report sheets generated by ACFM inspections will be specifically designed with the ACFM system and current inspection requirements in mind. The essential information contained on an ACFM data sheet will include:

General Information

Date

Operators Name

Probe Operator

Component number/name

File Number

Scanning Data

Filename

Page Number

Position on Weld (i.e. Chord toe, Brace toe, Weld cap)

Probe Number

Probe Direction

Clock or Tape Positions

Inspection Summary

Detailed Record of Indications/Anomalies

Filename

Page Number

Position on Weld

Start of Defect (Tape reference)

End of Defect (Tape reference)

Length of Defect (in millimetres)

Depth of Defect (in millimetres)

Remarks

Diagram/Drawing of component under inspection.

The overall inspection will most certainly be supplemented with video tapes and photography. However, the final report that ends up on the clients desk is the only visible outcome of an inspection campaign that will have cost many thousands of pounds. It is therefore impossible to over emphasise the importance of this document and the necessary care with which it needs to be completed.

A poorly filled in report sheet reflects badly on the operator, and the equipment, and will render off-line interpretation difficult if not impossible.

QFMu ACFM Report Form

Date: Time:	Location:	Sketch of geometry:
Operator:	Diver:	
Component ID:		
Summary of indications:		
Filename:		
Probe number/configuration:		Probe file:

Location: C/B/W	Direction of travel A/C	Circumf. Position	Page	Inspection report / comments

Probe Operator Briefing: Check off list

Operators name	
Date	
Probe operators name	

Tick boxes accordingly

Probe	**YES**	**NO**
1) Shown various probe selections and reasons for use		
2) Shown probe connections/connectors to instrument		
3) Shown probe identification markings and sensor centre-line		
4) Instructed on leading edge of probe direction ie A or C		
5) Shown how to hold the probe		

Scanning techniques	**YES**	**NO**
6) Instructed on marking up component under inspection		
7) Advised on scan starting procedure		
8) Advised on scanning rate and indicating circumf. posn.		
9) Instructed on overlapping procedure		

Visual Inspection	**YES**	**NO**
10) Made aware of visual defects that might influence scans		
11) Probe fit for tight geometries		

Marking and Sizing Defects	**YES**	**NO**
12) Instructed on how to size defects for length		

Interpretation of ACFM Signals

General Method

In general, a defect will product a characteristic signal on Bx and Bz signals and these combine to give the "butterfly". The rule adopted is that the signal represents a defect when

1) Bz responds by a peak and trough, and
2) Bx responds by a "dip" from the mean value.

In the majority of situations for, isolated and relatively short cracks, this will give a butterfly plot which moves to right or left (according to probe direction), then downward then returns to the original position to close the loop. Figure 12 The figure below shows the relationship between Bx, Bz and the butterfly trace where "A" represents the first Bz peak, "B" represents the deepest point in Bx, and "C" represents the Bz trough.

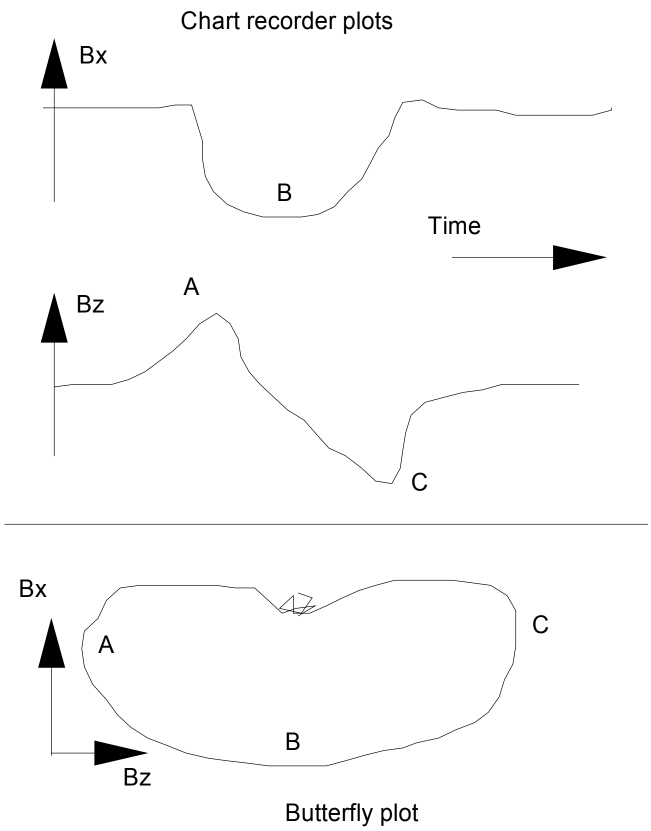


Figure 12.Schematic showing relationship between butterfly and chart recorder plots

Lift off, permeability changes, probe rocking etc. can cause responses from Bx and/or Bz. Lift-off, for example, causes the Bx signal to dip or peak (depending on material type) with little response from the Bz signal. This would produce a closed loop confined to the vertical axis rather than the open loop produced by a crack. A seam weld, on the other hand, usually causes a peak in Bx combined with Bz signals that result in an open loop moving upwards from the starting point. Hence, for the signal to represent a crack, the butterfly loop must move downwards. This rule is intended to eliminate false calls due to momentary lift off, perhaps as the probe runs over local weld imperfections. It therefore is intended for **small** signals.

There are exceptions to the general rules and these mainly apply to long defects (> 50mm).

For long cracks the Bz peak and trough may be some way apart. This means that at the centre of the crack there is no Bz signal and we rely on Bx (i.e. the dip in Bx) to make the butterfly go down. If there is a general drift on the Bx signal, i.e. if the top signal is not perfectly level, this may confuse the butterfly by acting against the crack signal. This conflicting Bx signal means the butterfly rules no longer can be relied on and it is necessary to use the Bx and Bz plots to look for tell-tale signals where there is a response from Bz followed by a downward deviation, from the **trend**, on Bx. This is particularly important for tight angles where the Bx signal trend rises toward the tight angle due to global geometry effects.

In theory it is possible for a weld to be cracked around the full circumference, thus resulting in no crack ends. If the crack has a uniform depth, the Bx signals would be lower than expected, but in all other aspects the signals could be similar to an uncracked connection. In this situation the presence of a signal centred much lower on the butterfly plot than for other connections should be an indication that a full circumference defect is present. This can be further investigated by comparing the Bx signals as the probe is moved from parent plate to the weld toe area and then repeating the exercise on the other weld toe.

In practice, cracks do not tend to grow this way in tubular connections. Experience has shown that full circumferential cracking is normally associated with significant variations in crack depth around the connection combined with crack branching. In this situation the crack branching provides Bz signals resulting in butterfly loops in the normal way. Thus in practice detection of full circumferential cracks on node connections is similar to normal cracks in that butterfly loops will normally be present together with significant depth variation represented by dips in Bx and downward movement of the butterfly trace.

Crack depth measurement is more complicated if full circumferential cracking is suspected because the "length" and background Bx readings will not be easily established. Refer to TSC if assistance is needed.

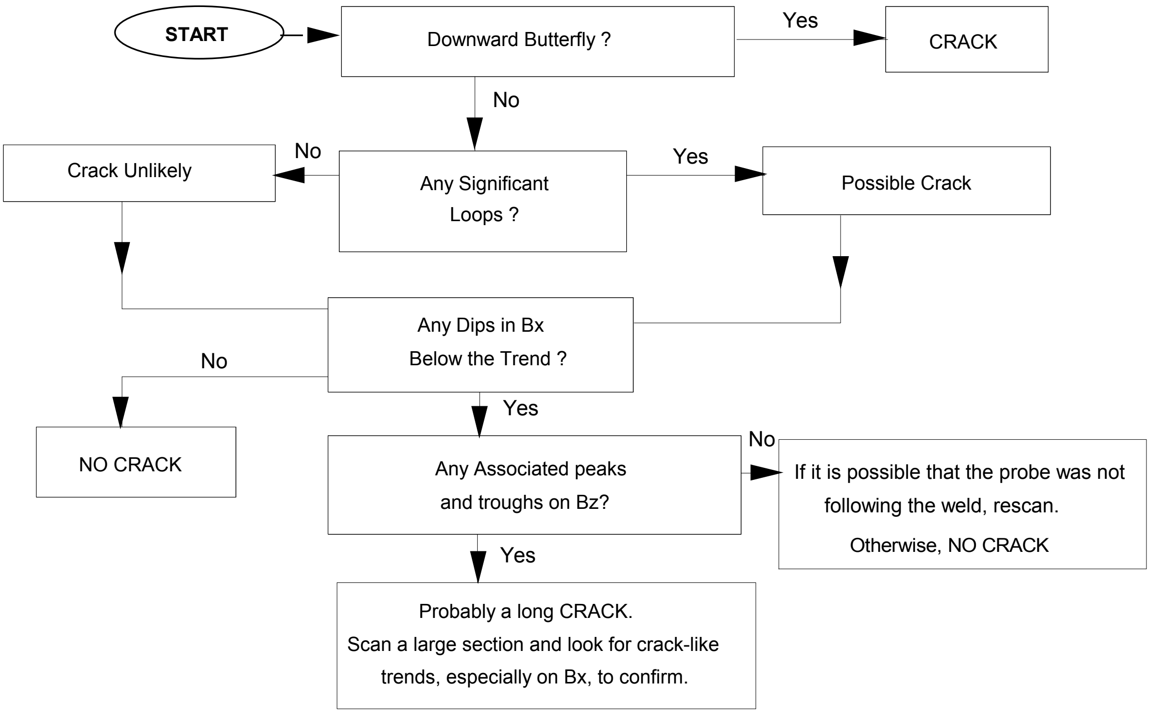


Figure 13. Decision Tree for Identification of a crack

At all times look at the Bx and Bz traces. If Bx has a dip then suspect a crack. If the butterfly makes any significant loops, look at a broad area either side of the signal. This is particularly important if the butterfly is moving up or down the screen. A butterfly moving up or down the screen with any sort of looping is likely to be a long crack.

Crack Sizing

Crack sizing can be carried out either on-line (immediately after the necessary data has been collected) or off-line (by recalling stored data). During the detection stage, scans of Bx and Bz are recorded for all defects found. A first estimate of length is also obtained from a manual measurement of the extent of the Bz signal. This data is then used to obtain sizing estimates using the QFMu program as outlined below. For more details, refer to the Level 1 Software User Manual.

1. Select a section of the Bx timebase plot to one side of the defect signal that is representative of the background level. This should simultaneously be near the centre of the area filled by the general off-crack background noise in the butterfly plot. This value is chosen as the Bx Background Level.

   N.B. If the background level is significantly different either side of the defect, the average of the two values should be used. This is normally necessary for defects in regions of changing geometry or near to a plate edge (see Inspecting Flat Plate Welded Supports/Stiffeners).

2. Select the minimum of the Bx timebase trace from the centre of the defect signal (or the bottom of the butterfly loop). This value is chosen as the Bx Minimum Level.

3. To calculate defect length and depth, the QFMu software requires three parameters - the two Bx values selected above, and the length estimate obtained during the detection stage (the length in mm between the Bz peak and trough indications at the inspection site).

Where the crack depth calculated is greater than the plate thickness this indicates that cracking may be completely through the plate and so the probe operator should be asked to look for further evidence of this. Such evidence may be visual crack opening or, if the back face is accessible (e.g. on flat plates), crack-like indications on a scan made there. Alternatively, because the currents follow the crack faces exactly in ferritic steel, depths apparently greater than the wall thickness can arise from crack branching into the parent plate, or from a highly curved crack path.

Using MPI With ACFM

When defects are being removed by grinding, it is often the case that MPI is used in conjunction with ACFM to monitor defect removal. In these cases it is tempting to save inspection time by using MPI lengths instead of Bz lengths when sizing defects. This will lead to errors and is not a recommended practice. This section considers the implication and suggests how, under certain conditions, data from MPI inspection can be used in the absence of any additional information.

When conducting MPI inspections an approved MPI inspection procedure should be used.

De-magnetise the area following MPI inspection (see "Magnetic State" on page 15).

Length Sizing With ACFM

The method of length sizing involves determining the location of the Bz peak and trough signals on the component. The distance between peak and trough is referred to as the ***Bz Length.*** The ACFM modeling shows that the Bz peak/trough actually occur just inside the physical ends of the crack. This is confirmed in practice when the crack ends are marked and compared visually. Thus the Bz lengths are ***always*** less than the actual crack length. This is taken into account in the sizing algorithms so that the ***ACFM calculated length*** is greater than the Bz length.

Because ACFM also considers the depth of the crack, ACFM will "concentrate" on those parts of a crack with significant depth.

If two cracks are joined at the surface by a shallow surface crack, ACFM will focus on the two deep parts, not the whole, and ACFM sizing procedures take this into account.

MPI Indications

MPI will simply indicate the length of a surface flaw and give no indication on depth. MPI lengths should not be used as a substitute for Bz lengths because:

1. For any crack MPI length > Bz Length. (Figure 14)
2. The crack may be made up of more than one deep section. MPI will treat it as one crack and therefore misrepresent the length. (Figure 15)
3. The crack may have long "tails", again misrepresenting the length of the significant crack. (Figure 16)

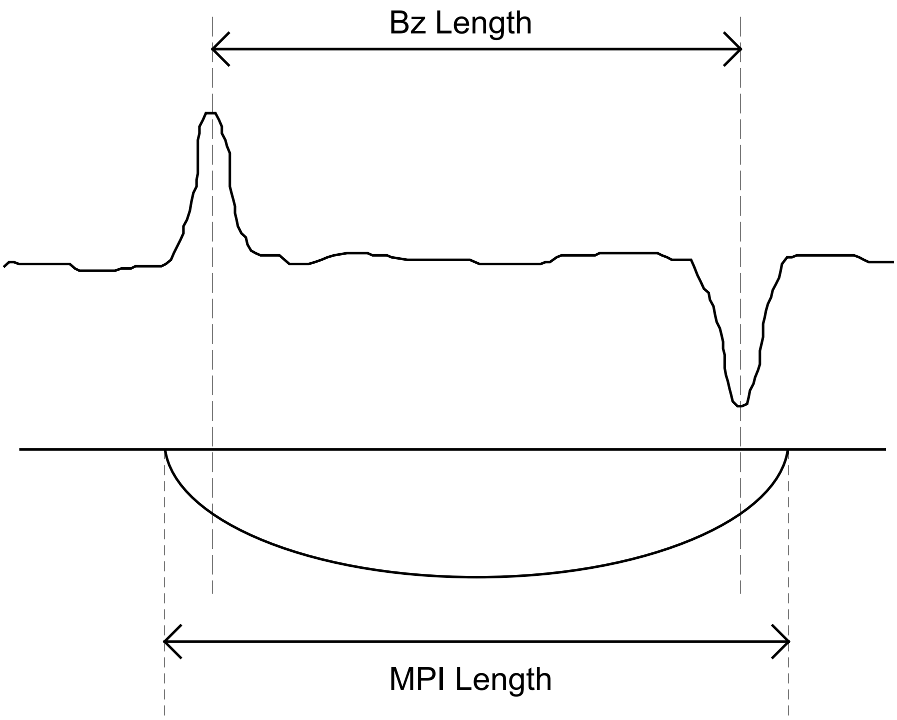


Figure 14. Comparison of Bz peak/trough with actual crack ends

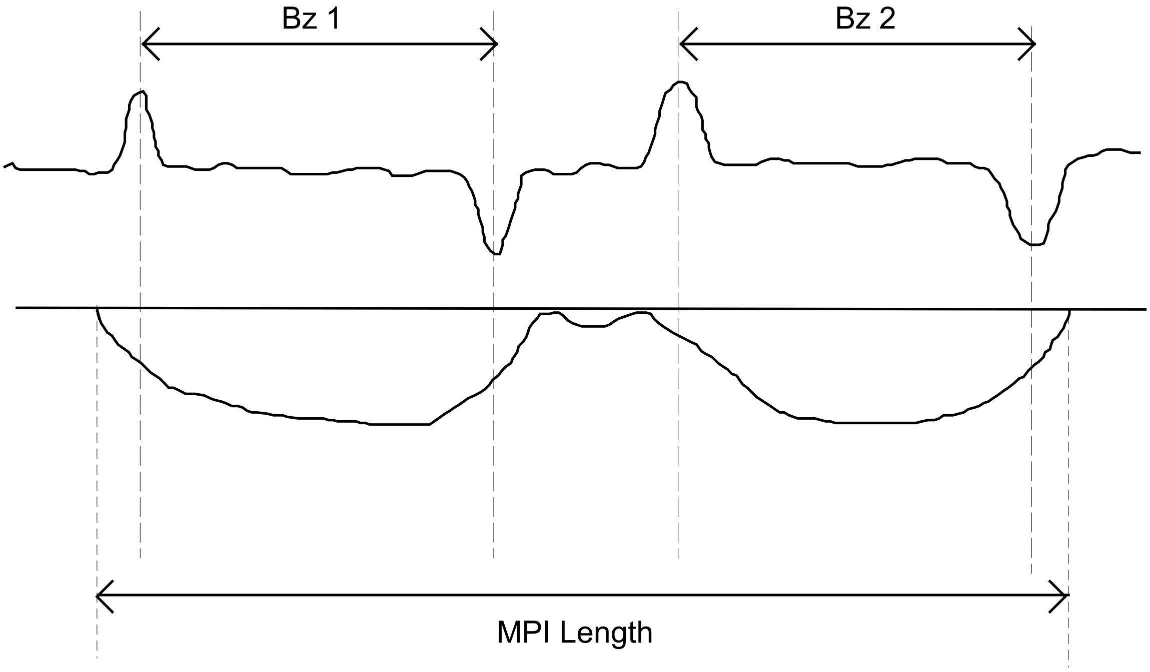


Figure 15. ACFM Bz signal compared to MPI indication for two adjacent cracks

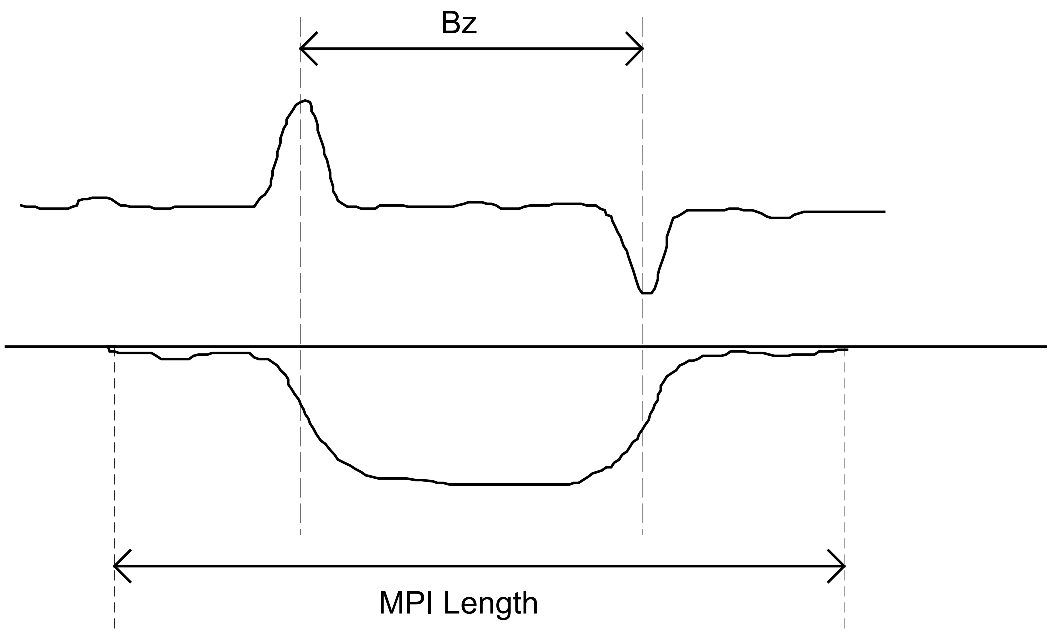


Figure 16. ACFM Bz signal compared to MPI indication for crack with shallow ends.

Use of MPI Lengths In ACFM Calculations

One example where it may be preferable to use MPI lengths instead of Bz lengths is a situation where ACFM is being used during a grinding process and it is found that there is a start/stop Bz signal at the grind profile ends which are close to the defect ends. Hence there may be some doubt as to whether the crack Bz locations are being masked by the grind profile end signals. As an alternative, MPI lengths may be used in the crack depth sizing. As described earlier, the use of MPI length as a substitute for Bz length is incorrect. However there is a work around if, and only if, certain criteria are met. The answer will still be approximate but may be acceptable. The criteria are:

1. Before grinding, carry out an ACFM inspection and use Bz to calculate the crack length.

   If:

   i) The calculated length agrees with the MPI length, and

   ii) The Bx signal indicates a simple crack

   continue to step 2. If either of these conditions are not satisfied, do not attempt to use MPI information with ACFM.

2. Estimate by how much the Bz length is less than MPI. You should find that the Bz length is between 80% and 90% of MPI length.

3. Carry out the grinding.

4. Re-inspect with ACFM. If the crack remains a single crack (i.e. no additional features appear on Bx) take the MPI length after grinding and apply the factor in (2) above. Then compare the estimated ACFM length with the factored MPI length. If they agree, the factored MPI length should give a reasonable depth estimate when used in the ACFM sizing procedure. If the two estimates do not agree, it is possible that a situation such as shown in Figure 12 has arisen and the MPI length should not be used to depth size the defect.

5. The above process can be repeated providing the crack remains as a single defect. Should it split into two, the process will not work and any depth calculation will be in error.

Operational Procedure

System Setup

Connections

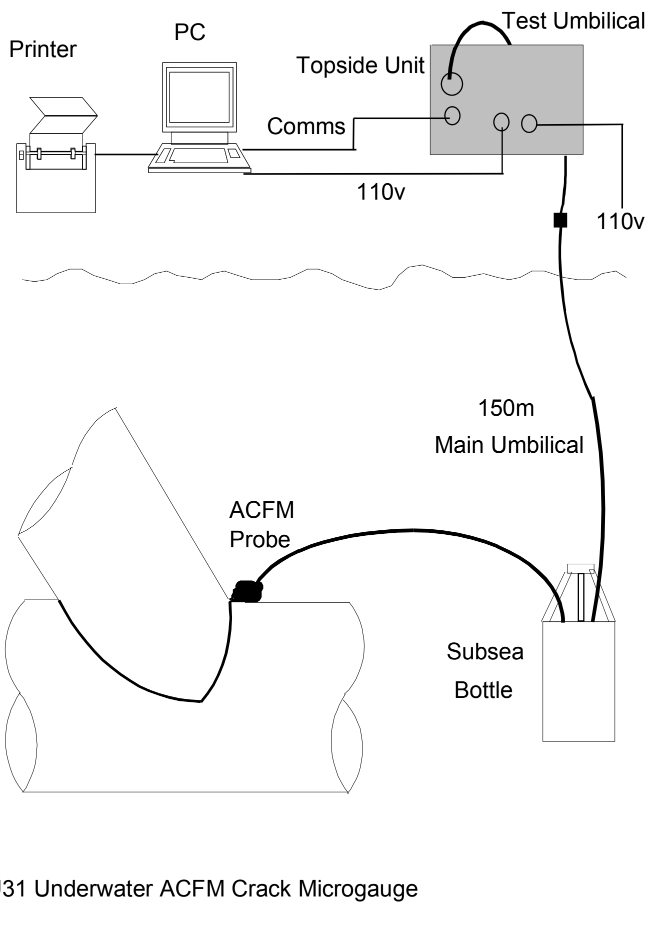


Figure 17. Overall System Connections

U31 Subsea Bottle

The U31 subsea bottle is designed to be deployed underwater with the diver. An ACFM probe is attached to the bottle via the 16 way Wetcon Connector. This connector may be broken subsea, to change probes for instance, but the bottle should be powered down first to prevent accelerated corrosion of the pins. Note that there is no shock hazard to the diver. An umbilical is connected to the 8 way Wetcon connector which carries power and communications to the bottle. The main umbilical is 150m long as standard but two may be joined together to give a 300m total length. Note that no more than two main umbilicals can be connected together. The main umbilical is deployed from the surface and attaches to the test umbilical which in turn is connected to the Topside Unit.

U31 Topside Unit

The topside unit provides power and communications to the subsea bottle. The test umbilical is connected to the 12 way Amphenol connector on the front panel. This umbilical can then be plugged directly into the subsea bottle for testing purposes or routed to a convenient location and attached to the main umbilical.

110V power is supplied to the unit via the 4 way Amphenol connector on the front panel. If the local supply is 240V then a suitable transformer will be required. Note that unlike previous underwater ACFM instruments the U31 does not require a centre tapped isolation transformer.

The power cable is supplied with an integral inline RCD protection device. Never operate the instrument without the RCD present or if the RCD fails setup tests.

A 110V output connector is supplied on the front panel to power the computer.

The topside unit is connected to the computer via a communications cable which is attached to the 6 way Lemo connector on the front panel.

Computer

The computer operates on its own internal battery or on 110/240V AC (50/60Hz) through a mains pack / battery charger. Refer to the computer user manual for details on how to connect the mains pack. The mains pack should be connected to the 110V output socket on the topside unit rather than to a separate mains connection to maintain protection from the RCD. A cable is supplied for this purpose but if the connector on the battery pack is of a different type than on the supplied cable, the 110V connector can be removed from the supplied cable and mounted onto the mains cable supplied with the computer.

The computer communicates to the U31 via the RS 232 cable supplied. The RS232 port is usually a 9-way D-plug on the rear of the computer. Refer to the computer user manual for more details.

Connection Procedure

1. Ensure all mains switches are OFF
2. Connect the topside unit to the mains supply using the RCD protected lead. If the local supply is 240V then a suitable transformer will be required.
3. Connect the computer to the topside unit using the RS232 cable (8-way Lemo to 9-way 'D'-type).
4. If the computer needs to be powered from the mains supply, instead of running from the internal battery, connect the mains lead to the 110V output connector on the topside unit. Note that when the topside unit power switch is turned off, the power to the output connector is cut. If there is no internal battery in the computer then the computer will shut down automatically in this event.
5. Connect the test umbilical to the topside unit and connect the main umbilical to the other end of the test umbilical.
6. Connect the main umbilical to the subsea bottle.
7. Test RCD by turning ON the mains supply to the lead (with the topside unit still switched OFF). Press the Reset button and verify that the red indicator is showing. Press the Test button and confirm that the red indicator is removed. Press the Reset button again and check that the red indicator reappears and remains.

IF THIS DOES NOT FUNCTION SUSPEND ALL OPERATIONS, TURN OFF MAINS SUPPLY AND SEEK SPECIALIST ADVICE.

8. Press the power switch on the topside unit panel to turn on the power to the system.

IF DURING OPERATION THE RCD TRIPS SUSPEND ALL OPERATIONS, TURN OFF MAINS SUPPLY AND SEEK SPECIALIST ADVICE.

Function Check

At the start and end of an inspection session a function check must be performed using the equipment. This is to ensure that the equipment is functioning correctly and to familiarise the operator with the relative levels of noise and defect signal. The following procedure assumes familiarisation with the QFMu software. For details, refer to the appropriate Software User Manuals.

1. Select Probes for next series of scans to be carried out (see "Probe Deployment Considerations" on page 9). If not already done, connect instrument as described in System Setup - Connection Procedure.
2. Create a directory to store the data for the new inspection session.
3. Start the QFMuv3 software, and check that U31 is initialised correctly.
4. Connect the first probe to the instrument and select the appropriate configuration from those available for that probe.
5. Create a new data file for the function check data.
   - The format for the file name should be

     FNppppnn.WDF where

     FN stands for Function-check

     pppp is the probe serial number (e.g. 1734)

     nn is the number of the function check of that day, i.e. first function check in the day would have n = 01.
6. Place probe on the test block and start data collection.
7. Scan along the test block slot at approximately 25mm/sec. After passing the slot stop the scan.

   Signals such as that shown below in Figure 18 should be displayed. Note that small differences in material or gain used between creating the probe file and doing the function check may mean that the display is just off screen, in which case the signal should be centred on the screen.

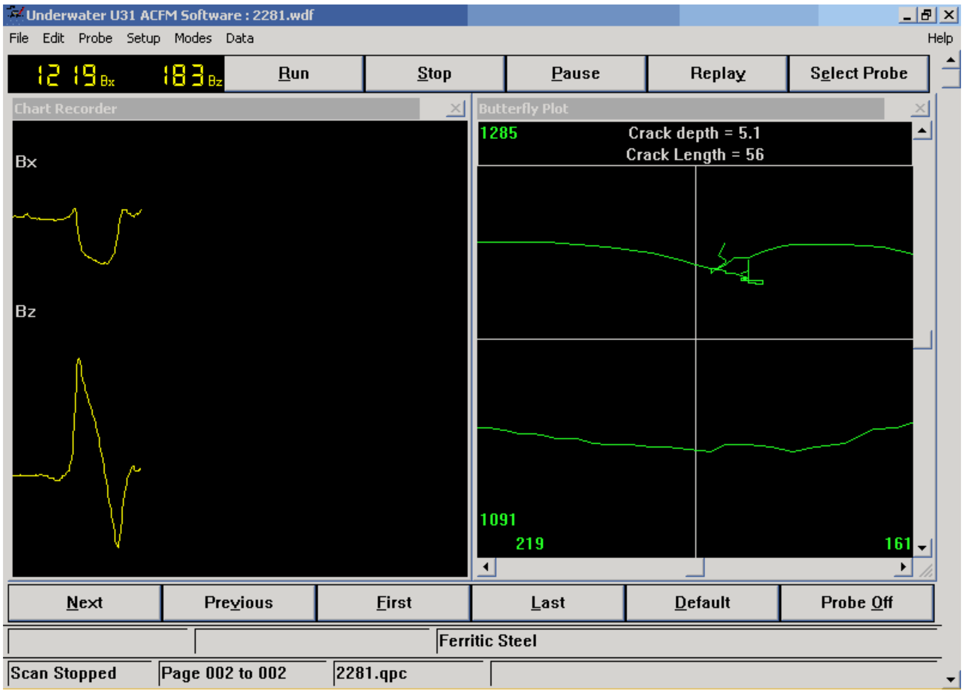


Figure 18.Typical plots for function check on a single defect

If the display is well off the screen, check that the correct configuration was chosen for the material of the function check plate, and that the serial number of the probe displayed by the software matches that marked on the probe. If no configuration matching the probe and/or the function check plate material is available, a new configuration file must be set up, as described in the Software Level 2 User Manual.

If a display similar to this Figure 18 cannot be produced, SEEK SPECIALIST ADVICE before proceeding.

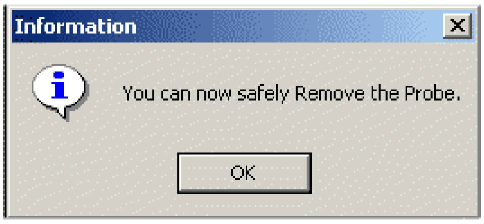
8. Save the data file.
9. Check all probes to be used in the session (Repeat steps 4-8)

Inspection Procedure

1. Mark up the inspection area. For flat plate and T-butt geometries, mark positions at 100mm intervals from left hand plate edge using paint stick or chalk. For cylindrical geometries, mark clock positions or 100mm markers as appropriate.
2. ACFM operator to inform diver of scan required and which probe to use.

The probe can be disconnected underwater to allow a different one to be used, but the ACFM operator must turn the power to the probe off while the change is made.

The ACFM operator should press the Probe Off button and confirm that the following message is displayed:



The operator should then instruct the diver that the probe can be changed. The diver should connect the new probe, ensuring that the connection is fully mated, and confirm the probe serial number.

3. When the diver has completed connecting the new probe, press the Select Probe button and select the required probe configuration. This will restore the power to the probe socket.

4. Create a new file for the inspection data.

   - Choose a filename in the form "XXXXXXXa"

   where: XXXXXXX = Identifying code for location to be inspected (up to 7 characters).

   a = Inspection number/letter for that location (e.g. a for first inspection, b for second inspection etc.).

   When choosing a data filename, make sure the file is uniquely identifiable and contains a reference to the component under test.

   Note: The individual scans within the inspection are described by pages within the file, in numerical order. A separate recording sheet or log-book must record the scan made on each page (i.e. the weld toe/bead inspected and the direction of the probe 'C' or 'A').

5. Set the range of the numbered marker lines (or clock-points) to be covered in the scan (start, end and direction)

   While recording data, reference markers can be entered which are called CLOCK POINTS. These are lines labelled with a number between 1 and 99. The numbers wrap around at the end point so that they can be used to mark positions when scanning around a tubular geometry. The default end point is 12, appropriate for conventional clock positions around a circle, however the markers can just as easily be used to scale mark a linear geometry. e.g. each marker may represent 100mm increments.

6. The diver should place the probe at beginning of scan, and confirm intended probe direction (Probe marker A or C leading) to the ACFM operator. When A is leading, the loop produced by a defect in the butterfly plot should be traced in an anti-clockwise direction, when C is leading it should be clockwise.

7. The ACFM operator should start the scan and instruct the diver to begin moving the probe. The scan speed should be approx. 25mm/sec, but if this needs to be reduced or increased for operational reasons, the data sampling rate should be set accordingly. Note that if scan rates are set too high that there is an increased chance of the diver not scanning the probe carefully along the weld line.

8. The diver should report when the centre of the probe passes a marker. The ACFM operator logs his position. The diver should report visual indications such as seam welds, weld run overlap, weld spatter or grinding marks when these are encountered. The ACFM operator may add an un-numbered marker to log these.

9. When the desired section is scanned or the end of the data page is reached or the diver cannot comfortably continue, then the ACFM operator should stop the scan.

10. When the scan has stopped the diver may be remove the probe from the component.

11. Study the data, looking for any defect indications.

    For defect detection refer to “Interpretation of ACFM Signals” on page 21.

    Any defect signal is to be noted in the report sheets by the operator and the area marked by the probe operator.

12. Continue scanning with a minimum of one clock position, or 100mm overlap on each scan (e.g. clock positions 11-3, 2-6, 5-9, 8-12).

    Repeat steps 5 to 11 until scan area is covered.

    When defects are detected, additional scans are necessary in order to facilitate sizing. These are:

    i) a slow scan to cover all defects within a region.

    ii) a scan or series of scans to locate the ACFM crack ends. In these scans the ACFM operator will ask the diver to move the probe so that it coincides with the peaks and troughs of the Bz signals (usually easiest to observe on the butterfly plot). When the ACFM operator is satisfied that the probe is in the correct place, the diver should place a mark or magnetic arrow to mark the location. The marking will normally be aligned directly with the probe centre. Alternatively, if the access does not allow this, the trailing edge of the probe can be marked first with the position of the centre of the probe marked later.
13. Save the collected data in the file selected at the beginning of this session.
14. The diver should place a ruler or tape on the specimen and read off crack end positions to the ACFM operator. The ACFM operator must record this "Bz crack length" and the distance to a datum on the data sheet.
15. Repeat steps 1 to 14 for all inspection areas on the specimen.
16. Crack depth sizing can be carried out immediately, or at a later date, in accordance with the procedure described in "Crack Sizing" on page 24.

End Of Session Function Check And Backup Procedure

Post-Session Function Check

To ensure that the system was functioning correctly during the session, the function check should be repeated on the appropriate sample at the end of the shift using the procedure outlined in "Function Check" on page 30, steps 3 to 9.

Backup Procedure

1. Mark back-up medium (e.g. floppy disc, magneto-optical disc, CD-R) with files to be copied.
2. Put back-up medium in appropriate drive
3. Back-Up all files created in the inspection shift.

Exit QFMu and check backup

1. Exit QFMu:
2. Check files are stored on the backup medium using (e.g.) Windows Explorer
3. Remove the backup medium from drive and write-protect (if applicable).
4. Switch off all power.

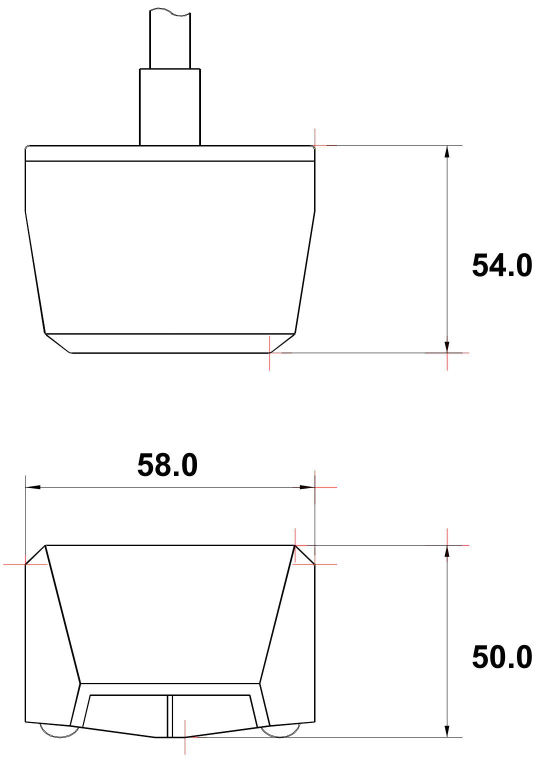
Appendix A

Probe Specifications

Underwater Weld Probe

The Underwater Weld Probe is designed for subsea inspection of welds, plate and tubulars. The bottom face is fitted with two feet which, together with the wear-resistant probe nose housing the sensors, give a stable tripod arrangement for ease of scanning. The probe is sealed and fitted with a 50m cable. The probe electronics are encapsulated in a bulge in the cable about 30cm from the probe body.

If the probe is to be used in an environment where sharp marine growth could easily damage the probe cable, it is recommended that the cable be protected using additional sheathing.



The underwater ACFM weld probe

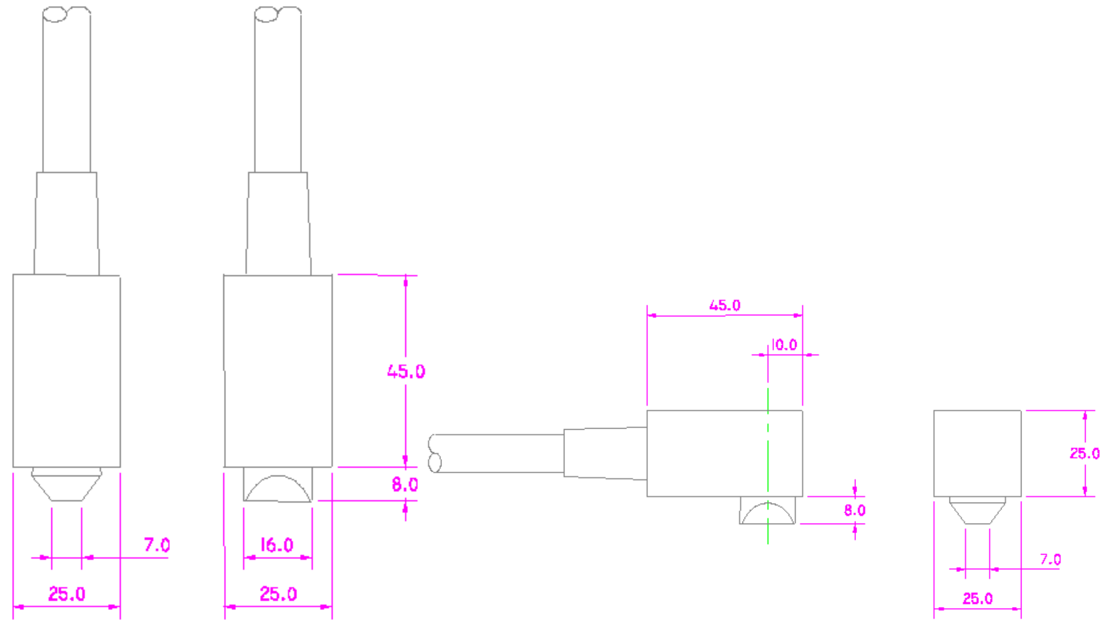
U31 Underwater Mini-Pencil Probe

Sub-Types Straight Entry Cable

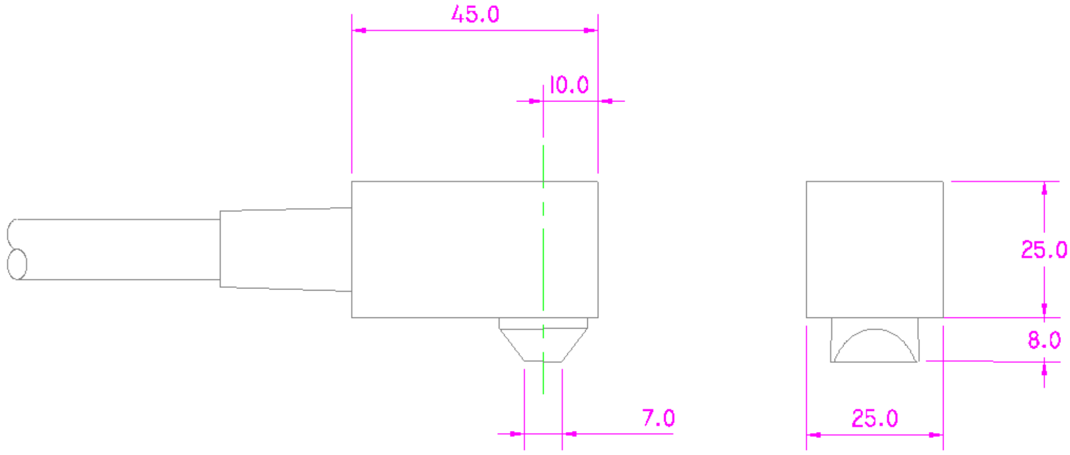
Right Angle Entry Cable, parallel nose

Right Angle Entry Cable, transverse nose

The Mini Pencil Probe maintains the sensitivity of the normal Weld Probes. They have the advantage of being able to access restricted areas and areas of weld associated with rat holes in structures. They are less prone to signal variations near plate edges, but are less accurate for depth sizing deep defects (>5mm). The parallel nose type is ideal for inspecting through rat-holes, or for longitudinal cracks inside pipes. The transverse nose is ideal for circumferential cracks inside pipes.



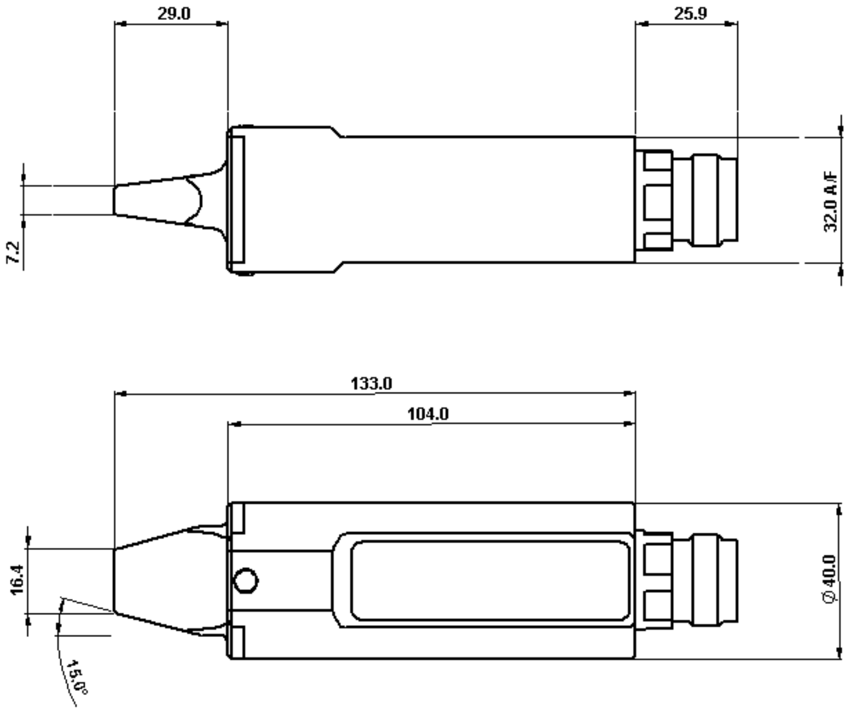
STRAIGHT CABLE ENTRY RIGHT ANGLE CABLE ENTRY (PARALLEL NOSE)



RIGHT ANGLE CABLE ENTRY (TRANSVERSE NOSE)

Underwater Pencil Probe

The Underwater Pencil Probes are designed to fit into grind repairs. They are built to be factory serviceable but should not be disassembled on site.



The underwater pencil probe

Other Probe Types

Other probe types may be introduced as part of TSC's continuing policy of product development. If a suitable probe for a particular application is not shown here, contact TSC.

Purpose of Probe Files

The aims of a probe file are:

a) To maintain a consistent detection sensitivity between inspections, and between probes.

b) To maintain sizing accuracy

The first aim is satisfied by the probe file containing graph scalings to give a standard size butterfly loop from a given defect.

The second aim is satisfied by the probe file containing calculated values for inherent coil lift-off and sensitivity.

If, after checking instrument settings etc., it is found that the issued probe file is unsuitable for a particular application (for example the inspection is not on ferritic steel or the readings are saturating), refer to TSC. If approval is given to create a new probe file on site, TSC will issue the appropriate procedure. It should be noted that to produce a new probe file, an function check plate in the same material as that under inspection will be needed, containing a slot (preferably 50mm long by 5mm deep).