INTRODUCTION

ACFM is routinely used for underwater inspection and there are a variety of probes and instruments available for shallow and deep water applications. Underwater probes with 50m cables are available for use with the standard AMIGO, which makes shallow water inspection possible without an underwater instrument. For deeper applications, the U31 Underwater Crack Microgauge instrument is available. The U31 package is small and light enough for easy diver deployment, with the robust durability needed for use with Remote Operated Vehicles. It is available for use in water depths down to 2000m using a variety of different probe types, which are selected according to the application. When choosing probes, consideration should be given to access and geometry, material type, weld quality and minimum detectable defect size.

Custom designed probes can also be produced to suit specific customer requirements.

Geometry and Access

ACFM underwater probes are available in several common body styles to allow access to a variety of common geometries and components.

The underwater Weld Probes are designed primarily for scanning along weld toes but can also be used to inspect for defects in general components. The Weld Probe type should be used wherever access allows because it is the most stable probe to deploy, and has the largest field inducer, making it best for accurate sizing, particularly on deep defects.

The underwater pencil probes are used in places that the weld probes cannot gain access and are particularly useful at plate edges where their smaller induction fields produce less of a geometry effect. Pencil probes are available with three different nose configurations and two main nose types. The mini pencil probes have a similar sensitivity to the weld probe whereas micro pencils are higher sensitivity and use smaller sensors. The nose configuration should be chosen depending on the access requirement.

Probe Cables

Separate probe cables are supplied with each probe, however cable lengths vary depending on the system purchased. As standard, an underwater probe purchased with an AMIGO for shallow inspection will be supplied with a 50 metre cable. For diver and ROV deployment using the U31, 5 metre probe cables are provided. The cables have the advantage of being replaceable, and other lengths can be supplied on special request. The probe cable is normally terminated with a LEMO connector when used with an AMIGO instrument and an underwater connector when used with the U31.
**Probe Types and Notation**

Each underwater probe available comes in three different options:

1. **AMIGO Deployed Underwater Probes (A)**

   The AMIGO Underwater Probes are for use with the topside AMIGO unit and are limited to a cable length of 50 metres. The electronics are contained within a plastic in-line bottle in the cable.

   The probe type number will be designated by the letter ‘A’ if it is designed for use with an AMIGO system.

   For example: Probe type 293A

2. **Diver Deployed Underwater Probes (D)**

   The Diver Deployed Underwater Probes are for use with the U31D unit and are rated at 300 metres depth. The electronics are contained within a plastic in-line bottle in the cable.

   The probe type number will be designated by the letter ‘D’ if it is designed for use with a U31D system.

   For example: Probe type 293D

3. **ROV Deployed Underwater Probes (R)**

   The ROV Deployed Underwater Probes are for use with the U31R unit and are rated at 2000 metres depth. The electronics are contained within a metal in-line bottle in the cable.

   The probe type number will be designated by the letter ‘R’ if it is designed for use with a U31R system.

   For example: Probe type 293R
Choose one of the four available configurations of pencil probe to fit the geometry to be inspected:

- **Ground** for fitting into weld repair grind.
- **Straight** for confined space, acute angle t-buts and ground out areas etc.
- **R.A.** for ratholes, axial cracks inside tubes etc.
- **Transverse** for circumferential cracks inside tubes etc.

**Check individual probe depth ratings before ordering**

- Is the inspection going to be conducted using a Diver or ROV?
- Is the inspection depth between 0m-40m or 40m-300m?
- Is the inspection area tubular or flat plate/weld?
- Is access good enough to deploy a Standard Weld Probe?
- Does local geometry include plate edges, stiffener plate ends, small dia pipes etc?

**Basic Underwater Probe Selection Diagram**

- For use with AMIGO or U31D
- For use with U31D
- For use with U31R
- General Path

**Underwater Probe Catalogue**

- Standard Weld Probe Type 293
- Transverse Pencil Probe Type 352 or Micro Type 355
- RA Pencil Probe Type 337 or Micro Type 354
- Straight Pencil Probe Type 336 or Micro Type 353
- Tight Access Weld Probe Type 312
- Array Probe Type 447
- Array Probe type 493
- Array Probe Type 311 or 454
PROBE TYPES (Standard Frequency)

Underwater Weld Probe
- Type 293A (Rated to 50 metres, used with AMIGO)
- Type 293D (Rated to 300 metres, used with U31)
- Type 293R (Rated to 2000 metres, used with U31)

The Underwater Weld Probe is designed for subsea inspection of welds, plate and tubulars. The probe is sealed and fitted with a replaceable cable. The probe electronics are encapsulated in an in-line bottle 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. Note that the marine cable used on underwater probes is more robust but is less flexible than that used on topside probe cables.
**Underwater Tight Access Probe**

Type 312A (Rated to 50 metres, used with AMIGO)

Type 312D (Rated to 300 metres, used with U31)

Type 312R (Rated to 2000 metres, used with U31)

The Tight Access Probe is designed for subsea inspection of tubular welded connections where the chord to brace angle prevents the use of the standard weld probe. Note that the probe relies on the tight geometry for efficient coupling of the input field and so should only be used in these situations.
Underwater Ground Weld Probe
Type 303A (Rated to 50 metres, used with AMIGO)
Type 303D (Rated to 300 metres, used with U31)
*Not available at rating of 2000 metres*

The ground weld probe is designed with a long slender nose to fit into a weld repair grind to inspect for new or residual cracking within the grind.

Underwater Mini-Pencil Probe
Sub-Types
- Straight Nose - Type 336 (Available in A, D and R ratings)
- Right Angle Nose - Type 337 (Available in A, D and R ratings)
- Transverse Nose - Type 352 (Available in A, D and R ratings)

The Mini Pencil Probe maintains the sensitivity of the normal Weld Probes but has the advantage of being able to access restricted areas and areas of weld associated with rat holes or plate edges in structures.
Underwater Micro-Pencil Probe

Sub-Types
- Straight Nose - Type 353 (Available in A, D and R ratings)
- Right Angle Nose - Type 354 (Available in A, D and R ratings)
- Transverse Nose - Type 355 (Available in A, D and R ratings)

The Micro Pencil Probes are similar to the Mini Pencil Probes but are manufactured with high sensitivity coils for the detection and measurement of shallow defects, less than 1mm deep.

The construction of the probe necessitates the search coils not being coincident, which makes the butterfly display skewed, because unlike normal ACFM probes the Bx and Bz signals are displaced.
Straight UW micro pencil probe

Right Angled UW micro pencil probe

Transverse UW micro pencil probe
ARRAY PROBES

By combining many sensors in the same probe body, array probes offer rapid inspection of wider areas than those achievable with standard probes. Probes can be custom made to suite many geometries. Please contact TSC if you wish to consider an array probe for a particular application.

Different ACFM Array Probes are available depending on the inspection task and the type of delivery system available. They can be split into two types - static arrays and swept arrays. Probes can be produced with a wide range of shapes, sizes and coverage. Those shown are presented as examples of each probe type; a number of further options are available, including deeper water versions.

The use of multi-channel probes requires an instrument upgrade.

The following section shows examples of underwater array probes produced by TSC. These are available in different configurations and depth ratings:

**Static Pick-and-Place Arrays**

Static arrays consist of a number of sensors packed together to form one large probe that can be simply placed onto the inspection area. Each of the sensors in the array is read and a composite scan produced from the sensor placements. The array is then lifted away and placed back further along on the surface. Overlapping placements ensure that no part of the inspection is missed.

The probe must be placed in contact with the surface and held steady for approximately 5 seconds while the data is collected.

**Type 130 and 497 Underwater Array Probe** (Rated to 350 metres)

Designed for inspecting large tubular intersection fillet welds. (Type 497 is a smaller version designed for use with the U31)
Type 447 Underwater Array Probe (Rated to 50 metres)

Designed for inspecting flat plate or T-butt welds

Swept Arrays

Swept arrays consist of a bank of sensors which are moved over the inspection surface while data is collected. Normally these probes are deployed on flat or large curvature surfaces such as pipe sections, ships hulls and propeller blades. The probe can be fitted with an encoder to provide position feedback during deployment.

The coil plate must be able to maintain contact with the surface as the probe is scanned, and be able to accurately track the desired probe path. A compliant mounting should be used to avoid excessive loading on the probe, or alternatively, the probe can be deployed using a separate scanning system with its own encoder. Uniform scan speeds are not required since the position encoder records the distance travelled. Scan speeds of up to 15mm/sec are possible.

Type 311 Underwater Array Probe (Rated to 50 metres)

Designed for inspecting flat surfaces, with optional encoder for accurate distance measuring and defect positioning.
Type 454 Underwater Array Probe (Rated to 50 metres)

Designed for inspection of flat plates or circular welds. Originally used in conjunction with a modified scanner, a U31 instrument can be upgraded to accept up to 4 array probes simultaneously.
CONTACT
For more information on any of the probes or to discuss your applications, please contact TSC.

TSC Inspection Systems  
6 Mill Square, Featherstone Road  
Wolverton Mill South  
Milton Keynes MK12 5RB  
UNITED KINGDOM

Tel No: +44 (0) 1908 317444  
Fax No: +44 (0) 1908 220959  
Email: info@tscinspectionsystems.com  
Web: www.tscinspectionsystems.com

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