CygFMD

Diver and ROV Mountable

Ultrasonic Flooded Member Detector

Operating Manual

Doc No. M1-FMD-M-01_Manual (Iss 13).docx

29 June 2021 Issue 13

1. Contents

Figures

Revision History

Date	Issue	Comments
05/04/2017	1	First Issue
16/08/2017	2	Update post trials
23/02/2018	3	Updated system test and new probe connector
08/05/2018	4	General Update
17/10/2018	5	Updated test Piece cleaning and typos
04/03/2018	6	CygFMD v1.1.13 Release; Added Work Plan Import Added Results Output Added System Test PDF report Added Custom Report Logo
12/06/2019	7	Added "Test Auto Log" feature details.
27/06/2019	8	Added "Insert Test After" to test list submenu. Added "Edit Setup" to test list submenu. Added "Log as Obstructed" to test list submenu. Added "Auto Save" survey option. Added 'Send Blank String' option to Results Output.
05/08/2019	9	Quality Policy Removal
06/09/2019	10	Corrected DIP-Switch number for disabling the automatic probe check on page 91.
04/04/2020	11	Updated Probe Position Calibration procedure in line with Subsea Firmware V2.12
10/02/21	12	Update images, probe connector, Auxiliary port removed
29/06/21	13	Added Probe Retainer & Face Protection.

Table 1 – Revision history table

References

Ref	Title	Rev.	Date	Comments
Ref 1	ISO 8501-01:2007	2	May 2007	
Ref 2	Probability of Detection Trials	1	Nov 2016	

Table 2 – References table

List of Terms

Term	Meaning
A-Scan	A display of a waveform which represents time of flight on the x-axis and amplitude in the Y-axis. The measurement on the x-axis illustrates the measured diameter of the detected flooded member.
Comms	Communications
Cygnus	Cygnus Instruments Ltd
CygFMD	Cygnus FMD Windows PC Application
FMD	Flooded Member Detector
Member	Section of pipe on which the FMD test is to be performed.
Microsoft Excel	Spreadsheet utility software supplied by Microsoft
PCU	Power and Comms Unit
PDF	Portable Data Format file
RF	Radio Frequency
QC	Quality checking
ROV	Remotely Operated Vehicle (in this case submersible)
Windows	PC Operating system software supplied by Microsoft

Table 3 – List of terms

2. Important Notice

The following important information must be read and understood by all users of the Cygnus FMD System.

The flooded member detector is a solid-state electronic instrument which, under normal operating conditions, will give many years of active service.

Although designed for ease of operation a first-time user should carefully read this manual to familiarise themselves with the features of the system.

Cygnus recommends that for correct use of the Cygnus FMD System that all users complete a Cygnus approved FMD training course.

Please contact Array Training for further information.

Array Training Limited | International Base | Greenwell Road | Aberdeen | AB12 3AX
Find out what's new at - www.arraytraining.com

Please read the important information about fitting the Probe Cable Connector on page 33.

3. Introduction

The **Cygnus FMD (Flooded Member Detection)** System has been developed to provide a quick, reliable and easy to use system for FMD testing. The system uses the ultrasound (sonar) method to detect echoes from the inside of the member when water is present. The system has been developed for use on members with a wide range of wall thickness and wide range of member diameters. Performance on corroded members is good due to the use of a piezo-composite ultrasound probe and high sensitivity receiver.

The systems primary use is for the detection of internally flooded members which can be horizontally, vertically or diagonally oriented. These members would have been sealed originally and have become flooded over time, normally because of a breach caused by the corrosion of the outer wall, physical damage or failure of a critical weld. It can also be used to test buoyancy tanks to check for flooded compartments.

The Cygnus FMD system is operated topside using CygFMD software which is installed on a Windows computer. Communication down to the subsea unit is via a Serial Data link which can RS-485 down an umbilical cable for a Diver, or RS-232 when used with a ROV multiplexer.

The FMD Tests are performed after first setting the member diameter, the test results are displayed as a simple Red/Green (Flooded/Dry) indicator. An A-Scan display shows the ultrasound signal which can be used to visually verify the findings when marginal. All the test results are saved in a Survey file which can be saved as a PDF report or exported to Microsoft Excel.

The Cygnus FMD System comes with a System Test procedure that verifies the correct operation of the system and is performed before each deployment subsea.

The Cygnus FMD System has been designed and tested to work up to 300m water depth.

Advantages of Ultrasonic Flooded Member Detection

Compared with other types of flooded member detection systems the Cygnus FMD system has several distinct advantages:

- Member Diameter Range of 200mm to 2.5m
- Single person operation.
- Simple and conclusive flooded/not flooded result.
- Detailed A-Scan display for verification of marginal results.
- Compact probe holder design.
- Gimbal in probe holder to correctly align Probe to Member Surface.
- Has a Surface Contact Sensor to ensure tests are only performed when the probe is in contact with the member.
- Cygnus FMD software with Survey logging and ability to export survey details including A-Scans to Microsoft Excel and PDF formats.
- Checking of FMD tests can be performed offline by third party or Level III UT inspector.

4. Kit Contents

ROV Mounted System Contents

1. Subsea Electronics Unit (stainless steel or acetal)
2. Probe & Probe holder (stainless steel or acetal)
3. Probe Cable assembly, 5 metres.
4. Probe Retainer / Face Protectors (3 off)
5. Patch Cable (power and coms), 0.6 metres.
6. RS232 to USB adapter cable
7. Software Installation on USB memory stick
8. Dual test lead RS485 and RS232 to 2 9-way D-Type connectors
9. Cable Securing guard

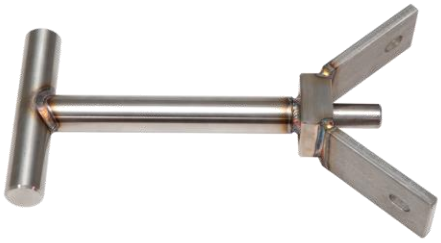
Subsea Electronics Unit

Probe, Probe Holder and Cable

Accessories for the ROV Mounted System

1. System Test Piece
2. T-bar handle for Probe Holder
3. Fish-tail handle for Probe Holder
4. Straight handle for Probe Holder

System Test Piece



T-bar handle

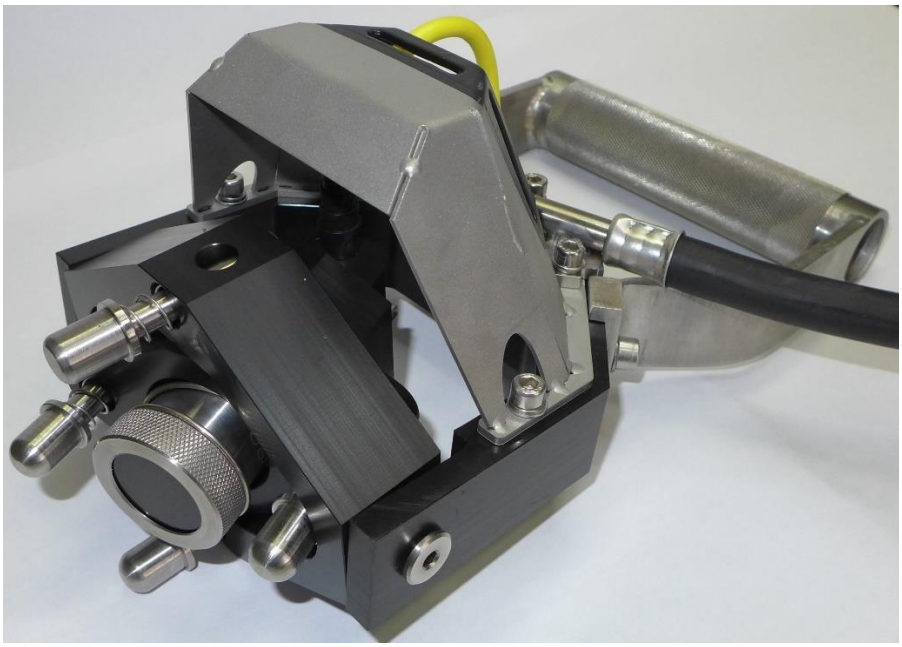
Fish-tail handle

Diver Held System Contents

1. Subsea Electronics Unit (stainless steel or acetal)
2. Probe & Probe Holder (stainless steel or acetal)
3. Probe Cable assembly, 5 meters
4. Probe Retainer / Face Protectors (3 off)
5. Cable Securing Guard.
6. Power & Comms Interface Box
7. USB A-B Cable
8. Umbilical Test Lead, 3 meters
9. Software Installation on USB memory stick

Subsea electronics bottle with Cable Securing Guard fitted.

Power & Coms Interface Box



Probe, Probe Holder fitted with D-Handle.

Accessories for the Diver Held System

1. System Test Pot
2. D-Handle for Probe Holder
3. Umbilical extension, 120m (power & coms)
4. Umbilical extension, 350m (power & coms)

D-Handle for Probe Handler

5. Flooded Member Detection Background

The task of flooded member detection is to determine whether a member (usually a sealed cylinder) contains water.

Flooded member detection using ultrasound is performed by emitting an ultrasound pulse into a member (which is in contact with the ultrasound probe).

Ultrasound propagates through the near wall of the cylinder which is usually steel. If the cylinder does **not** contain water virtually all of the sound is contained in the near wall and a flood is not detected, however if the cylinder does contain water sound travels through the water and is reflected off the second (far) wall as an echo and a flood can be detected.

A flooded member detection system must detect the ultrasound echo reflected off the far wall. If an echo is detected, then the FMD system must determine whether the member is 'flooded' or 'not flooded'.

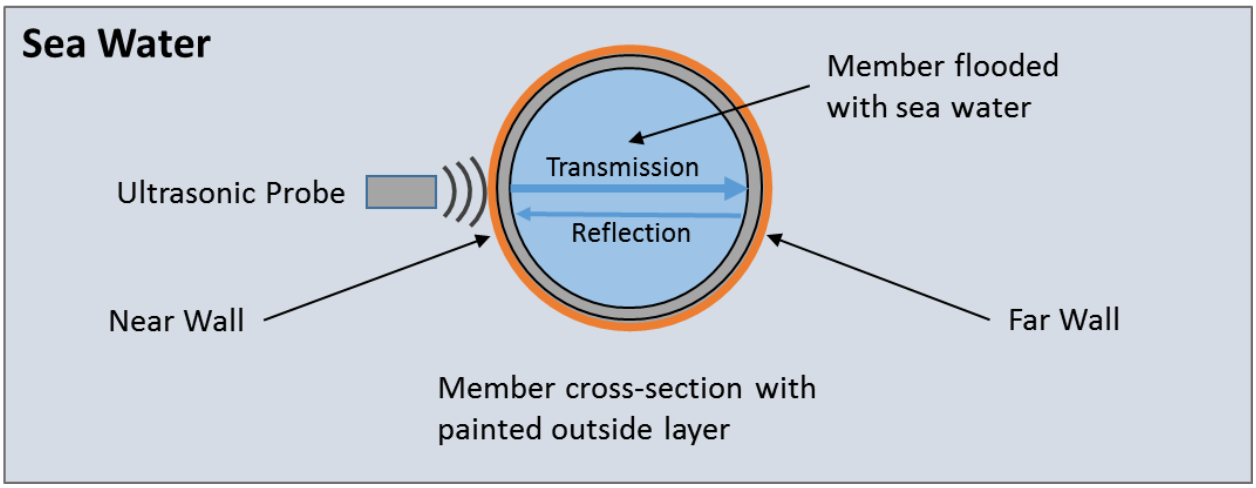


Figure 1 – FMD ultrasound reflections in flooded member

The diagram below shows the reflections that would be seen with a FMD test on a member that is flooded.

Initial reflections within the near wall can be seen as a signal that 'rings-down' slowly over time. There is then a quiet period until the ultrasound reaches the far wall. The ultrasound reflects off

the far wall and travels back to where the ultrasound and a signal is received by the ultrasound probe. It is possible for multiple reflections within the member to be received by the ultrasound probe.

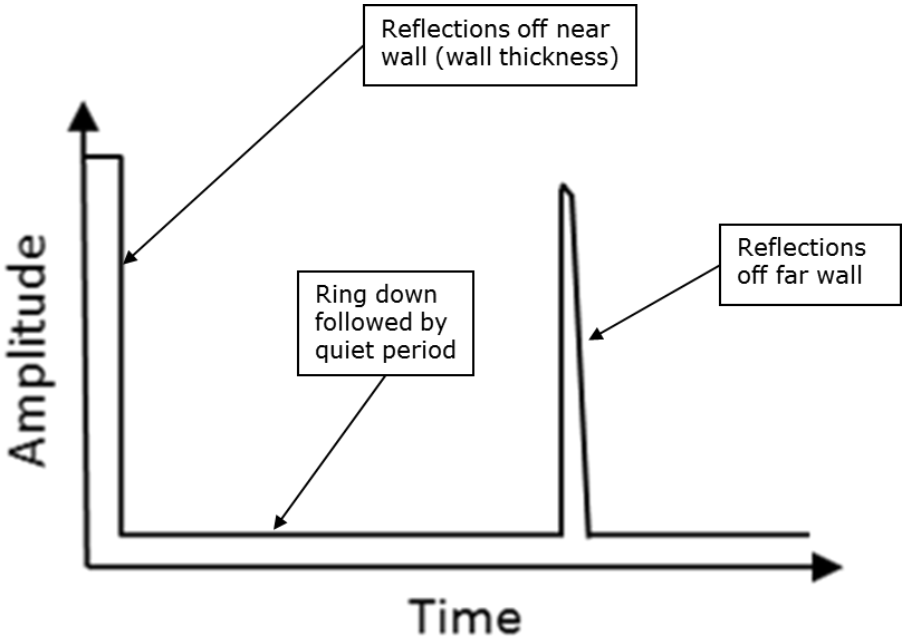


Figure 2 – FMD ideal waveform in a flooded member

A good FMD test should show the initial internal reflection inside the near wall (this will widen as the gain is increased) followed by a quiet period, then followed by the reflection or echo off the back wall followed again by a quiet period.

A member is considered flooded when a back-wall echo is visible.

6. System Overview

Subsea Electronics Unit

The subsea electronics unit contains circuit boards with connections to the outside world, there are DIP switches for configuration and Status LEDs. A USB port is provided for updating the firmware.

The subsea electronics unit is carried by a Diver or mounted on an ROV and communicates with the surface computer via an RS232 or RS485 serial data link.

There are two connection ports available: Power/Coms and Ultrasound Probe.

The only setting that needs to be applied is to select either RS232 or RS485 comms mode. See **Setting Comms Mode for RS232 or RS485,** See page **31**.

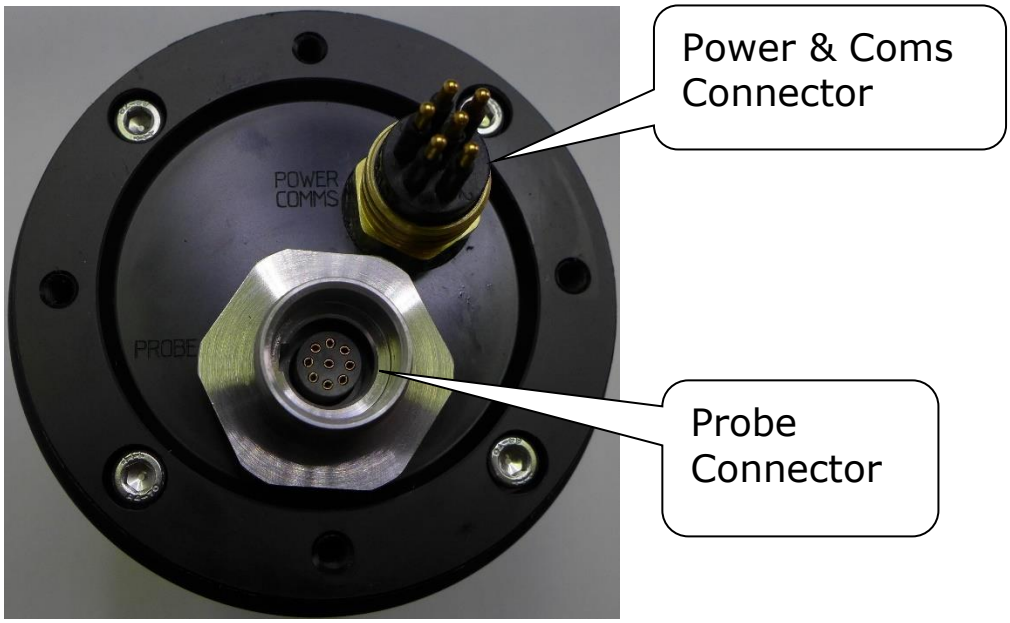


Figure 3 –Subsea Electronics Unit Connectors

Probe Holder

The probe holder consists of a three-dimensional gimbal, which a spring-loaded ultrasound probe is slotted into. It enables contact with a member with up to ±20 degrees of misalignment.

The gimbal has four spring loaded plungers that align the gimbal and probe to the member surface when pressure is applied. The plungers also help to protect the probe from overloading.

A surface contact sensor monitors the position of the probe and is used to detect when the probe has been "pushed" onto the test member surface sufficiently. This signal is also displayed topside so the user can monitor what the Diver or ROV is doing. Should the probe move away from the member surface during an FMD test this will be detected, and the test will be aborted. Similarly, an FMD test cannot be started until the probe is in contact with the member surface.

The probe holder is available with the following handles:

- Stainless steel D-handle for Divers
- Stainless steel Fishtail
- Stainless steel T-bar ¾"
- Stainless steel T-bar ½"

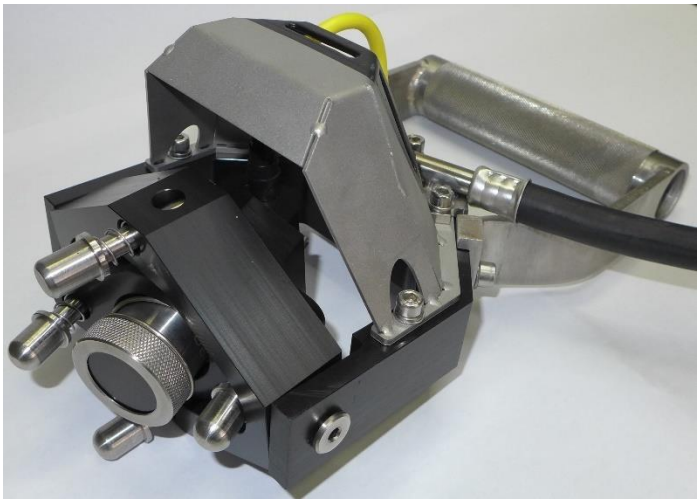


Figure 4 – Probe holder (stainless steel) with D-Handle

Power and Comms Unit

The Power and Comms (M1-FMD-PCU) unit is required when deploying a Diver held system with an umbilical cable (which can be supplied by Cygnus), see Figure 74 – Test scenario 3 (Diver).

It provides RS485 communication between the FMD bottle and the Cygnus FMD software computer to its USB port.

It provides 24V DC Power to the Subsea Electronics Unit and this is also fused at the Power and Comms unit.

It is AC mains powered from a 230V or 110V AC supply.

Figure 5 – Power and Comms unit

Kit Carry Case

The Cygnus FMD kit is supplied in a hard carry case, except for the Umbilical cable reels and the System Test Pot.

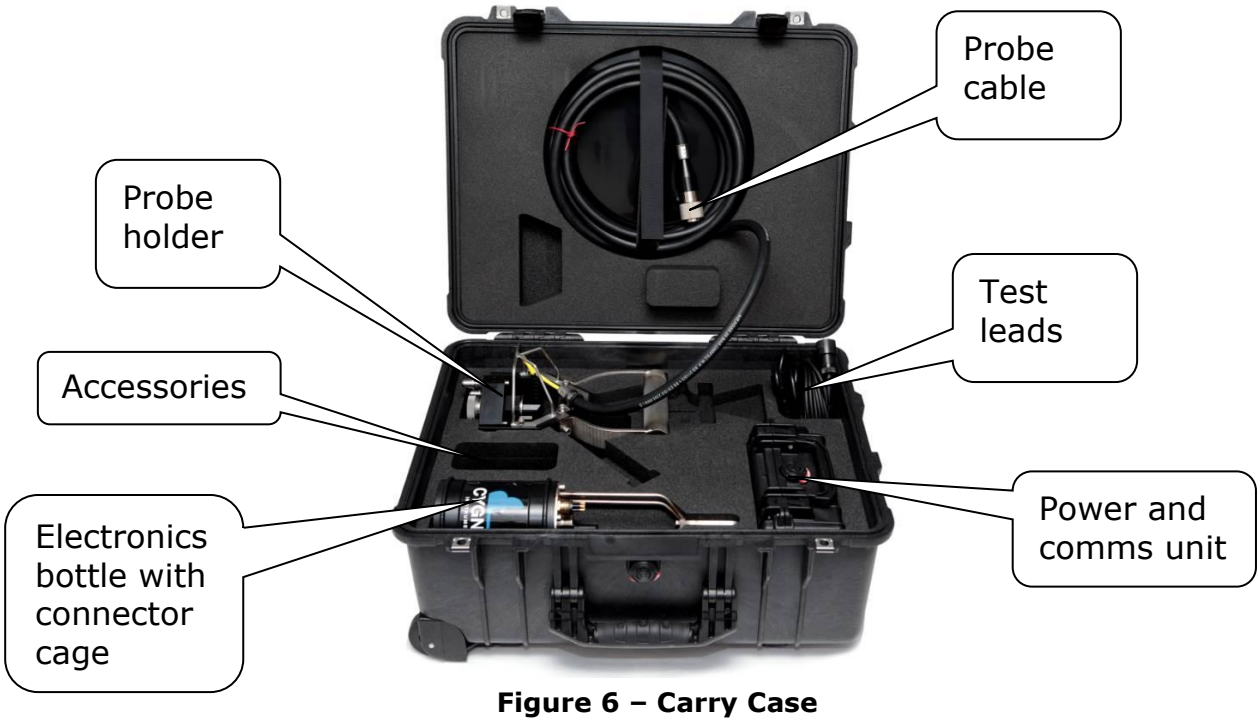


Figure 6 – Carry Case

System Test Pot

The System Test procedure requires use of a "system test piece". Using the system test piece supplied by Cygnus the System Test is a one-man operation. The system test piece has been designed to hold the probe in position while the user operates the software.

Figure 7 – System test piece

Cygnus can supply CAD drawings for the user to fabricate their own system test piece.

You cannot use a plastic system test piece as the System Test has been specified to look for ultrasound signals that have passed through a steel-water-steel interface. A plastic-water-plastic interface will result in incorrect signals and thus fail the system test.

7. Preparing the System

To get the system up and running both ROV and Diver systems require a Comms link, a connection to a Power Source and connection of the ultrasound Probe.

Diver held systems use an Umbilical Cable to connect Power and Comms to the Subsea Electronics Unit. (*See Scenario 3 – Diver using Cygnus umbilical, page 105*).

ROV Mounted system use the ROV's power supply and multiplexer to provide power and comms to the Subsea Electronics Unit. (*See Scenario 1 – ROV using fibre optic multiplexer, page 105*).

For Mini and Micro ROVs where the customer supplies their own umbilical the Subsea Electronics Unit is connected via a short patch cable. The user can supply their own power and coms via their own umbilical. An RS485 to USB converter supplied by Cygnus is required topside (*see Scenario 2 – ROV using customer umbilical, page 105)*.

Subsea Electronics Unit Setup

Tools required

Item No.	Description
1.	4mm hex key
2.	5mm hex key
3.	Torque wrench (1.5nm)
4.	Silicon grease

Table 4 – Tools required for electronics bottle

The first step is to ensure that the Comms Mode DIP switch settings are correct if you don't know their current setup.

Removing the Endplate

To access the DIP switches, remove the bottom end plate of the electronics unit (the opposite end to the one with the connectors). Remove the four hex bolts using a 4mm hex key (*see item 1 of Table 4 – Tools required)*.

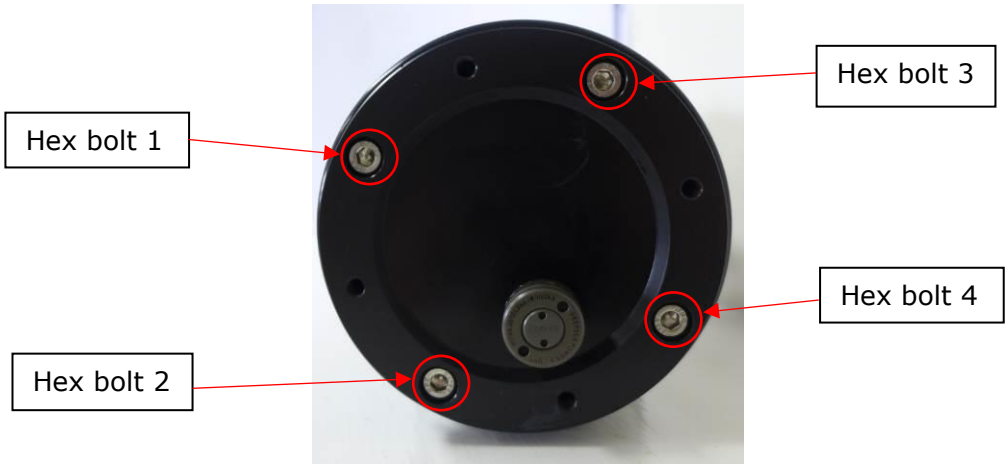


Figure 8 – Electronics bottle end plate fixing holes

The electronics unit uses a radial O-ring seal arrangement. When all four bolts are removed, if the plate does not come off, screw down the four bolts in the removal holes to release any O-ring friction.

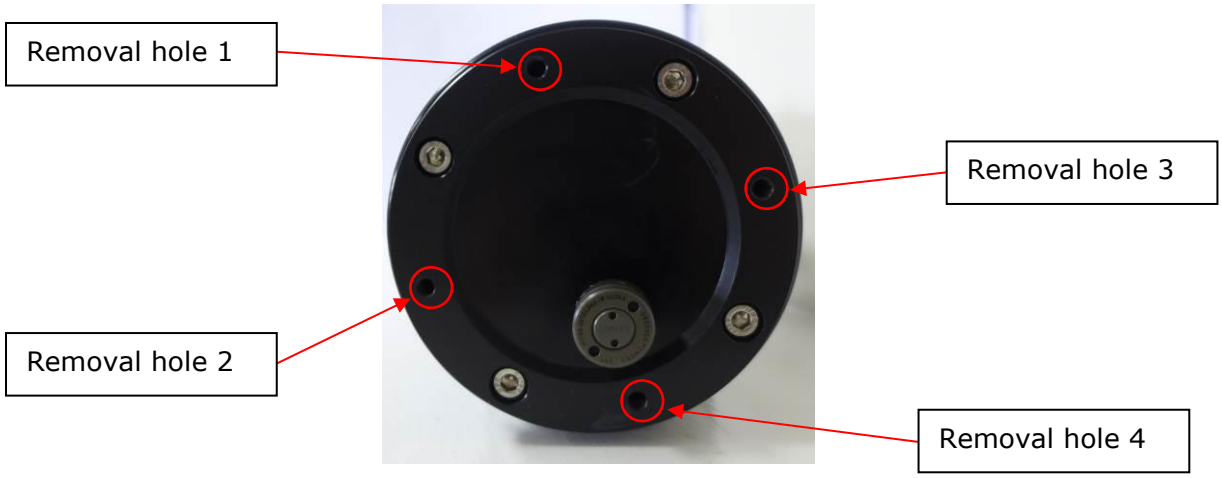


Figure 9 – Electronics bottle end plate removal holes

Remove the end plate and O-ring, there is now access to the DIP Switches, Fuse, Status LEDs, USB Port and an SD Card Slot.

Setting Comms Mode for RS232 or RS485

For use with an umbilical where RS485 is required position Switch 1 to the RS485 position (OFF). Please see below:

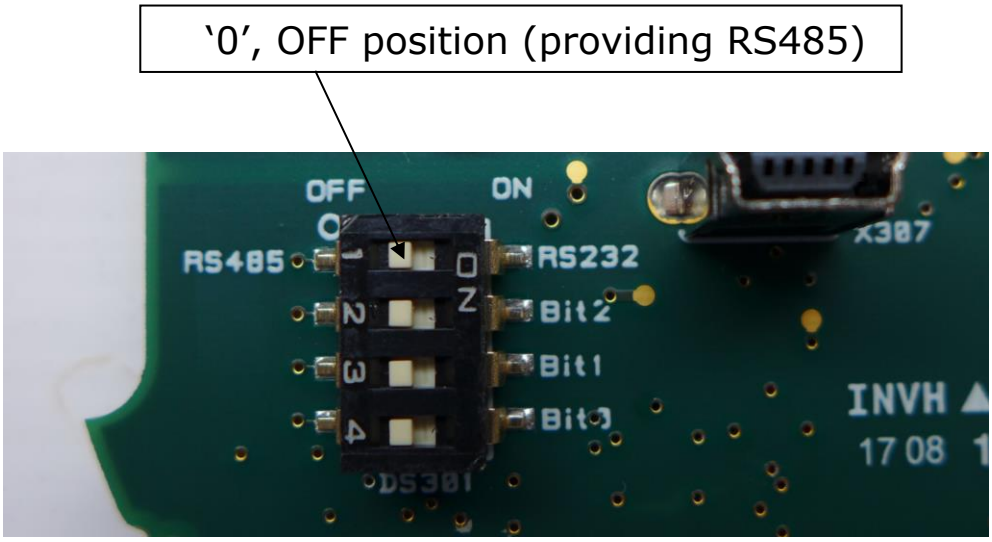


Figure 10 – Switch settings for RS485 connection

When using the RS232 i.e. for use with an RS232 fibre-optic multiplexer position Switch 1 to the RS232 position (ON). Please see below:

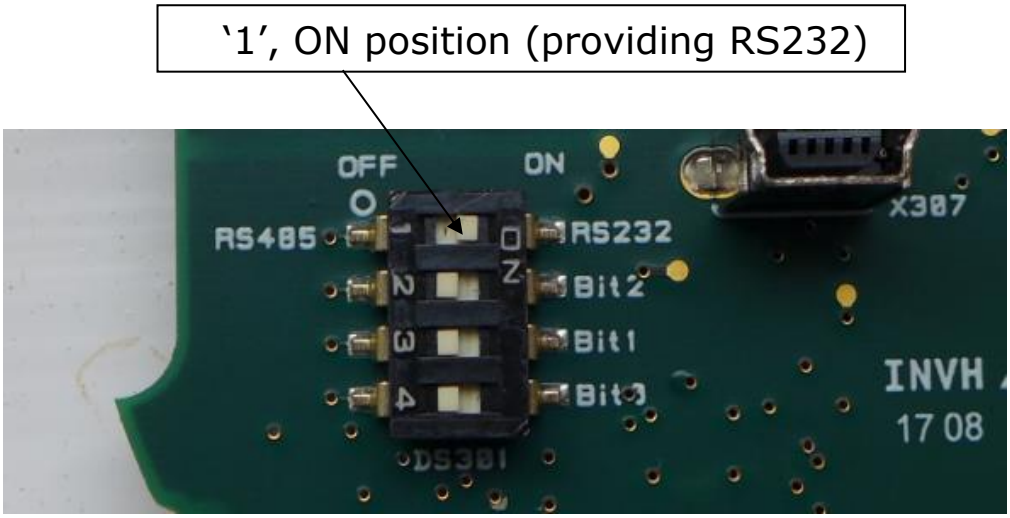


Figure 11 – Switch settings for RS232 connection

LED Status Indicators

There are two LEDs visible when the bottom end plate is removed, LD301, LD302 and LD303. Note the system must be powered up to observe the status LEDs.

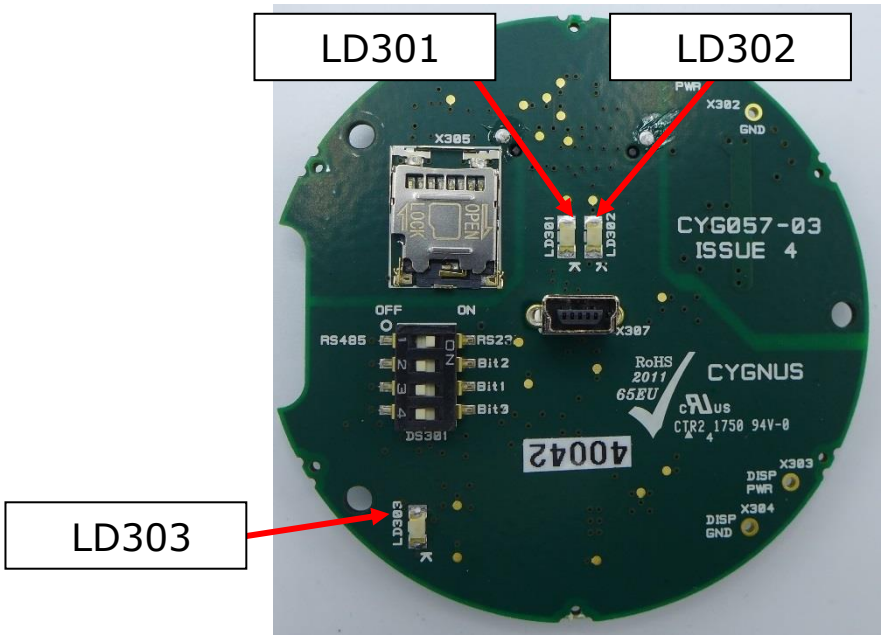


Figure 12 – LED indicators

The functions of the LEDs are detailed below:

LED No.	Mode	Meaning
LD301	Constant (ON)	6.5V supply for electronics
LD302	Flashing	System running
LD303	Not used	-

Table 5 – LEDs meanings

Refitting the Endplate

With the DIP switch settings have been completed, the end plate can now be refitted. Ensure that the internals are clean and free from debris. Ensure that the endplate has an O-ring fitted. Always lubricate the O-ring with silicon grease (see item 4 of Table 4 – Tools required).

Line up the end plate onto the electronics bottle with the four holes lined up. Hand tighten the screws first tightening 12 and 6

o'clock positions and then 3 and 9 o'clock positions. Repeat until all screws are hand tight.

To finish, ensure that each of the screws for the endplate are tightened with a torque wrench (*see item 3 of Table 4 – Tools required*) to 1.5nm.

Subsea Connectors

Make sure that all subsea connectors are mated in the dry using a suitable cable or dummy connector. Connectors are only subsea rated when mated.

The rubber Subcon connectors can be lubricated with silicone grease.

The stainless-steel Probe connector does not require lubricating.

Probe Connection

The probe lead is a 5m long rugged, flexible cable that connects the ultrasound transducer to the pulser-receiver in the subsea electronics unit. The connectors have a pin and notch to ensure correct alignment.

Before connection the connectors should be visually inspected to ensure they are free from contaminating substances, debris and water. Ensure that the connector pins have not been damaged in any way before connection.

Spraying the inside of both connector parts with a moisture replant such as WD40 will help to drive out any water.

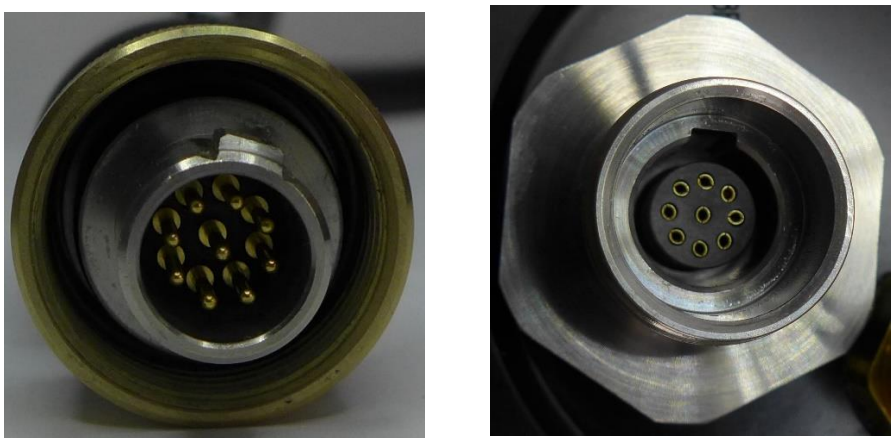


Figure 13 – Probe connections

Power and Coms Connection

Patch Cable for ROV

If using the Cygnus FMD system with an ROV, use the patch cable for connecting to the subsea electronics unit via the Power and Coms bulkhead plug.

The other end of the patch cable has flying leads which need to be connected to the power source and comms port of the ROV. This could be via a fibre-optic multiplexer (*see Figure 85 - In-Line patch cable*).

Umbilical Cable for Diver use

For the Diver held system simply connect the umbilical cable to the Power and Coms bulkhead plug (six-way underwater connector, see Table 9 – Power and comms port pinout) on the subsea electronics unit.

Umbilical Cables

Umbilical lengths are supplied in 120m and 350m + 50m lengths. It is recommended to use a single umbilical rather than combining multiple lengths for better strength.

The full length of umbilical should not exceed 400m.

Umbilical Specification

If using a custom umbilical not supplied by Cygnus, it is recommended that the specification meets the following:

General	
Length max.	<= 400m
1 twisted pair	
Nominal Conductor Resistance	<= 61Ω/Km
Characteristic Impedance	= 120Ω
Mutual Capacitance	<= 64pF/m
2 power conductors	
Nominal Conductor Resistance	<= 13.5Ω/Km
Maximum Voltage	>= 1000V
Maximum Current / Conductor	>= 20A

Table 6 – Umbilical specification

Cable Securing Guard

The Cable Securing Guard that protects the connectors and allows the Umbilical and Probe cables to be secured to the guard by cable ties. There is a metal plate with a number of holes that can be used to cable tie to.

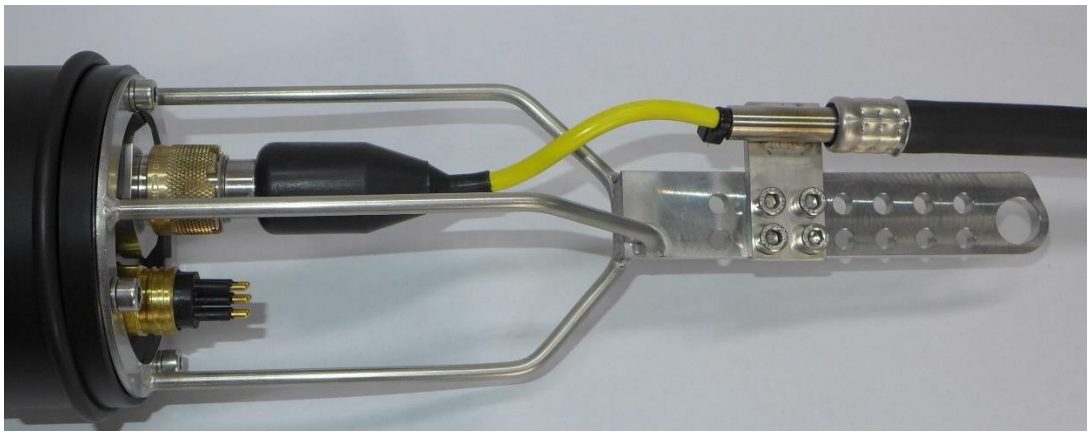


Figure 14 – Securing of probe cable to bottle.

Diver Scenarios

There are several configurations that the diver FMD system could be used in:

Diver with bottle on belt: The diver operates the FMD whilst the bottle is secured to the diver's belt. The probe will also have to hang off the diver when moving to other test locations.

Diver with bottle suspended on structure: When there are several test points local to each other, the bottle could be suspended from a structure allowing the diver to move freely having to carry only the probe.

Diver with bottle on seabed: Similar to having the bottle suspended from a structure. Test points will be limited to a range of 5m.

Care must be taken when operating the equipment not to damage cables and other equipment on sharp objects such as subsea structures and barnacles.

Probe Holder

Fitting Handles to the Probe Holder

The D-handle is fitted onto the probe holder two of the M5 holes at the rear of the probe holder.

Tools required.

Item No.	Description
1.	5mm hex key

Table 7 – Tools required for fitting probe handle.

Fit two M5 bolts with spring washers and plain washers…

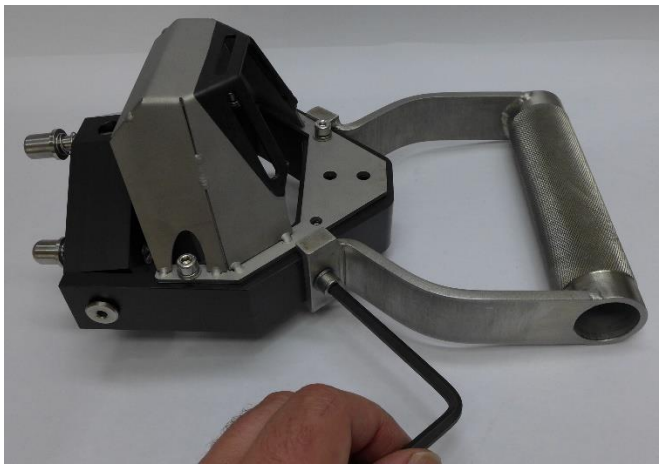


Figure 15 – Fitting the diver D-handle

Probe Retainers / Face Protector

The metal Probe Retaining ring has been replaced with a clear Acrylic Probe Retainer / Face Protector. Both are screwed onto the front of the probe to contain the probe spring and probe when fitted in the probe holder.

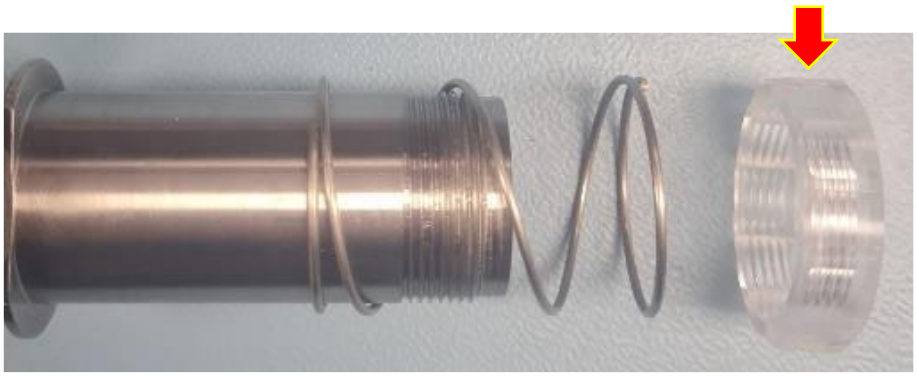


Figure 16 – Acrylic Probe Retainer / Face Protector

The Acrylic Probe Retainer / Face Protector must have a layer of couplant between it and the black probe face.

Fitting a Probe into the Probe Holder

The following instructions describe how to fit the probe cable assembly to the probe holder. No tools are required.

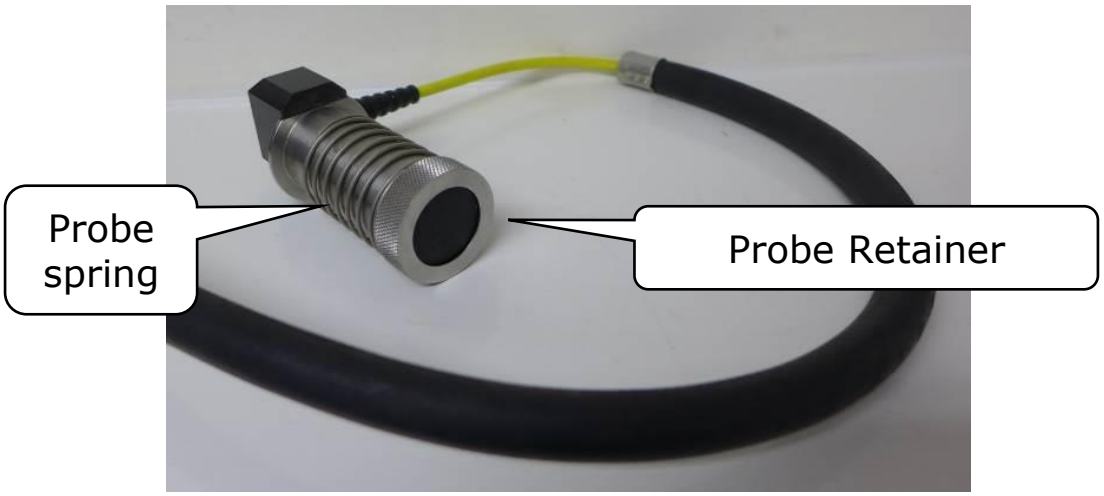


Figure 17 – Ultrasound probe cable assembly

Remove the probe retainer and spring from the probe body. The probe is then inserted into the probe holder gimble ensuring the slot in the probe body aligns with the locating pin…

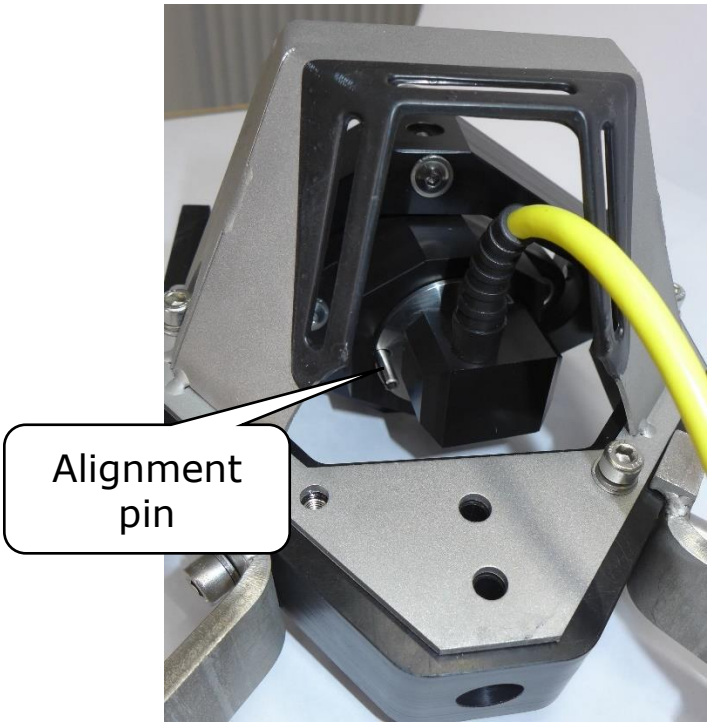


Figure 18 – Inserting the probe into the probe holder.

From the front, fit the spring over the probe body and into the recess in the gimbal.

Figure 19 – Spring fitted over the probe.

Using some membrane couplant, place 5-7 drops of couplant into the inside face of the probe retainer.

Figure 20 – Adding Couplant oil to the Probe Retainer.

Screw the probe retainer onto the probe ensuring the spring is held back and that any excess couplant and air escapes through the bleed holes on the face of the probe retainer. Hand tighten only.

Check there are no air bubbles between the probe face and the inside face of the probe retainer.

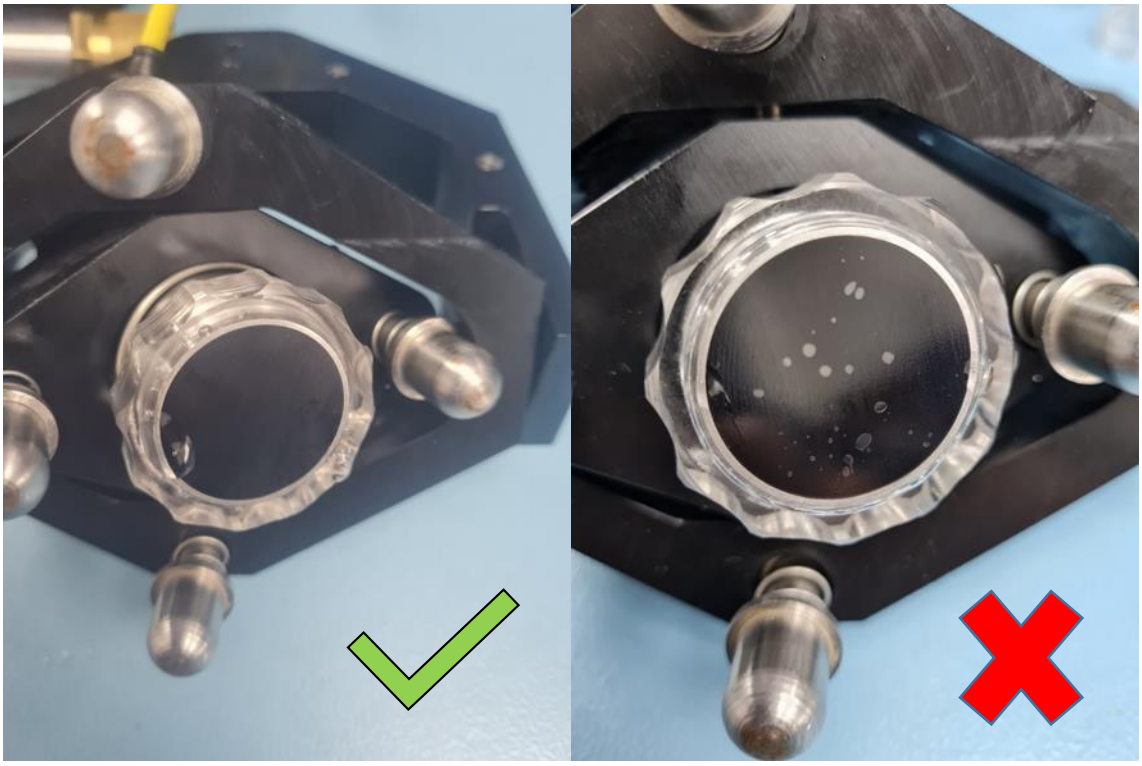


Figure 21 – Probe Retainer correctly and incorrectly fitted.

Air bubbles will normally occur if insufficient couplant has been applied to the inside face of the protection cap. These air bubbles will interfere with the ultrasound giving poor performance of the system.

Next, push the probe inwards against the spring and ensure that the spring returns the probe to the outer position and the movement is smooth.

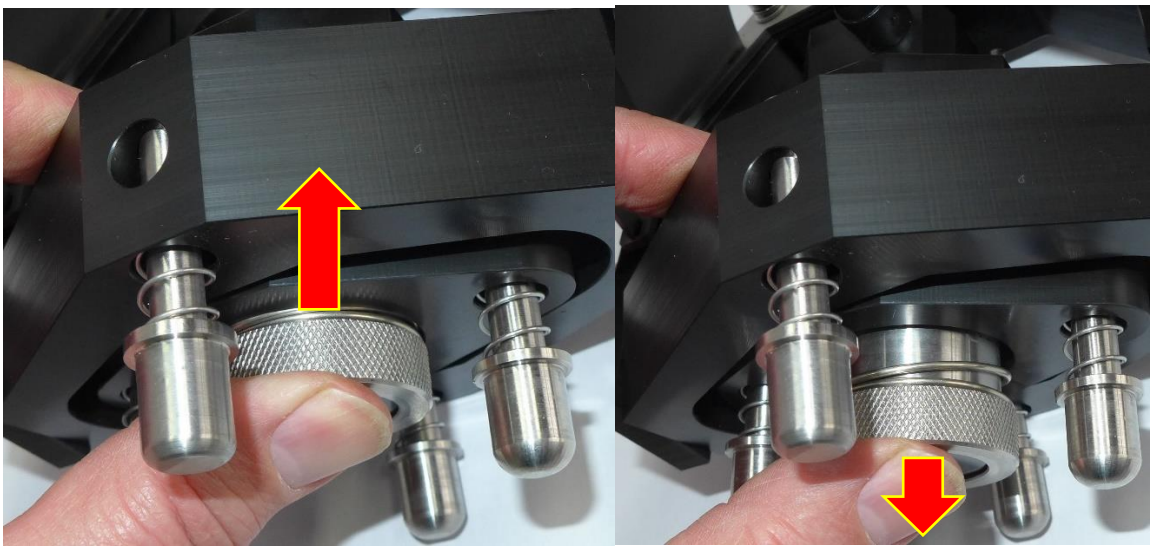


Figure 22 – Checking probe movement in-out.

Finally secure the probe cable to the probe holder using the M5 fixings provided. The smaller flexible yellow cable should be free to move with the probe gimble.

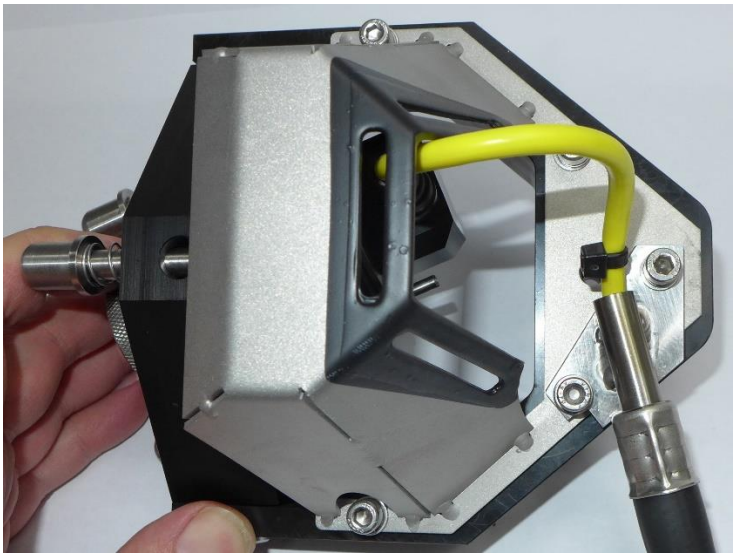


Figure 23 – Fixing the probe cable assembly to the probe holder

8. CygFMD Software Operation

System Requirements

The minimum system requirements for the FMD system are as follows:

OS: Windows 7 64 Bit service Pack 1
Processor: Intel Celeron 1.1GHz or equivalent
Memory: 2GB RAM
Storage: 128GB Hard Drive
Display: 10.1” LCD display
Graphics: Intel HD or similar
Network Adapter: Not applicable
Connections: 1 x USB port
Control: Keyboard and Touchpad or mouse
Storage Space Requirements: 1GB

Compatibility with Windows

The Cygnus FMD Topside software is currently compatible with Windows 7 Professional Service Pack 1 and Windows 10 Professional.

Installing the Software

If using a third-party computer then the CygFMD software will need to be installed, it can be found on the Cygnus USB memory stick supplied with the kit. Connect the memory stick and double click on the “setup.exe” or “setup” file to start installation and follow the on-screen instructions.

CygFMD Software Introduction

Loading the software

There should be a 'CygFMD' shortcut icon on the PC desktop, otherwise navigate to C:\Program Files (x86)\M1-FMD-TOPSIDE. Double click to load.

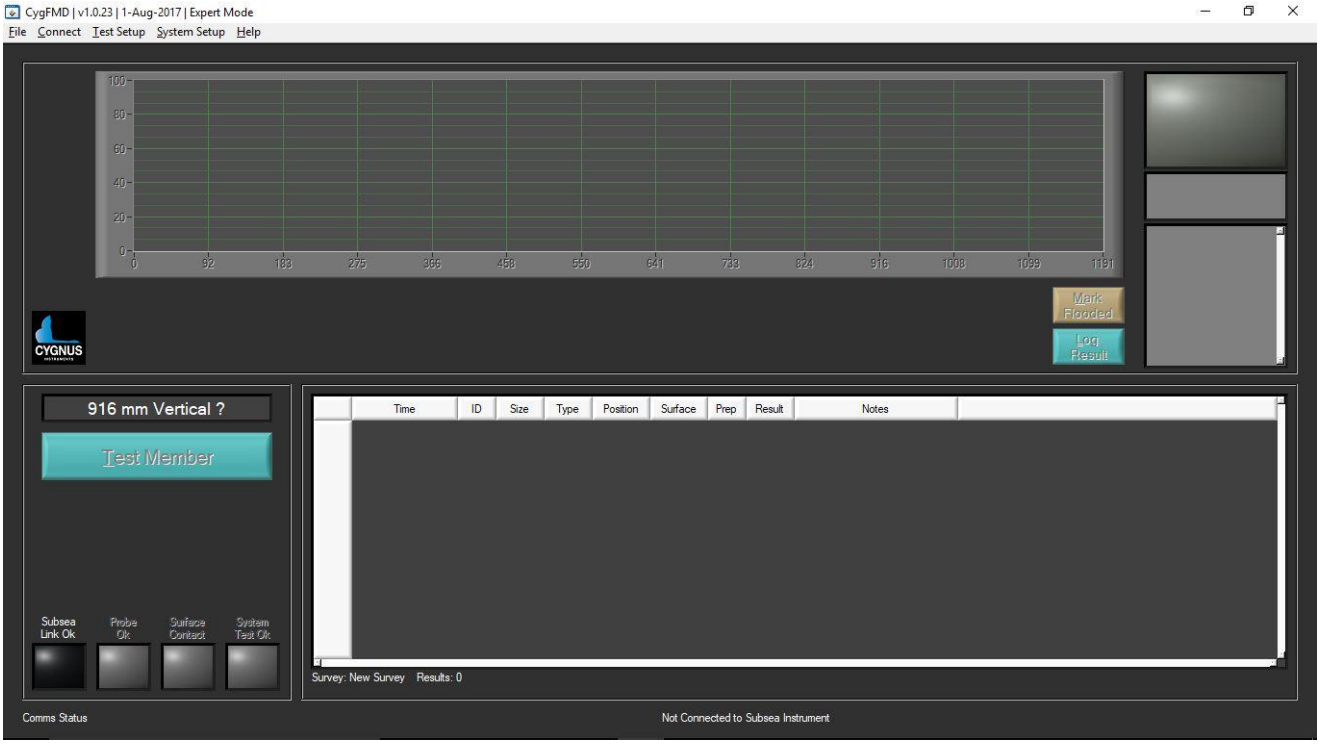


Figure 24 – FMD software not connected

Connecting to the Subsea Unit

When testing a Diver held system on the bench you can use the short Test Umbilical cable provided in the kit to connect up the system. Otherwise connect up the power and comms between the subsea unit and the computer.

Turn on the power to the Subsea Electronics Unit.

From the CygFMD Menu select **Connect->Discover and Connect** if this is the first time the system has been run in this configuration otherwise you can choose **Connect->Connect**.

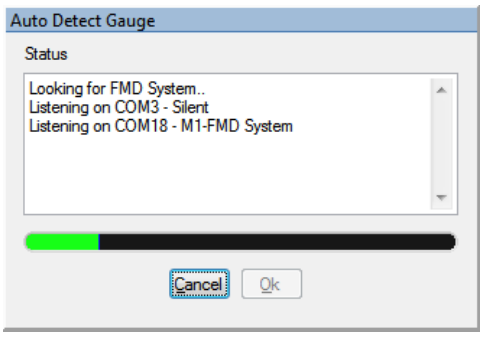


Figure 25 – Auto detect FMD system

The screen should look as below, the software is informing the user that a system test needs to be carried out:

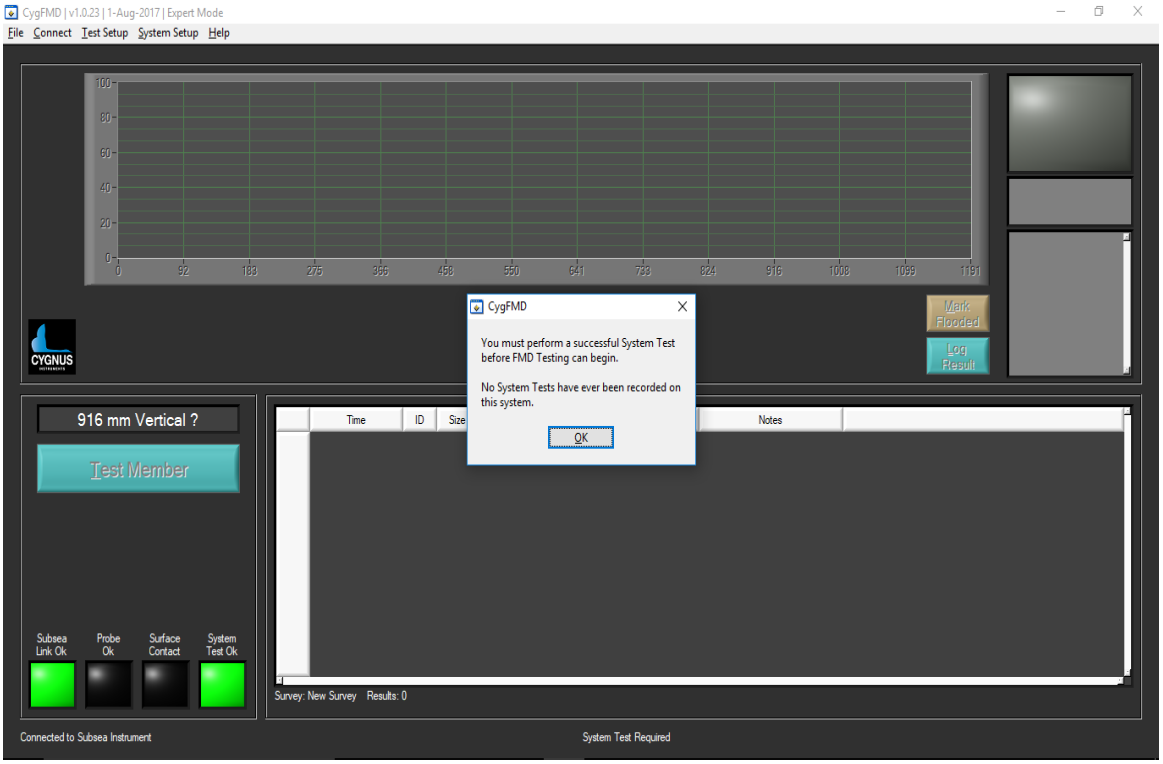


Figure 26 – FMD software connected

PDF Report Setup

Custom Report Logo

You can add a custom company logo to the PDF reports, the logo must be a JPG file and 100 x 100 pixels or bigger is recommended.

From the Main Menu, select **System Setup->PDF Report Setup**;

Figure 27 – PDF Report Setup, Custom Logo.

Use the **Load Custom Logo File** button to select and load your logo. The new image should be displayed in the box, *don't worry if it looks stretched here, it will be displayed correctly in the PDF report.*

To revert back to the default Cygnus Instruments logo just un-tick the Use Custom Logo box.

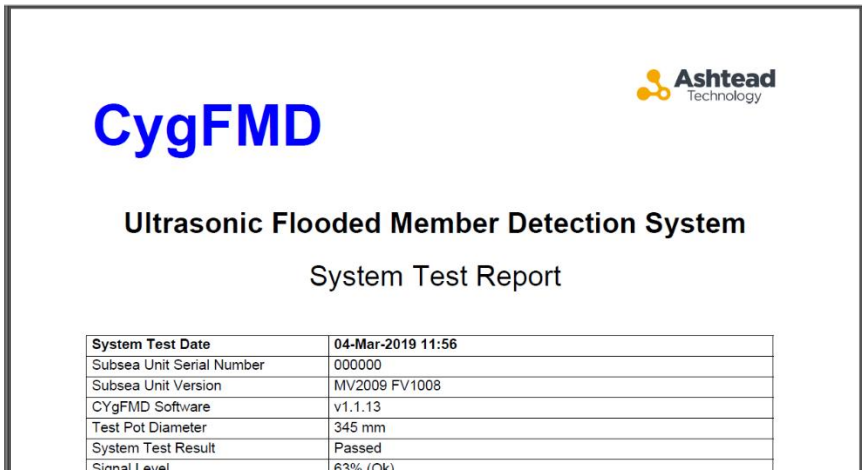


Figure 28 – PDF Report with Custom Logo.

Test Auto Log Feature

The CygFMD software can automatically log every FMD Test into the survey, this can be useful in some situations.

By default, this feature is turned on after installation.

However, when Auto Test Log is On, you will not have the opportunity to manually log and over-ride an FMD Test result to flooded. If you want to manually log FMD Tests into the survey, and over-ride results to Flooded, then you must turn Auto Test Log off.

The Auto Test Log setting is found in the System Settings, from the Main Menu, select **System Setup->System Settings**;

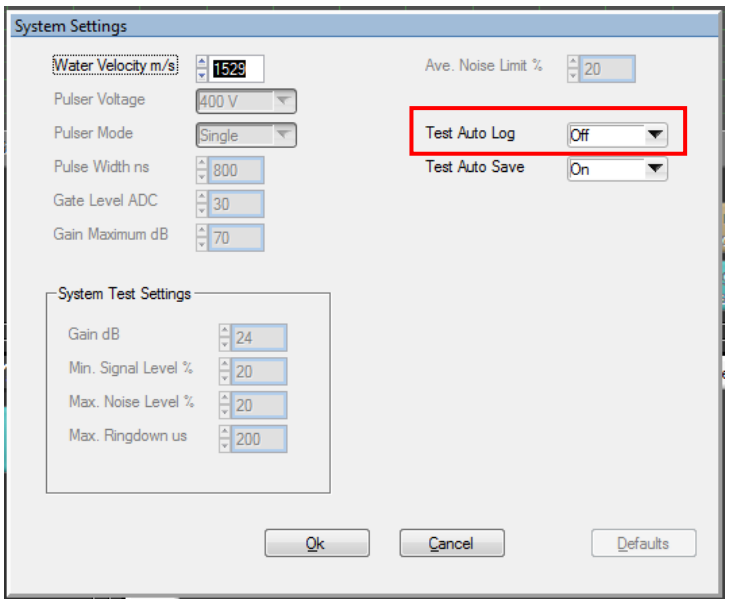


Figure 29 – Test Auto Log in System Settings.

Test Auto Save Feature

The CygFMD software can automatically save the Survey after an FMD Test has been logged, this will help to ensure test results are not lost should the software or computer lock-up.

By default, this feature is turned on after installation.

The Auto Save Log setting is found in the System Settings, from the Main Menu, select **System Setup->System Settings**;

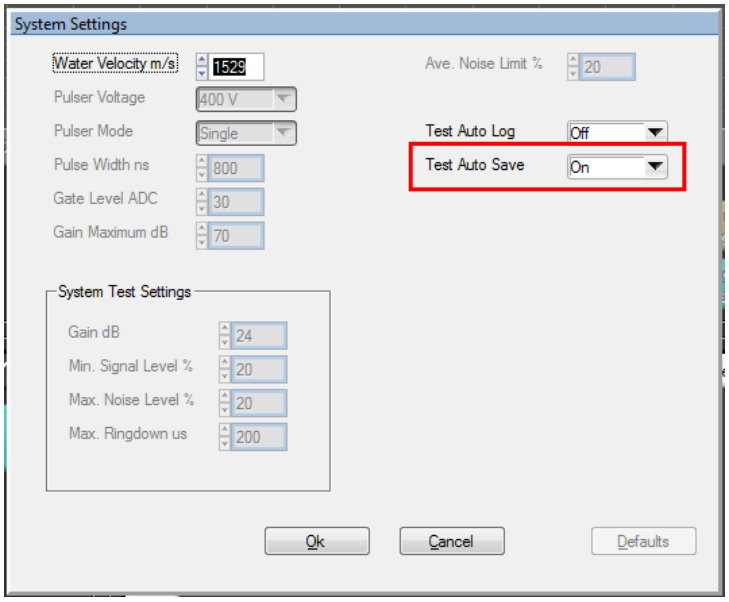
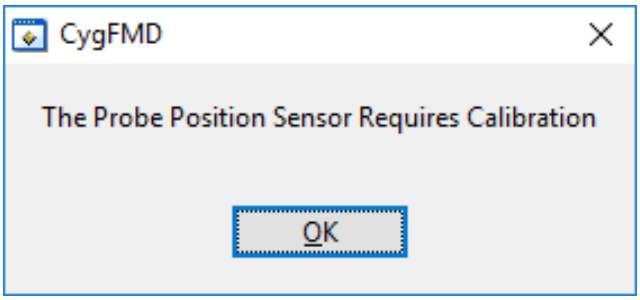


Figure 30 – Test Auto Save in System Settings.

9. Preparing for Deployment

Before deploying the system subsea you will need to perform a successful System Test. This will test the system including that the ultrasound probe is working correctly.

If you are using a new probe, or you have not used this system before then you must perform a Probe Position Sensor Calibration first. You may see this message;



The System Test will be valid for 24 hours, after which a warning message will be displayed that a test is required. You can continue to use the system, should this occur during a dive.

Connect up the System

For Diver systems connect the Subsea Unit to the Power and Comms unit with the Umbilical cable you will be using.

For ROV systems the power and comms connections should be wired through the ROV system to the control room.

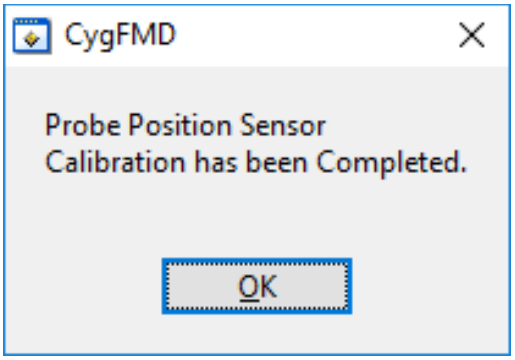
With the system connected and powered on, start the CygFMD software and connect to the subsea unit as normal (From the Menu, select; **Connect -> Discover New Subsea Instrument and Connect**).

Probe Position Sensor Calibration

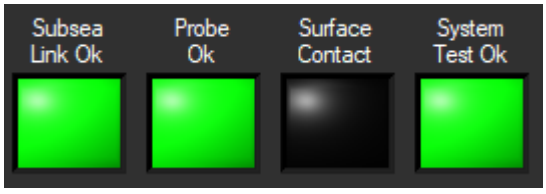
Calibration ensures that the sensing of contact with a member is optimised for the probe being used.

Perform a quick Probe Position Sensor Calibration as follows;

1. Get someone to hold the probe holder and get ready to push the probe fully 'in' against the spring when signalled to do so.
2. On the CygFMD software, from the Menu, select; **System Setup -> Probe Position Sensor Calibration**
3. The Probe Position Sensor Calibration dialog box should appear.
4. Click the **Start Calibration** button and signal to the person with the probe holder to
    a. push in the probe fully,
    b. wait about 1 second,
    c. let the probe return to the out position.
5. After 6 seconds the CygFMD software should report the calibration has been successful.



6. The Probe Ok LED should be Green

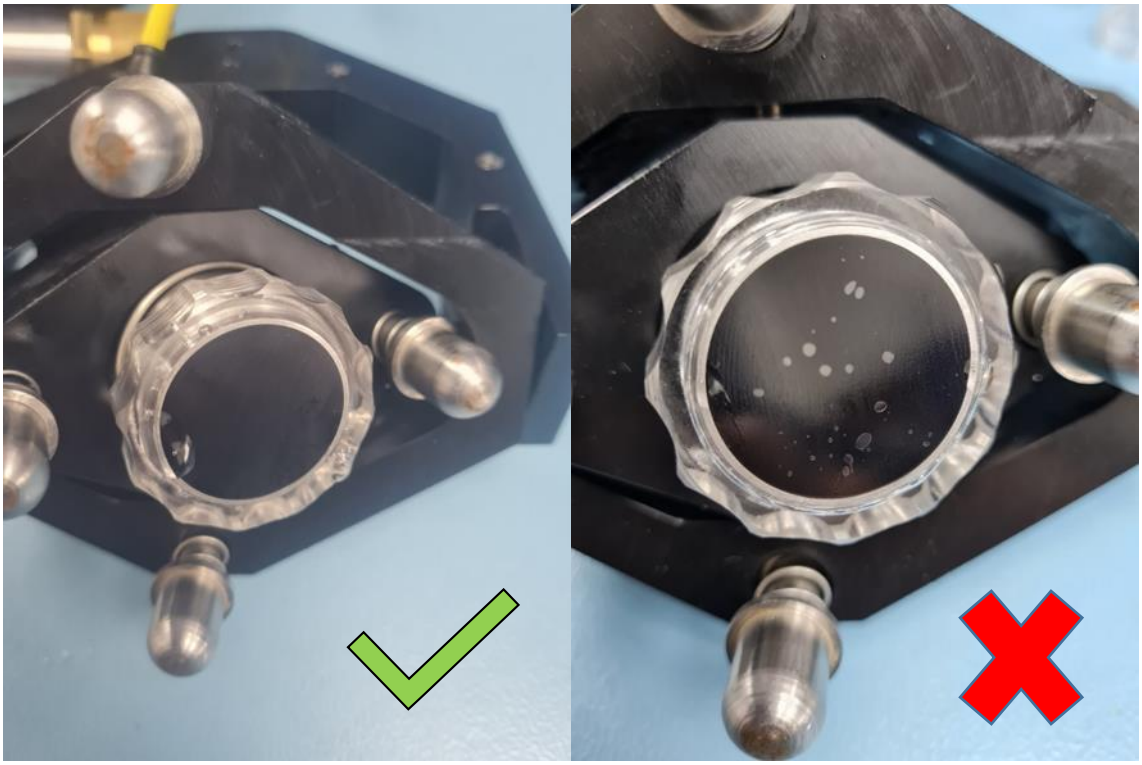


7. You should be able to push the probe in and out and see the **Surface Contact** green LED change in the CygFMD software screen.

8. If the calibration is unsuccessful then this could signal a faulty sensor in the probe unit, or a damaged probe cable.

Check the Probe Retainer

Check there are no air bubbles behind the Probe Retainer. See Probe Retainers / Face Protector on page 37



Performing a System Test

1. Using a wire brush clean off the inside surface of the test pot. This is to normalize the acoustic path for the ultra-sound and produce a standardised test result.

2. Fill both sections of the yellow System Test Piece with water (sea or fresh water is ok), fill both to 1” below the top of the pot.

3. Let the water settle down any bubbles disperse, if you see bubbles forming on the walls of the Test Piece just disperse them with your hand.

4. Remove any handles from the probe holder.

5. Wind out the bolt in the side of the Test Piece so you can get the Probe holder in.

6. Put the probe holder in the side water pocket so the bolt goes into the hole in the end of the probe holder. The Probe face should contact the surface of the Test Piece diameter. See the photo below.

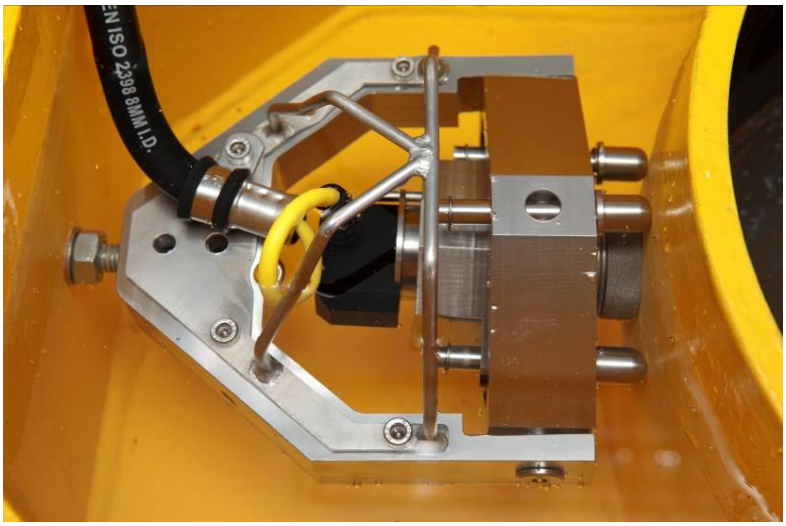


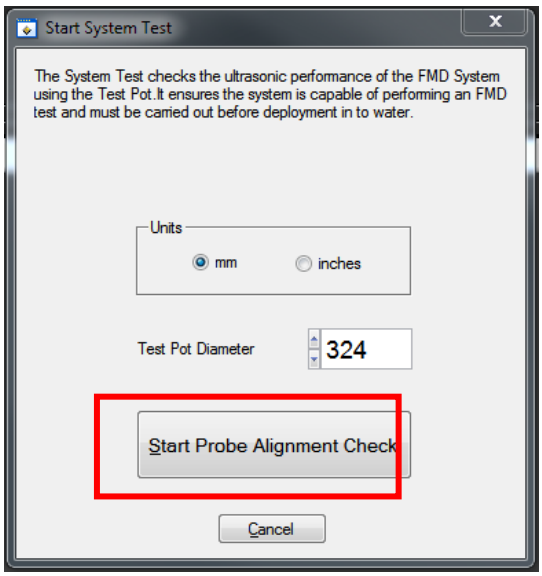
Figure – Fixing probe holder into the test piece

7. Next wind in the Bolt so the Probe holder is pushed against the test piece surface and the plunger's compress. Don't overtighten – just enough to compress the springs in the plungers.

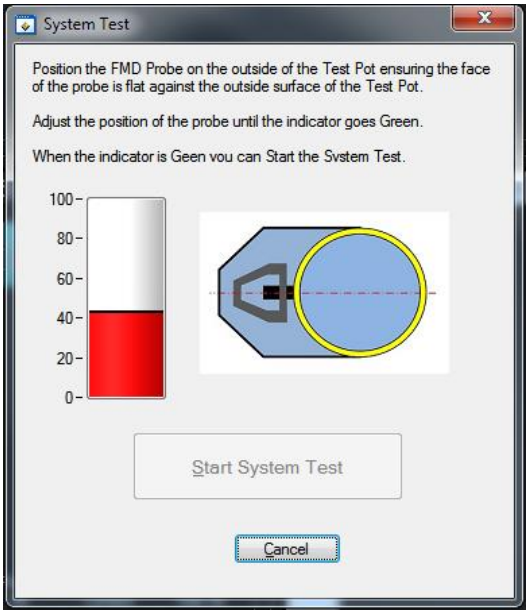
8. On the CygFMD check the '**Probe Ok'** and '**Surface Contact**' lights are lit **Green**.

9. Start the System Test by selecting from the Menu; **System Setup->Start System Test**.

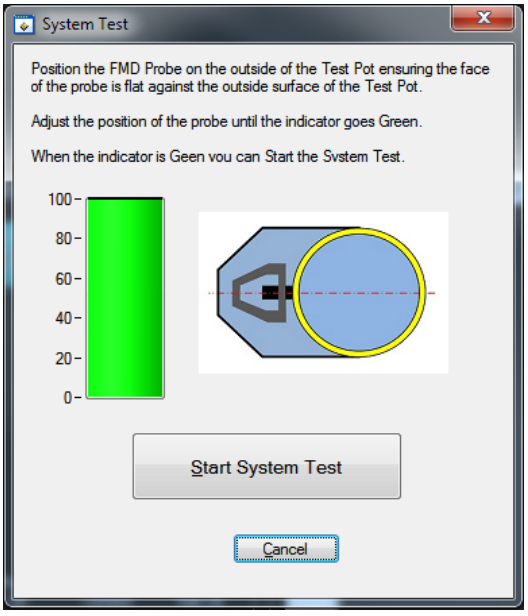
10. Enter the system test piece external diameter. This should be **324mm**. Then select '**Start Probe Alignment Check**'.



11. The aim next is to align the Probe on the Surface so the vertical bar on the screen goes **Green**. When the ultrasound signal is too low the bar stays Red. To align the probe, you can move it by hand (up/down, left/right) while watching the screen bar change. *It can take a few attempts until you realise how to find the best position. Small, slow movements are best.*



Signal Too Low



Signal Ok to Proceed.

12. If the probe alignment bar remains red even after re-alignment of the probe then see the Troubleshooting section for problems performing a System test, page 76.

13. When the bar is **Green** click the **Start System Test** button.

14. The System Test is run, it takes a few seconds to report back a result.

15. If the System Test was successful then a **Green** indicator is displayed and "**System Test Passed**" shown, see below;

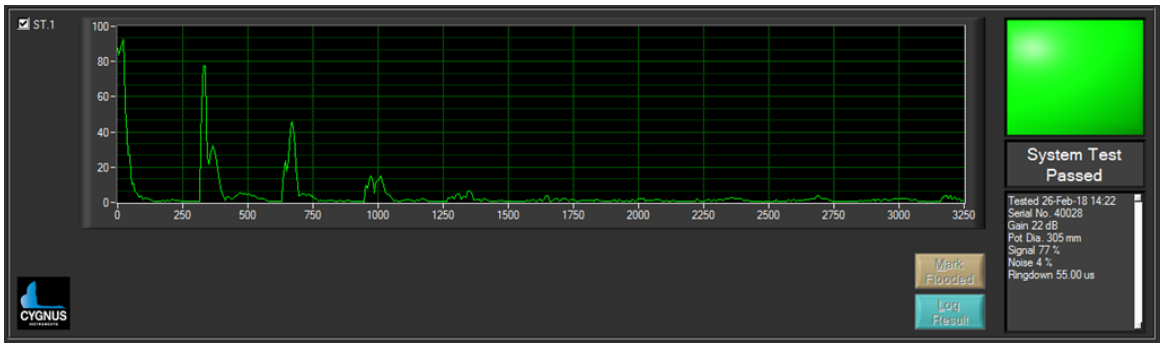
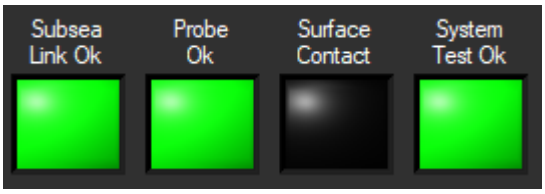


Figure 31 – System Test Passed Screen

16. The **System Test Ok** LED should also be Green;



17. If the System Test failed, then a **Red** indicator is displayed and "**System Test Failed**" shown. You should try and repeat the test. If the test still does not succeed, then consider contacting Cygnus for assistance.

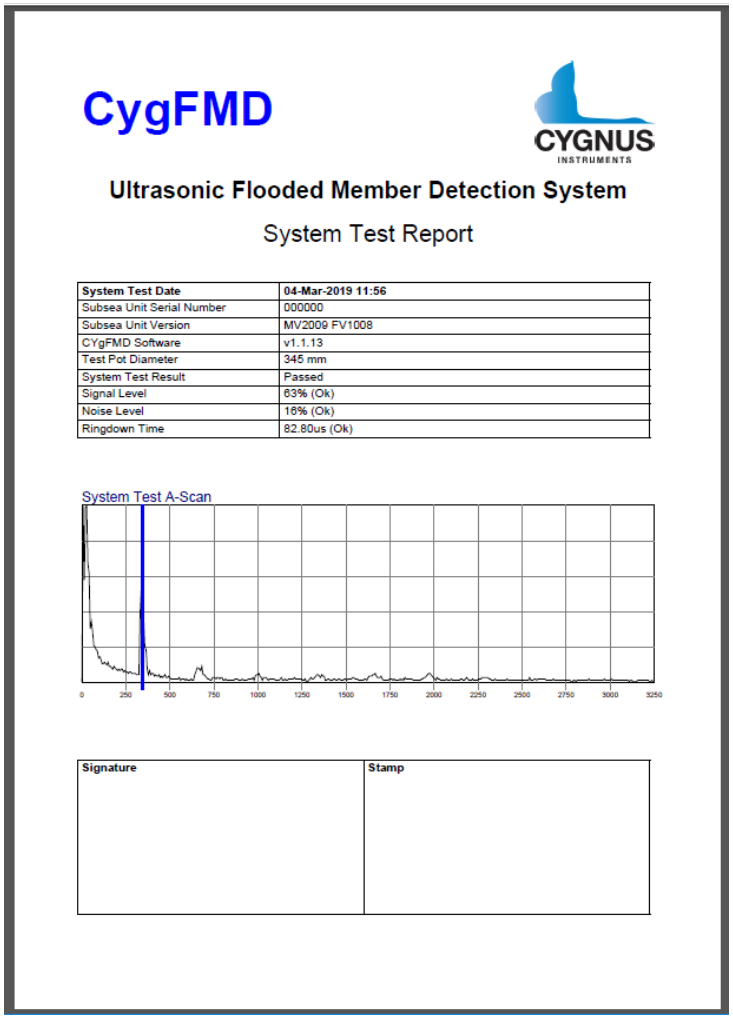
Printing a System Test Report.

You can generate a System Test Report .pdf file that can be included with your survey documentation. After a successful system test, from the menu select; **Main Menu ->System Setup -> Create System Test Report Document**.

You will be prompted for the file locations, the filename of the report is based on the subsea units serial number and the date-time.

There are areas for a signature and QA stamp if a hard-copy is printed out.

*Note. You can change the company Logo in the top right corner, see **PDF Report Setup**.*



CygFMD

CYGNUS INSTRUMENTS

Ultrasonic Flooded Member Detection System

System Test Report

System Test Date	04-Mar-2019 11:56
Subsea Unit Serial Number	000000
Subsea Unit Version	MV2009 FV1008
CygFMD Software	v1.1.13
Test Pot Diameter	345 mm
System Test Result	Passed
Signal Level	63% (Ok)
Noise Level	16% (Ok)
Ringdown Time	82.80us (Ok)

System Test A-Scan

Signature	Stamp

Figure 32 – System Test Report PDF Document.

10. Preparing for an FMD Test

Create the Survey

It's best to create a new Survey file before starting FMD testing.

Opening an Existing Survey

From the CygFMD Menu, select **File->Open Survey** and select the location of the survey.

Creating a New Survey

From the CygFMD Menu, select **File->New Survey** to create a new survey. This allows the user to enter information about the job.

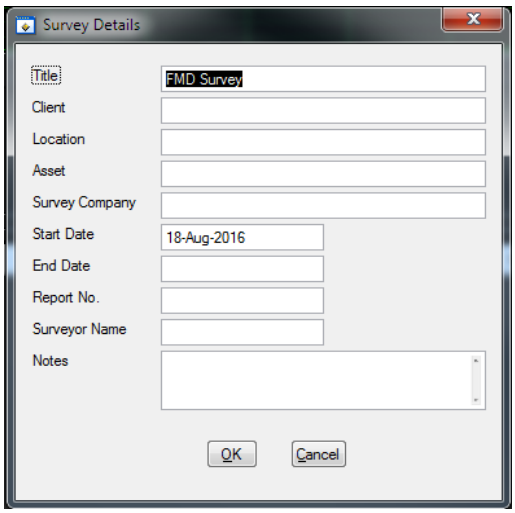


Figure 33 – FMD survey details

It is at this point that the survey should be saved providing a location and name for the survey.

Saving a Survey

From the CygFMD Menu, select **File->Save Survey**, choose a file location and enter a filename. All survey files will have the '.csf' extension.

It is recommended to save all surveys into a new directory with sub-directories created for each individual job.

Saving a Survey with a New Filename or Location

To save an already saved survey to a new location and/or new filename select **File->Save Survey As...**. Select the new filename and location.

Surface preparation

For best performance from the FMD system, it is recommended that the surface of the member is prepared prior to testing, however successful tests have been achieved through low levels of soft marine growth with no cleaning.

Surface cleaning would normally be carried out by ROV using a pressure jet however cleaning by a diver can be performed using a hammer, wire brush and scraper.

For best results cleaning to level SA1 is standard. See - international standard ISO 8501-01 (*Ref 1*).

Finding a Flood

The simplicity of the Cygnus FMD flooded member detector allows the user to know a test result conclusively. As soon as the **Surface Contact** light goes green, the user can press the '**Test Member**' button to begin a test.

After the FMD has completed a red 'Flooded' light will be illuminated if any of the tests detected an echo, indicating the presence of water inside a member. A green 'Dry' result is displayed if no echo was detected. An A-Scan for each test cycle backs up the result from each test.

It is recommended that multiple readings are taken at each test location to confirm the likelihood of a flood especially in areas of excessive marine growth or heavy internal corrosion.

Finding the Waterline

Once a flood has been detected it is customary to want to find what level the member is flooded to. Repeat the test moving the

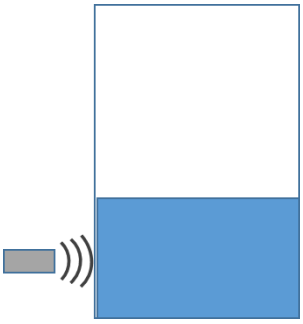
probe up the member until a dry result is returned. A dry result will show the level of the flood.

Internal Member Reinforcements

Before starting an FMD test the test operator should be aware of any internal structural geometries within the member, as this could have an impact on how the tests should be performed and how to interpret the test results. See Probability of Detection Trials *Ref 2*, page 13.

Orientation of the Member

The FMD test is designed to be performed on members which are positioned horizontally, vertically and diagonally.



The user should be aware of the implications of measuring members of different orientations.

Vertical Members

Flooded results should be returned no matter what position around the circumference of the member the test is taken as long as the tests taken are below the waterline inside the member.

If the member type selected is 'vertical' result shall be either flooded or dry.

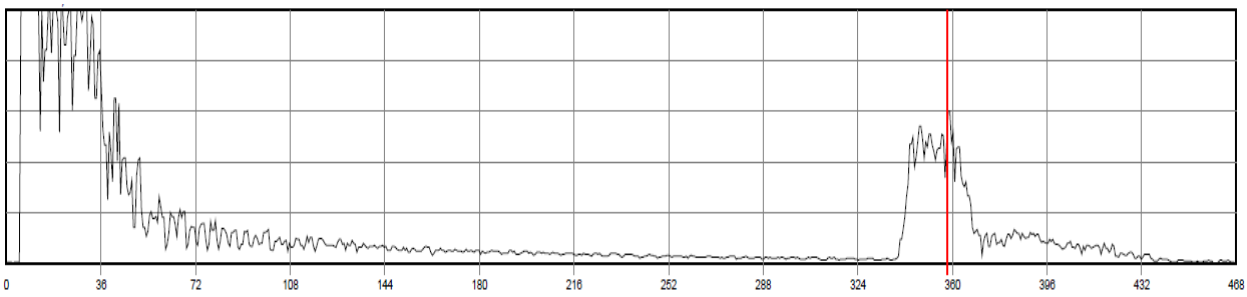
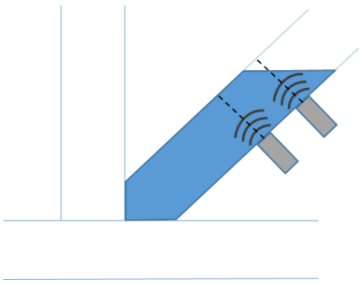


Figure 34 – Typical Flooded A-Scan result

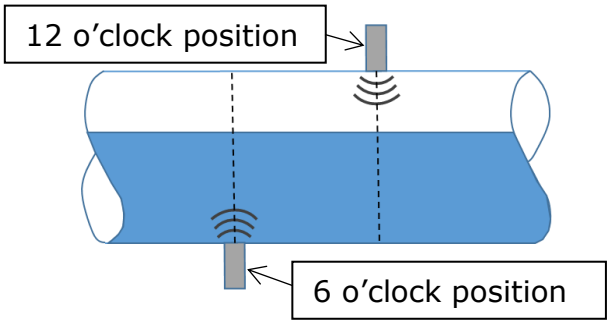
Diagonal Members

When testing a diagonal member, it is easy to understand from the diagram opposite how a false reading could be returned if the sound path is in line with the water level internal to the member.



Horizontal Members

Care should be taken when measuring a horizontal member as the diagrams show. Tests taken at the 6 o'clock position shall give a reliable dry/flooded/partially flooded result.



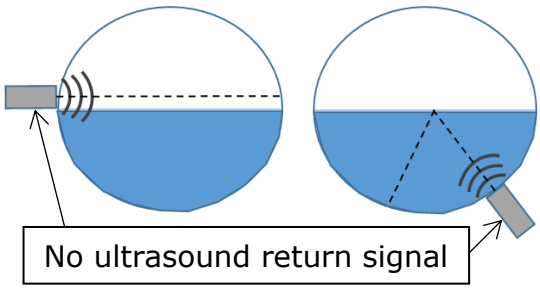
If tests are taken at angles other than 6 o'clock, as the diagram shows, false readings could be seen.

Horizontal Members - Partially Flooded

When testing in horizontal member orientation, a result can be dry, partially flooded or flooded.

The partially flooded result indicates that a peak has been detected that is less than the member diameter entered, indicating where the air/water interface (water level) is.

This test should normally be taken cardinal positions i.e. at the 6 o'clock, 3 o'clock and 9 o'clock positions.



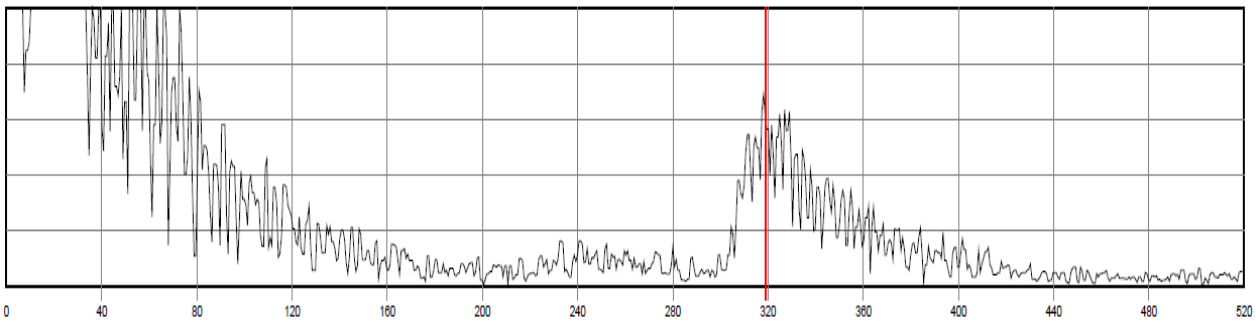


Figure 35 – A Partially flooded A-Scan result

FMD Test Cycles

The Cygnus FMD performs multiple test cycles automatically with different Gain levels. The first test cycle starts with a Normal Gain level for the member diameter entered;

- If a Flood is detected the FMD Test concludes and returns a Flooded result - as no additional testing can alter a Flooded result.

- If a Dry member is detected the FMD Test is instantly repeated at an increased Gain level, this is to ensure a member with internal corrosion is catered for as the ultrasound signal will need more gain. This process is repeated until either (a) maximum gain has been reached or (b) a Flooded result has been found.

- Only when consecutive Dry results have been found will the FMD Test return a Dry result.

Gain Values

The Starting and Maximum gain values are taken from pre-defined gain vs member diameter tables. Gain values are automatically calculated according to the member diameter selected.

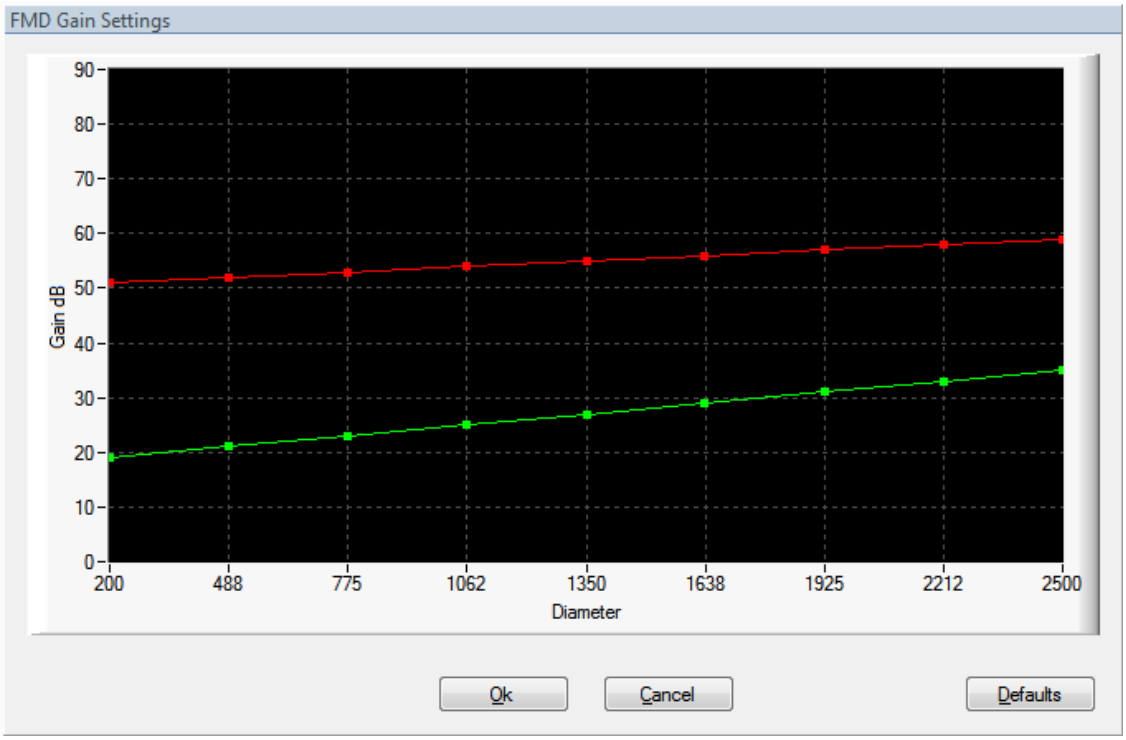


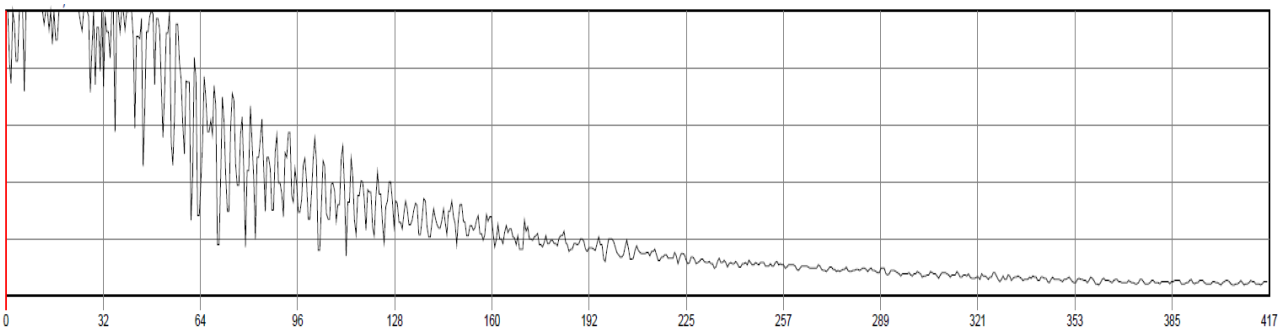
Figure 33 – Typical Start/Max Gain Values.

Flooded Echo Detection

For each test cycle the ultrasound signal is analysed to look for echoes that would represent a flooded member. Essentially a flood will be detected if it crosses the detection threshold (default is 20%).

A Dry Test Result

This is what a dry result should look like…

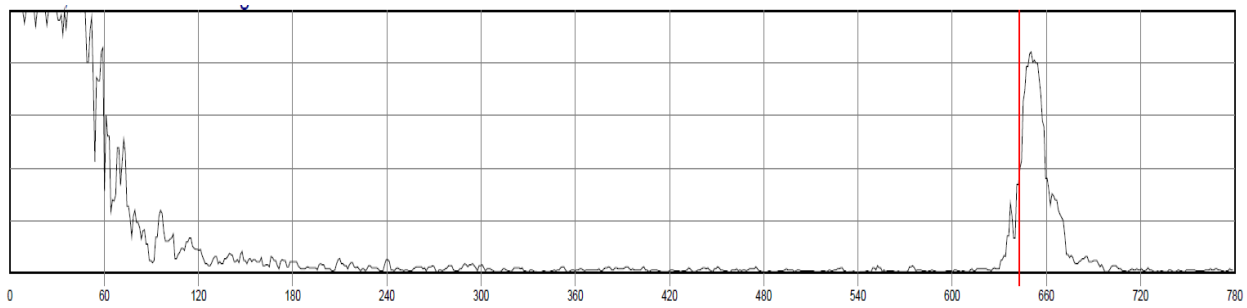


A dry A-Scan result should show:

- Ringdown decaying
- No peak at member diameter

Flooded result

This is what a flooded result should look like…



A flooded A-Scan result should show:

- Ringdown ends early on with fast decay
- Quiet period before peak with almost no signal
- Easy to recognise peak at the diameter of interest

11. Performing an FMD Test

Assuming the Cygnus FMD system has been connected up, tested and a successful System Test has been carried out.

1. First you should set the diameter and orientation of the member you are testing.

2. From the CygFMD Menu, select **Test Setup->Flooded Member Test Setup**. The following dialogue box should appear:

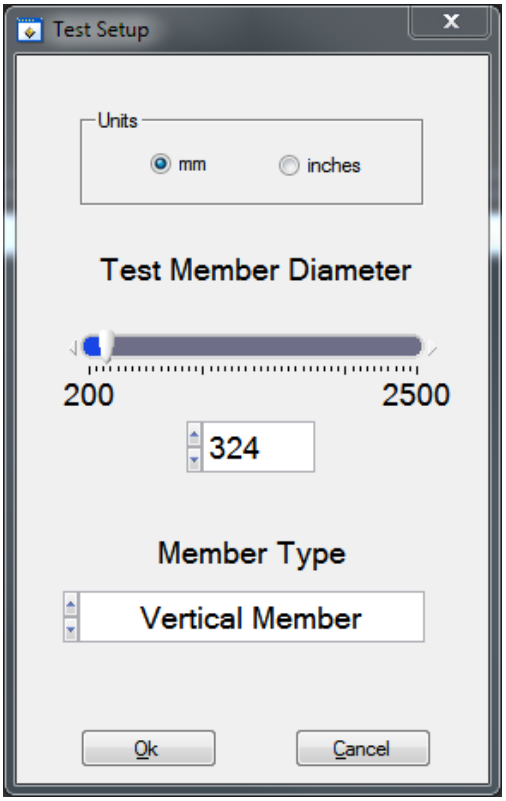


Figure 36 – FMD test setup

3. Choose whether to record tests in mm or inches and set the **Test Member Diameter**. Choose the orientation of the member under test under **Member Type**. Click OK.

4. For every test to be performed, it is vital that the correct diameter and orientation of the member to be tested is entered.

5. The Probe Holder is positioned on the member surface and pushed to compress the springs and align the probe.

6. When the probe comes into contact with the member the '**Test Member**' button will be highlighted, allowing the user to perform an FMD test.

7. Press the '**Test Member**' button.

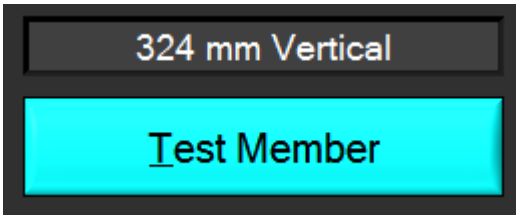
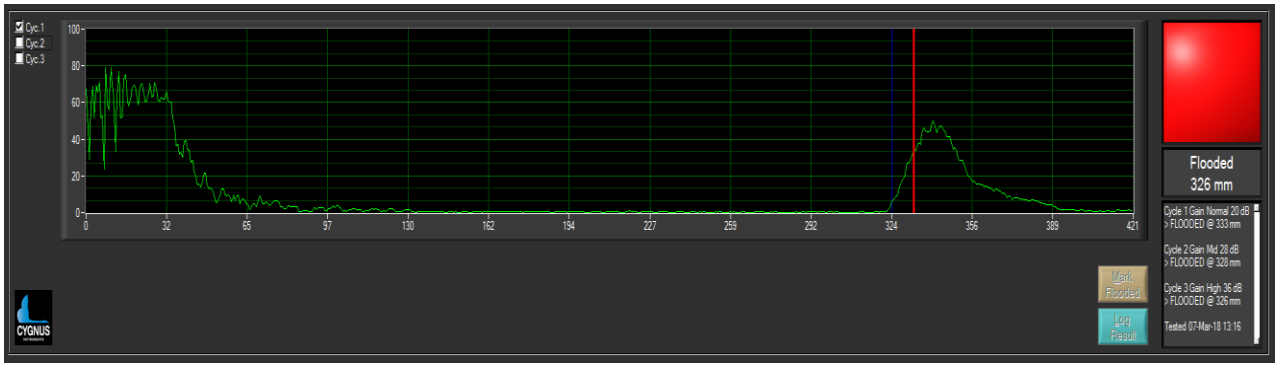


Figure 37 – FMD test ready

18. Make sure the probe remains in contact with the member for the short duration of the test.

19. When the test is complete the results are displayed with a dry or flooded result.



20. As part of an FMD test the system checks to see whether the following issues have occurred:

    a. The Probe lost contact with member during test.

    b. The Ultrasound signal was too noisy (possibly representing poor coupling).

If any of these events have occurred during a test, then the test shall be aborted. The user shall still see the resulting A-Scan waveform(s) but instead of the test indicator showing green and "dry" or red and "flooded", a red and the "**Aborted**" message shall be displayed.

If the user chooses to **Log** the test, the "**Aborted**" result shall be recorded.

If the probe has lost contact or the signal is reported as 'too noisy' then the test should be repeated.

21. Below are examples of a flooded and dry test:

Figure 38 – Flooded FMD Test Result

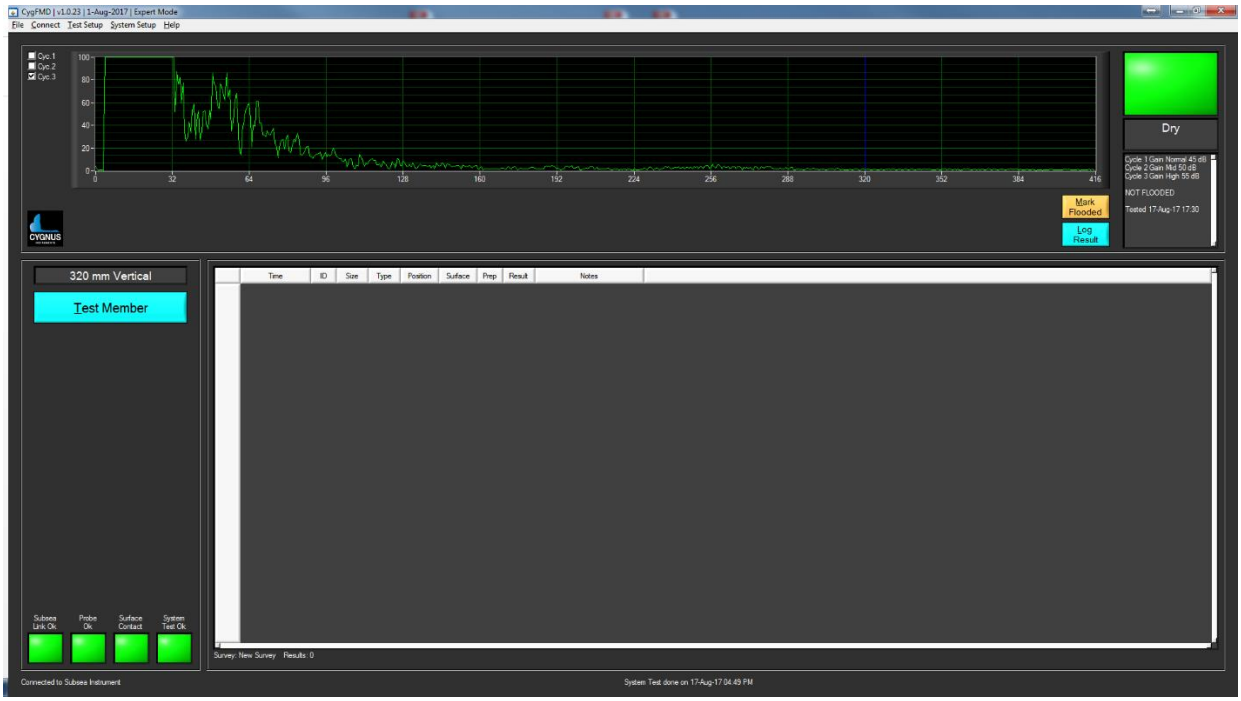


Figure 39 – Not Flooded FMD Test Result

Manual Override to Mark as Flooded

If the FMD test return a Dry result but the user can see what they think is an Echo signalling a flood on the A-Scan, they have the option to force a flooded result to be recorded by using the **Mark Flooded** button. If clicked they will be asked to type a short reason why a flooded result was suspected.

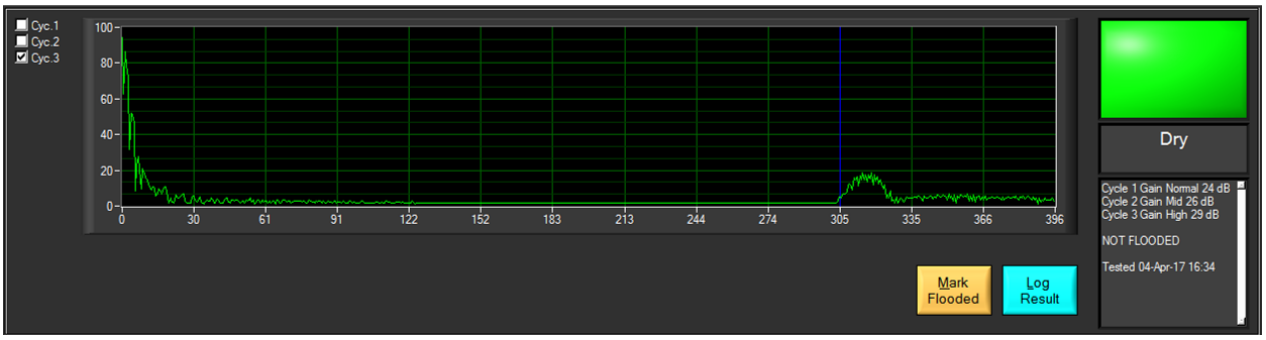


Figure 40 – Mark Flooded a Dry Result when small Echo Signal seen.

Logging an FMD test

After an FMD test has been performed the user can choose whether to log these tests to the current survey.

Press the **'Log Result'** button to log the current FMD test.

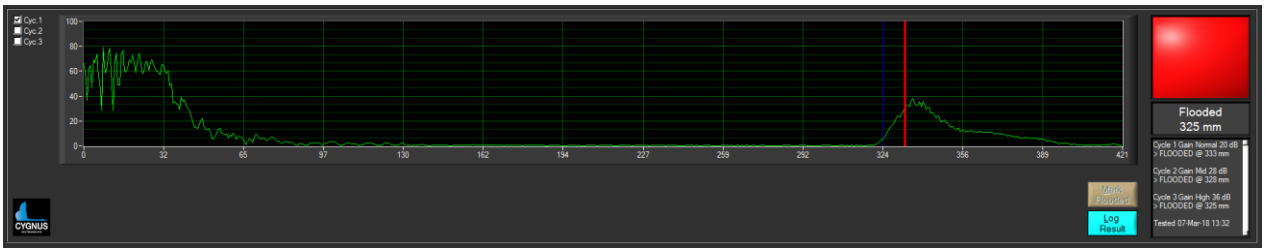


Figure 41 – Log FMD result

Note. If the Log button is not enabled, see Test Auto Log Feature on page 46.

After pressing the '**Log Result**' button the following dialogue appears giving the user the choice to enter information relating to the current FMD test. The only mandatory field that needs to be filled in is the *Member ID*.

If the Test Auto Save feature is enabled, the Survey will be automatically saved to file. See Test Auto Save Feature on page 46.

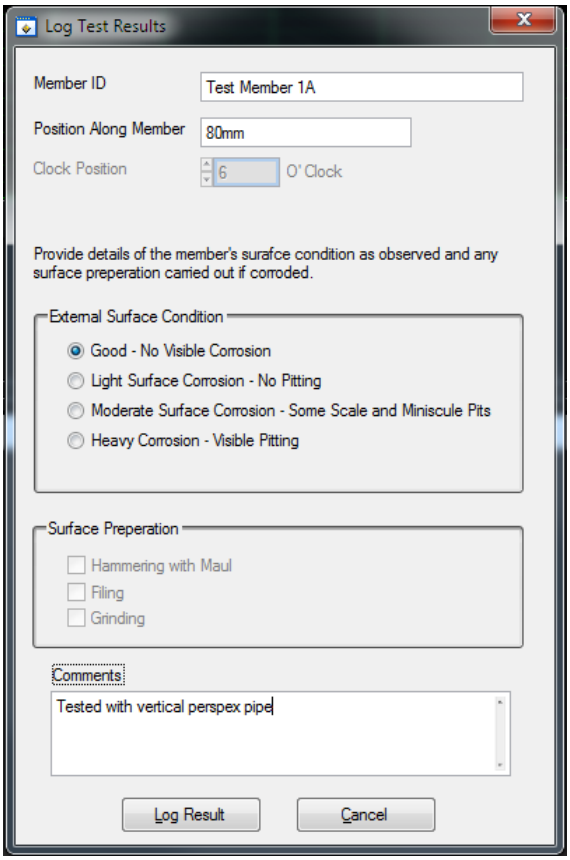
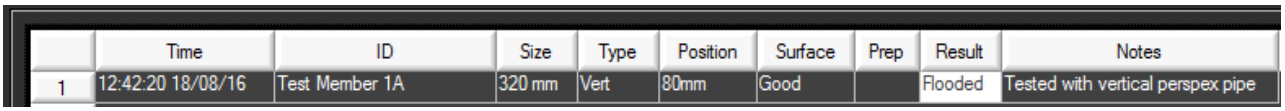


Figure 42 – Log Test Results dialogue

With the FMD test logged the test appears in the logging window. See below:



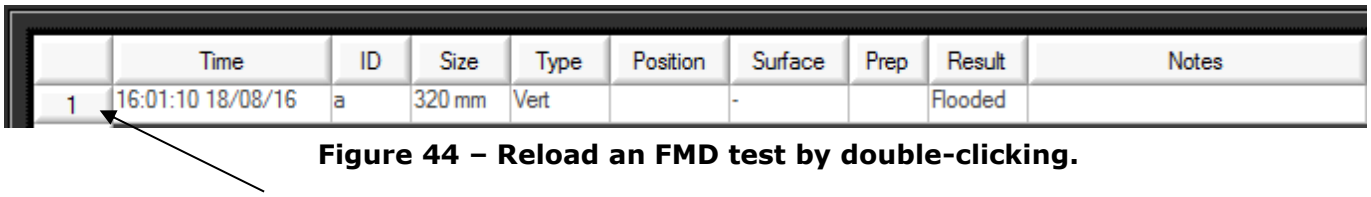
	Time	ID	Size	Type	Position	Surface	Prep	Result	Notes
1	12:42:20 18/08/16	Test Member 1A	320 mm	Vert	80mm	Good		Flooded	Tested with vertical perspex pipe

Figure 43 – Logging window

Reloading Logged FMD test

If the Survey contains FMD tests in the log window, then these tests can be reloaded for analysis after the test has been run without the need to be connected to the equipment.

To reload an FMD test double-click the grey record selector on the left of the test of interest's row:



	Time	ID	Size	Type	Position	Surface	Prep	Result	Notes
1	16:01:10 18/08/16	a	320 mm	Vert		-		Flooded	

Figure 44 – Reload an FMD test by double-clicking.

Double-click here

The FMD Test information is recalled and displayed:

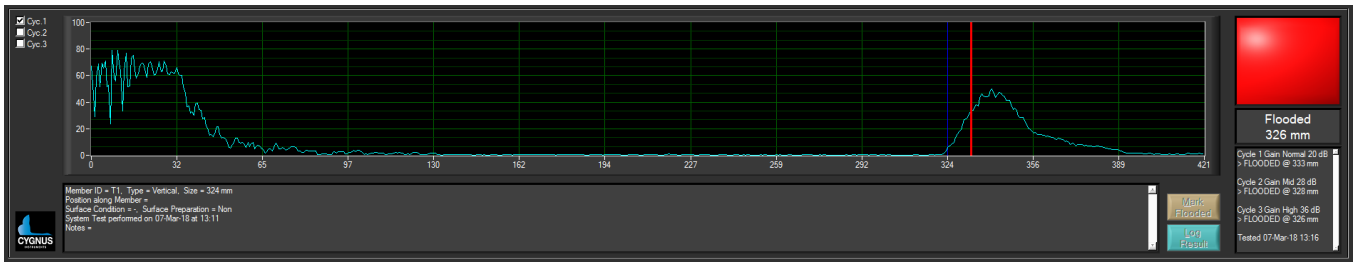


Figure 45 – A-Scan and Summary of a Logged FMD Test.

Exporting a survey to PDF

Once the survey has been saved, the data can be exported to a PDF or CSV report.

The PDF report will only show the FMD tests contained in the current survey.

From the CygFMD Menu, select **File->Print Survey to PDF**, choose a directory to store the PDF file, the location will default to the location where the survey has been saved.

It is recommended to create a separate sub-folder where all FMD reports will be stored.

*Note. You can change the company Logo in the top right corner, see **PDF Report Setup**.*

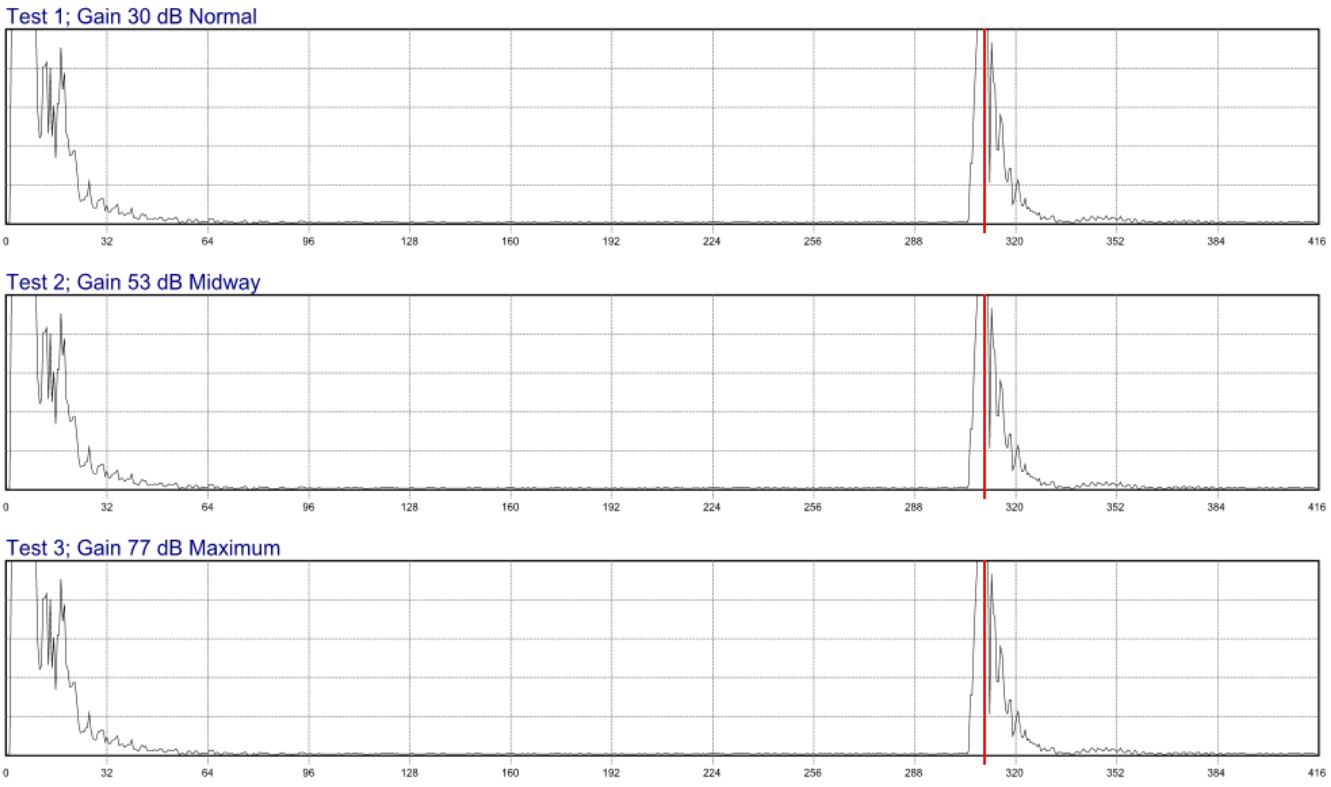


Figure 46 – Survey A-Scan's In PDF Document

Exporting a Survey to Microsoft Excel

To view the FMD test data using Microsoft Excel in CSV (comma separated value) format, from the CygFMD menu select **File->Export Survey to Microsoft Excel**. If Microsoft Excel is installed on the PC being used, this will open Microsoft Excel automatically to display the data.

See below for an example of a data set opened in Microsoft Excel.

UFMD Survey Details								
Title	New Survey							
Client	-							
Location	-							
Asset Reference	-							
Survey Company	-							
Surveyor	-							
Report Number	-							
Start Date	-							
End Date	-							
Notes	-							
FMD Test Results Summary								
No. Tests	1							
No. Dry	0							
No. Flooded	1							
No. Partial Flooded	0							
No. Forced Flooded	0							
FMD Test Results								
Date and Time	**Member ID**	**Member Size**	**Member Type**	**Test Position**	**Surface Condition**	**Surface Preparation**	**Result**	**Notes**
16:40:43 04/04/17	a	305 mm	Vertical		-		Flooded	

Figure 47 – Export to Excel (survey summary)

MemberID	a	a	a
Test No	1	2	3
Gain dB	30	40	50
Gain Mode	Normal	Midway	Maximum
A-Scan Range	396	396	396
Result	Dry	Flooded	Flooded
ASCAN_0	211	255	255
ASCAN_1	121	255	255
ASCAN_2	252	255	255
ASCAN_3	206	255	255
ASCAN_4	229	255	255
ASCAN_5	76	255	255
ASCAN_6	125	255	255
ASCAN_7	154	255	255
ASCAN_8	117	241	255
ASCAN_9	35	117	255
ASCAN_10	76	255	255
ASCAN_11	74	242	255
ASCAN_12	67	215	255
ASCAN_13	28	105	255
ASCAN_14	58	224	255
ASCAN_15	53	183	255
ASCAN_16	44	166	255

Figure 48 – Export to Excel (test data)

12. Loading a Work Package into CygFMD

You can load in a Work Package that contains a list of Members to be tested along with their size, orientation and identification codes. Once loaded in the FMD survey appears as a set of empty test points that can be logged into sequentially as each member is tested.

Work Package File Format

The work package is contained in a CSV delimited text file and should be in the following format;

Location ID, Point ID, Diameter, Orientation,

An example of a work package in Excel with 4 members is shown below;

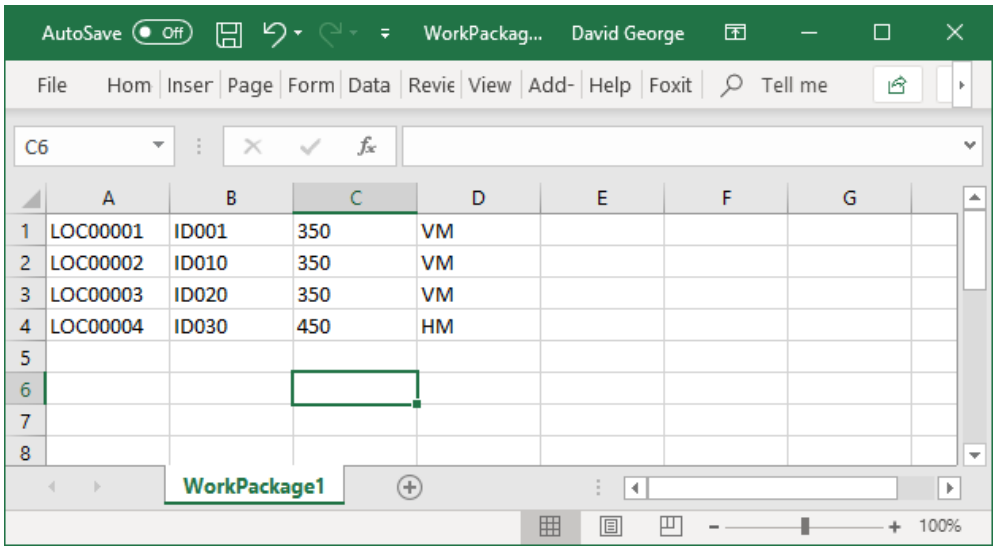


Figure 49 – Example Work Package in Excel.

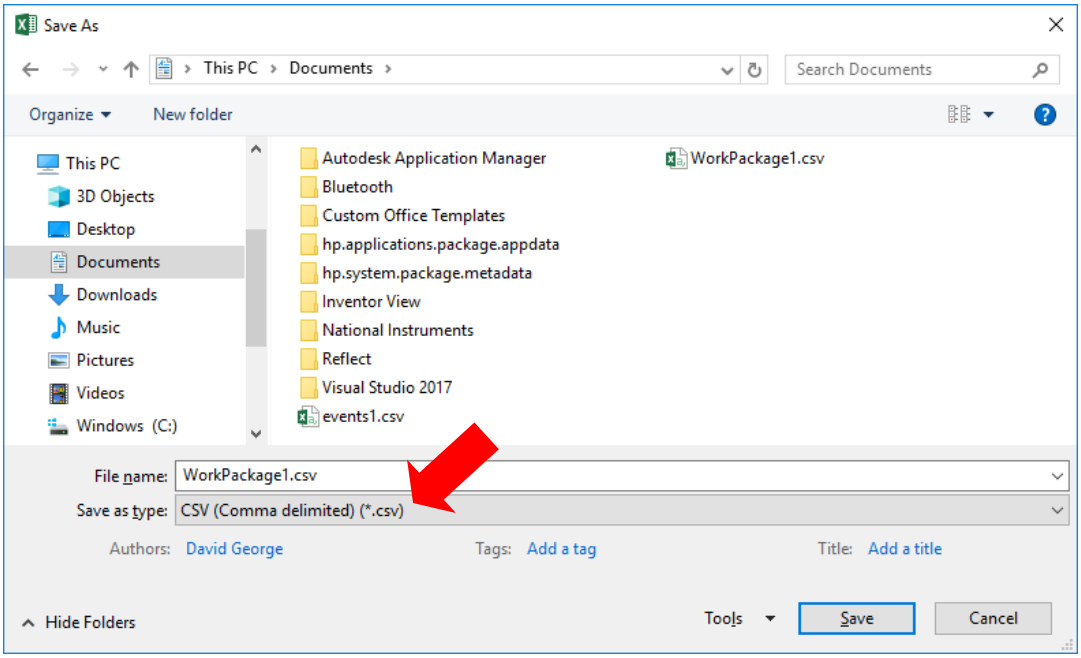
Note. The diameter values are in mm regardless of the units set in CygFMD.

The Orientation codes are;

HM	Horizontal Member
VM	Vertical Member
VDM	Vertical Diagonal Member

HDM Horizontal Diagonal Member

When saving from Excel choose a Text File (CSV) format.



Loading a Work Package File

From the main menu select; **File -> Import Work Package**

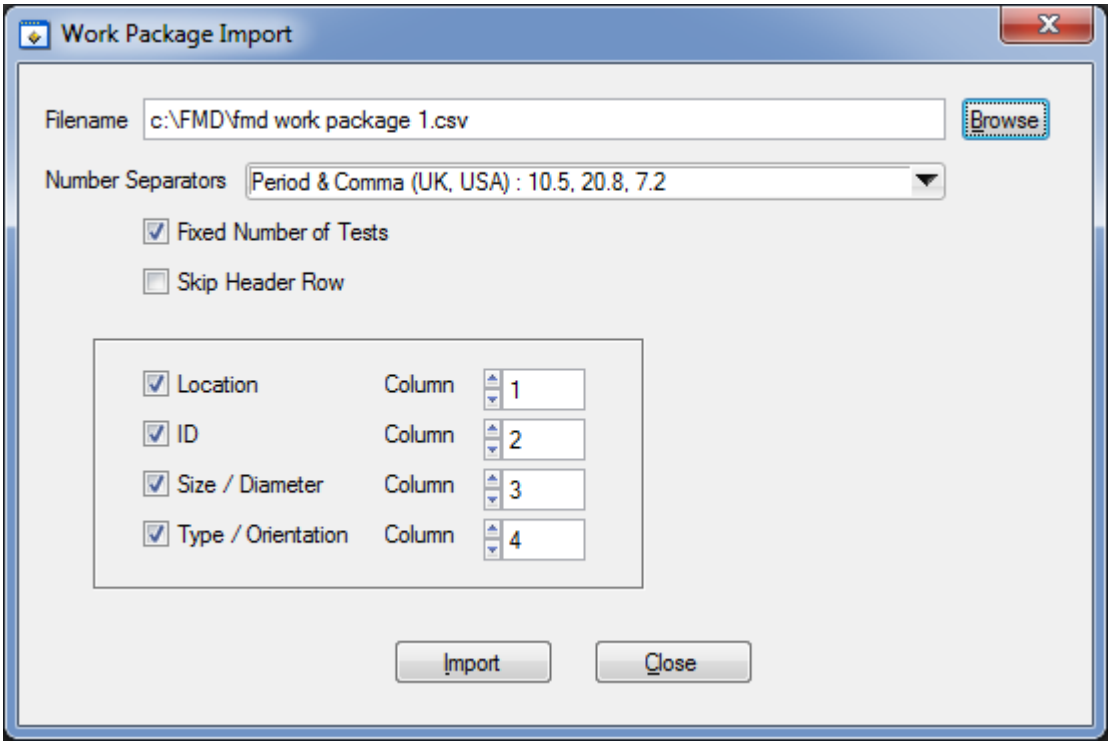


Figure 50 – Work Package Import.

Click the **Browse** button to select your work package file.

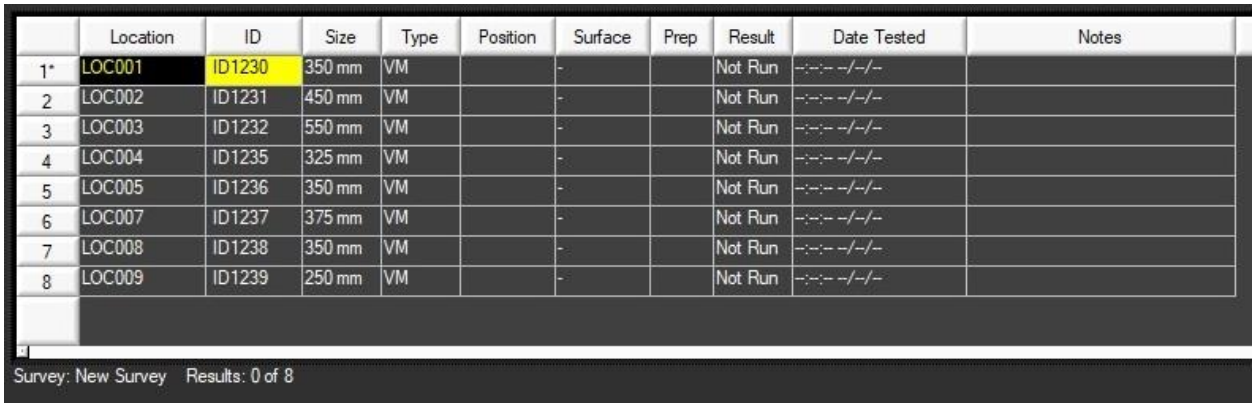
Tick or un-tick the **Location, ID, Size** and **Type** checkboxes as required.

The **Number Separators** selects between UK/USA decimal points (. ,) and European commas (, ;) as the decimal separators.

The **Fixed Number of Tests** checkbox should be ticked if you don't want the FMD operator to be able to add more tests to the Survey, when ticked only the imported members are allowed.

The **Skip Header Row** checkbox should be ticked if you want to ignore the first row, as it contains header text/info.

Finally click the **Import** button to read in the work package file, a new empty Survey is created, and each member is added as a row ready to receive an FMD Test Log. The Result column shows '**Not Run**' for rows that have no FMD Test result logged.



	Location	ID	Size	Type	Position	Surface	Prep	Result	Date Tested	Notes
1*	LOC001	ID1230	350 mm	VM		-		Not Run	--:--:-- --/--/--	
2	LOC002	ID1231	450 mm	VM		-		Not Run	--:--:-- --/--/--	
3	LOC003	ID1232	550 mm	VM		-		Not Run	--:--:-- --/--/--	
4	LOC004	ID1235	325 mm	VM		-		Not Run	--:--:-- --/--/--	
5	LOC005	ID1236	350 mm	VM		-		Not Run	--:--:-- --/--/--	
6	LOC007	ID1237	375 mm	VM		-		Not Run	--:--:-- --/--/--	
7	LOC008	ID1238	350 mm	VM		-		Not Run	--:--:-- --/--/--	
8	LOC009	ID1239	250 mm	VM		-		Not Run	--:--:-- --/--/--	

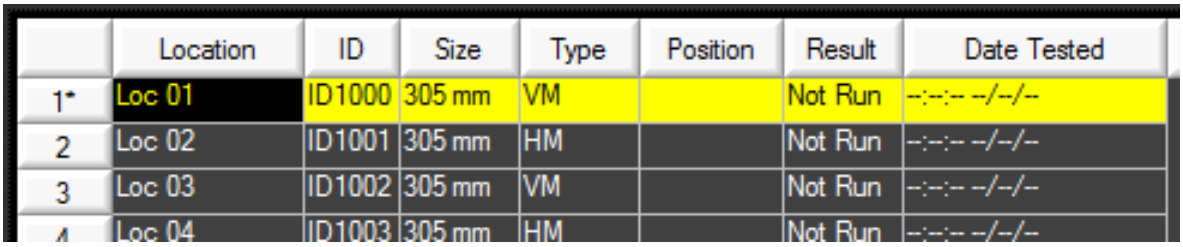
Survey: New Survey Results: 0 of 8

Figure 51 – New Work Package Imported into Survey.

Logging FMD Tests into the Survey.

FMD Tests are performed as usual, the only difference is now the Member Diameter and Orientation values come from the Survey.

After importing a Work Package, the next Row in the Survey to receive the FMD Test is highlighted in Yellow and contains an asterisk in the row header.



	Location	ID	Size	Type	Position	Result	Date Tested
1*	Loc 01	ID1000	305 mm	VM		Not Run	--:--:-- --/--/--
2	Loc 02	ID1001	305 mm	HM		Not Run	--:--:-- --/--/--
3	Loc 03	ID1002	305 mm	VM		Not Run	--:--:-- --/--/--
4	Loc 04	ID1003	305 mm	HM		Not Run	--:--:-- --/--/--

When the FMD Test has been completed, and the results are ready to log, the operator clicks the LOG button and the FMD Test is saved into the survey in the highlighted row. The Survey then moves forward to the next blank row in the survey.

Setting the Next FMD Test

You can control where the next FMD test is logged by first clicking the row of the next row you want to log into, then right clicking on the Row Header, a context menu is displayed – click **Set Next Test**;

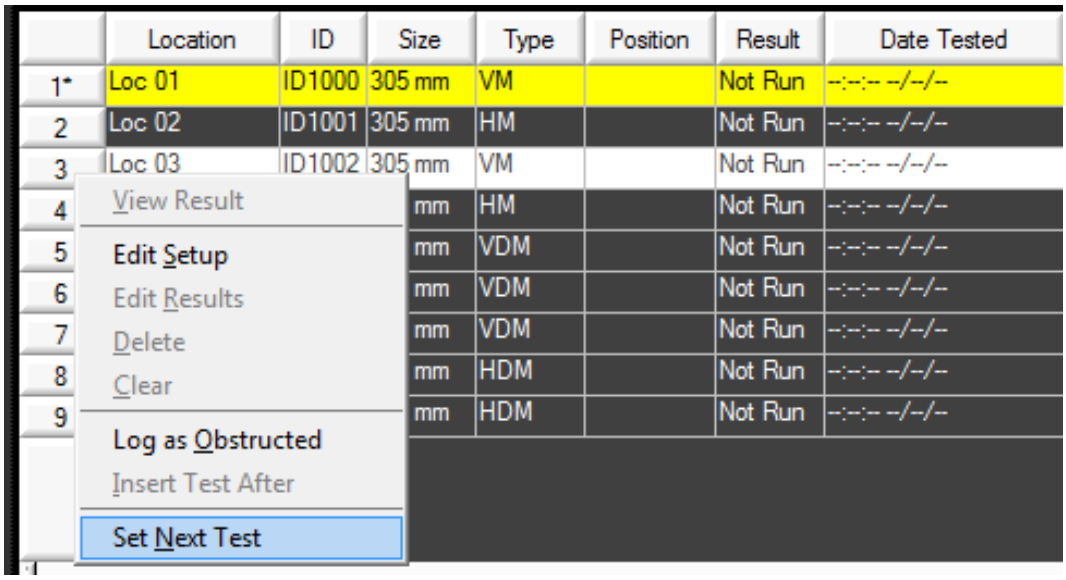


Figure 52 – Right Click to Control Next Row.

Clearing an FMD Test Result.

To clear an FMD Test Result, select the row, then right click and select **Clear**.

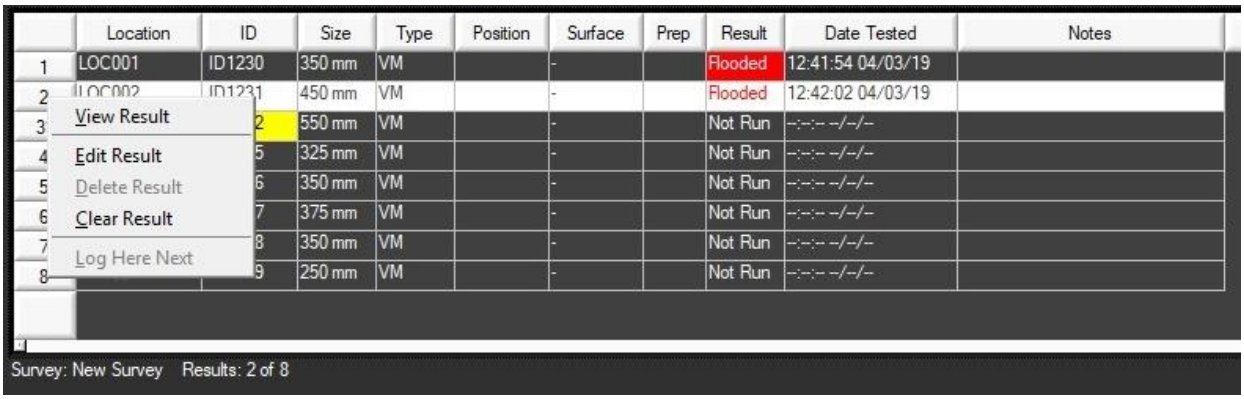


Figure 53 – Clearing a Test Result.

Inserting a Blank FMD Test.

If the Survey is not set to 'fixed number of tests' you can insert new FMD Tests into the list. Select the row, right click and select **Insert Test After**.

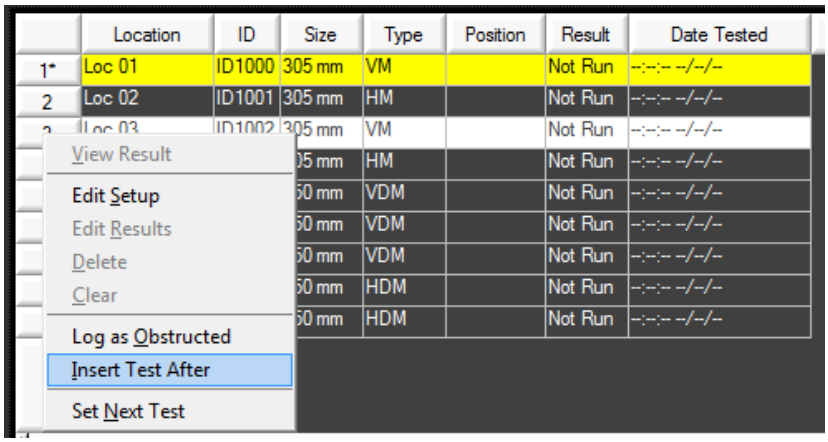


Figure 54 – Inserting a Blank Test.

You will be asked to enter the Test Setup for the new test;

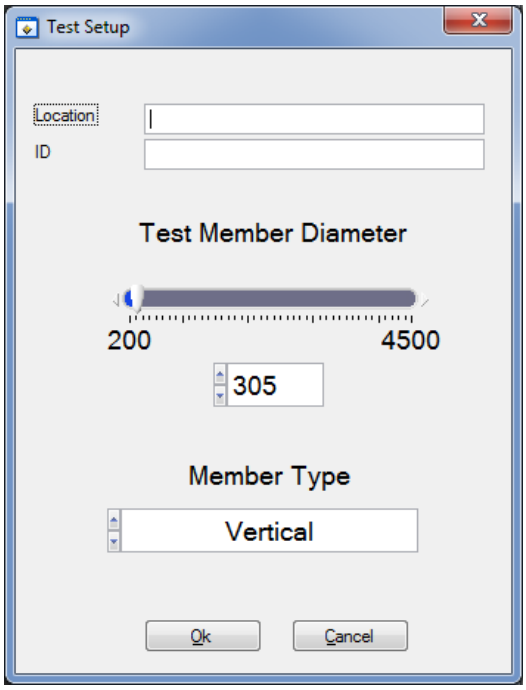


Figure 55 – New Blank Test Setup.

Logging an Obstructed FMD Test.

If the survey requires an FMD Test at a location you cannot access, you can log this test as **Obstructed**.

Select the row, right click the FMD Test row, and select **Log as Obstructed**.

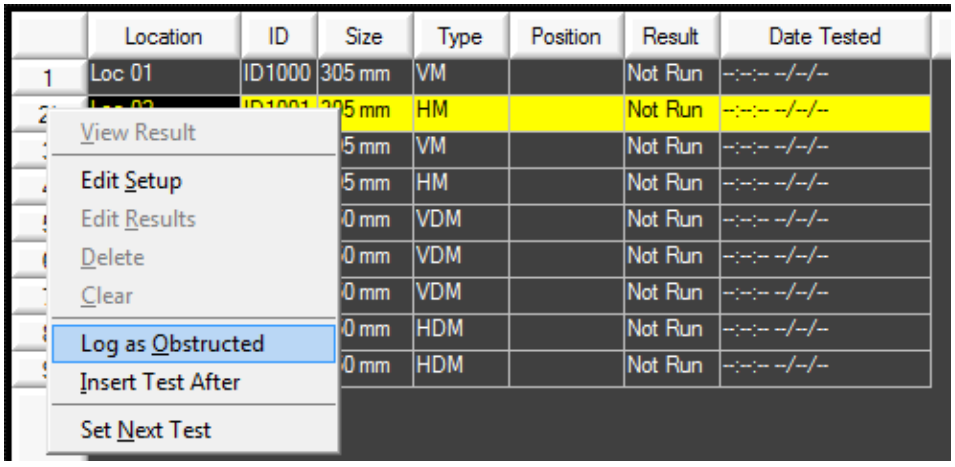
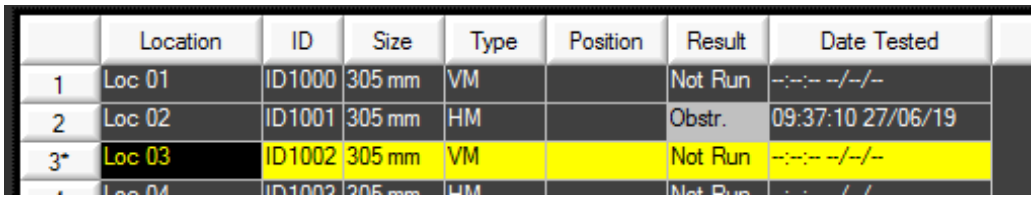


Figure 56 – Log Test as Obstructed.



	Location	ID	Size	Type	Position	Result	Date Tested
1	Loc 01	ID1000	305 mm	VM		Not Run	--:--:-- --/--/--
2	Loc 02	ID1001	305 mm	HM		Obstr.	09:37:10 27/06/19
3*	Loc 03	ID1002	305 mm	VM		Not Run	--:--:-- --/--/--

Figure 57 – Obstructed Test in the Survey.

13. Data Output via Serial Port

The CygFMD software can output a serial data string at the end of each FMD Test, this serial data can be configured to include various test values.

The serial data can be connected into a DVR System such as Digital Edge, this can be used to display and record the results of each FMD Test in the DVR software.

Output String Setup

To configure the output, from the main menu select; **System Setup -> Results Output Setup.**

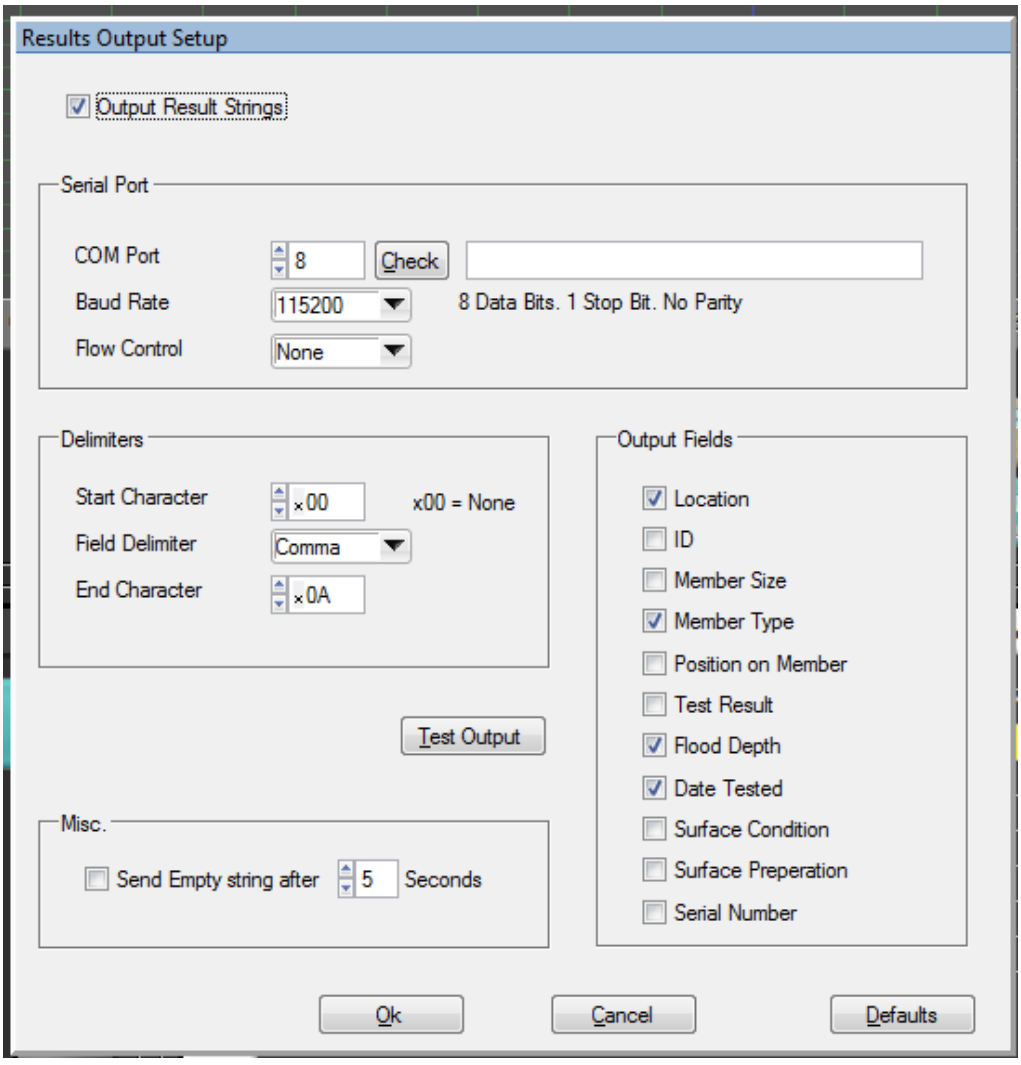


Figure 58 – Results Output Setup.

To enable the Results Output feature, tick the **Output Results Strings** checkbox.

You must select the appropriate COM port, clicking the **Check** button will test if the port can be accessed and opened.

String Format

The output string is formatted as follows;

1. Start Character (or none if set to x00)
2. Output Fields in screen order (if ticked);
    a. Location first
    b. ID next
    c. Member Size next
    d. …
    e. Serial Number last
3. After each Field a Field Delimiter is added (Comma)
4. At the end of the string the End Character is added (x0A)

Example;

```
LOC00001,0001,350,HM,DRY,<CR>
```

Sending an Empty String

To clear the last FMD Test info from the DVR screen, the system can automatically send a blank string after N seconds. To enable this feature, check the '**Send Empty string after**' checkbox. You can also set the delay time in **Seconds**.

14. Troubleshooting

Power issues with PCU

Remove bottom end plate to see if LD301 is on (see LED Status Indicators page 32). If the LED is not on when the electronics bottle is connected to a power and comms box through an umbilical, perform the following actions to locate the fault:

1. Check light on PCU. If no light is visible, then continue to step 2.
2. Using a multi-meter read the voltage at the output of the PCU. This should be 24V +/-1V. If the voltage is 0V continue to step 3.
3. Check the following:
    a. Check 1.25A fuse in PCU.
    b. Check light in mains switch of PCU.
    c. Check both 5A fuses in mains switch on PCU.
    d. Check 5A fuse in mains lead.
    e. Check mains power is being supplied to PCU.
4. If the PCU is supplying 24V then check continuity of the umbilical.

Communication issues

Communication with computer

If the electronics bottle cannot connect with the PC software:

⇨ With the FMD system connected to a PC and powered on, use the device manager to check which com port is in use for the FMD.

Click on the Windows Start button and type 'device manager'. Device Manager should be listed. Click on it to run Device Manager.

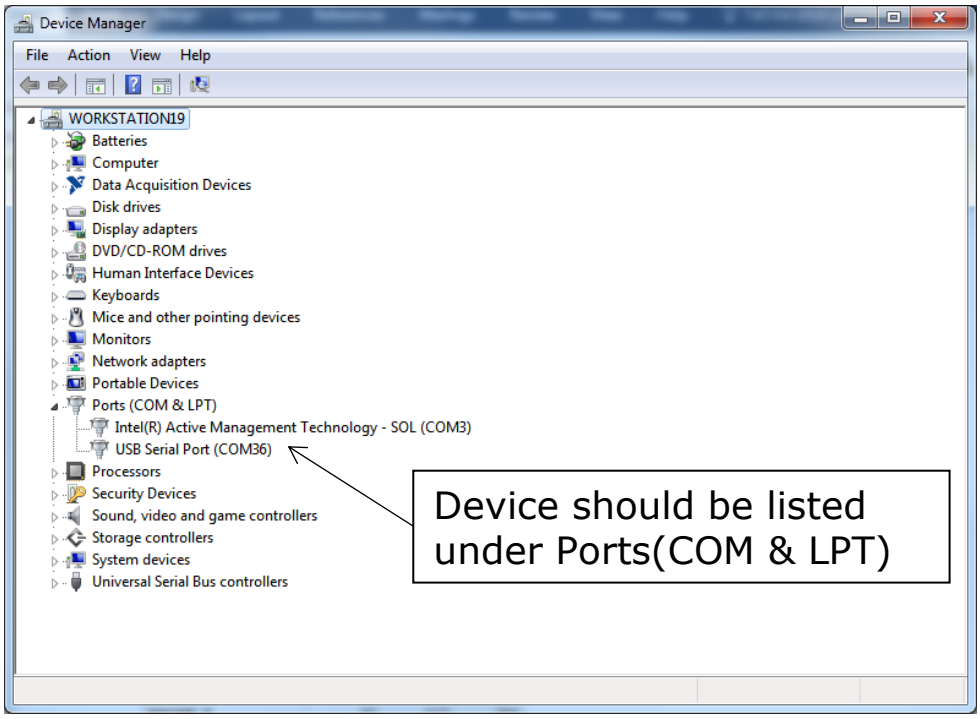


Figure 59 – COM Port No.

Now check to see if the port is seen. Unplug the USB cable and plug back in to recognise the port number.

As in the screen below in this example the computer has detected COM18. The port is functioning correctly but no data is being received by the computer.

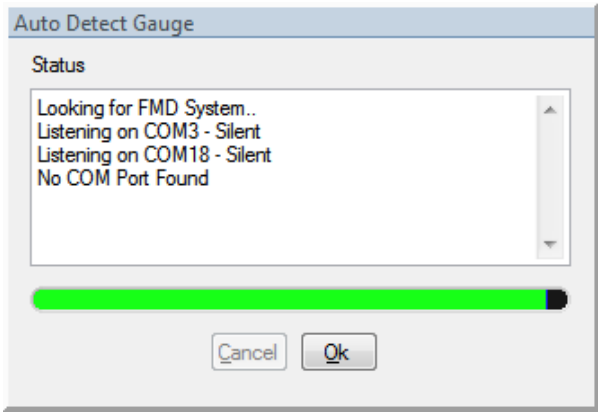


Figure 60 – No com port found

If no Com port is found then in the case of a diver setup the problem must exist with either the USB cable, Power & Coms Unit

or electronics bottle, see Figure 74 – Test scenario 3 (Diver), page 105.

In the case of an ROV setup the problem must be with the wiring between ROV and the computer via the RS232 adapter, see Figure 72 – Test scenario 1 (ROV, fibre comms) page 105.

- ⇨ Check USB connection inside power and comms unit.
- ⇨ Ensure that the CygFMD software is up to date.
- ⇨ Download the USB-Serial device driver, see below.

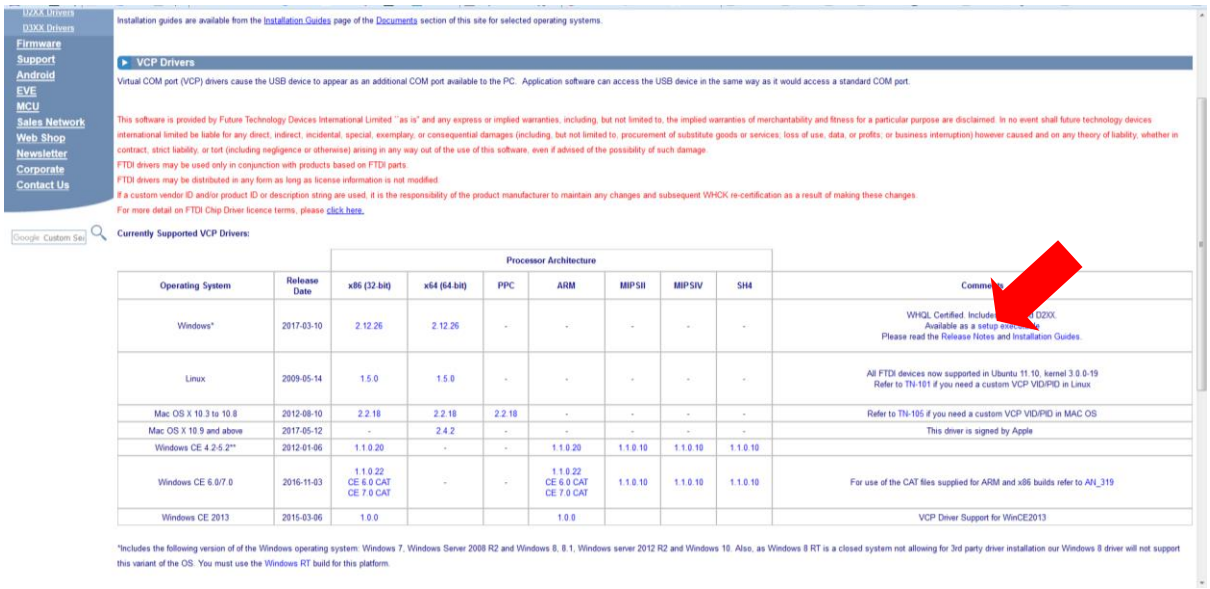
Download the Latest USB – Serial Device Driver

Make sure the CygFMD **Power & Comms Unit** is connected to the computer using the USB lead supplied.

Get the latest copy of the FTDI Driver Setup file - follow this hyperlink (or ask Cygnus to send the file):

http://www.ftdichip.com/Drivers/VCP.htm

You need the **FTDI VCP** Driver for Windows – choose the '**setup executable**' option in the Comments column on the right (red arrow);



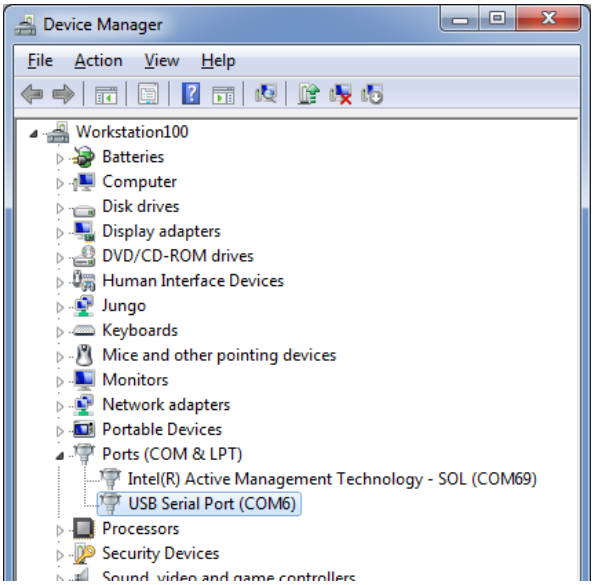
FTDI VCP Driver Website Page

Comments

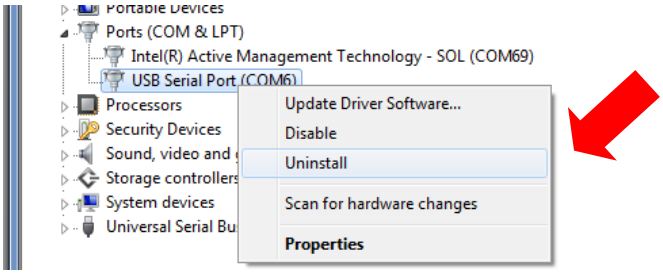
WHQL Certified. Includes VCP and D2XX.
Available as a setup executable
Please read the Release Notes and Installation Guides.

Click the **setup executable** download link

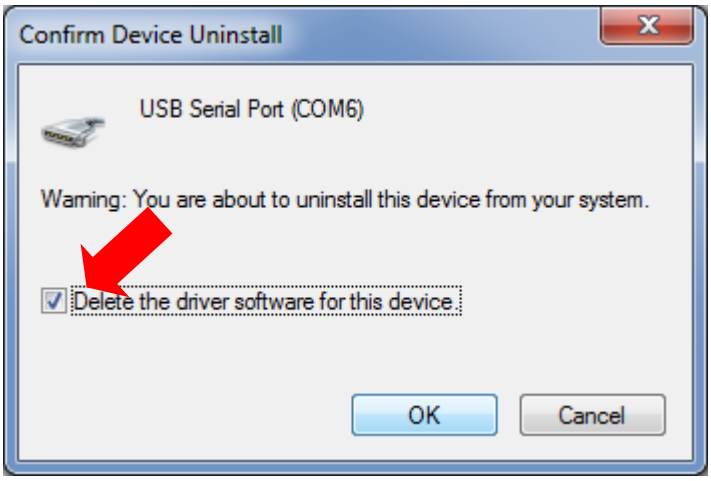
Open Windows Device manager and expand the **Ports (COM and LPT)** entry;
(Windows Start, then search for 'device manager')



Right Click on the **USB Serial Port** entry and select **Uninstall**

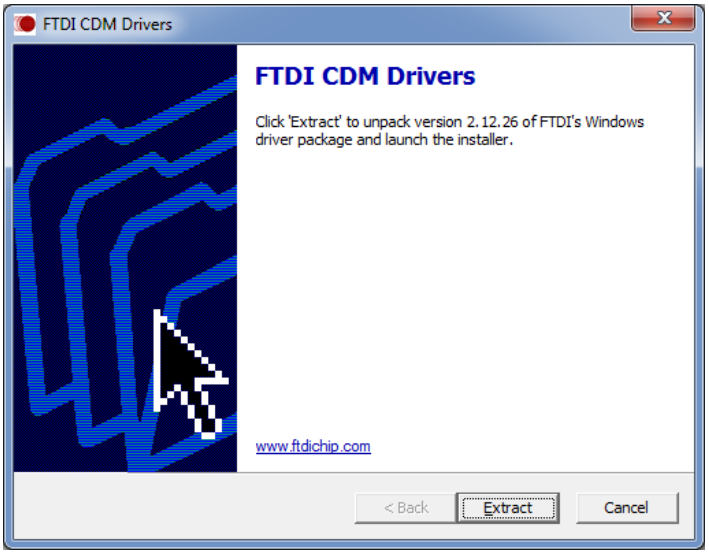


Make sure the "**Delete the driver software for this device**" box is ticked and click **OK**

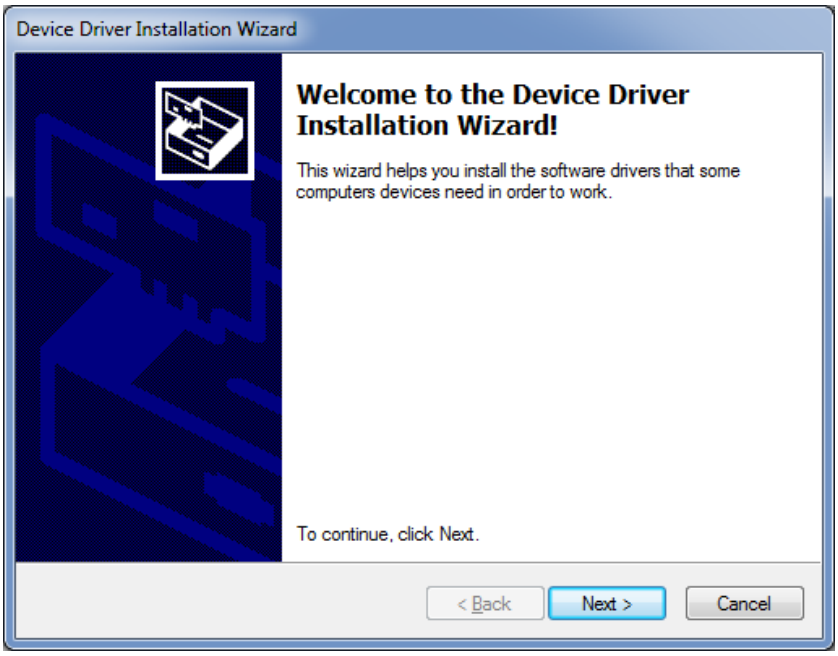


Unplug the USB Cable from the CygFMD **Power & Comms Unit**.

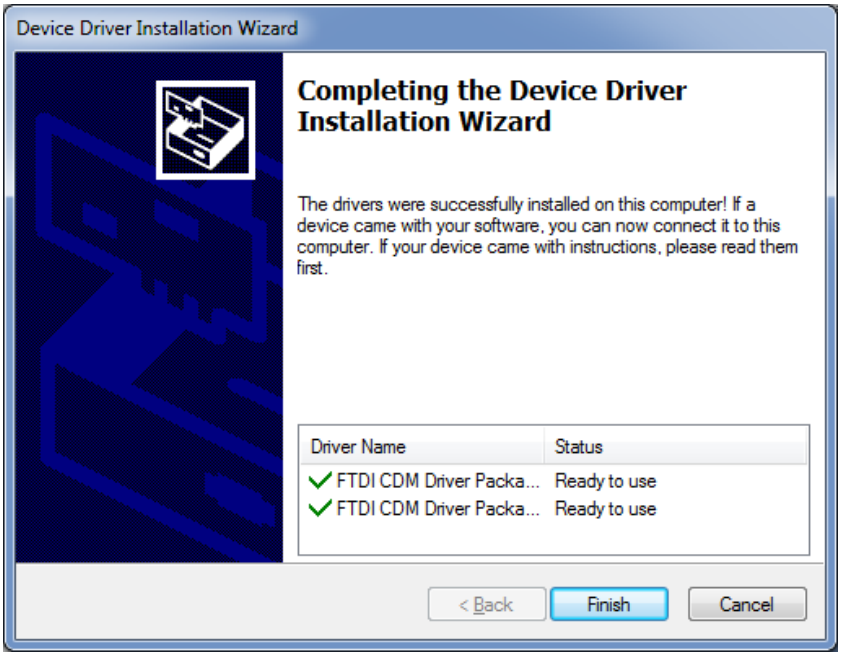
Unzip and **Run** the "**CDM21226_Setup.exe**" file you downloaded from the FTDI Website;



Click **Extract**



Click **Next** and also Accept the License Agreement next..



You should end up with this screen. Click **Finish**.

Re-boot your computer – **<u>this is Important as it forces Windows to reload the driver</u>**.

Plug in the CygFMD USB Cable from the Power and Comms unit. Open Device Manager and you should see the USB Serial Port (COM--) entry.

Run the **CygFMD** Software as normal and select from the Menu, **Connect->Discover New Subsea Instrument and Connect**. You should now get a connection.

If there is still no connection see the following section for diagnosing problems with the subsea electronics bottle.

Communication with Subsea Electronics Bottle

If the com port is found but no FMD system is detected, then the coms connection is working but there is no data detected from the electronics bottle.

First check the condition of all cables and the quality of the connections. The next step is to remove the top plate as detailed in the section named *Subsea Electronics Unit* Setup*,* page *29.*

- ⇨ Check the switch settings to make sure that the system is setup as required (RS232 or RS485).
- ⇨ Check to make sure that 12-24V is applied across pins 1 and 2.
- ⇨ Check to see that the LED LD302 is flashing on the PCB (see LED Status Indicators, page 32). This is an indication that the processor is running.

For all test configurations (see the *Standard Test* Scenarios section) a ground wire should be connected for the RS485 and RS232 communications (*see Figure 85 - In-Line patch cable* for wiring information).

Troubles with the FMD test

There are two types of failures that can be encountered during an FMD test:

- ***Probe lost contact*** *(re-run test)* – this is due to the probe losing contact with the member surface. The software is warning that the probe might have lost contact and the test result could be unreliable. If this happens simply repeat the test.

- ***Signal too noisy*** *(re-run test)* – this could mean one of two things, either that the probe is at a bad angle producing bad results or that there is a problem with the probe cable assembly.

Whilst performing all FMD tests beware of the following:

- *Member condition (poor surface preparation)* - Beware that in extreme situations if the surface of the member is of poor quality; covered in marine growth or heavily corroded the ultrasound will be scattered to such an extent that detecting a flood may not be possible.

- Objects behind the probe could cause false signals to be visible on the A-Scan. Be mindful of objects within the range of the system. A flood should only be confirmed if at the member diameter selected.

- *Shallow water measurement* - Ensure that measurements are taken sufficiently below the surface of the water so that reflections off the surface of the water are minimised.

System Test

The Cygnus FMD System Test should always be performed with a System Test Piece supplied by Cygnus. Use of other apparatus for performing a system test could result in poor FMD performance unless approved by Cygnus Instruments Ltd.

A system test can fail due to the following reasons:

1. Too noisy
2. Ringdown decay takes too long
3. Peak level low
4. Air bubbles behind the Probe Retainer / Face Protection
5. Severely scratched Probe Retainer / Face Protection

As the system has a probe alignment check, it is unlikely that the system test will fail due to low signal if the probe alignment check is successful.

- If the system test does fail however reposition the probe and try again.
- Make sure that the condition on the System Test Piece is good and that there is no debris inside.
- Ensure that probe is well below the waterline or that sufficient couplant has been applied.
- Make sure there are no bubbles in the water, or bubbles have not formed on the sides of the Test Piece.
- Check the fitting of the Probe Retainer / Face Protection making sure there are no air bubbles.
- Check the condition of the Probe Retainer / Face Protection making sure there are no deep scratches or cracks. If suspect fit a new Probe Retainer.
- If there are still problems, try swapping to the spare probe if possible.

There are two other possible failures when performing a system test:

1. *Probe lost contact* – this is due to the probe losing contact with the surface of the test piece. When this happens, the results may not be reliable, so the system test should be repeated making sure that the probe remains in contact for the duration of the test until the software shows that the system test has been completed. When using the Cygnus System Test Piece this problem is eliminated.

2. *Coupling with member* - Always ensure that there is good contact with the System Test Pot. If there is an air gap between the probe and the test piece, that is not detected by the probe position sensor then this can cause bad readings to be received. Ensure that there is good coupling to the member; probe perpendicular to member and without any air/water gaps.

Probe Position Sensor Calibration

If the user is having difficulties with performing the probe sensor calibration, ensure the following:

- ⇨ The user has inspected the probe cable assembly for damage. Both probe connector and bulkhead should be free from debris or water and with no sign of bent pins.

Ensure that the probe cable connector is fitted correctly, see Probe Connection on page 33.

- ⇨ Ensure probe has full range of movement
- ⇨ Repeat test

No Probe Ok Light

If the Probe Ok light does not light even if a probe is connected, then there are two possible reasons for this:

1. Faulty Probe – try a different probe
2. Faulty Electronics Bottle – try a different bottle.

Check resistance of probe from signal to ground, 1KOhm or more indicates a fault with the probe, reading should be around 50 Ohms.

To disable the automatic probe check this will allow an FMD test to be run so that an A-Scan can be viewed. Switch the DIP Switch No 4 to 'ON'. When set to 'ON' this will disable the probe check.

Comms selection switch (1)
RS485/OFF : RS485 Mode
RS232/ON : RS232 Mode

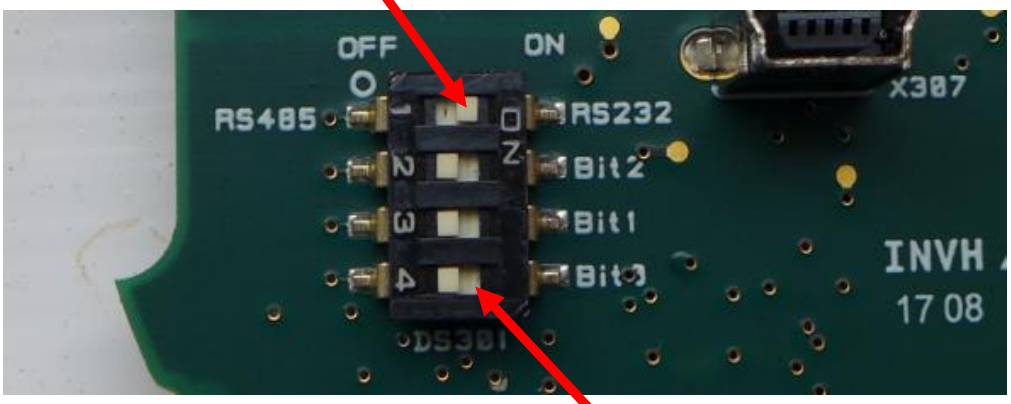


Figure 61 – Switch settings for RS232 connection

Probe checking disable switch (4)
ON: Probe Check Disabled
OFF: Probe Check Enabled

Perform an FMD test using the System Test Piece. If a ringdown is seen but no echo then the probe could be faulty. If no ringdown is seen and no echo then the probe or the bottle could be faulty.

Notes on Members with Thick Walls

The thickness of a member wall can have an impact on how the A-Scan looks, with larger members the gain applied when doing an FMD test will be greater than testing smaller diameter members.

When performing an FMD test on a large member with thick walls the user should be aware that more ringing within the near wall of the member will be seen on the A-Scan.

The A-Scan below shows a dry 916mm diameter member with a 33mm wall thickness. As you can see the third test shows a lot of ultrasound noise, but this shouldn't be mistaken for a flood. All tests clearly show no signal is detected at the 916mm point.

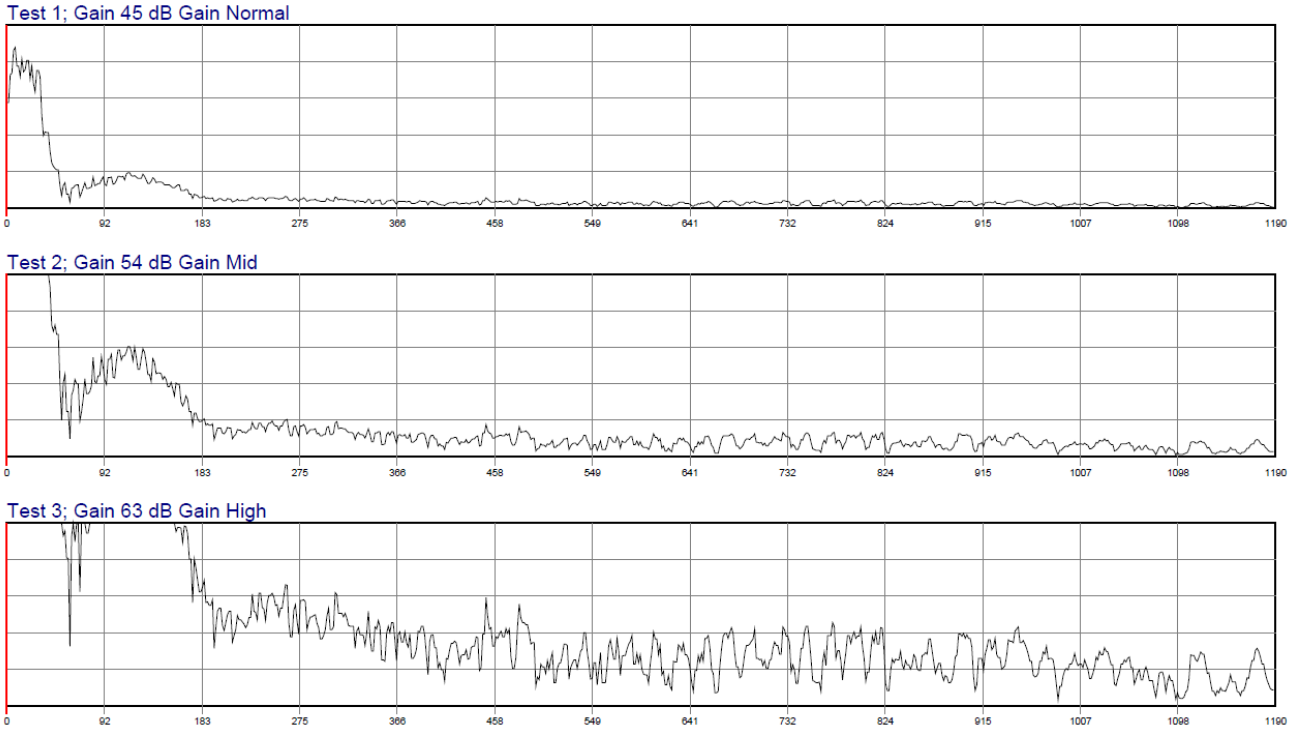


Figure 62 – Dry A-Scan for thick walled member

The A-Scan below shows a flooded 916mm diameter member with a 33mm wall thickness. All the three FMD tests (Test 1, 2 & 3) show a good echo signal around the 916mm point. It is clear that this is a flooded member even at the highest gain with a clear

ringdown, water-path and peak. There is overwhelming evidence that this member is flooded.

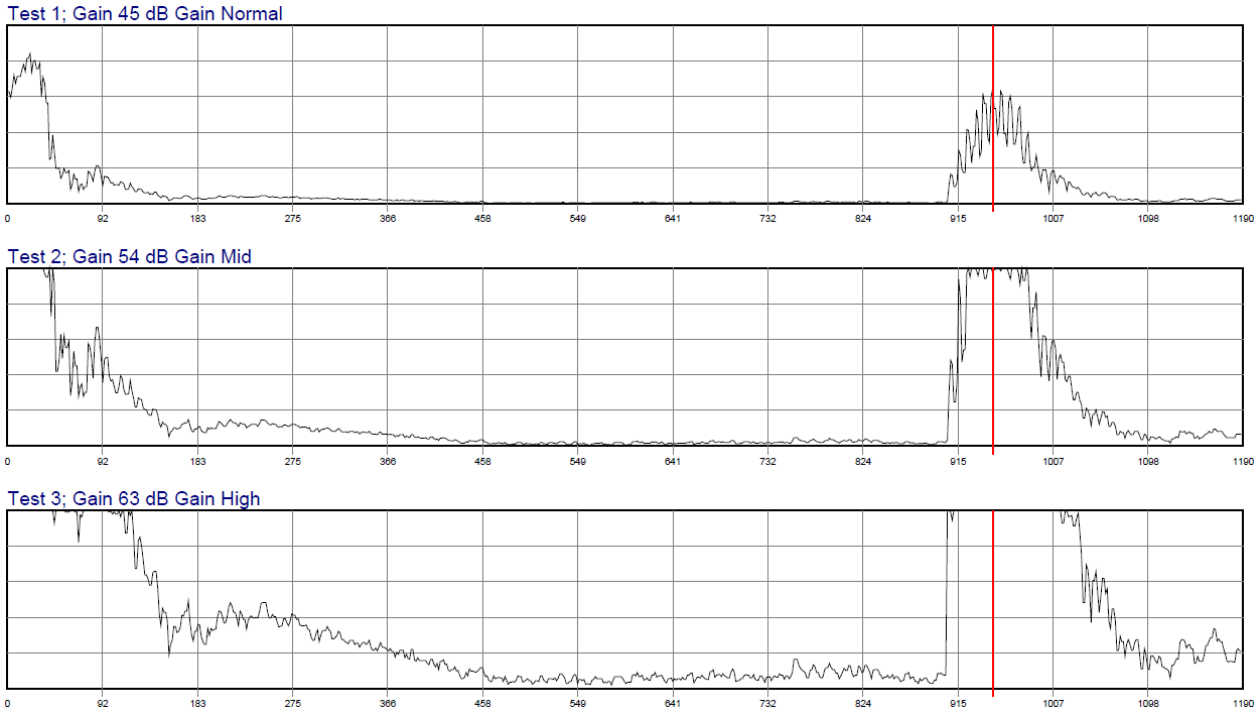


Figure 63 – Flooded A-Scan for thick walled member

Manually Determining if a Member is Flooded

Use the following points to make a decision on whether a member is flooded:

The member is flooded if:

1. Ringdown is visible at left hand side of A-Scan.
2. There is good water-path at a low level < 20%.
3. There is an Echo visible in all three tests at the expected diameter.

If a flood is detected and the above points are not true the member should be retested. Consult Cygnus for a second opinion.

15. Maintenance and Information

Assembling the Probe Holder

Tools required

Item No.	Description
1.	3mm hex key
2.	4mm hex key

Table 8 – Tools required for assembling gimbal

Take the probe holder gimbals…

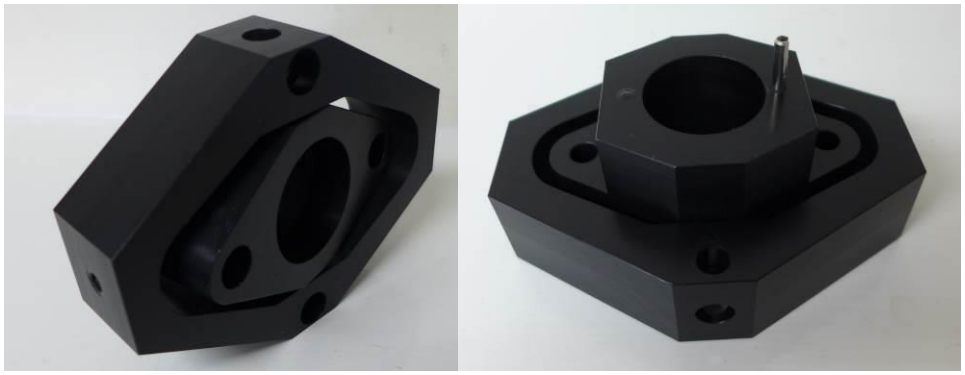


Figure 64 – Probe holder gimbal

Insert the bumpers and springs…

Figure 65 – Inserting the probe holder spring loaded bumper stops

Secure the bump stops using the M5 screw, apply a small drop of thread lock.

Figure 66 – Fitting the screws

Fit the bolts to the yoke…

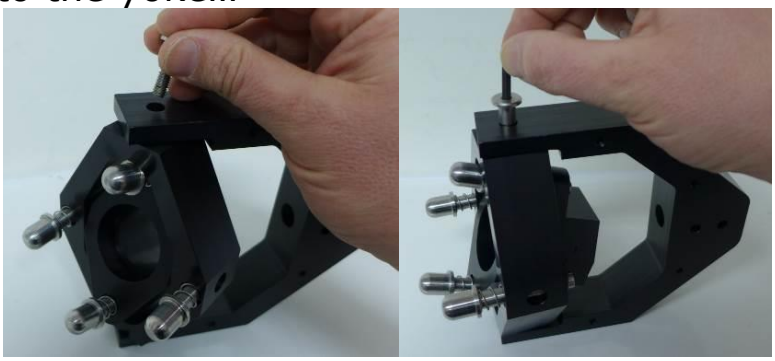


Figure 67 – Fitting the probe gimbal

Fit the cage…

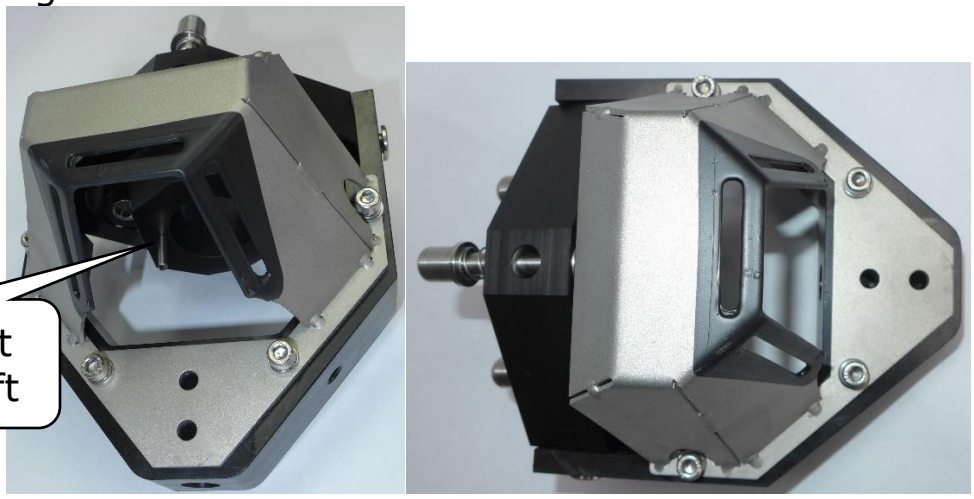


Figure 68 – Fixing the probe holder cage

Repeat in reverse order to disassemble the probe holder.

Subsea Connectors Information

Power & Comms Port (bulkhead plug)

MCBH6M (mates with MCIL6F). The picture below is shown looking into the bulkead connector.

No.	Colour	Description
1	Black	Ground
2	White	12-24V Input
3	Red	RS485 + / RS232 TX
4	Green	RS485 - / RS232 RX
5	Orange	No connect
6	Blue	No connect

Table 9 – Power and comms port pinout

See cable diagrams for how to connect the FMD system using RS232 communications (*Figure 85 - In-Line patch cable*).

Probe Port (bulkhead)

CRE PL-A-09-M Bulkhead Socket Assembly.
Mates with CRE BR-A-09-F Type 19 Cable Plug Assembly.
The picture below is shown looking into the bulkead connector.

Pin	Colour	RF Signal
1	Coax center	No connected
2	Coax GND	Ground – 0V
3	Brown	Sense - 0V – 3.3V
4	Red	Power - 3.3V
5	Black	
6	N/C	
7	N/C	
8	Coax GND	
9	Coax GND	

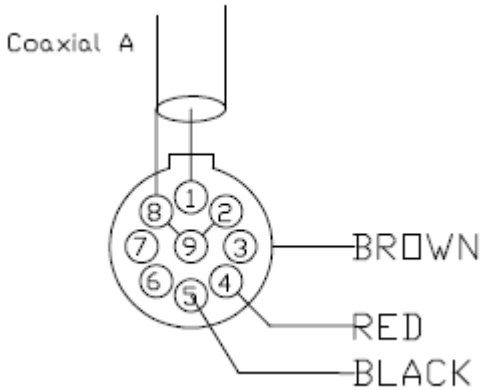


Table 10 – Probe port pinout

Grounding scheme of system

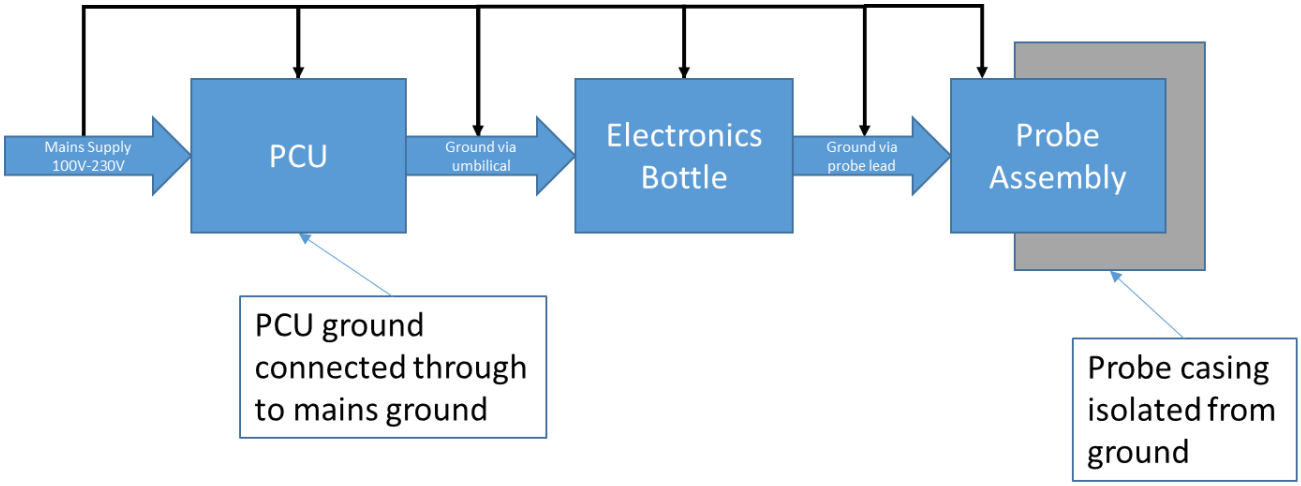


Figure 69 – Grounding scheme for diver Cygnus FMD system

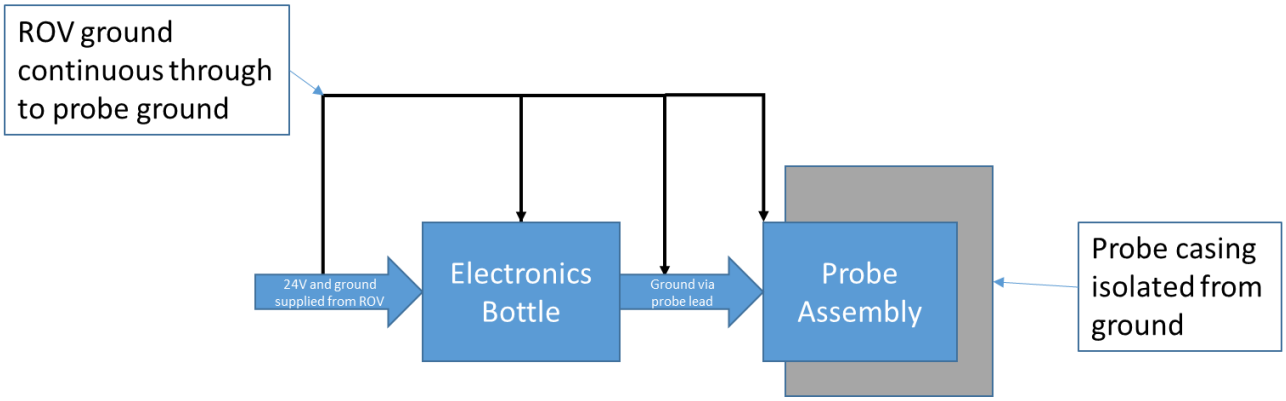


Figure 70 – Grounding scheme for ROV Cygnus FMD system

User Fabricated System Test Piece

System Test Piece must be made from Steel typically with a 13mm wall thickness and diameter between 200mm and 330mm.

FMD Test Flow Diagram

The diagram below illustrates the steps required to be able to perform an FMD test.

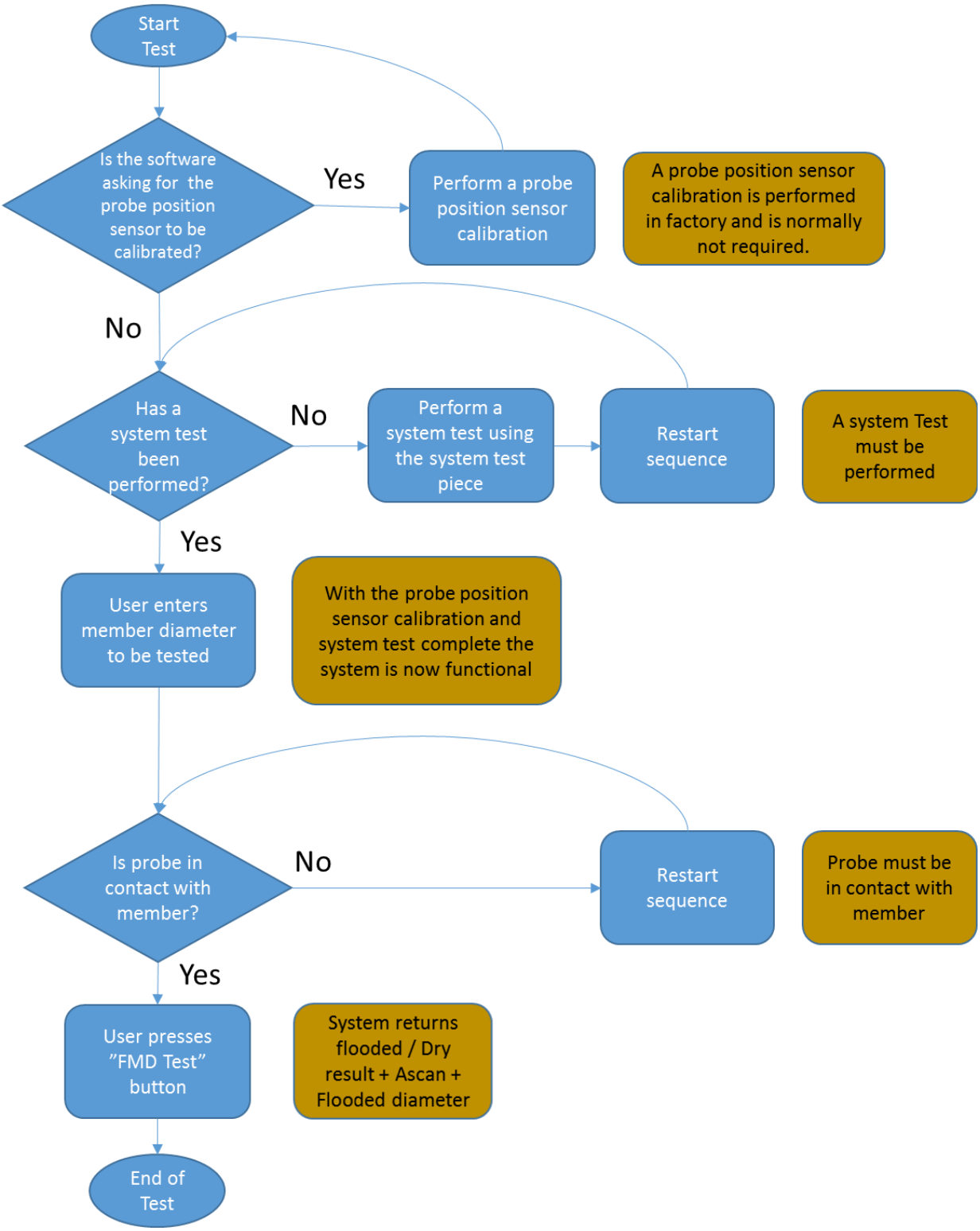


Figure 71 – Test flow for Cygnus FMD system

16. Care and Servicing

Spares List

Each system comes with a set of replacement screws, washers and bumpers for the probe holder as well as a set of replacement O-rings for the probe connector and electronics bottle.

For ordering of replacement parts please see the following table:

Item no.	Part Number	Description
1	110-0317	O-ring kit (stainless steel)
2	110-0318	O-ring kit (acetal)
3	110-0201	Probe cable assembly
4	110-0300	Probe knurled ring nut (stainless steel)
5	110-0213	Subsea module cable support cage
6	110-0301	Probe holder probe body spring
7	110-0307	Probe holder outer yoke (stainless steel)
8	110-0308	Probe holder middle yoke (stainless steel)
9	110-0309	Probe holder inner yoke (stainless steel)
10	110-0310	Probe holder outer yoke (acetal)
11	110-0311	Probe holder middle yoke (acetal)
12	110-0312	Probe holder inner yoke (acetal)
13	110-0334	Probe holder bumper kit (one)
14	110-0314	Probe holder pivot kit

Table 11 – Parts ordering list

Subsea Electronics Unit maintenance

- ✓ Clean the electronics unit and accessories with a damp cloth. Use water with a mild detergent household cleaner.
- ✓ Replace and lubricate the O-rings for the internals of the bottle annually.
- ✗ Do not use solvents to clean the system.
- ✗ Do not use any abrasive cleaner.

Probe holder maintenance

- ✓ Disassemble the probe holder and clean with a damp cloth. Use water with a mild detergent household cleaner.
- ✓ Replace as necessary and reassemble probe holder.
- ✓ Clean the probe with a damp cloth. Use water with a mild detergent household cleaner.
- ✗ Do not use solvents to clean the system.
- ✗ Do not use any abrasive cleaner.

Environmental

- ✗ Do not subject the electronics bottle to temperatures greater than 75°C (167°F).
- ✗ Do not store the electronics bottle for long periods in conditions of high temperature or humidity.

Storage

- ✗ Do not store the Equipment in temperatures greater than 55°C (131°F).

Repairs

- ✗ There are no user serviceable parts inside the electronics bottle, therefore all repair work should be carried out by Cygnus Instruments or by an authorised Cygnus service centres.

Returning the Cygnus FMD System for Servicing

A full Manufacturer's Factory Service is available from Cygnus Instruments.

The Complete Kit should always be returned for Service or Repair.

If you do need to return your Cygnus FMD system for repair please let us know the details of the problem, to help us guarantee the best possible service.

17. Advanced CygFMD Software Settings

Setting the FMD parameters

The Cygnus FMD system relies on the principle that sound travels through a medium at a constant velocity or speed. If you can accurately measure the time it takes for sound to travel through a medium and you know the velocity of sound through that medium, then you can calculate the distance that the sound has travelled:

$$\text{Distance} = \frac{\text{time x velocity}}{2}$$

Setting the Velocity of Sound

The Cygnus FMD uses the Velocity of Sound value to calculate the diameter of the member detected. It is therefore important to enter the velocity of sound in sea water for the types of sea water where the tests are being performed.

Different velocity values are due to differences in the temperature and salinity of the water.

To set the velocity of sound select System S*etup->System Settings* from the menu and enter the velocity of sound in the 'Water velocity m/s' box. By default, it is set to 1520m/s.

FMD Gain Settings

The Cygnus FMD system employs a fixed Gain curve for minimum and maximum gains.

For FMD testing the gains increase as the member diameter increases. Each FMD test performs three tests with minimum (cycle 1) / medium (cycle 2) / maximum (cycle 3) gains applied.

Go to System Setup->Gain Settings for FMD Test to view the two gain curves.

Contact Cygnus to adjust these settings if required.

18. Pressure Test Certificate

Cygnus House
30 Prince of Wales Road
Dorchester, Dorset,
DT1 1PW, England

Tel: +44 (0) 1305 265533
Fax: +44 (0) 1305 269960
Email: sales@cygnus-instruments.com
Web: www.cygnus-instruments.com

CERTIFICATE OF PRESSURE TEST

As part of Cygnus Instruments' pre-delivery inspection, this document hereby certifies that the following instrument:

CYGNUS MK1 FMD
ULTRASONIC FLOODED MEMBER DETECTOR
ELECTRONICS BOTTLE

Is pressure tested prior to shipping at Cygnus House to an equivalent depth of 300msw (meters of sea water) 435psi / 30bar.

This certificate is part of Cygnus Instruments Ltd manufacturing procedures. Details of design pressure test certificates can be found in the Operating manual.

19. Technical Specifications

Cygnus M1-FMD Technical Specifications	
Power Supply Requirements (Generic)	
Power Supply Input to Electronics Bottle	12-24V supply input @ 60mA (average current) @ 200mA (maximum current)
Power Supply Requirements for Power Supply and Comms Unit (Diver)	
Mains supply	110AC or 230VAC
Connections	
Probe connector	CRE PL-A-09-M Mates with Bulkhead CRE BR-A-09-F Type 19
Power/Comms connector	MCBH4F
External Power/Comms connector	MCBH6M
General Attributes	
Operating Temperature Range	-10°C to +50°C (14°F to 122°F)
Storage Temperature Range	-10°C to +35°C (14°F to 95°F)
Measurement Ranges	200mm(0.2m) to 2500mm(2.5m), 0.66ft to 6.56ft
Measurement Resolution	1mm
Transmitter	
Pulser Voltage	100V to 400V (adjustable)
Pulse Width	850ns (adjustable)
Damping	470 Ohm
Receiver	
Useable Gain range	0dB to 70dB (adjustable)
Probe	
Centre Frequency	0.5MHz
Technology	Piezo-composite.
Pressure Rating	
Electronics Bottle	Tested to 400m
Probe Assembly	Tested to 400m
Other	
Compliance	CE, UKCA, RoHS. Declarations of Conformity supplied with kit.
USB Mini B Connector under end cover (other end to connectors). Can be used to update the instrument firmware.	

Specifications are subject to change for product improvement.

20. Size and weights

Cygnus M1-FMD Size and Weight Specifications	
Dry Weights	
Electronics bottle (stainless steel)	4.87kg
Electronics bottle (acetal)	0.9kg
Probe Holder (stainless steel)	4.5kg max.
Probe Holder (acetal)	1.95kg max.
Cable reel with umbilical (120m)	23kg
Cable reel with umbilical (50m)	13kg
Cable reel with umbilical (350m+50m)	100kg
Large rugged carry case (with acetal FMD)	13.3kg max.
Large rugged carry case (with stainless steel FMD)	20kg max.
System test piece	27kg
Weights in fresh water	
Electronics bottle (stainless steel)	3.27kg
Electronics bottle (acetal)	0.1kg
Probe holder (stainless steel)	3.7kg max.
Probe holder (acetal)	1.26kg max.
Sizes	
Large rugged case	560mm x 450mm x 270mm
Cable reel (350m + 50m)	450mm x 600mm x 930mm
Cable reel (120m)	310mm x 450mm x 555mm
Cable reel (50m)	290mm x 380mm x 490mm

Specifications are subject to change for product improvement.

21. Standard Test Scenarios

Scenario 1 – ROV using fibre optic multiplexer

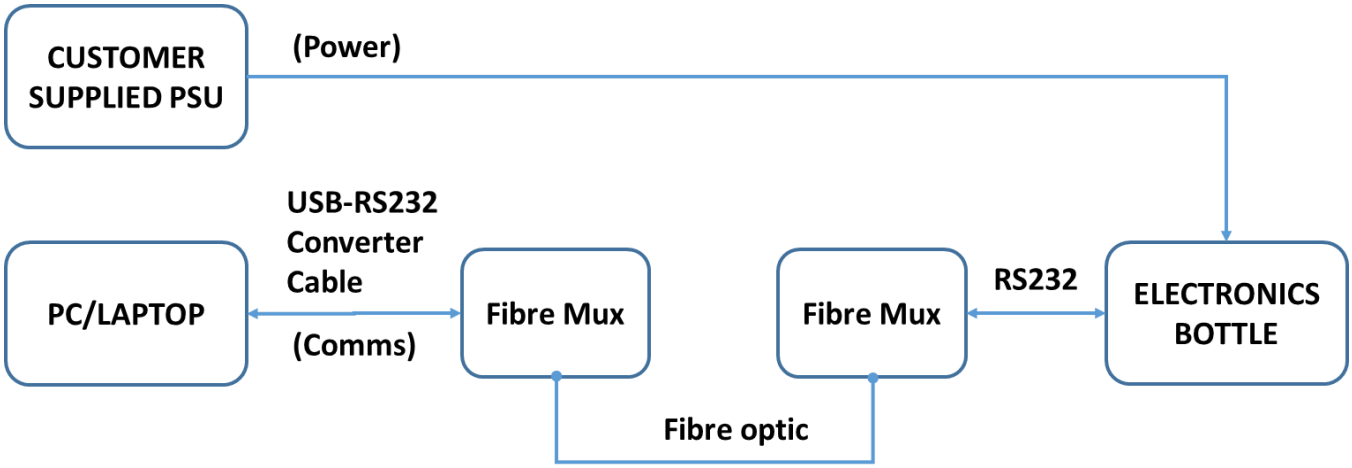


Figure 72 – Test scenario 1 (ROV, fibre comms)

Scenario 2 – ROV using customer umbilical

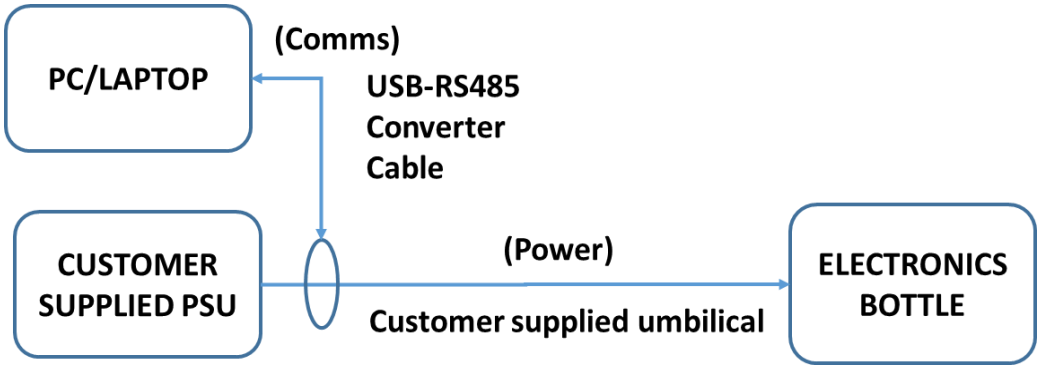


Figure 73 – Test scenario 2 (ROV, customer umbilical)

Scenario 3 – Diver using Cygnus umbilical

Figure 74 – Test scenario 3 (Diver)

22. CygFMD Software Shortcut Keys

File

Shortcut key	Operation
Ctrl-N	New Survey
Ctrl-O	Open Survey
Ctrl-S	Save Survey
Ctrl-P	Print Survey to PDF
Ctrl-X	Exit FMD Topside Software
Alt-F	File Menu

Connect

Shortcut key	Operation
F9	Connect to Cygnus FMD System
Alt-C	Connect Menu

Test Setup

Shortcut key	Operation
F3	Flooded Member Test Setup
Atl-T	Test Setup Menu

System Setup

Shortcut key	Operation
F1	About
Alt-S	System Setup Menu

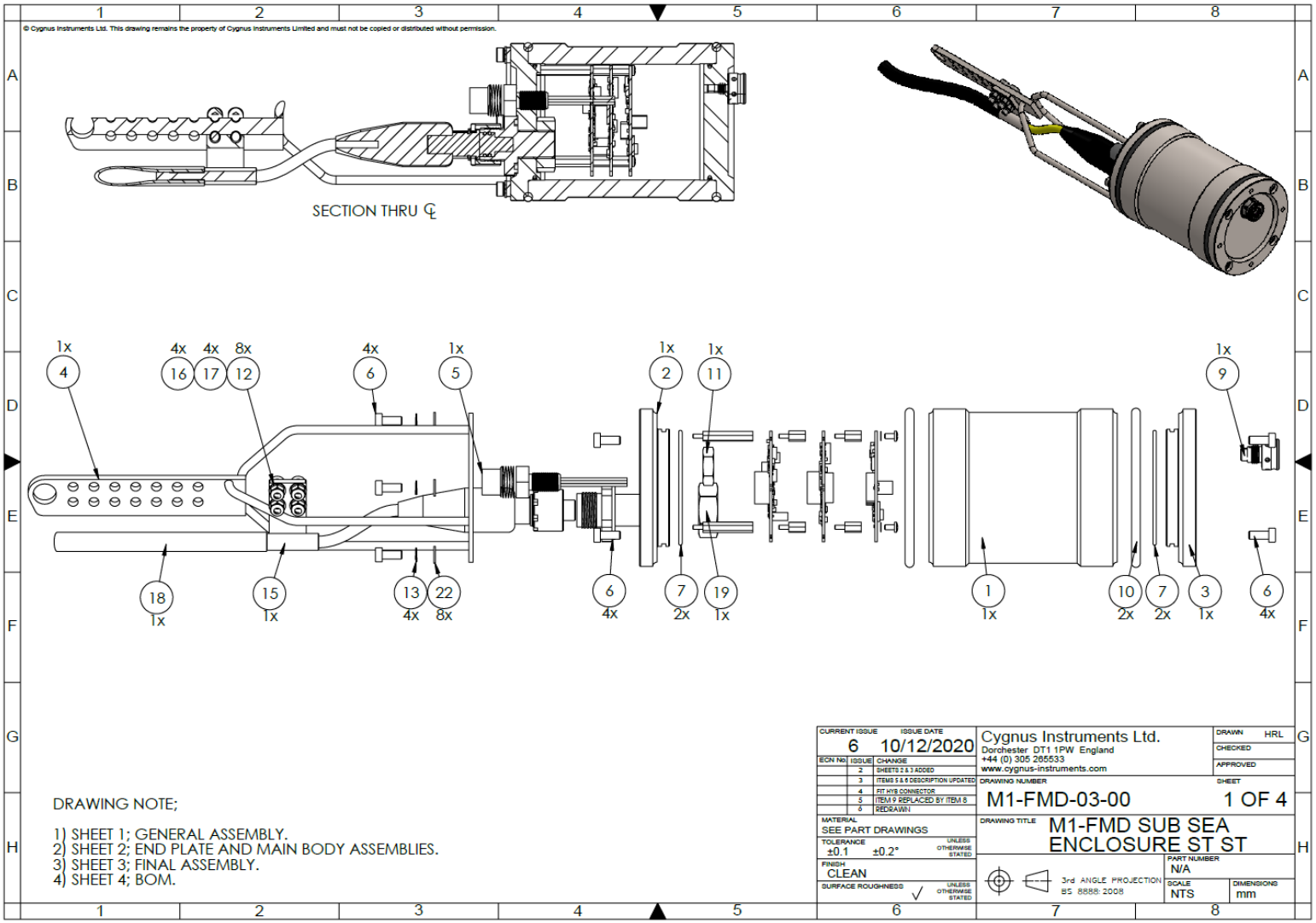


Figure 75 –Cygnus FMD Electronics Bottle Assembly – page 1

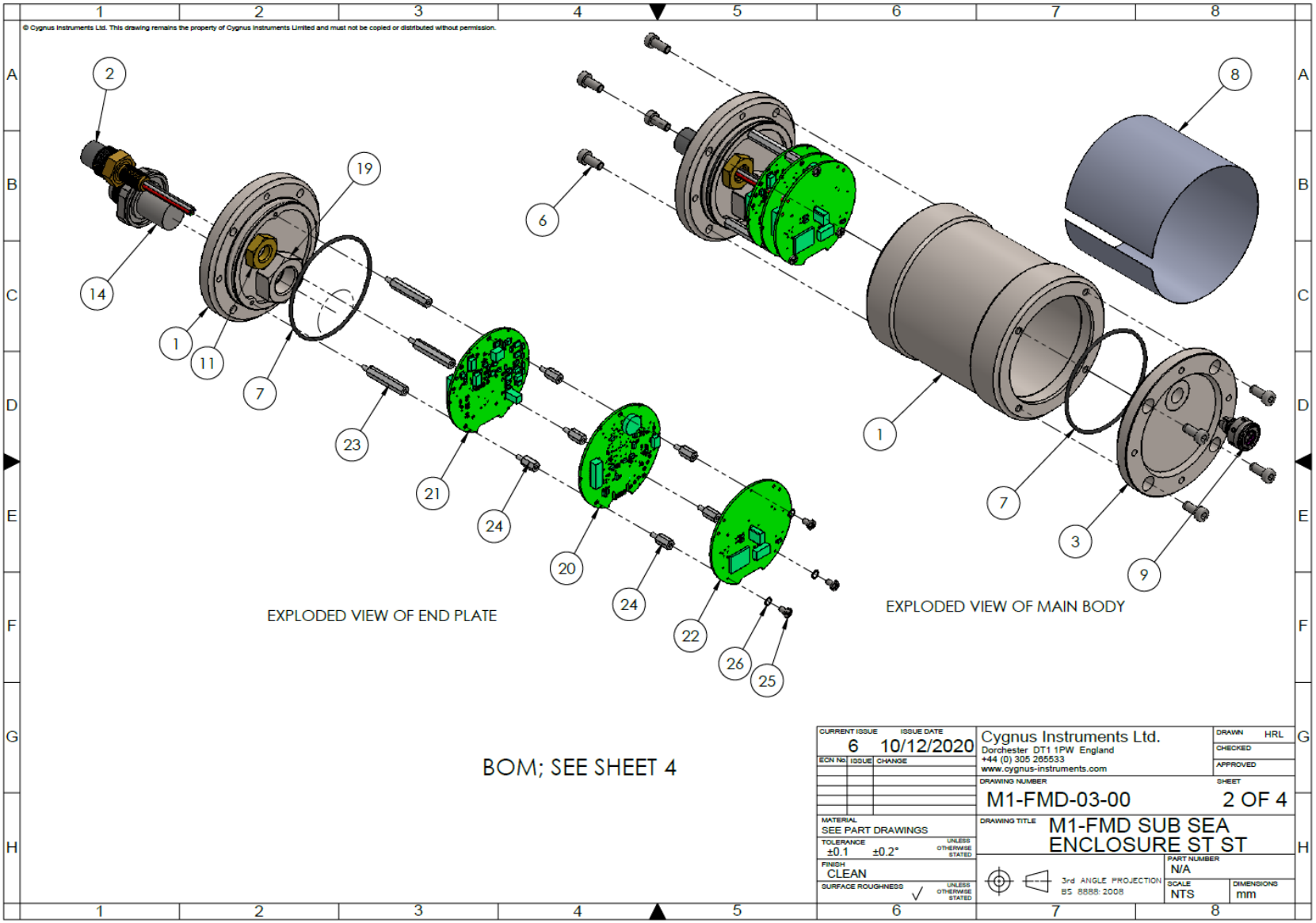


Figure 76 –Cygnus FMD Electronics Bottle Assembly – page 2

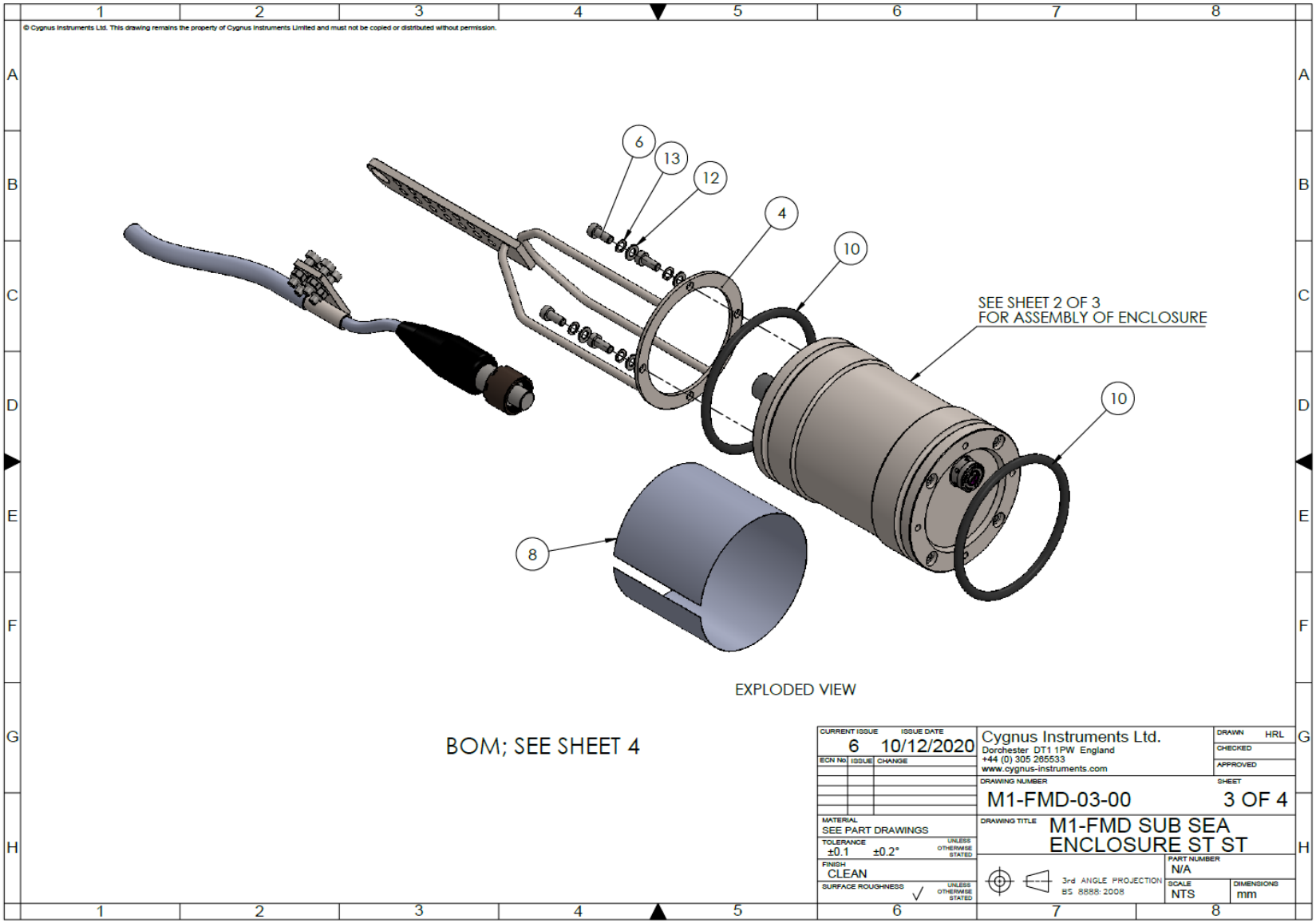


Figure 77 –Cygnus FMD Electronics Bottle Assembly – page 3

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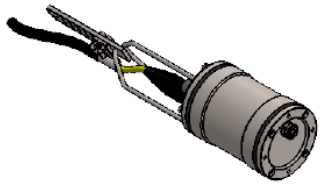
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	60-037	ENCLOSURE SUBSEA ENCLOSURE BODY ST ST M1-FMD	1
2	60-038	SUBSEA ENCLOSURE BODY TOP PLATE (CRE)	1
3	60-039	SUBSEA ENCLOSURE BODY BOTTOM PLATE	1
4	60-040	GAUGE BODY SUPPORT BRACKET	1
5	50-003	CONNECTOR SUBCONN 6W BULKHEAD PLUG MCBH6M(BRASS)	1
6	13-473	FIXING M5 x 12 CAP HEAD SCREW A4 STAINLESS	12
7	14-477	O-RING 0620-25 NBR70 NITRILE 62 ID x 2.5 CS	2
8	60-033	LABEL SUBSEA ENCLOSURE M1-FMD	1
9	50-013	ENCLOSURE GAUGE - PRESSURE RELIEF VALVE	1
10	13-471	O-RING BS-340 NBR70 85ID X 5.33 CS	2
11	13-317	FIXING NUT LOCKING 7/16-20 UNF 2A THREAD BRASS 6.4MM THICK	1
12	40-157	FIXING WASHER M5 PLAIN STAINLESS STEEL	8
13	13-345	FIXING M5 SINGLE COIL WASHER RECTANGULAR	4
14	10-306	CONNECTOR BULKHEAD CRE BRA	1
15	60-070	PROBE CABLE BRACKET B	1
16	13-550	FIXING M5 NYLOCK NYLON INSERT THICK S/STEEL A4	4
17	13-548	FIXING M5x20mm SCREW CAP HEAD S/STEEL A4	4
18	90-017	AIR HOSE BLACK 8mmx15mmx25M	1
19	13-546	FIXING NUT LOCKING 3/4-UNF A2	1
20	60-015	FMD DIGITAL PCB (CYG057-01)	1
21	60-017	FMD ANALOGUE PCB (CYG057-02)	1
22	60-016	FMD POWER PCB (CYG057-03)	1
23	13-340	HEX STANDOFF M3 X 30 X 6	3
24	13-341	HEX STANDOFF M3 X 10 X 6	6
25	13-299	FIXING M3 X 6MM POZIDRIVE PAN HEAD A2 STAINLESS	3
26	13-070	FIXING WASHER M3 SHAKE-PROOF ZINC PLATED	3



CURRENT ISSUE 6 ISSUE DATE 10/12/2020
ECN No | ISSUE | CHANGE

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DRAWN HRL
CHECKED
APPROVED

DRAWING NUMBER M1-FMD-03-00
SHEET 4 OF 4

MATERIAL SEE PART DRAWINGS
TOLERANCE ±0.1 ±0.2° UNLESS OTHERWISE STATED
FINISH CLEAN
SURFACE ROUGHNESS √ UNLESS OTHERWISE STATED

DRAWING TITLE M1-FMD SUB SEA ENCLOSURE ST ST

3rd ANGLE PROJECTION BS 8888: 2008
PART NUMBER N/A
SCALE NTS
DIMENSIONS mm

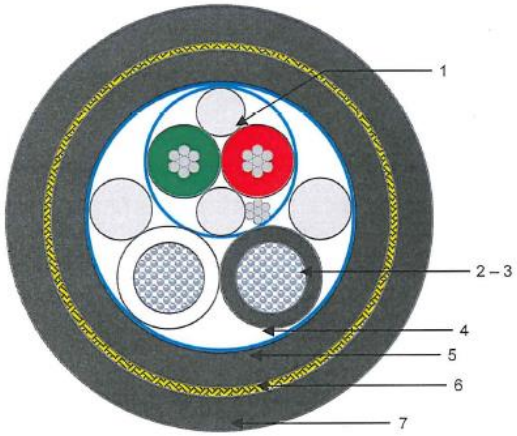
Figure 78 –Cygnus FMD Electronics Bottle Assembly – page 4

Part No: CYG020

Customer Ref: 14-111

Quotation Drawing No: Q9488 00C

RoHS COMPLIANT 2011/65/EC



No	Description	Colr	Dia mm
1	**1 Position Screened Twisted Pair** 0.34mm² (7/0.25mm) Tinned Copper Polyolefin Insulated to 1.65mm 2 no twisted together with fillers in interstices and 1 no Tinned Copper drain wire. Overall Helical 12/23µm Ali/PET foil screen, minimum overlap 50%	RD/GN	3.40
2 3	**2 Position Power Conductors** 1.50mm² (30/0.25mm) Tinned Copper HDPE Insulated to 0.35mm nom RTI	BK WH	2.30
4	**Lay Up** Items 1 – 3 cabled together with fillers in interstices. Overall Helical PET binding tape, minimum overlap 30%	N/A	6.00
5	**Bedding** Polyether Polyurethane 4394 85 Shore A Halogen Free 0.80mm nom RTI	BK	7.60
6	**Strength Member** Vectran® Fibre Braid, Minimum 26,600 dTex	N/A	8.00
7	**Jacket** Polyether Polyurethane 4394 85 Shore A Halogen Free 1.00 nom RTI	BK	10.00 -0.40 +0.0

Notes	
Electrical Characteristics	
0.34mm² Screened Twisted Pair	
Nominal Conductor Resistance	61.00 Ω/KM @ 20°C
Calculated Characteristic Impedance	120 Ω
Calculated Mutual Capacitance	64 pF/m
1.50mm² Power Conductors	
Nominal Conductor Resistance	13.50 Ω/KM @ 20°C
Max Recommended Voltage	1,000 V
Max Recommended Current / Conductor	20 A
General	
Minimum Insulation Resistance	
Core – Core	>900 MΩ/KM @ 1000V
Core – Screen	>500 MΩ/KM @ 1000V
Mechanical Characteristics	
Maximum Operating Temp	
Static	+90°C
Dynamic	+80°C
Cold Flex Temp	-40°C
Minimum Break Load	470 KGF
Recommended Safe Work Load	120 KGF
Min Recommended Bend Radius	
Static	75 mm
Dynamic	130 mm
Nominal Weight	
In Air	156 KG/KM
In Sea Water @ SG 1.025	28 KG/KM

Drawing Approved

Name J R GOODEY

Signed

Date 24/11/16

Page 1 of 1

ISSUE	DESCRIPTION	DRWN	DATE	APPD	DATE
01	Issue Part Codes	CH	24/11/16		
00C	Revise	AJK	17/11/16		
00B	Revise Design to reduce O/D	SMO	20/10/16		
00A	Remove Bedding, Reduce Size	SMO	19/10/16		
00	Quotation	SMO	11/10/16		

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Conceptcables FROM CONCEPT TO CABLE

TITLE: 4C-1STP-PU-SB-PU 10.00 BK

DESCRIPTION:

CUSTOMER: Cygnus Instruments Ltd

Figure 79 – Umbilical datasheet

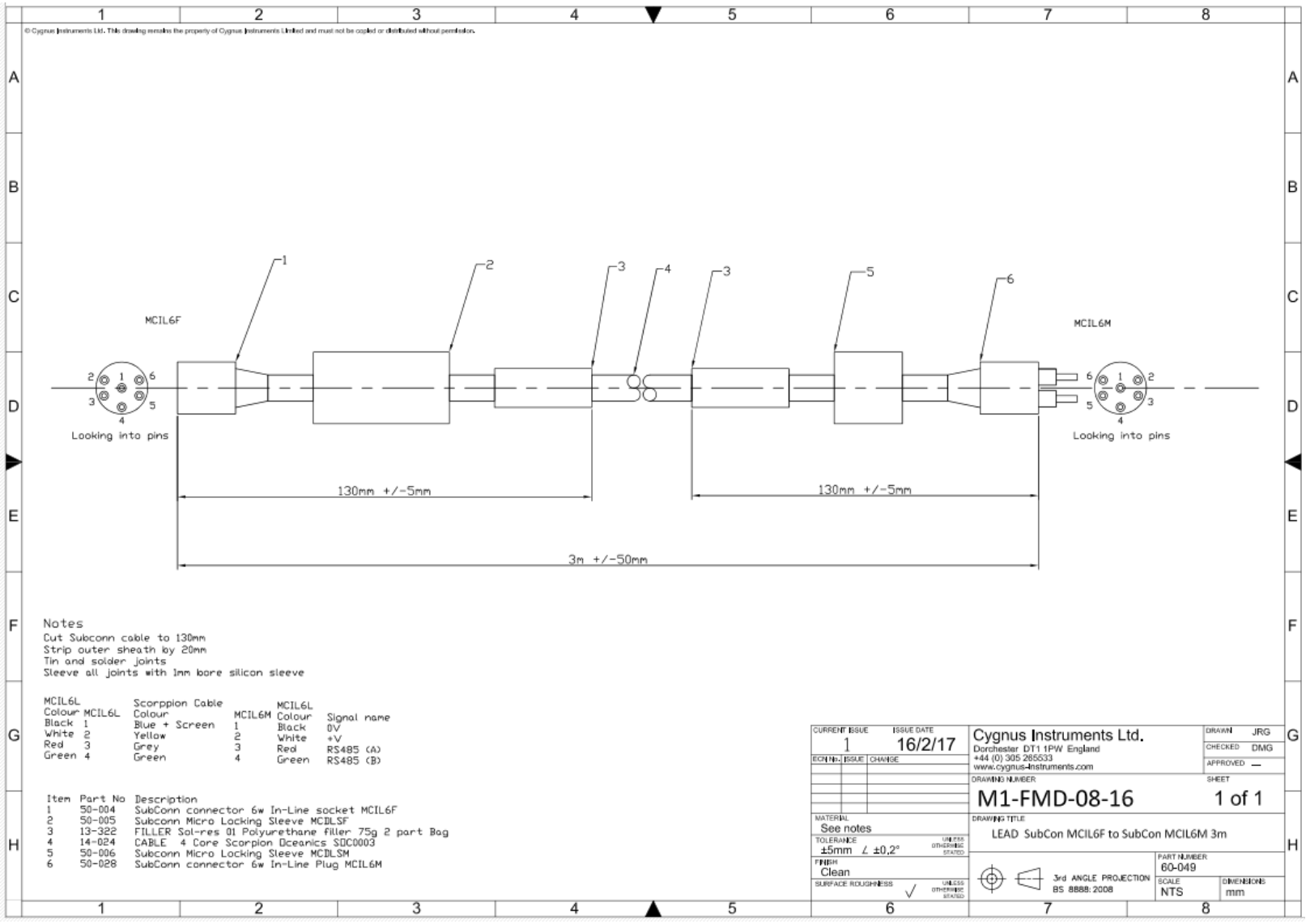


Figure 80 – 3m umbilical test lead

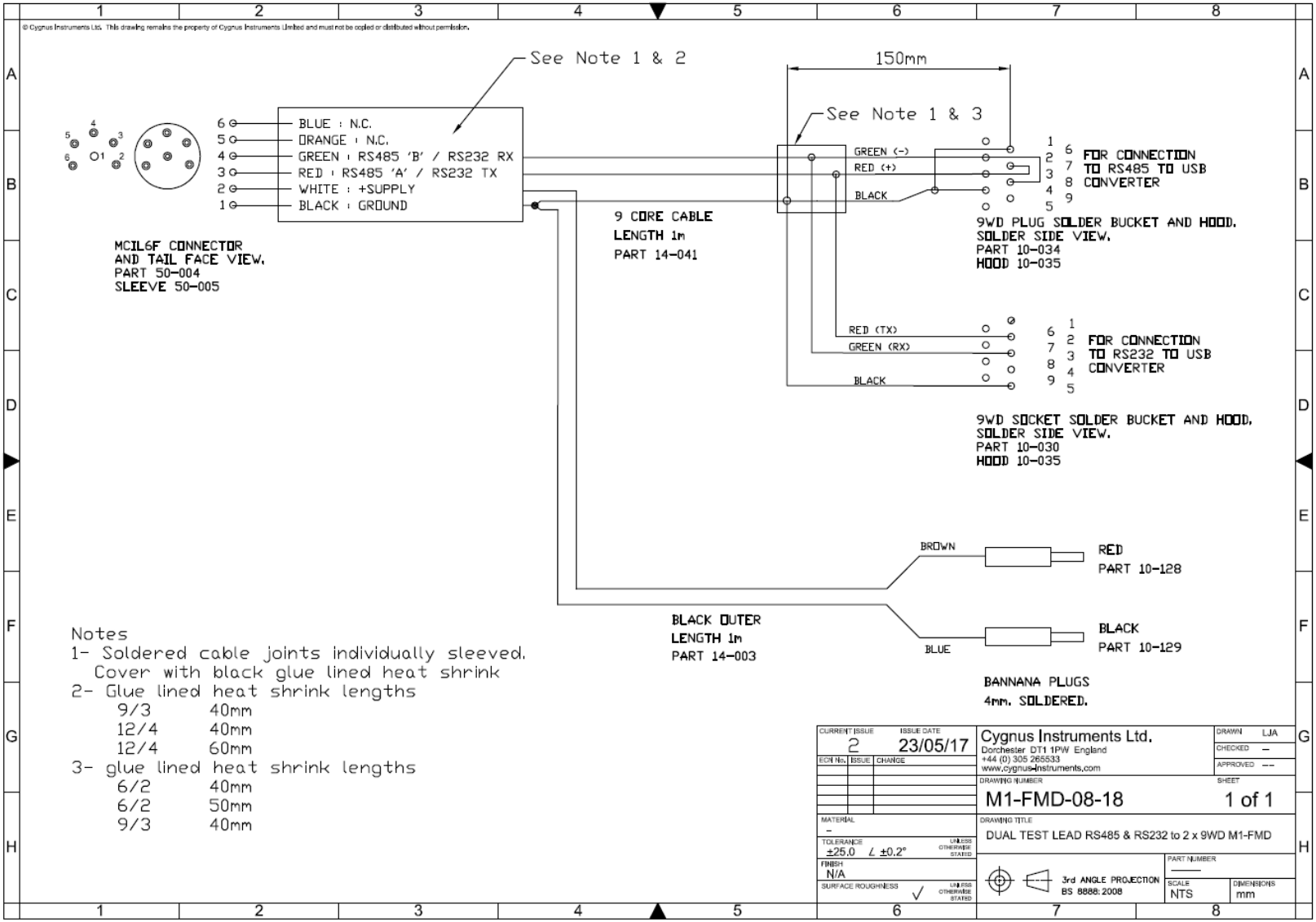


Figure 81 – Dual test lead

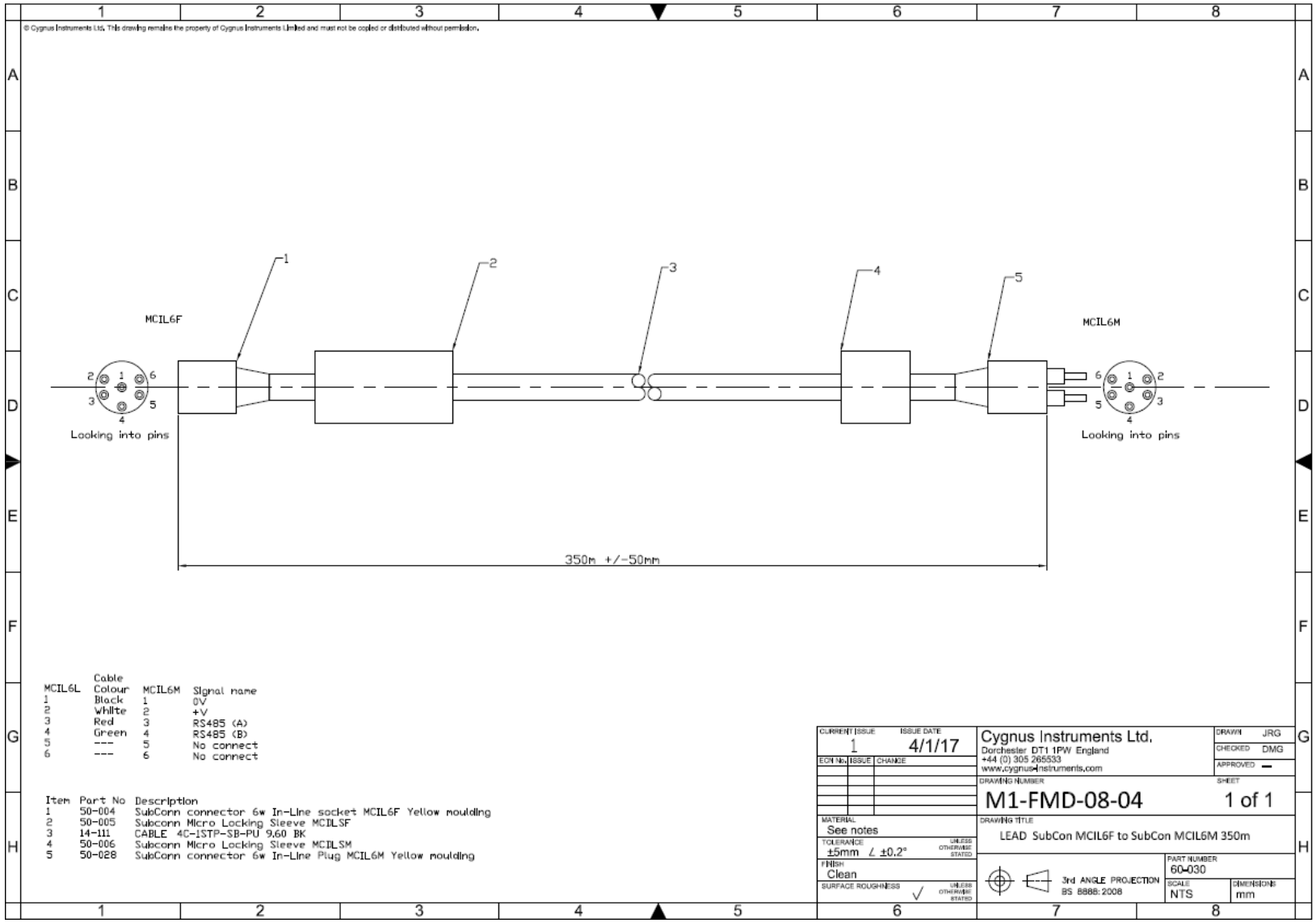


Figure 82 – 350m umbilical

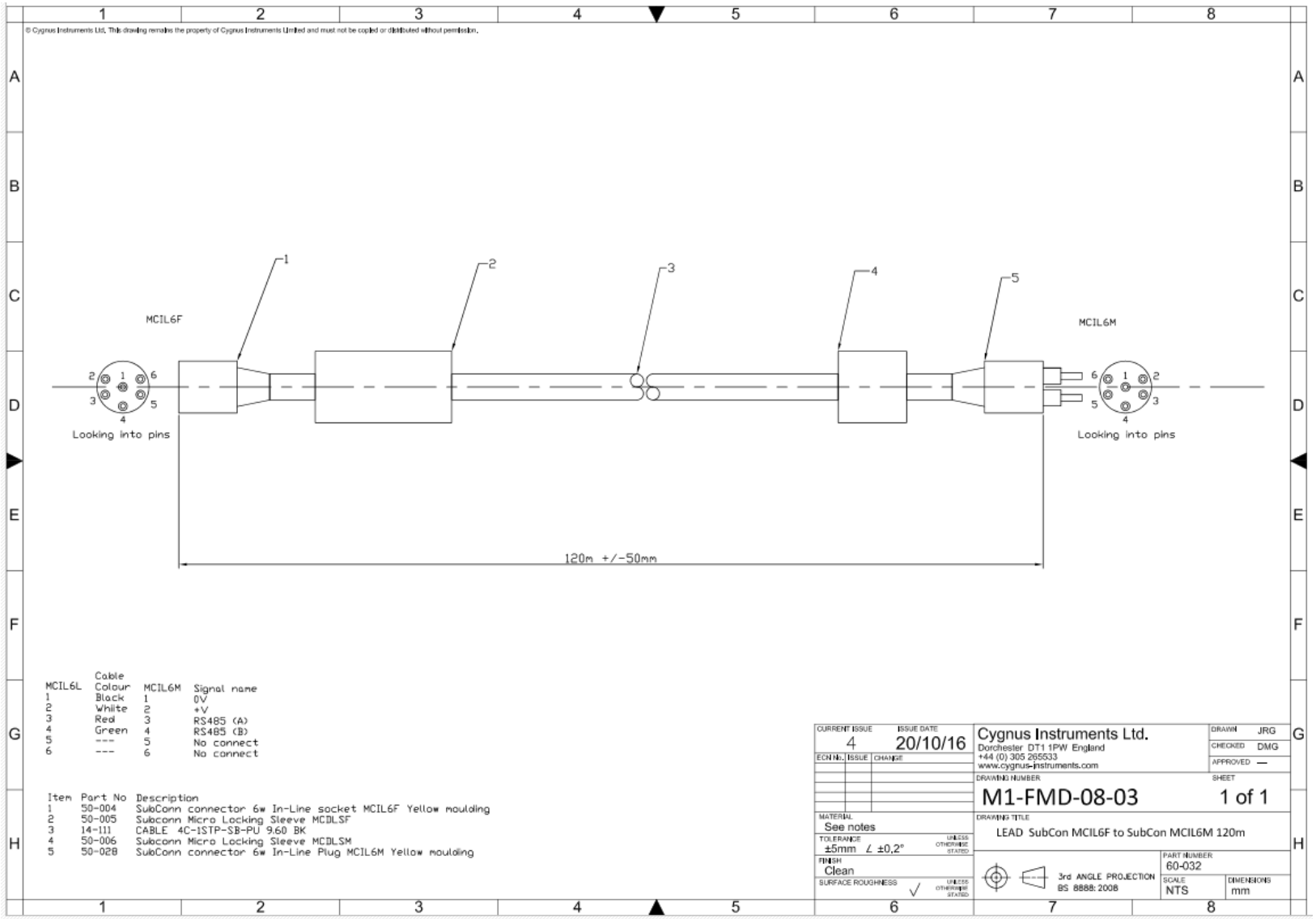


Figure 83 – 120m umbilical

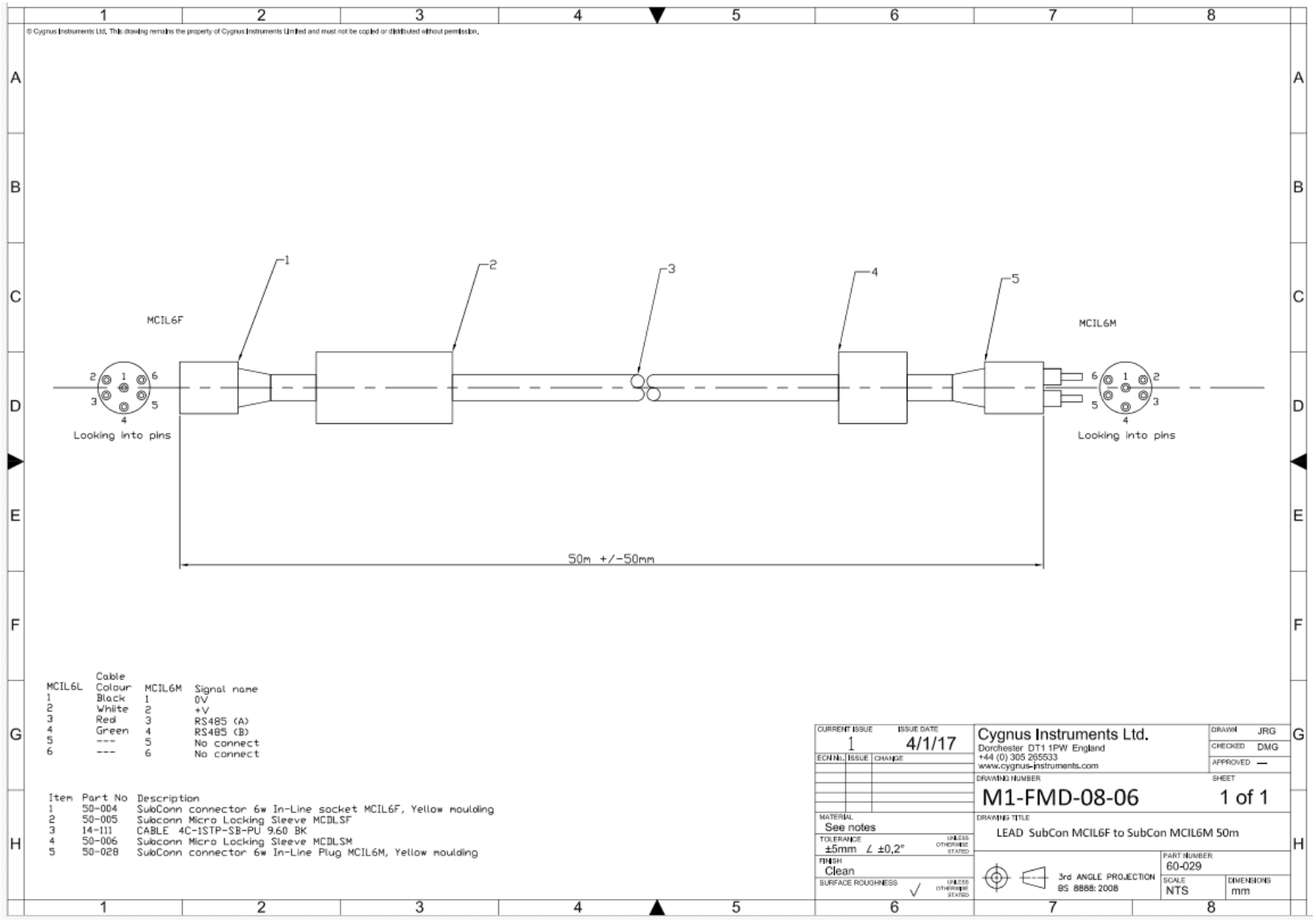


Figure 84 – 50m umbilical extension

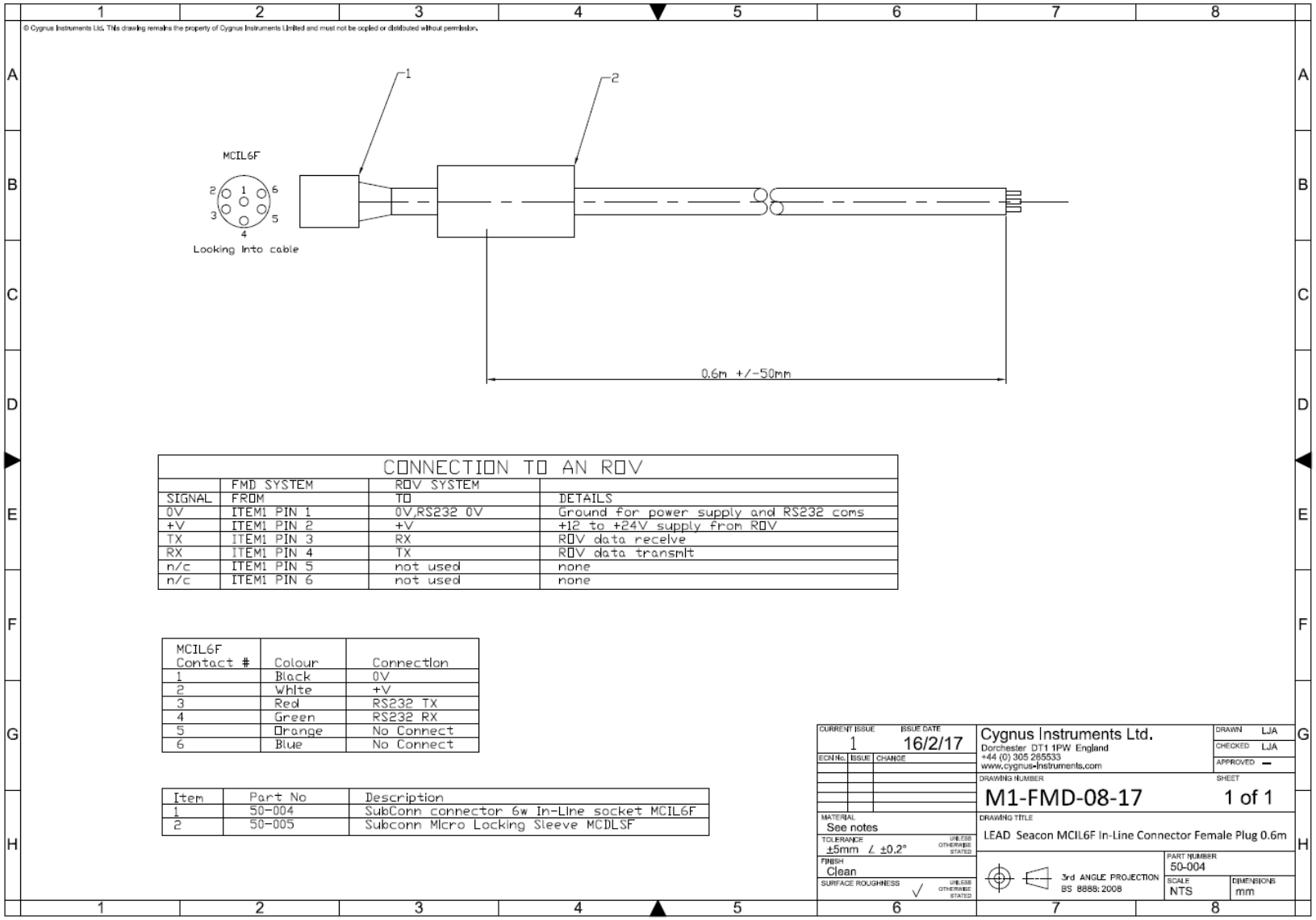
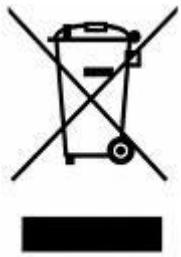


Figure 85 - In-Line patch cable

23. Recycling and Disposal (EC Countries)

The WEEE Directive (Waste Electrical and Electronic Equipment 2002/96.EC) has been put into place to ensure that products are recycled using best available treatment, recovery and recycling techniques to ensure human health and high environmental protection.

This equipment has been designed and manufactured with high quality materials and components which can be recycled and reused. It may contain hazardous substances that could impact health and the environment. In order to avoid the dissemination of those substances in our environment and to diminish the pressure on natural resources we encourage you to dispose of this product correctly.



DO NOT dispose of this product with general household waste.

DO dispose of the complete product including cables, plugs and accessories in the designed WEEE collection facilities.

This product may also be returned to the agent or manufacturer who supplied it for safe end-of-life disposal.

Cygnus Instruments Ltd registration number for The WEEE Directive is WEE/HE1274RU.

24. Warranty Information

LIMITED THREE YEAR WARRANTY
FOR CYGNUS ULTRASONIC FMD SYSTEMS

1. Cygnus Instruments Limited ("CYGNUS") warrants that, subject as set out below, the Products manufactured by it (excluding consumables, batteries, probes, leads, microphones and telescopic extensions) will be free from defects in materials and workmanship for a period of three years from the date of purchase either from CYGNUS or from an Authorised CYGNUS Distributor. Batteries, probes, leads, microphones and telescopic extensions are warranted for 6 months. This warranty is limited to the original Purchaser of the Product and is not transferable. During the warranty period, CYGNUS will repair, replace or refund, at its option, any defective Products at no additional charge, provided that the product is returned by the original Purchaser, shipping prepaid, to CYGNUS or an Authorised CYGNUS Distributor. If shipped by mail or any common carrier, the Purchaser must insure and accept all liability for loss or damage to the Product and must use shipping containers equivalent to the original packaging. Replacement products or parts will be furnished on an exchange basis only. All replaced products or parts become the property of CYGNUS.

2. Any defects in materials or workmanship must be notified to CYGNUS by the Purchaser within seven days after the discovery of the defect or failure.

3. Dated proof of purchase must be provided by the Purchaser when requesting warranty work to be performed or making any other claim under this warranty. CYGNUS will not be liable under this warranty unless the total price for the Product was paid by the due date for payment.

4. This warranty does not extend to any products which have been damaged as a result of, accident, misuse or abuse, natural or personal disaster, service, modification or repair by anyone other than CYGNUS or an Authorised CYGNUS Service Centre, failure to properly store or maintain the Product, negligence, abnormal working conditions, fair wear and tear, or failure to follow the instructions issued by CYGNUS in relation to the Product.

5. Except as expressly set forth above or in the CYGNUS Terms of Sale, subject to which the Products were purchased, all warranties, conditions or other terms implied by Statute or Common Law are extended to the fullest extent permitted by law.

6. Except in respect of death or personal injury caused by the negligence of Cygnus, Cygnus shall not be liable to the Purchaser or to any other person by reason of any representation (unless fraudulent), or any implied warranty, condition or other term, or any duty at common law, or under the express terms of the contract for purchase of the Products, for loss of profit or for any indirect, special or consequential loss or damage, costs, expenses or other claims for compensation whatsoever (whether caused by the negligence of Cygnus, its employees or agents or otherwise) which arise out of or in connection with the supply of the Products or their use or resale by the Purchaser or by any other person. The entire liability of Cygnus under or in connection with the Products shall not exceed the price paid for the Products, except as expressly provided in this warranty.

Cygnus Instruments

Our philosophy is to work closely our customers to provide high quality products, engineered to serve heavy industry & harsh environments. Cygnus' ultrasonic systems are designed to be reliable and simple to use. We have an unrivalled reputation in over 45 countries around the world.

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