## 1.0 INTRODUCTION:

### 1.0.1 PRINCIPLES OF CORROSION AND CATHODIC PROTECTION:

Metallic corrosion is an electro-chemical reaction in which the metal combines with a non metal, such as oxygen, to form a metal oxide or other compound. This depends upon the nature of the environment.

Different metals have different tendencies to corrode, termed *activity* or *potential*. These potentials can be tabulated and form the electro-chemical series.

A more practical approach is the determination of the tendency of certain metals to corrode in a particular electrolyte, such as sea water. This is termed the galvanic series of which the following table is an abridged form.

Active or Anodic

Magnesium
Zinc
Mild Steel
Wrought Iron
Cast Iron
Ni-Resist
18.8.3 % Molybdenum SS, Type 316 (Active)
Lead
Tin
Manganese Bronze
Naval Brass
Aluminium Bronze
Copper
70 Copper 30 Nickel
Nickel (Passive)
Monel, 70% Nickel - 30 % Copper
18.8.3 % Molybdenum SS, Type 316 (Passive)

Noble or Cathodic

Note Some metals and alloys have two positions in the series, marked *Active* and *Passive*; the active position is equivalent to the position if corrosion is occurring and approaches the electro-chemical series position for the material. The passive position relates to a non-corroding situation where the material is protected by a self forming surface film. For example, type 316 stainless steel in sea water is more likely to be passive than type 304 and is therefore generally preferred for immersed marine applications.

If two metals are placed in an electrolyte (e.g. sea water or damp soil) and are in direct electrical contact, a current will pass through the electrolyte from the more active metal onto the least active metal. The least active metal does not corrode and is termed the cathode. The more active metal, the anode, passes into solution and the flow of electrical current increases. This is a metal ion and electron transfer process i.e., it corrodes.

This simple cell may be represented as:

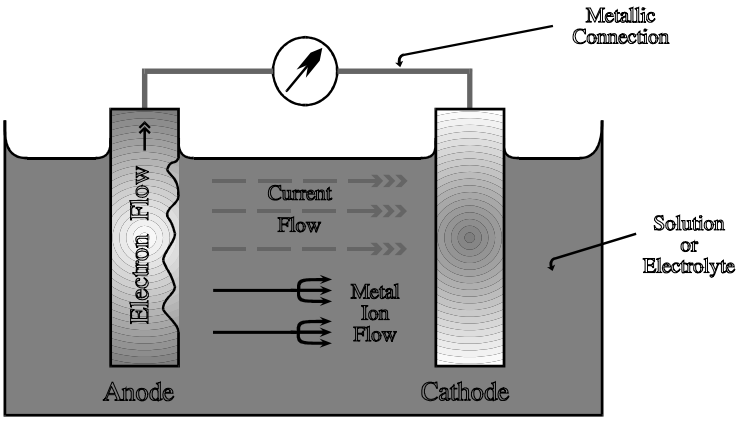



Figure 1.1 - Simple Corrosion Cell

The Anodic and cathodic areas in a corrosion cell may be due to the electrical contact of two dissimilar metals, termed *galvanic corrosion*. Anodic and cathodic areas may be formed on a single metal surface as *micro-cells* for instance by rain drops on uncoated steel. Alternatively, they may be close but discrete cells found when accelerated corrosion occurs at uncoated Anodic areas on a generally coated cathodic structure. In addition there are long line type cells that occur on pipelines that pass through aggressive low resistivity soils. These sections form Anodic areas and corrode in preference to cathodic areas in less aggressive higher resistivity soils.

Large currents can occur at small Anodic areas and lead to rapid corrosion of marine structures such as ship's internal tanks, external hull plates, sheet steel piling in harbours and tubular structures common in jetties and petrochemical drilling and production platforms.

*Cathodic Protection is a system of preventing corrosion by forcing all surfaces of a structure to be cathodes by providing external anodes.*

As described above, a galvanic corrosion cell occurs when dissimilar metals are in contact with each other within an electrolyte. Care should be taken in the

construction of structures that will be buried or immersed in an electrolyte to ensure a galvanic cell is not created.

Typical examples of galvanic cells are:

a ) Steel or cast iron water boxes in contact with non ferrous (often copper based) tube plates in condenser water boxes in ships or generating plant. Rapid corrosion of the ferrous water box occurs close to the tube plate.

b) Brass or bronze valves fitted to immersed steel buoyancy tanks or flooding chambers on marine petrochemical structures. Accelerated corrosion of the steel occurs near the valve.

c) The connection of steel pipes into an otherwise cast iron system. Accelerated corrosion of the steel occurs near the cast iron sections.

Sacrificial anode cathodic protection achieves corrosion prevention on a particular structure or component by forming a galvanic cell where an additional *anode* of zinc, magnesium or aluminium corrodes in preference to the structure. The galvanic corrosion current (see simple cell before) available from this anode / electrolyte / structure combination should be sufficient to overcome the local surface corrosion currents on the structure until no current flows from Anodic areas of the structure i.e the structure is entirely cathodic or under complete cathodic protection.

The potential, or measure of activity, between the structure and the electrolyte is a relatively easily measured indication of whether the structure is Anodic or cathodic. For steel under normal non anaerobic conditions it can be shown theoretically, and is accepted practically, that a steel/electrolyte potential more negative than -0.85 volts measured against a standard copper/copper sulphate electrode indicates that cathodic protection is achieved. This is equivalent to -0.80 volts measured against silver / silver chloride electrode and + 0.24 volts against a zinc electrode as indicated in figure 1.3.

SACRIFICIAL ANODE CATHODIC PROTECTION:

As indicated previously, a metal can be made cathodic by electrically connecting it to a more Anodic metal within the electrolyte. The most commonly used Anodic metals are alloys of aluminium, zinc and magnesium. Anodes of these metals corrode preferentially; the corrosion current of the anode achieving cathodic protection of the structure to which they are connected. The anodes deteriorate as an essential part of their function and they are therefore termed *sacrificial*.

## 2.0 GENERAL DESCRIPTIONS:

### 2.1.1 IMPRESSED CURRENT CATHODIC PROTECTION:

A metal also can be made cathodic by electrically connecting it to another metallic component in the same electrolyte through a source of direct electric current and directing the current flow to occur off the surface of added metallic component (anode), into the electrolyte and onto the metal (cathode). This can easily be visualised by reference to the simple cell and assuming yet another electrode with a power source is introduced and that the current flow from this electrode is sufficient to overcome the natural corrosion current.

Because an external current source is employed, this type of protection is termed *'IMPRESSED CURRENT CATHODIC PROTECTION'*.

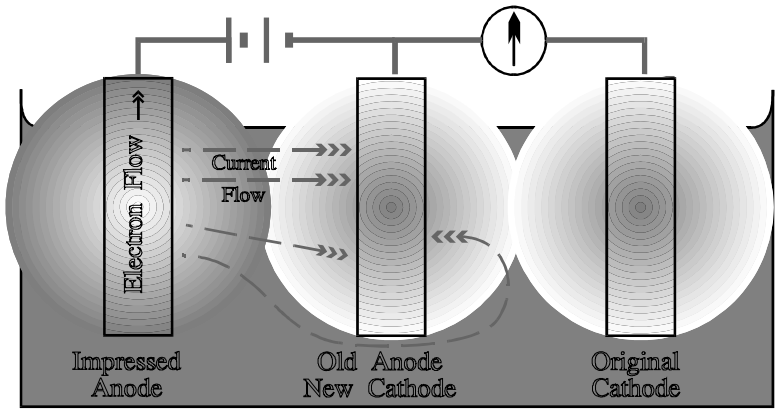



Figure 1.2 - Cathodic Protection Applied to a Simple Corrosion Cell

A source of direct current is required, this is generally obtained from mains power units that contain a transformer and rectifier. The magnitude of this current may be automatically controlled in response to a continuous monitor of the cathode / electrolyte potential or may be manually controlled after intermittent measurement.

The impressed current anode material is ideally non-consumed by the passage of current from it into the electrolyte, in practice the materials used are a compromise between this ideal and the cost and physical properties of available materials. Impressed current anodes are made from graphite, silicon iron, lead alloys some with platinum bi-electrodes, platinised titanium or more exotic combinations such as platinum clad niobium. The selection of the correct anode material is critical in the formulation of an effective and economic cathodic protection scheme.

Generally, for a given current demand, less impressed current anodes than sacrificial anodes are required for protection, as high anode currents are feasible. Impressed current systems of cathodic protection are more sophisticated in design than sacrificial systems.

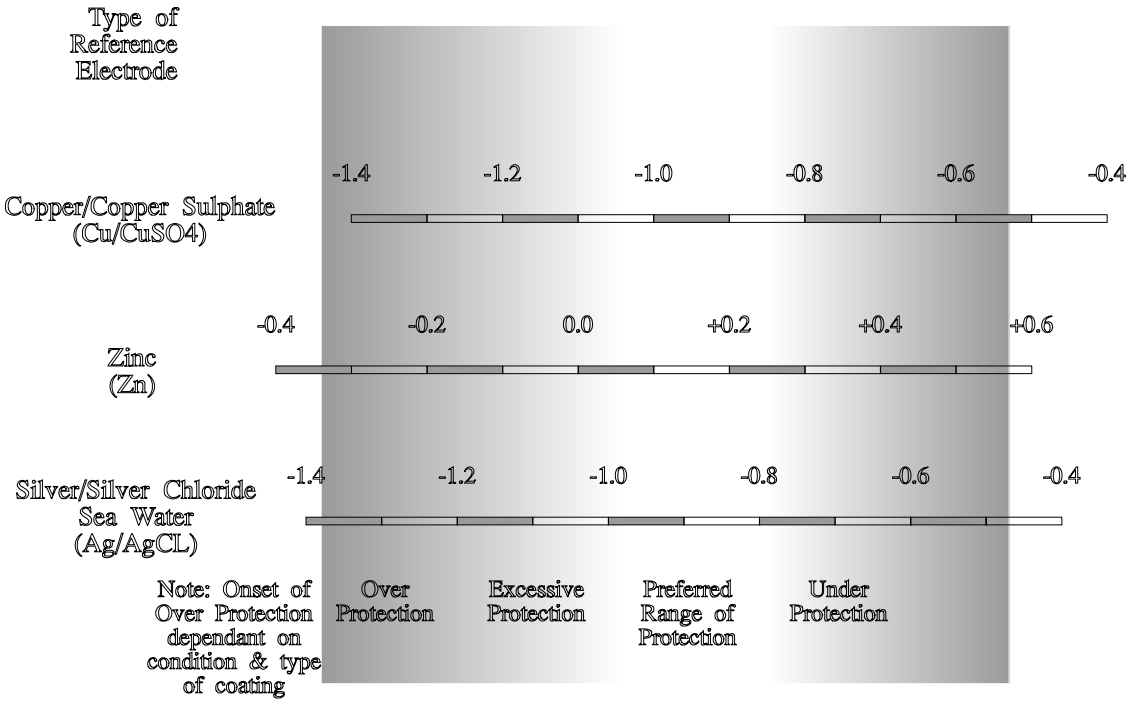



Figure 1.3 - Comparison of Reference Electrodes & Interpretation

## 2.2.0 MARINE IMPRESSED CURRENT SYSTEM:

The C-Shield Marine Impressed Current System comprises the following components, as illustrated in figure 1.4.

### 2.2.1 Impressed Current Anodes

The function of the anode is to conduct the d.c. protective current into the sea water. C-Shield anodes have been designed to perform this function whilst maintaining a low electrical resistance contact with the sea water. Standard surface mounted anodes are available with from 50 to 300 Ampere ratings. For forward mounted systems and for special applications 50 and 75 Ampere recessed anodes are available.

Materials now used by C-Shield for Anodes have now gone beyond lead alloy with specialist coated titanium based Anodes now available. All C-Shield anode designs utilise a tough, chlorine resistant, but slightly flexible plastic carrier.

The use of a 12 volt system reduces the number and length of the anodes from that required with a 6 volt system. The increased anode/sea water resistance resulting from this decrease in anode size is overcome by the additional voltage. Recommended cable sizes for various run lengths are tabulated in section 3.4.

The potential of the hull steel to the sea water is unaffected by this increase in driving voltage, as the resistive effects are local to the anode and the hull/sea potential is a function of the current flow, the sea water and the coating condition, not the driving voltage.

The electrical connections to the active surface are made at the back of the anode and are fully encapsulated and protected by the hull penetration. Recessed anodes of essentially similar construction are provided for bow section applications.

All hull penetrations are provided with substantial doubler plates and cofferdams. The penetrations themselves are made watertight with heavy duty packing glands, the cofferdams are fully sealed and provided with watertight cable glands, all conforming to the requirements of Classification Societies.

2.2.2 Impressed Current Reference Electrodes.

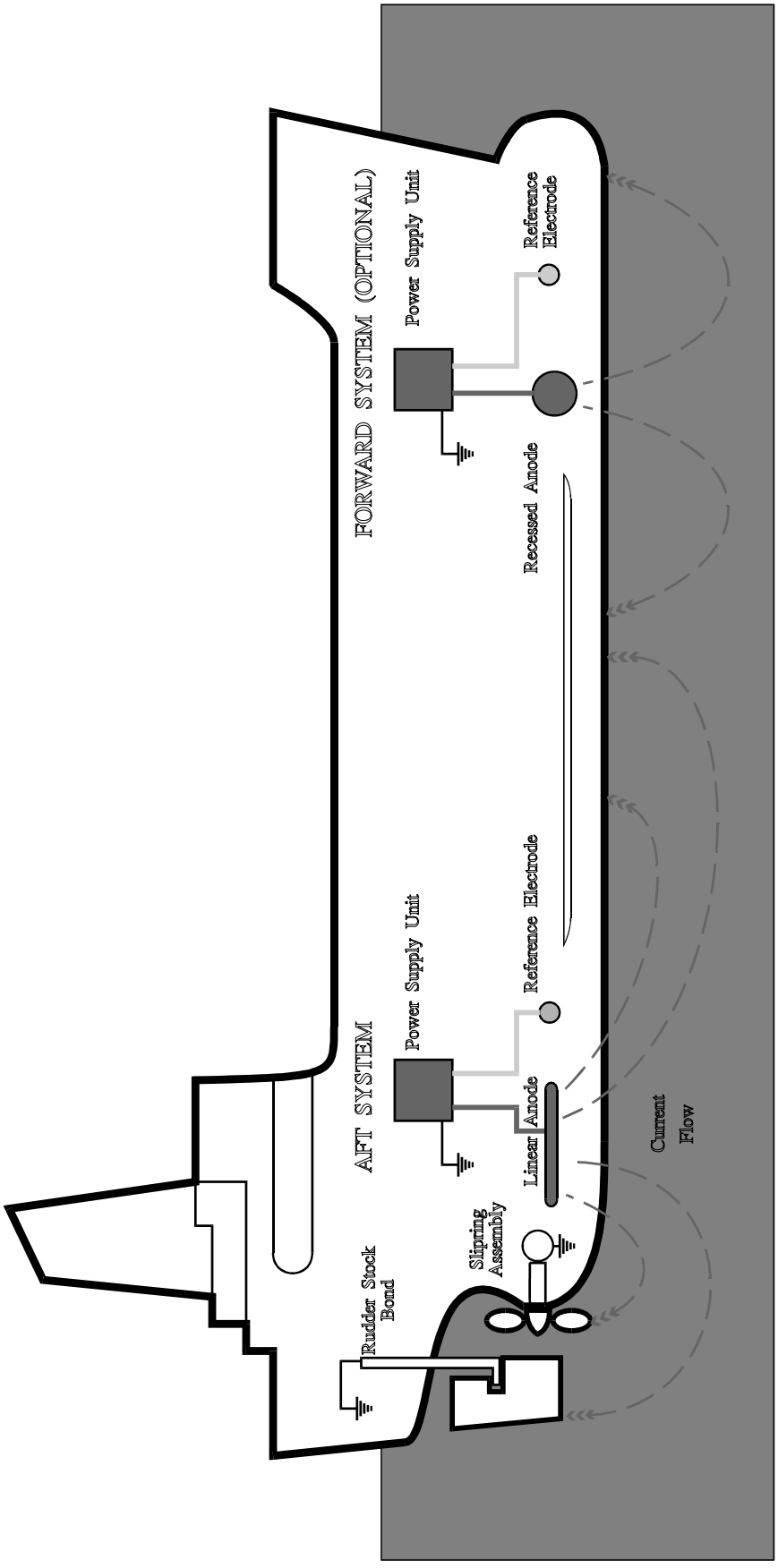
The high purity, high stability, zinc reference electrodes are designed to give a stable reference against which the hull/sea potentials can be measured and a small current flow that is used in the closed loop circuit to maintain the pre-set levels of protection.

The construction and the quantity of zinc employed within the electrodes are such that a minimum life of fifteen years is available without maintenance or replacement.

The minimum number of reference electrodes per power supply is one although normally two will be fitted. Ideally, these should be located a minimum of 7.5 metres distant from the anodes. In the case of a stern only installation with the anodes more than 150 metres from the bows, one reference electrode may be located in the bows.

A novel feature of the C-Shield closed circuit is that additional reference cells may be placed at areas that may be susceptible to over-protection such as adjacent to the anode dielectric shields. These additional reference cells provide a permanent check, thus preventing any coating damage due to over-protection if conditions of operation change from those anticipated. This feature is offered as an optional extra to the standard schemes.

All hull penetrations are provided with substantial cofferdams. The penetrations themselves are made watertight with heavy duty packing glands. The cofferdams are fully sealed and provided with watertight cable glands all conforming to the requirements of the Classification Societies.


FORWARD SYSTEM (OPTIONAL)
Power Supply Unit
Reference Electrode
Recessed Anode
AFT SYSTEM
Power Supply Unit
Reference Electrode
Linear Anode
Slipring Assembly
Rudder Stock Bond
Current Flow

2.2.3 Power Supply Unit:

The C - Shield impressed current Cathodic protection power supply unit is a thyristor system housed in a range of different sized cabinets. The specific power supply unit supplied is illustrated on the drawing included with this manual. The system comprises of a control PCB, a Thyristor PCB and a Thyristor unit (consisting of a transformer, a choke and a thyristor bridge) ranging in size from 100 Amperes upto 800 Amperes. The supply requirements are 415 Vac +/-10%, three phase, 50/60 Hz.

The control PCB is a micro-processor based system having a 2 line 16 character backlit LCD display which is located in the top centre of the cabinet door. The display is used to monitor and allow control of the system. Below the LCD are four push buttons, which are the controls for changing the system parameters. To the right of the LCD is a power on indicator, which also acts as an alarm indicator. On the reverse side are a rotary switch and a potentiometer. The switch toggles between manual override and normal operation. This allows the operator, in the event of a fault, to disable the micro-processor control system, and to control the output current with the potentiometer.

DISPLAY:

This allows the operator to control and monitor the running and set parameters of the system. It comprises of a 2 line 16 character backlit LCD display, 4 push button switches and an Alarm LED. This is mounted on the door of the cabinet.

MAIN CONTROL PCB

This board controls the operation of the system. It provides control signals to the thyristor driver PCB, which allow control over the output current and voltage of the system. This is mounted on the back of the cabinet door.

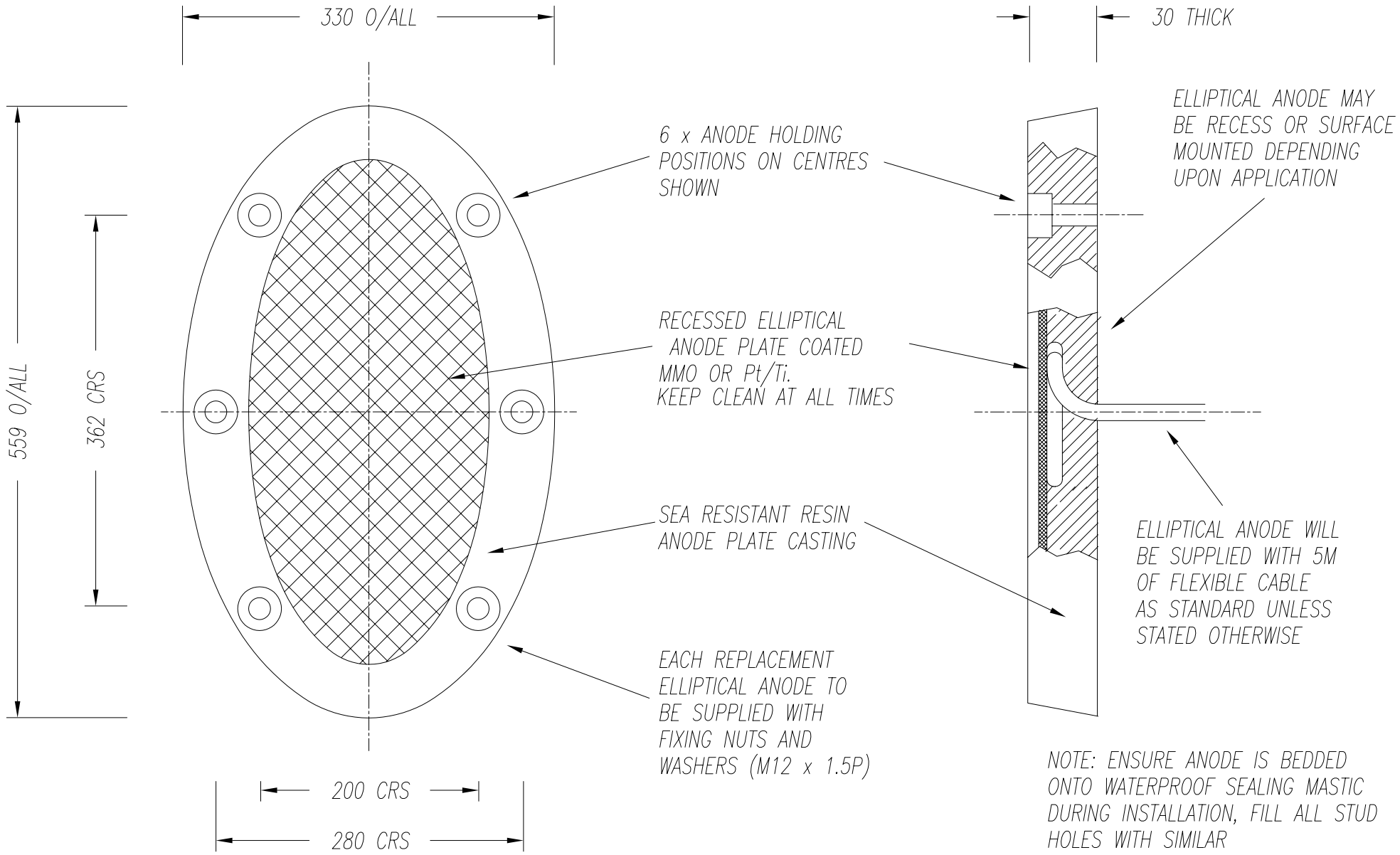
THYRISTOR PCB

This board monitors and conditions the signals supplied to the thyristor unit.

### 2.2.4 Bonding

To enable the rudder to receive protection it is provided with a dedicated electrical bond in the form of a flexible cable from the top of the rudder stock to the main ship structure. In the same way any stabilisers are bonded to allow protective current to these surfaces.

To allow protection of the bare propeller and any exposed shafting and to prevent electrical arcing between shaft and bearings the propeller shaft is fitted with a slipring assembly. A set of brushes provide the completion of a low resistance path to allow current to flow to the propeller blades along the shaft and back to the hull. The slipring is formed from a copper strip clamped around the shaft with high copper content heavy current capacity brushes held in geared brush holders. The C-Shield slipring track is silver plated as standard and in addition silver graphite brushes are used to minimise contact resistance.




NOTE: ENSURE ANODE IS BEDDED ONTO WATERPROOF SEALING MASTIC DURING INSTALLATION, FILL ALL STUD HOLES WITH SIMILAR

C-SHIELD (ICCP)

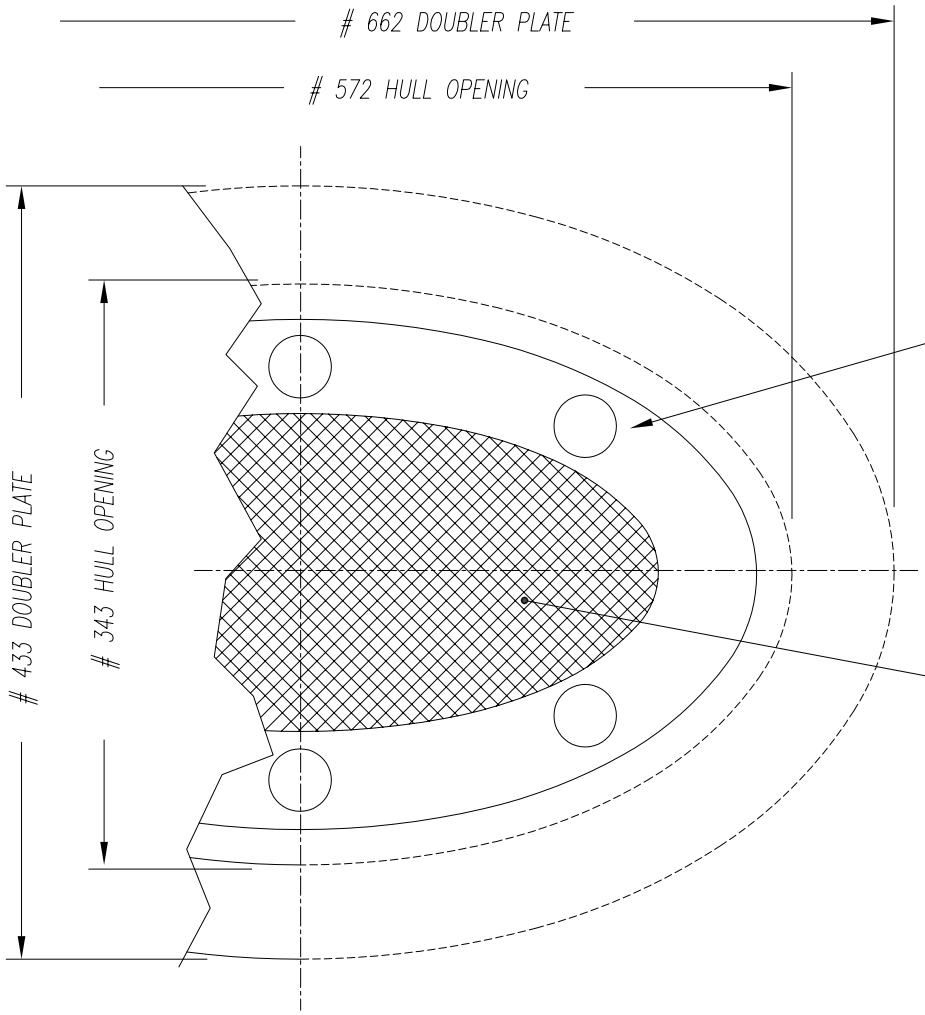
**CATHELCO LIMITED**
MARINE HOUSE, 18 HIPPER STREET SOUTH,
CHESTERFIELD, DERBYSHIRE, S40 1SS, UK.

| REV: | DATE: | MODIFICATION: |
|---|---|---|
| A | 24.03.04 | MMO & Pt/Ti ADDED, TITLE MOD |

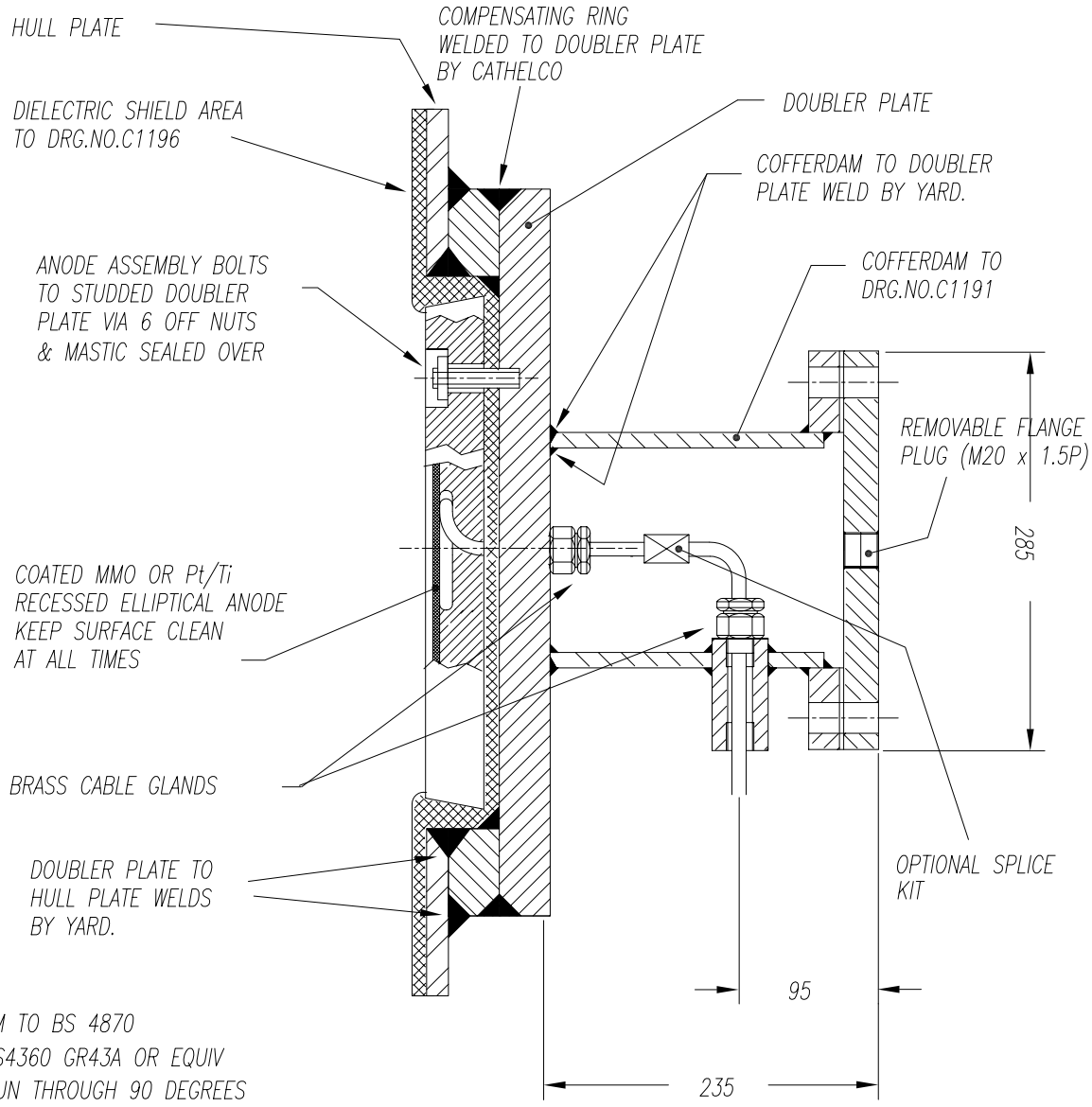
TITLE: C-SHIELD 50A TO 125A OUTPUT TYPE ELLIPTICAL COATED ANODE

| PA NO: | DATE: | SCALE: |
|---|---|---|
| | 09:06:94 | NTS |

| DRAWN: | CHECK: | DRG NO: |
|---|---|---|
| JRH | DP | C1202/A |




ABOVE VIEW IS SYMMETRICAL ABOUT ITS CENTRE LINES




NOTES:

1) ANY WELDS BY CATHELCO CONFORM TO BS 4870
2) ALL STEEL MATERIALS TO BE TO BS4360 GR43A OR EQUIV
3) # – ANODE ASSEMBLY MAY BE SPUN THROUGH 90 DEGREES TO SUIT NARROW FRAME SPACINGS
4) MORE DETAILS OF ANODE INSERT SHOWN ON DRG.NO.C1202

C-SHIELD (ICCP)

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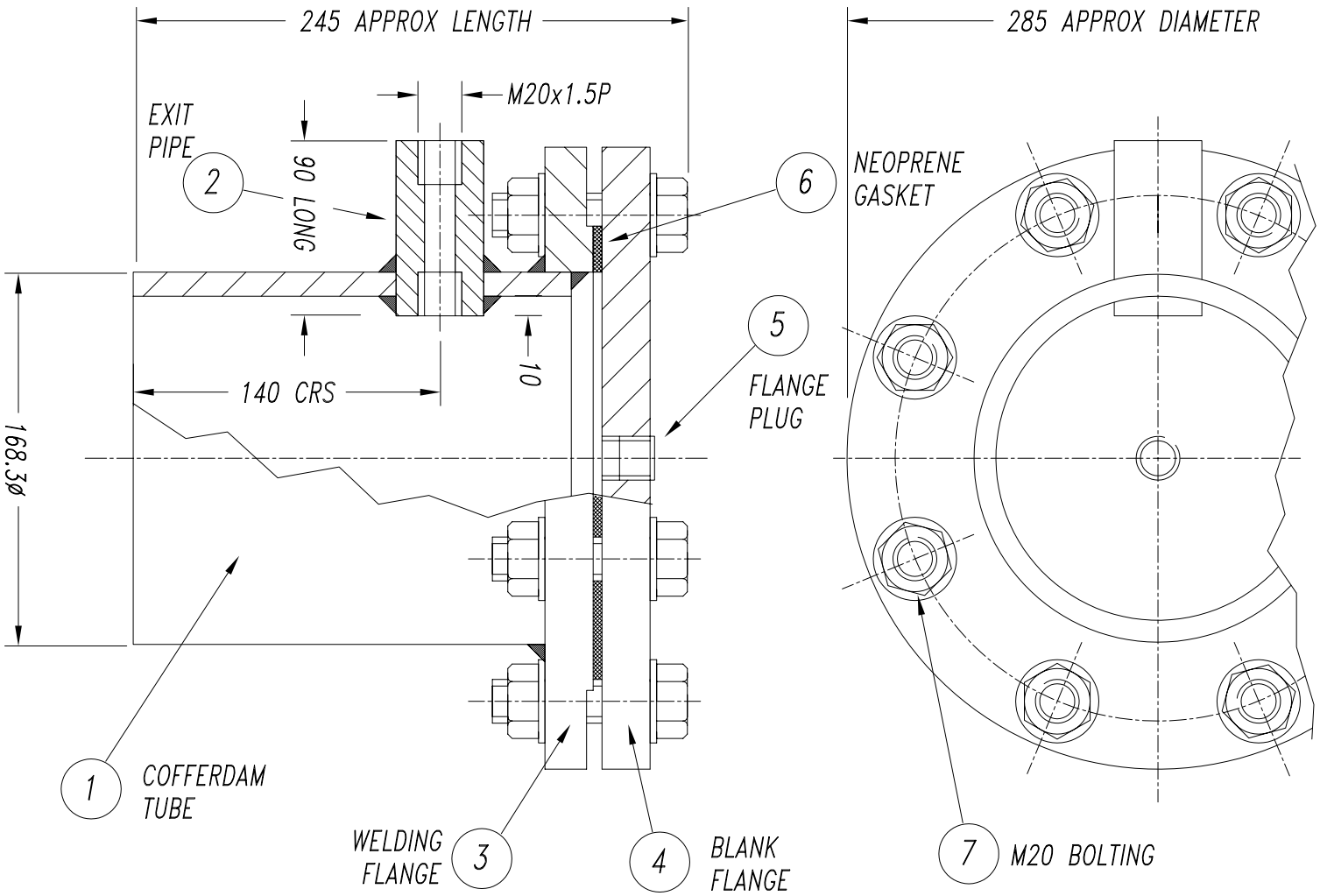
CHESTERFIELD, DERBYSHIRE, S40 1SS, UK.

| REV: | DATE: | MODIFICATION: |
|---|---|---|
| D | 11:08:04 | DETAILS CLARIFIED |
| C | 24:03:04 | TITLE & NOTES MOD |
| B | 23:04:97 | DIMENSION AMENDED |

TITLE:
ASSEMBLY ARRANGEMENT OF 50–125A ELLIPTICAL COATED RECESSED ANODE PLAIN OUTLET TYPE

| PA NO: | DATE: | SCALE: |
|---|---|---|
| | 29:09:94 | NTS |

| DRAWN: | CHECK: | DRG NO: |
|---|---|---|
| AIR | RP | C1186 |




## KEY TO COFFERDAM DRAWING ITEMS:

| ITEM: | DESCRIPTION: | REQD: |
|---|---|---|
| 1 | 6" NOMINAL BORE SCH 80 TUBE OF SIZE 168.3 O/D x 10.97 WALL x 200 LG WITH 40.5 HOLE CUT TO ALLOW ENTRY OF BOSS ITEM 2 | 1 |
| 2 | 40ø EXIT PIPE DRILLED THROUGH & TAPPED EACH END M20 x 1.5 PITCH x 20 DEEP. PIPE IS 90 LONG TO DRG C1947 ITEM 3 | 1 |
| 3 | 6" STEEL PLATE FLANGE FOR WELDING TO BS4504, CLASS 150, PN 16, CODE 101, OF SIZE 285 O/D x 170.5 I/D X 22 THICK WITH 8 X 22ø HOLES ON A 240 PCD. NOTE FLANGE HAS 212ø x 3 RAISED FACE | 1 |
| 4 | 6" STEEL BLANK FLANGES TO BS4504, CLASS 150, PN 16, CODE 105, OF SIZE 285ø x 22 THICK WITH 8 X 22ø HOLES ON A 240 PCD. DRILL & TAP CENTRE OF FLANGE TO SUIT M20 x 1.5P TO ACCEPT ITEM 5 | 1 |
| 5 | M20 x 1.5P BRASS FLANGE PLUG | 1 |
| 6 | NEOPRENE FLANGE SEALING GASKET OF SIZE 210 O/D x 170 I/D x 3 THICK | 1 |
| 7 | M20 BOLTS x 75 LONG COMPLETE WITH NUTS AND FLAT WASHERS | 8 |

PRODUCTION NOTES:

1) MATERIALS: ALL STEEL ITEMS TO BS4360 GR43A OR EQUIVALENT. TUBE TO BE API 5L TESTED
2) WELDS: ALL CONTINUOUS FILLET TYPE OF MIN SIZE 6MM x 45° AND TO CONFORM TO BS4870
3) FINISH: DEGREASE THE SURFACE AND APPLY ONE COAT OF GREY WELDABLE PRIMER

WEIGHT 28.5KG

C-SHIELD (ICCP)
CATHELCO LIMITED
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CHESTERFIELD, DERBYSHIRE, S40 1SS, UK.

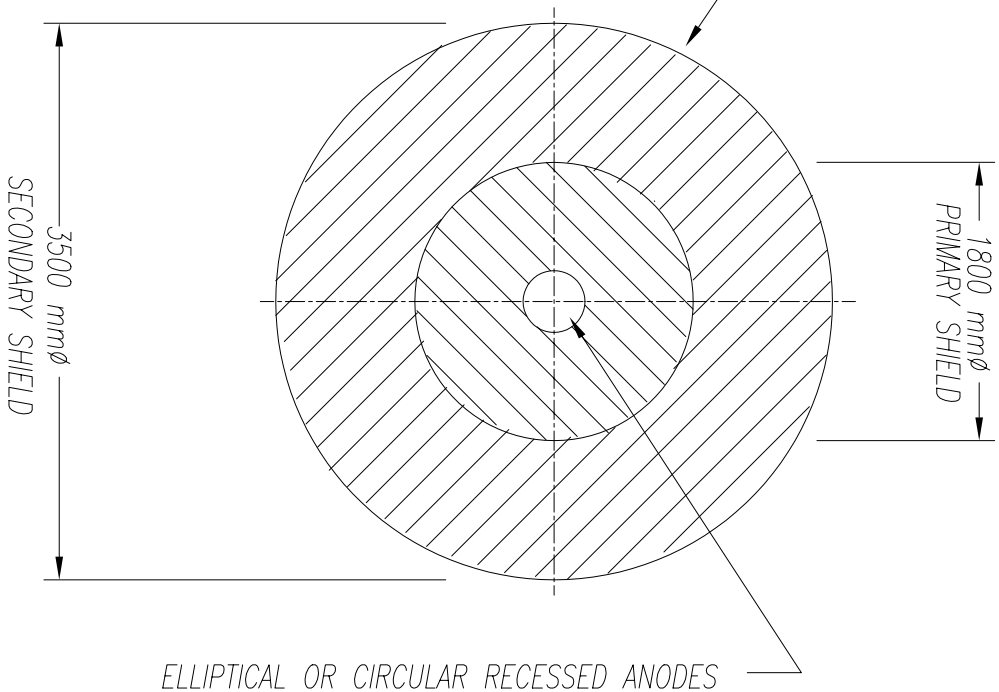
| REV: | DATE: | MODIFICATION: |
|---|---|---|
| B | 16.02.05 | ITEM 2 DRG NO, WEIGHT ADDED |
| A | 18:01:95 | RE-DRAWN |

TITLE: 6" NOMINAL BORE COFFERDAM WITH M20 THREADED CABLE EXIT DETAILS

| PA NO: | DATE: | SCALE: |
|---|---|---|
| | 18:JAN:95 | NOT TO SCALE |

| DRAWN: | CHECK: | DRG NO: | REV |
|---|---|---|---|
| JRH | DP | C1191/M20 | B |

NOTE:
GRITBLAST AREA OF PRIMARY DI-ELECTRIC SHIELD TO S.A. 3 BEFORE APPLICATION OF MASTIC. CHECK SURFACE PROFILE IS WITHIN 50 – 70 MICRONS.....OR SIMILAR




ELLIPTICAL OR CIRCULAR RECESSED ANODES
SEE DRAWING LIST BELOW:

50 – 75A ELLIPTICAL ANODE TO DRAWING NO C1202
100 – 125A ELLIPTICAL ANODE TO DRAWING NO C1571
50 – 75A CIRCULAR ANODE TO DRAWING NO C1567
100 – 125A CIRCULAR ANODE TO DRAWING NO C1619

KEY TO MASTIC AREAS:

AREAS OF C-SHIELD PRIMARY DI-ELECTRIC SHIELD MASTIC. COATING TO RUN FROM 4 TO 1 mm THICK IN AREA SHOWN. CATHELCO TO SUPPLY.

AREAS OF C-SHIELD SECONDARY DI-ELECTRIC SHIELD MASTIC. USE STANDARD HULL COATING 500 MICRONS MINIMUM THICK IN AREA SHOWN. YARD TO SUPPLY.

THE SHAPE OF THE SHIELD IS TECHNICALY APPROVED FOR BOTH ELLIPTICAL AND CIRCUALR ANODES

C-SHIELD (ICCP)

CATHELCO LIMITED
MARINE HOUSE, 18 HIPPER STREET SOUTH,
CHESTERFIELD, DERBYSHIRE, S40 1SS, UK.

| REV: | DATE: | MODIFICATION: |
|---|---|---|
| C | 27:3:97 | ANODE DETAILS AMMENDED |

TITLE:
DI-ELECTRIC SHIELD AREAS FOR ELLIPTICAL AND CIRCULAR RECESSED ANODES

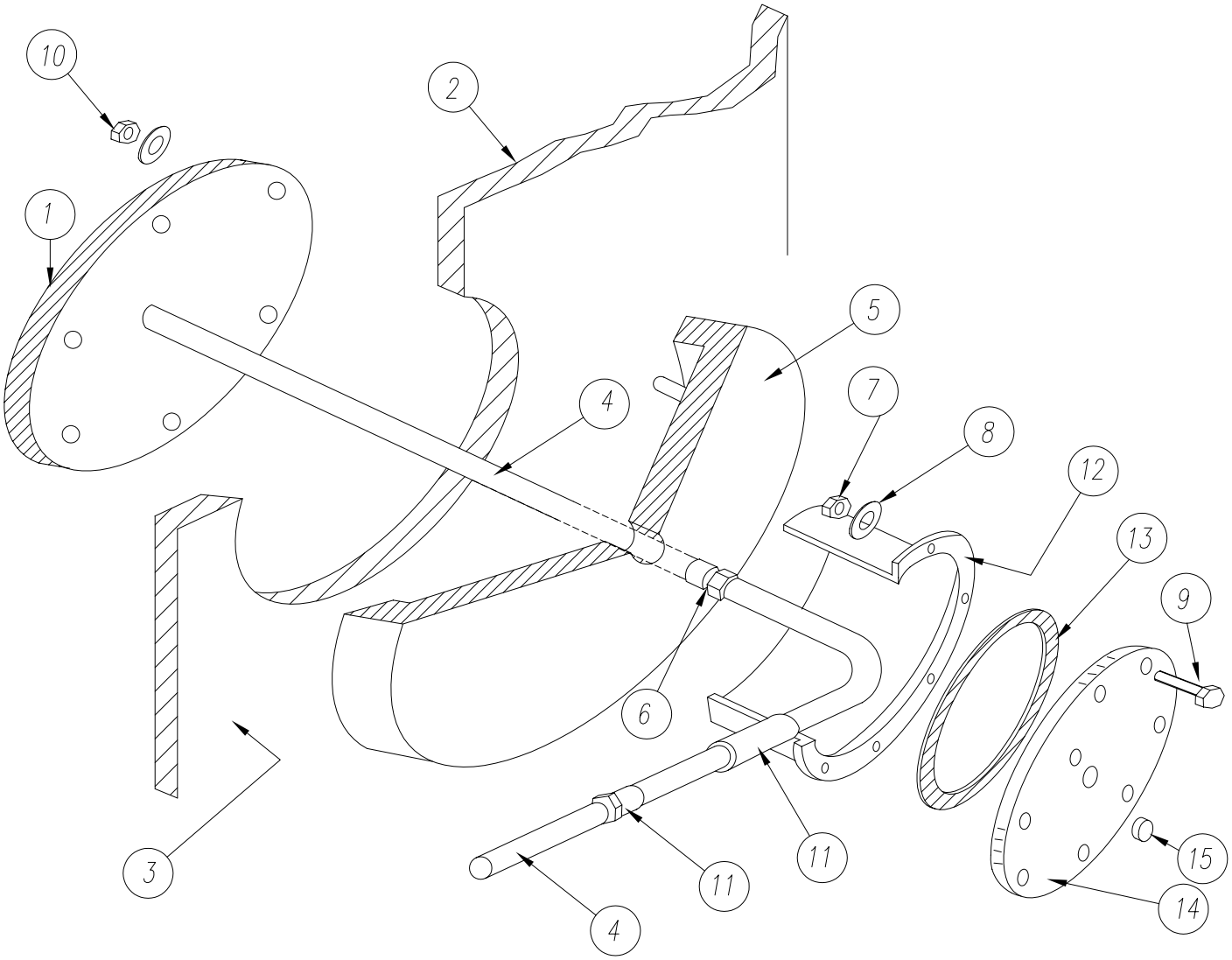
| PA NO: | DATE: | SCALE: |
|---|---|---|
| | 05:SEPT:92 | NOT TO SCALE |

| DRAWN: | CHECK: | DRG NO: |
|---|---|---|
| JRH | DP | C1196/C |

NOTES:

FOR FURTHER DETAILS OF A TYPICAL ELLIPTICAL RECESSED ANODE ASSEMBLY SEE DRG. NO. C1202

FOR CORRECT INSTALLATION INSTRUCTIONS FOR THIS ANODE TYPE ALWAYS CONSULT THE CATHELCO C-SHIELD MANUAL SUPPLIED




| ITEM No. | DESCRIPTION |
|---|---|
| 1 | RESIN ANODE HOLDING ASSEMBLY INCORPORATING THE ANODE ELEMENT |
| 2 | DIELECTRIC SHIELD MASTIC COATING REFER TO DRG. NO. C1196 |
| 3 | HULL PLATE SHOWING RECESS FOR INSERTION OF ELIPTICAL ANODE |
| 4 | 35mm² CABLE X 5m LONG TO B.S. 638 PART 4 |
| 5 | ANODE DOUBLER / MOUNTING PLATE WELD INTO HULL RECESS. C/W STUDS |
| 6 | BRASS CABLE GLAND SUPPLIED WITH DOUBLER / MOUNTING PLATE |
| 7 | M20 STEEL NUT FOR COFFERDAM ASSEMBLY 8 x NUTS REQUIRED |
| 8 | M20 STEEL WASHER FOR COFFERDAM ASSEMBLY 8 x WASHERS REQUIRED |
| 9 | M20 STEEL BOLT FOR COFFERDAM ASSEMBLY 8 x BOLTS REQUIRED |
| 10 | M12 PLATED NUTS & WASHERS FOR ANODE TO DOUBLER PLATE ASSEMBLY |
| 11 | COFFERDAM CABLE GLAND MOUNTING SLEEVE C/W CABLE GLAND |
| 12 | 6" NOMINAL BORE FLANGED COFFERDAM ASSEMBLY |
| 13 | NEOPRENE SEALING GASKET FOR COFFERDAM ASSEMBLY |
| 14 | COFFERDAM ASSEMBLY TOP COVER 6" FLANGE. |
| 15 | COFFERDAM FILLING / INSPECTION BRASS PLUG |


C-SHIELD (ICCP)

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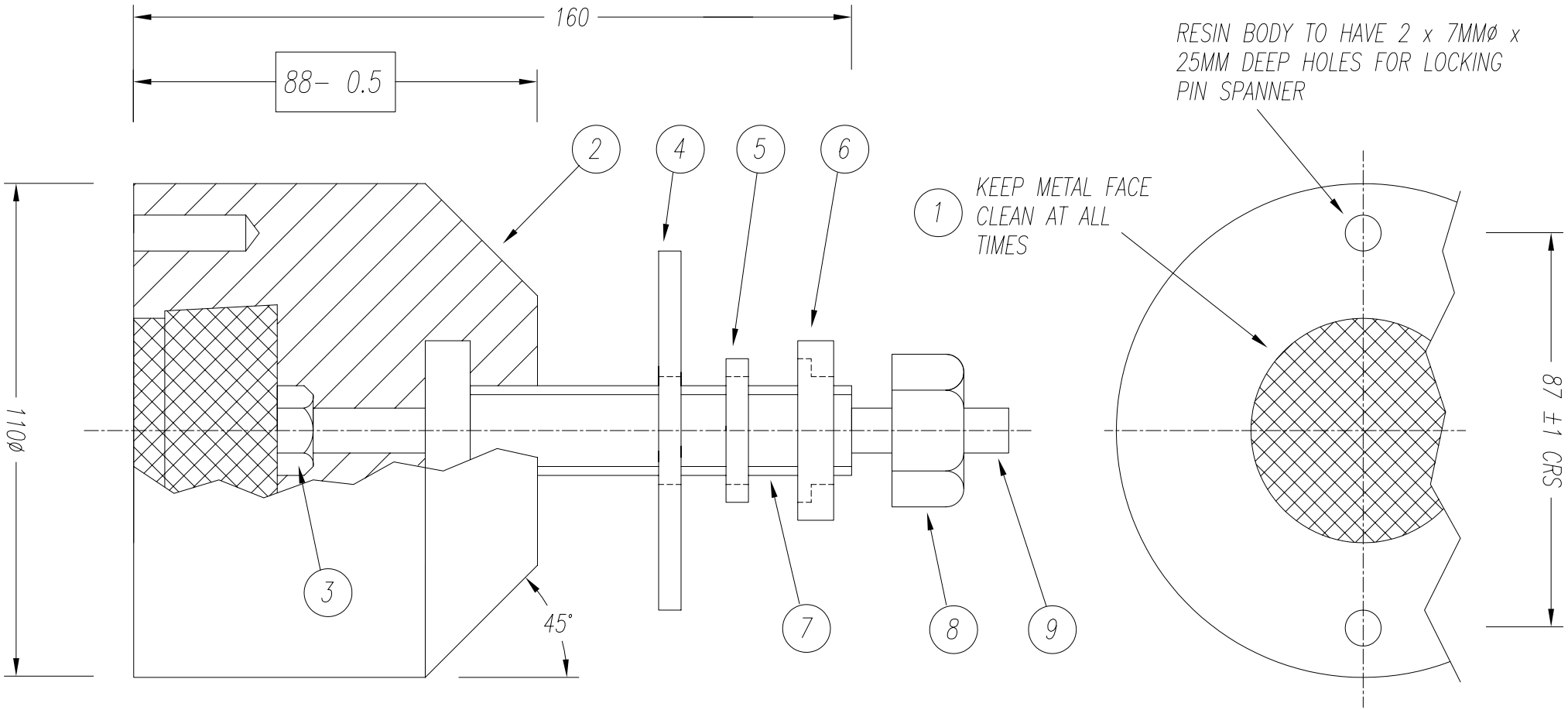
| REV: | DATE: | MODIFICATION: |
|---|---|---|
| B | 19.10.01 | ITEM 10 DESCRIPTION CORRECTED |
| A | 19.04.01 | RE-DRAWN IN AUTOCAD |

TITLE:
EXPLODED DIAGRAM OF TYPICAL 50-125A ELLIPTICAL RECESSED ANODE INSTALLATION

| PA NO: | DATE: | SCALE: |
|---|---|---|
| | 17.01.93 | NTS |

| DRAWN: | CHECK: | DRG NO: |
|---|---|---|
| JRH | DP | M1000/B |




1. ELECTRODE ZINC BLOCK TO DRG.NO.C1103
2. RESIN BLOCK AS FORMED BY MOULD TOOL
3. CABLE CONNECTOR TO DRG.NO.C1105
4. NEOPRENE SEALING RING TO DRG.NO.C1108
5. NEOPRENE WASHER TO DRG.NO.C1109
6. STEEL DISHED WASHER TO DRG.NO.C1110
7. STEEL MOUNTING SLEEVE TO DRG.NO.C1107
8. BRASS M20 x 1.5P FULL NUT
9. FLEXIBLE CABLE SEE ORDER JOBCARD 16MM SQ 10.1MM O/D

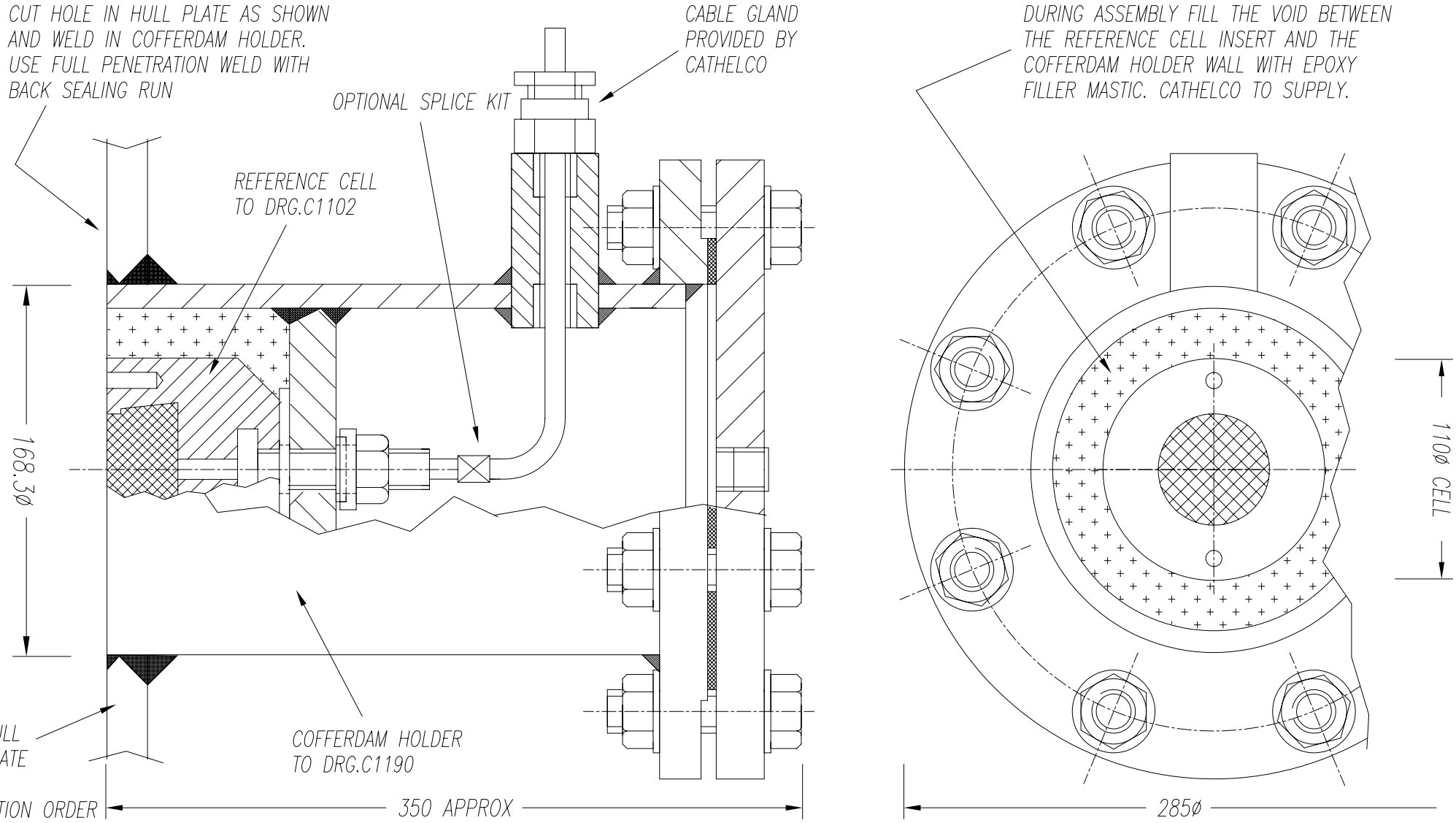
C-SHIELD (ICCP)
CATHELCO LIMITED
MARINE HOUSE, 18 HIPPER STREET SOUTH,
CHESTERFIELD, DERBYSHIRE, S40 1SS, UK.

| REV: | DATE: | MODIFICATION: |
|---|---|---|
| E | 23:08:01 | ELEMENT AMENDED |
| D | 27:02:97 | DIMENSION AMENDED |
| C | 14:03:95 | RE-DRAWN |

TITLE: ZINC TYPE REFERENCE CELL INSERT

| PA NO: | DATE: | SCALE: |
|---|---|---|
| | 14:MARCH:95 | 3/4 FULL SIZE |

| DRAWN: | CHECK: | DRG NO: |
|---|---|---|
| JRH | DP | C 1102/E |




INSTALLATION ORDER

1) CUT HULL PLATE
2) WELD COFFERDAM INTO POSITION
3) PLACE REFERENCE CELL CABLE THROUGH COFFERDAM
4) COVER BACK OF REFERENCE CELL IN EPOXY
5) SCREW REFERENCE CELL IN THROUGH COFFERDAM
6) FIT WASHER AND RETAINING NUT INSIDE COFFERDAM
7) SMOOTH EPOXY TO SURFACE OF COFFERDAM AND REFERENCE CELL

C-SHIELD (ICCP)

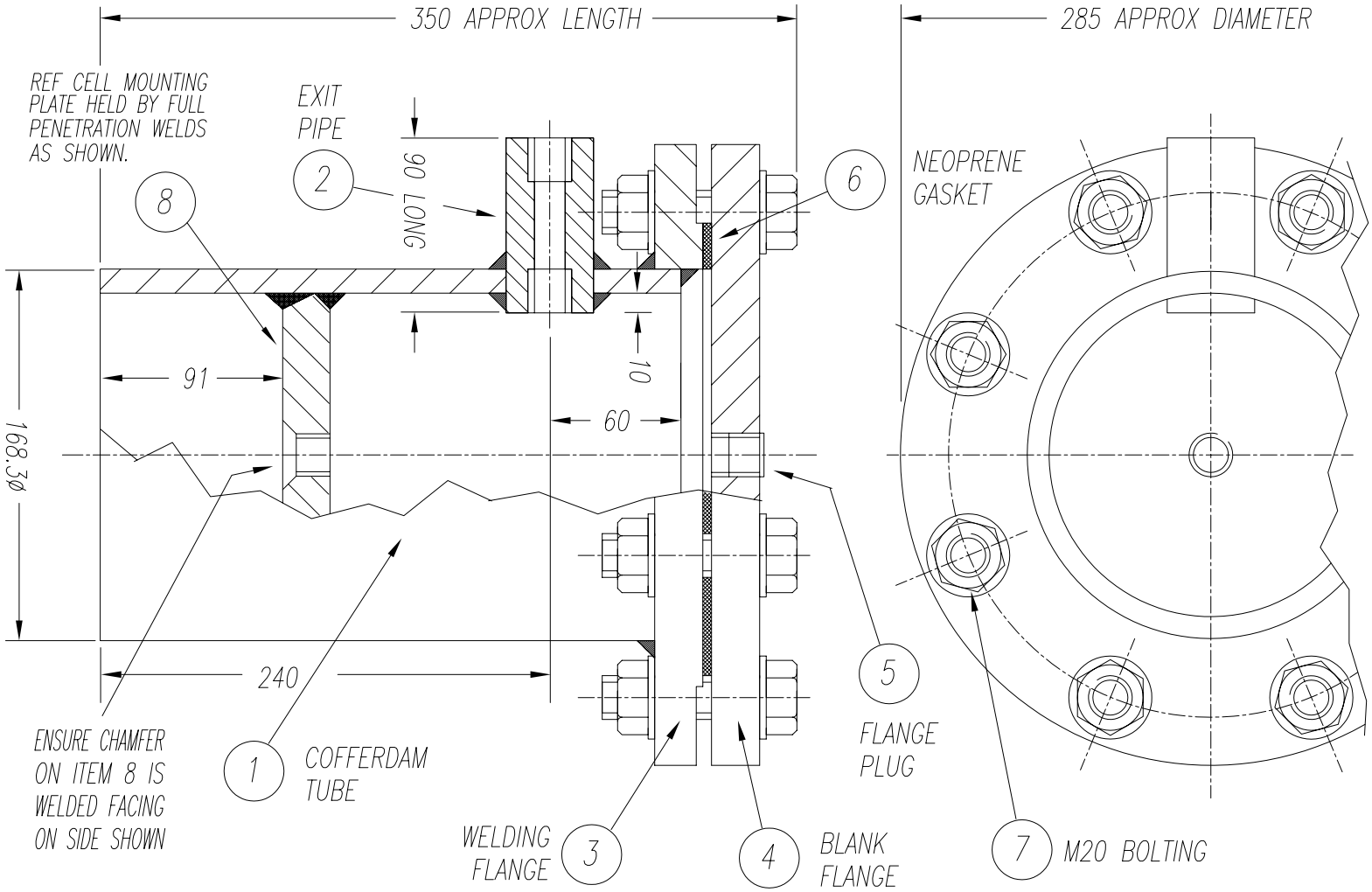
CATHELCO LIMITED
MARINE HOUSE, 18 HIPPER STREET SOUTH,
CHESTERFIELD, DERBYSHIRE, S40 1SS, UK.

| REV: | DATE: | MODIFICATION: |
|---|---|---|
| B | 14:03:95 | RE-DRAWN |

TITLE: DETAILS OF ZINC REFERENCE CELL MOUNTED INTO COFFERDAM HOLDER

| PA NO: | DATE: | SCALE: |
|---|---|---|
| | 14:MAR:95 | NOT TO SCALE |

| DRAWN: | CHECK: | DRG NO: |
|---|---|---|
| JRH | DP | C1162 |




## KEY TO COFFERDAM DRAWING ITEMS:

| ITEM: | DESCRIPTION: | REQD: |
|---|---|---|
| 1 | 6" NOMINAL BORE SCH 80 TUBE OF SIZE 168.3 O/D x 10.97 WALL x 300 LG WITH 40.5 HOLE CUT TO ALLOW ENTRY OF BOSS ITEM 2 | 1 |
| 2 | 40ø EXIT PIPE DRILLED THROUGH & TAPPED EACH END M20 x 1.5 PITCH x 20 DEEP. PIPE IS 90 LONG TO DRG C1947 ITEM 3 | 1 |
| 3 | 6" STEEL PLATE FLANGE FOR WELDING TO BS4504, CLASS 150, PN 16, CODE 101, OF SIZE 285 O/D x 170.5 I/D X 22 THICK WITH 8 X 22ø HOLES ON A 240 PCD. NOTE FLANGE HAS 212ø x 3 RAISED FACE | 1 |
| 4 | 6" STEEL BLANK FLANGES TO BS4504, CLASS 150, PN 16, CODE 105, OF SIZE 285ø x 22 THICK WITH 8 X 22ø HOLES ON A 240 PCD. DRILL & TAP CENTRE OF FLANGE TO SUIT M20 x 1.5P TO ACCEPT ITEM 5 | 1 |
| 5 | M20 x 1.5P BRASS FLANGE PLUG | 1 |
| 6 | NEOPRENE FLANGE SEALING GASKET OF SIZE 210 O/D x 170 I/D x 3 THICK | 1 |
| 7 | M20 BOLTS x 75 LONG COMPLETE WITH NUTS AND FLAT WASHERS | 8 |
| 8 | MOUNTING PLATE TO DRG C1430 | 1 |

PRODUCTION NOTES:

1) MATERIALS: ALL STEEL ITEMS TO BS4360 GR43A OR EQUIVALENT. TUBE TO BE API 5L TESTED
2) WELDS: CONTINUOUS FILLET TYPE OF MIN SIZE 6MM x 45° UNLESS STATED OTHERWISE AND CONFORM TO BS4870
3) FINISH: DEGREASE THE SURFACE AND APPLY ONE COAT OF GREY WELDABLE PRIMER

C-SHIELD (ICCP)
CATHELCO LIMITED
MARINE HOUSE, 18 HIPPER STREET SOUTH, CHESTERFIELD, DERBYSHIRE, S40 1SS, UK.

| REV: | DATE: | MODIFICATION: |
|---|---|---|
| | | |
| | | |
| B | 25:05:95 | TUBE LENGTH CORRECTED |

TITLE:
6" NOMINAL BORE COFFERDAM FOR REFERENCE ELECTRODE CELL

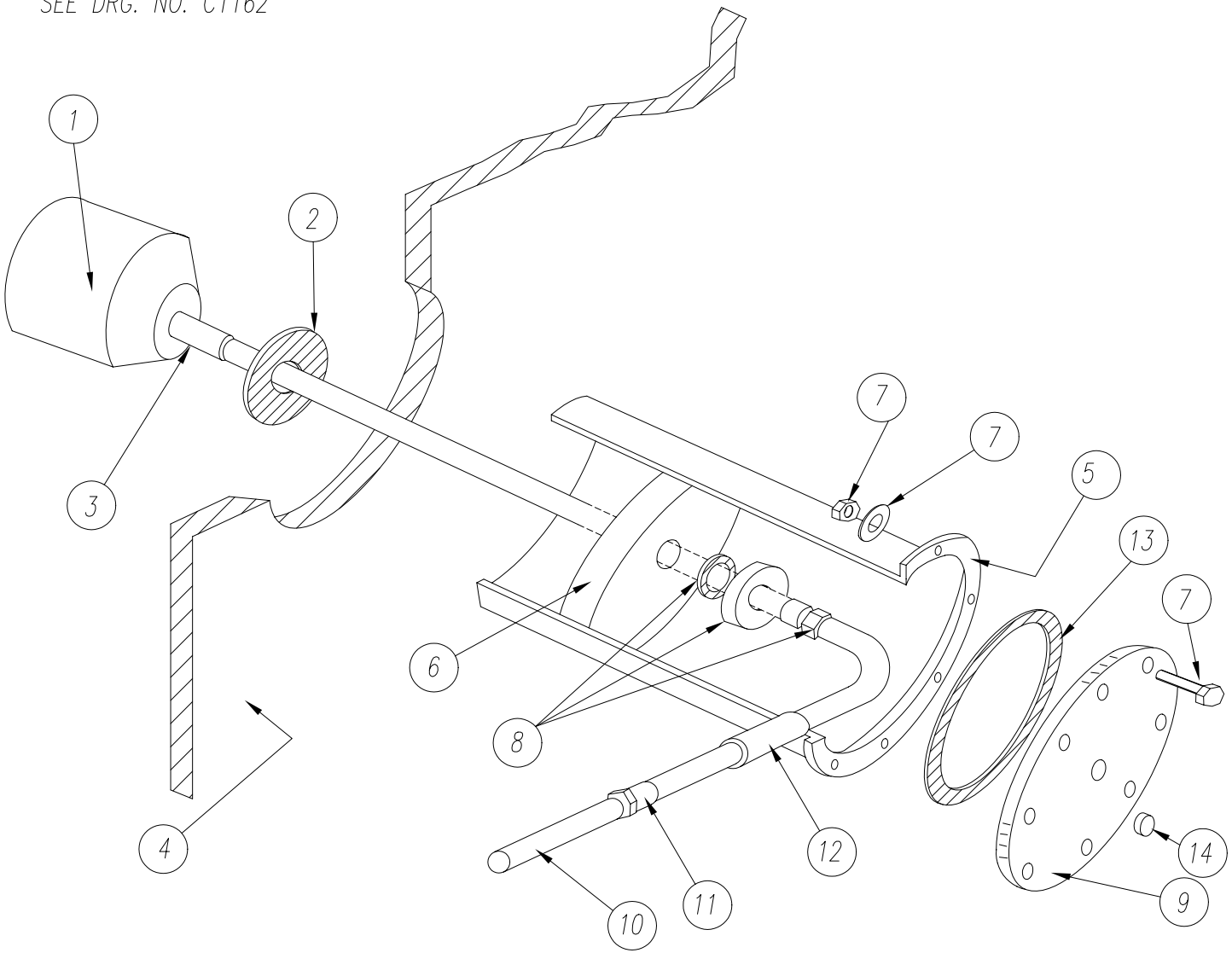
| PA NO: | DATE: | SCALE: |
|---|---|---|
| | 18:JAN:95 | NOT TO SCALE |

| DRAWN: | CHECK: | DRG NO: | REV: |
|---|---|---|---|
| JRH | DP | C1190 | B |

NOTES:

FOR FURTHER DETAILS OF A TYPICAL REFERENCE ELECTRODE ASSEMBLY SEE DRG. NO. C1162

FOR CORRECT INSTILLATION INSTRUCTIONS FOR THIS ANODE TYPE ALWAYS CONSULT THE CATHELCO C-SHIELD MANUAL




| ITEM No. | DESCRIPTION |
|---|---|
| 1 | REFERENCE ELECTRODE HOUSING WITH ELECTRODE ELEMENT |
| 2 | REFERENCE ELECTRODE NEOPRENE SEALING RING |
| 3 | REFERENCE ELECTRODE STEEL MOUNTING SPINDLE / SLEEVE |
| 4 | HULL PLATE SHOWING RECESS FOR INSTILLATION OF COFFERDAM |
| 5 | REFERENCE ELECTRODE FLANGED COFFERDAM ASSEMBLY, 6" N/B |
| 6 | REFERENCE ELECTRODE THREADED MOUNTING PLATE |
| 7 | M20 NUTS, BOLTS & WASHERS FOR COFFERDAM ASSEMBLY. NOTE 8X SETS REQUIRED PER COFFERDAM |
| 8 | REFERENCE ELECTRODE INSTILLATION KIT COMPRISING: NEOPRENE WASHER, DISHED WASHER & M20 TIGHTENING NUT |
| 9 | COFFERDAM ASSY TOP COVER 6" FLANGE |
| 10 | 16mm CORE CABLE X3m EXTENSION TO B.S. 638 PART4 |
| 11 | BRASS CABLE GLAND AS SUPPLIED WITH COFFERDAM MOUNTING SLEEVE |
| 12 | COFFERDAM CABLE GLAND MOUNTING SLEEVE |
| 13 | NEOPRENE SEALING GASKET FOR COFFERDAM ASSEMBLY |
| 14 | COFFERDAM FILLING / INSPECTION BRASS PLUG |


C-SHIELD (ICCP)

CATHELCO LIMITED

MARINE HOUSE, 18 HIPPER STREET SOUTH, CHESTERFIELD, DERBYSHIRE, S40 1SS, UK.

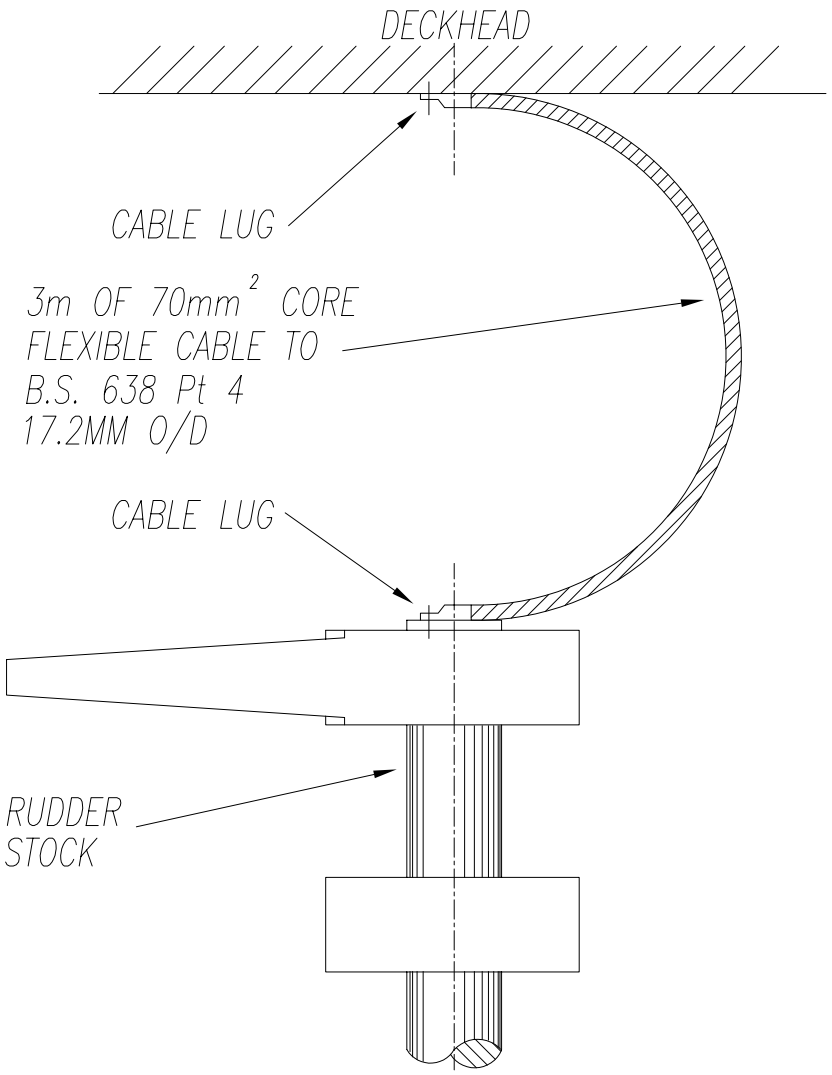

| REV: | DATE: | MODIFICATION: |
|---|---|---|
| | | |
| | | |
| A | 20.04.01 | RE-DRAWN IN AUTOCAD |

TITLE:

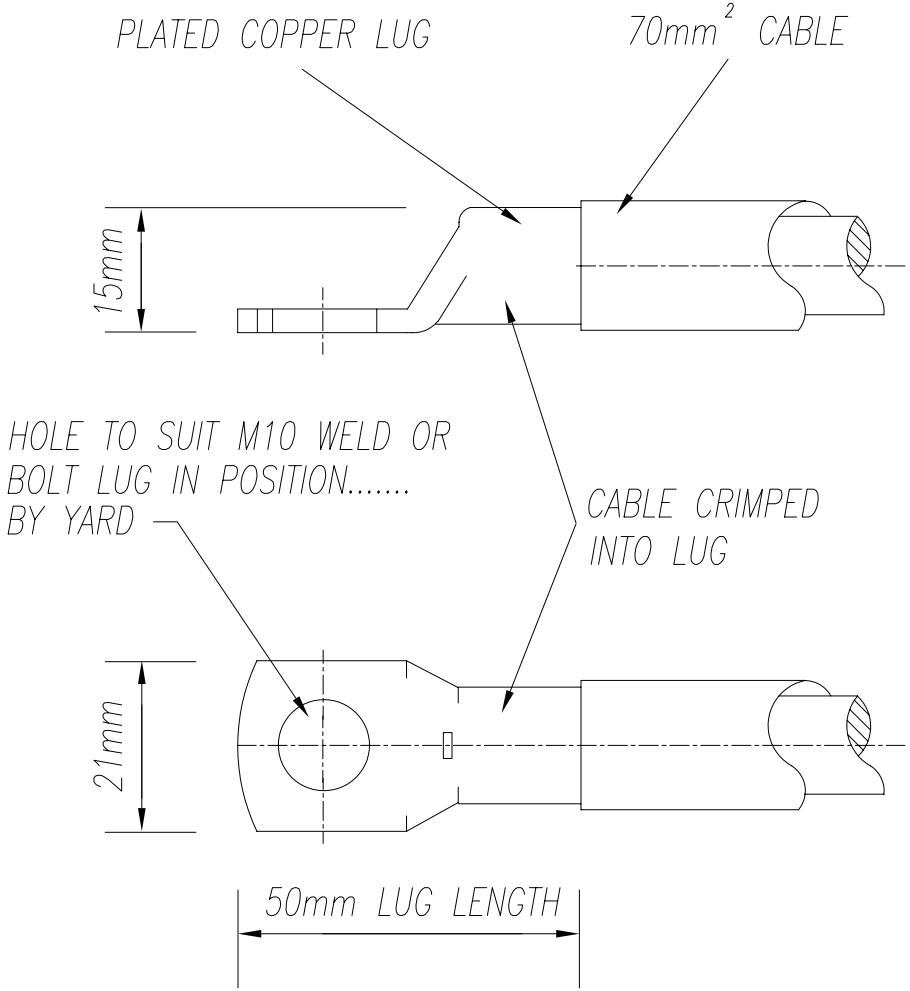
EXPLODED DIAGRAM OF TYPICAL REFERENCE ELECTRODE INSTILLATION

| PA NO: | DATE: | SCALE: |
|---|---|---|
| | 12.10.92 | NTS |

| DRAWN: | CHECK: | DRG NO: |
|---|---|---|
| JRH | DP | M1004/A |




RUDDER STOCK BONDING ARRANGEMENT
(DO NOT SCALE)




CABLE LUG ARRANGEMENT
(SCALE : FULL SIZE)

C-SHIELD (ICCP)

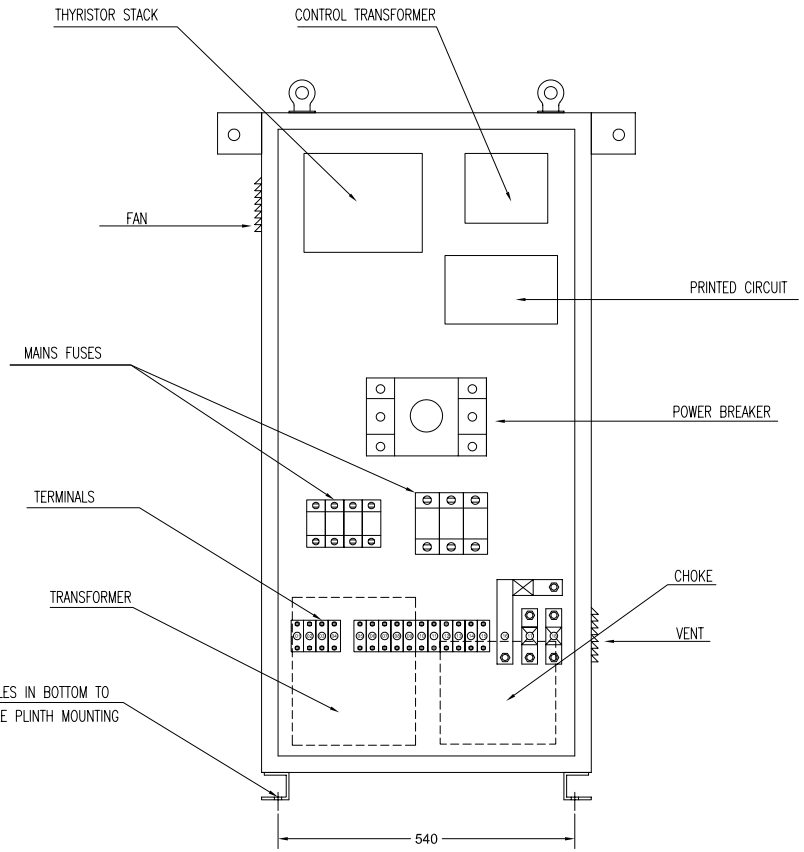
CATHELCO LIMITED
MARINE HOUSE, 18 HIPPER STREET SOUTH,
CHESTERFIELD, DERBYSHIRE, S40 1SS, UK.

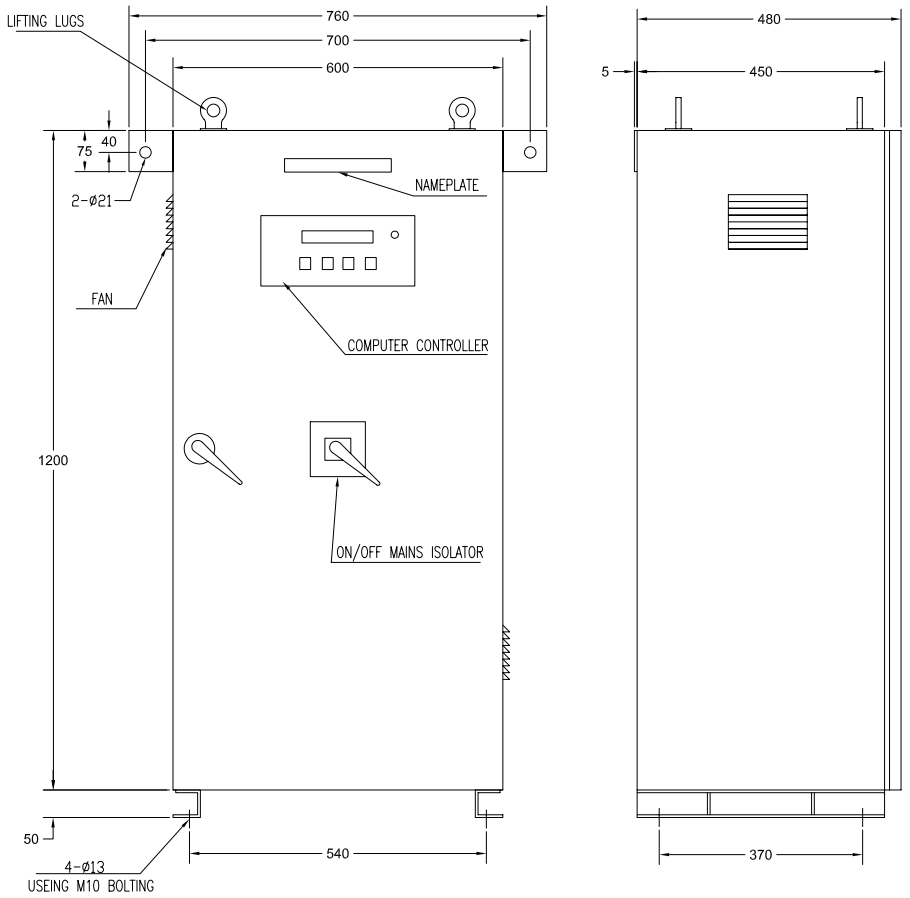
| REV: | DATE: | MODIFICATION: |
|---|---|---|
| B | 15.03.04 | CABLE LENGTH WAS 7MTR |
| A | 1.4.99 | PUT ON AUTOCAD |

TITLE:
GROUND ARRANGEMENT
FOR RUDDER STOCK

| PA NO: | DATE: | SCALE: |
|---|---|---|
| | 13:JULY:92 | SEE DRAWING |

| DRAWN: | CHECK: | DRG NO: |
|---|---|---|
| JRH | DMcG | C1165/B |




NOTE:

A) : INTERNAL TERMINAL WIRING DETAILS ARE SHOWN ON A SEPARATE DRAWING.
B) : ENCLOSURE PAINT FINISH IN TEXTURED STOVE ENAMEL TO RAL 7035 OR AS REQD.
C) : POWER CONSUMPTION OF UNITS : 100A=3, 150A=4.5, 200A=6, 250A=8, 300A=10KW.
D) : NET WEIGHT OF UNITS : 100A=190, 150A=210, 200A=230, 250A=255, 300A=325KG.
E) : SYSTEM COMPUTER KEYPAD AND READING DISPLAY UNIT TO DRAWING C1623

C-SHIELD (ICCP)

CATHELCO LIMITED
MARINE HOUSE, 18 HIPPER STREET SOUTH,
CHESTERFIELD, DERBYSHIRE, S40 1SS, UK.

| REV: | DATE: | MODIFICATION: |
|---|---|---|
| | | |
| | | |
| A | 09.02.05 | NETT WEIGHTS ADDED |

TITLE:
100A TO 300A O/P 3 PHASE THYRISTOR TYPE POWER SUPPLY UNIT DETAILS

PA NO:

DATE: 21/07/04

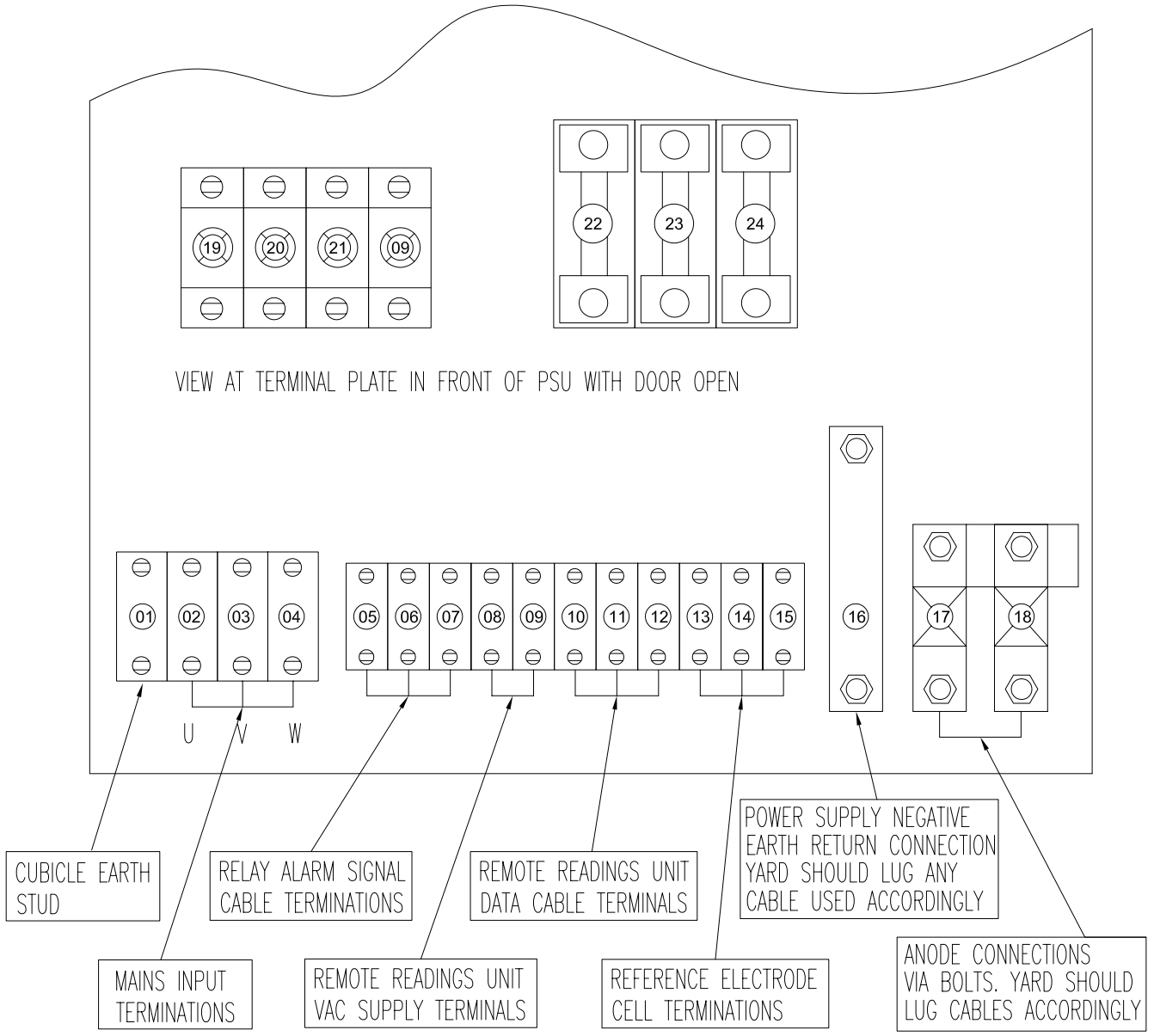
SCALE: NOT TO SCALE

DRAWN: RJP

CHECK: PL

DRG NO: C 2130

| KEY TO CABLE TERMINATIONS: | CABLE SUPPLY |
|---|---|
| 01 ENCLOSURE EARTH | CATHELCO |
| 02 LIVE1–MINS IN (U)<br>03 LIVE1–MINS IN (V)<br>04 LIVE1–MINS IN (W) | YARD |
| 05 NORMALLY CLOSED RELAY<br>06 COMMMON RELAY<br>07 NORMALLY OPEN RELAY | YARD |
| 08 18V AC POWER RETURN<br>09 18V AC POWER OUT–FUSED(F7) | YARD |
| 10 DATA CORE 1<br>11 DATA CORE 2<br>12 DATA EARTH–SCREEN | YARD |
| 13 PORT ELECTRODE CELL<br>14 STBD ELECTRODE CELL<br>15 ELECTRODE CELL EARTH –SCREEN | YARD |
| 16 MAIN HULL EARTH RETURN | CATHELCO |
| 17 PORT ANODE<br>18 STBD ANODE | YARD |
| 19 TRANSFORMER CONTROL FUSE(F4)<br>20 TRANSFORMER CONTROL FUSE(F5)<br>21 FAN CONTROL FUSE(F6) | CATHELCO |
| 22 MAINS FUSE –LIVE1(F1)<br>23 MAINS FUSE –LIVE2(F2)<br>24 MAINS FUSE –LIVE3(F3) | CATHELCO |




C-SHIELD (ICCP)

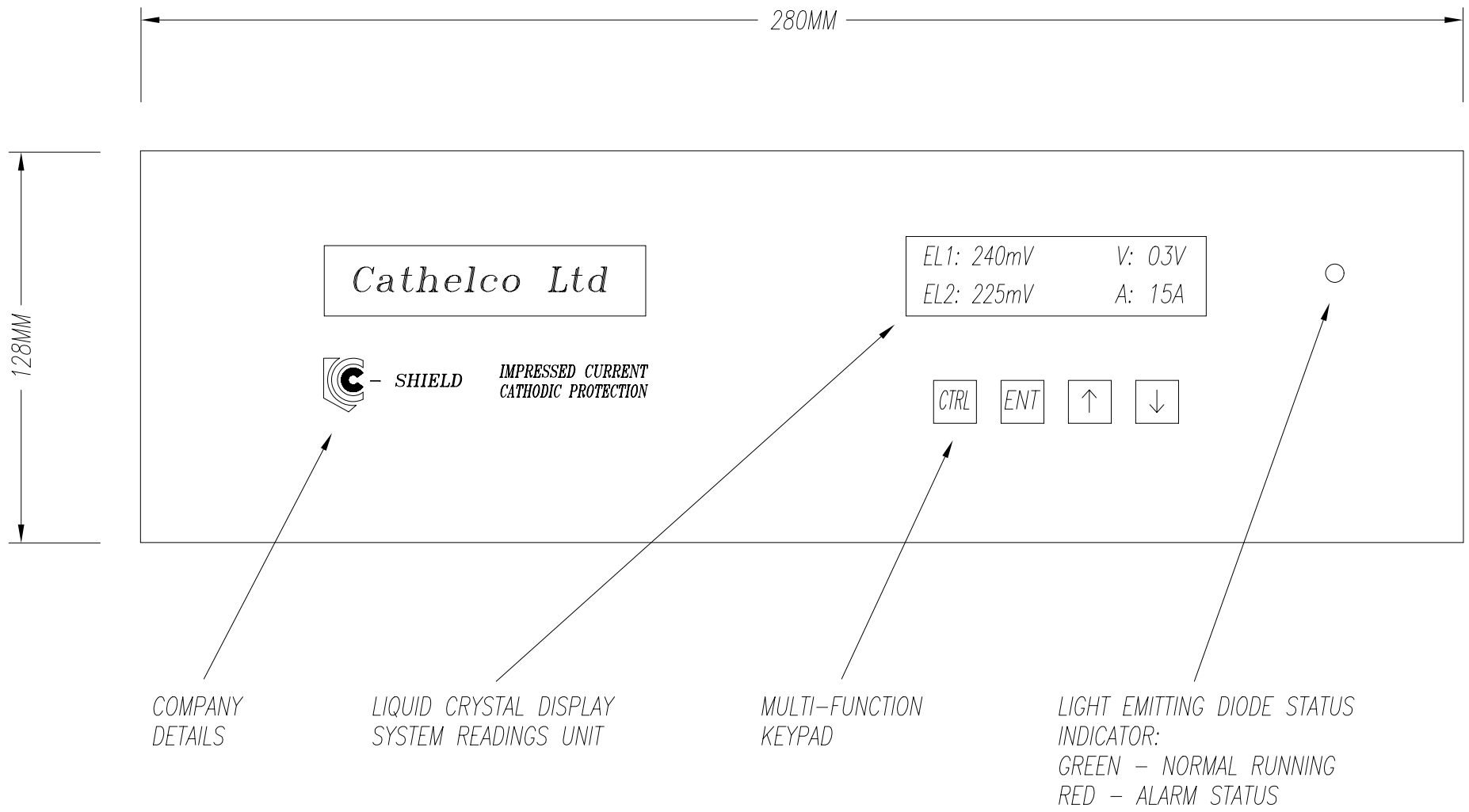

CATHELCO LIMITED
MARINE HOUSE, 18 HIPPER STREET SOUTH,
CHESTERFIELD, DERBYSHIRE, S40 1SS, UK.


| REV: | DATE: | MODIFICATION: |
|---|---|---|
| B | 20.09.04 | FUSE CABLES CATHELCO SUPPLY |
| A | 16.06.04 | 18V CORRECTED |

TITLE: INPUT CABLE TERMINAL DETAILS FOR 3 PHASE POWER SUPPLY UNIT

| PA NO: | DATE: | SCALE: |
|---|---|---|
| | 01/08/03 | NOT TO SCALE |

| DRAWN: | CHECK: | DRG NO: |
|---|---|---|
| CAN | PL | C 2082 |




C-SHIELD (ICCP)

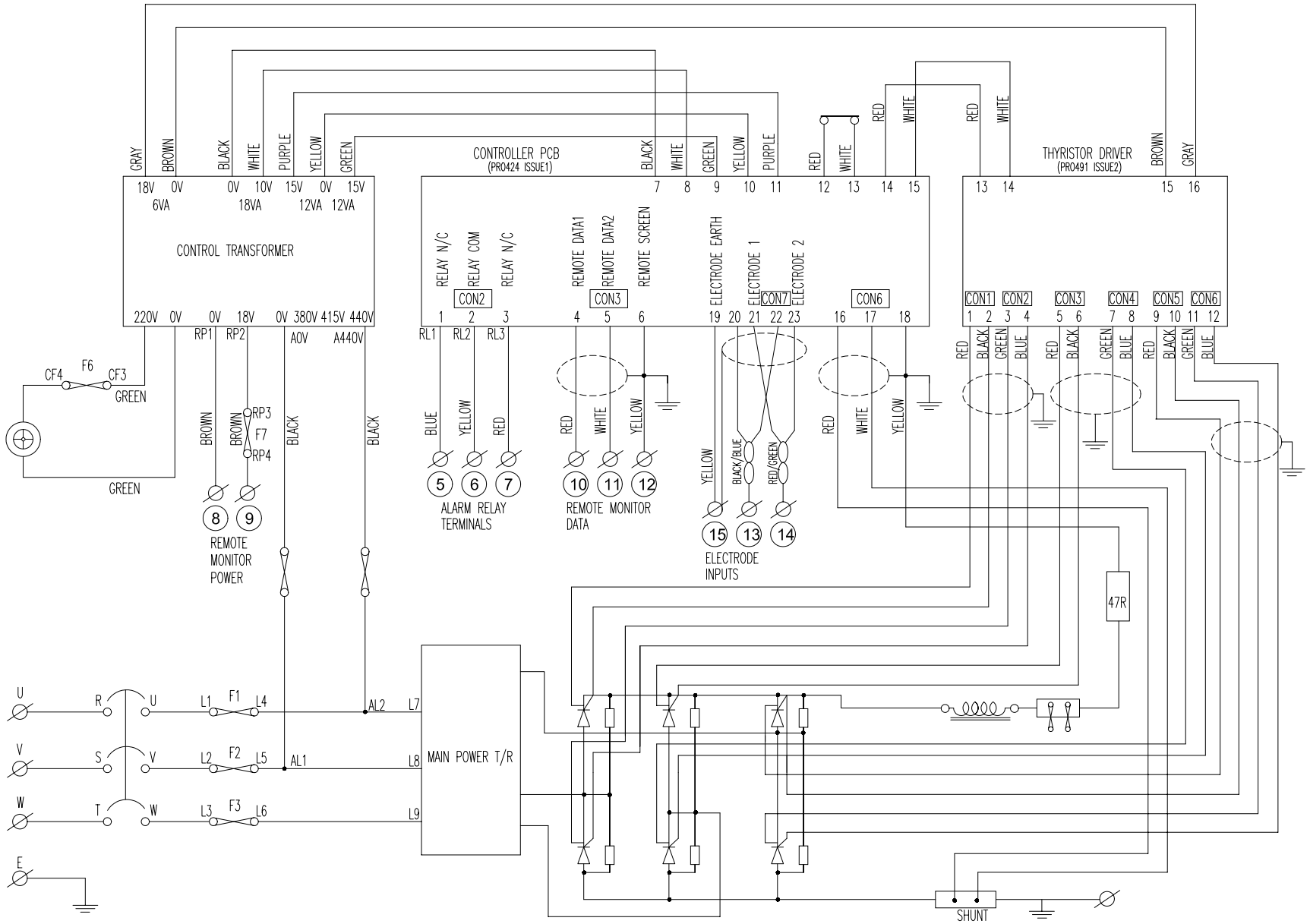
CATHELCO LIMITED
MARINE HOUSE, 18 HIPPER STREET SOUTH,
CHESTERFIELD, DERBYSHIRE, S40 1SS, UK.

| REV: | DATE: | MODIFICATION: |
|---|---|---|
| | | |
| | | |
| | | |

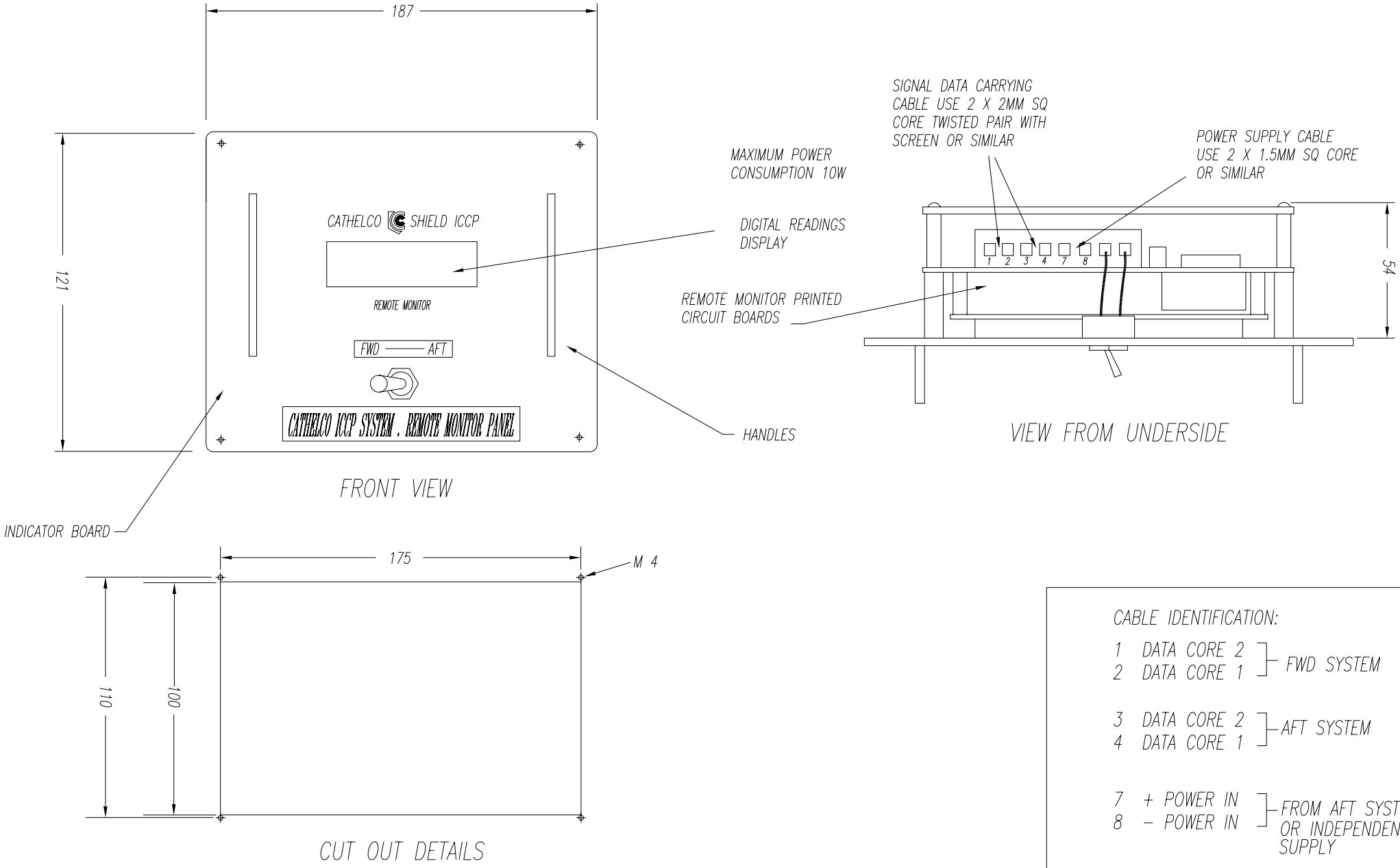
TITLE:
COMPUTER KEYPAD AND DISPLAY UNIT FOR THYRISTOR POWER SUPPLY (MK5)

| PA NO: | DATE: | SCALE: |
|---|---|---|
| | 11:MARCH:97 | NOT TO SCALE |

| DRAWN: | CHECK: | DRG NO: |
|---|---|---|
| KAS | PRS | C1623 |




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| C-SHIELD (ICCP) | CATHELCO LIMITED<br>MARINE HOUSE, 18 HIPPER STREET SOUTH,<br>CHESTERFIELD, DERBYSHIRE, S40 1SS, UK. | REV: | DATE: | MODIFICATION: | TITLE:<br>SCHEMATIC CIRCUIT BLOCK DIAGRAM FOR 3 PHASE THYRISTOR POWER SUPPLY UNIT | PA NO: | DATE: 01/08/03 |
| | | | | | | DRAWN: CAN | CHECK: PL |
| | | | | | | SCALE: NOT TO SCALE | DRG NO: C 2083 |
| | | | | | | | REV: |




CABLE IDENTIFICATION:

| | | |
|---|---|---|
| 1 | DATA CORE 2 | FWD SYSTEM |
| 2 | DATA CORE 1 | |
| 3 | DATA CORE 2 | AFT SYSTEM |
| 4 | DATA CORE 1 | |
| 7 | + POWER IN | FROM AFT SYSTEM OR INDEPENDENT SUPPLY |
| 8 | – POWER IN | |

C-SHIELD (ICCP)

**CATHELCO LIMITED**
MARINE HOUSE, 18 HIPPER STREET SOUTH,
CHESTERFIELD, DERBYSHIRE, S40 1SS, UK.

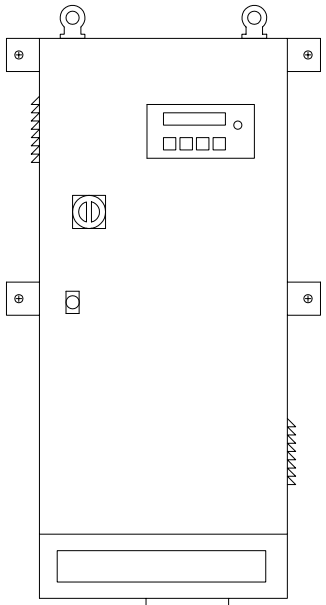
| REV: | DATE: | MODIFICATION: |
|---|---|---|
| A | 04.11.04 | Redesigned |
| – | 30.01.04 | Renumbered (was M1184A) |

TITLE:
C-SHIELD DESK MOUNTED FWD & AFT REMOTE MONITOR PANEL DETAILS

| PA NO: | DATE: | SCALE: |
|---|---|---|
| | 03/07/03 | NTS |

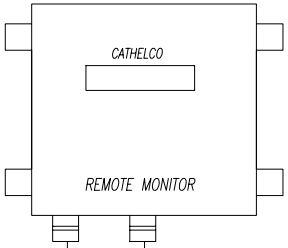
| DRAWN: | CHECK: | DRG NO: |
|---|---|---|
| CAN | PRS | M1238/A |

AFTER SYSTEM POWER SUPPLY UNIT
FOR DETAILS OF INTERNAL TERMINALS
REFER TO APPROPRIATE TERMINAL DRG



REMOTE READINGS UNIT
FOR DETAILS OF INTERNAL
CONNECTIONS REFER TO
DRG.NO.M1249

18V AC POWER
SUPPLY CABLE
USE 2 x 1.5mm$^2$
CORE CABLE OR
SIMILAR



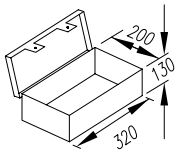
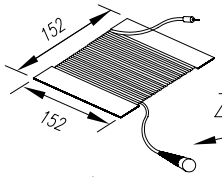
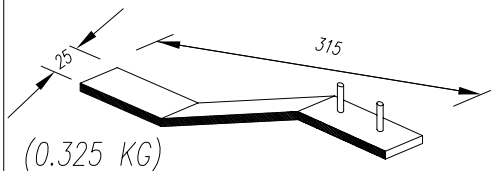

NOTE: ALL CABLES USED TO BE
PROVIDED BY YARD

DATA CARRYING CABLE: USE 2 x 2mm$^2$ CORE
SCREENED CABLE OR SIMILAR

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| C-SHIELD (ICCP) | CATHELCO LIMITED<br>MARINE HOUSE, 18 HIPPER STREET SOUTH,<br>CHESTERFIELD, DERBYSHIRE, S40 1SS, UK. | | | | TITLE: TYPICAL WIRING DIAGRAM FOR REMOTE READINGS UNIT (AFT ONLY TYPE) | PA NO: | DATE: 12:OCT:06 |
| | | B | 18.04.06 | Drg M1249 WAS DRG M1084 | | | SCALE: N.T.S. |
| | | A | 23.10.97 | VOLTAGE AMENDED | | DRAWN: AIR | CHECK: IG |
| | | REV: | DATE: | MODIFICATION: | | DRG NO: C 1205 | REV: B |

# CATHELCO C-SHIELD ICCP SYSTEM: SPARE PARTS & TOOLS LIST

DRG No. C1273

| No. | NAME. | SKETCH / WEIGHT | MAT'L | REMARK | | DRG No. | REMARK |
|---|---|---|---|---|---|---|---|
| | | | | WORKG. | SPARE | | |
| 1 | SPARES STORAGE BOX |   (0.361 KG) | HARD-WEARING PLASTIC | | 1 | C1267 | CS/ICCP/3640 |
| 2 | PORTABLE TEST ELECTRODE FOR TAKING READINGS (SEE CATHELCO C-SHIELD MANUAL & DRD. No.C1606) |   (0.735 KG) | ZINC / PLASTIC | | 1 | C1267 | CS/ICCP/3627 |
| 3 | PIN SPANNER TOOL: FOR INSTALLATION OF REFERENCE CELL |   (0.325 KG) | STEEL | 1 | – | C1332 | CS/ICCP/3642 |
| 4 | CLAW FOOT SPANNER TOOL: FOR INTL. INSTALLATION OF REFERENCE CELL | CUT OUT FOR M20 NUT  70mmø (0.225 KG) | STEEL | 1 | – | C1147 | CS/ICCP/3641 |
| | | | | | | | |

C-SHIELD (ICCP)

CATHELCO LTD

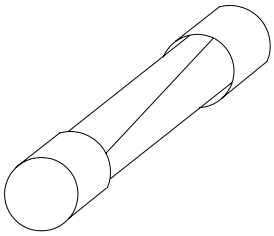
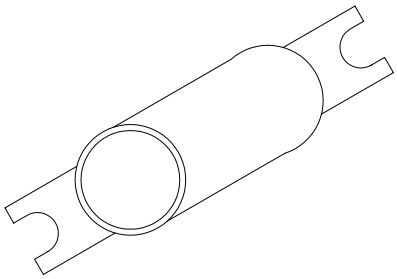
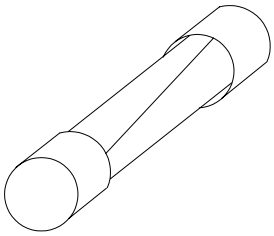
MARINE HOUSE, 18 HIPPER STREET SOUTH, CHESTERFIELD, DERBYSHIRE, S40 1SS, UK.

| DATE | REV | MODIFICATION |
|---|---|---|
| 22/07/04 | D | BRUSHES REMOVED |
| 29/8/03 | C | TITLE BLOCK MODIFIED, C1332 WAS C1272 |
| 15/8/97 | B | DRAWING PUT ON AUTOCAD |

| DATE | SCALE |
|---|---|
| 30:05:93 | NTS |
| DRAWN | CHECK |
| JRH | DP |

# CATHELCO C-SHIELD: ELECTRICAL SPARE PARTS LIST

DRG No. C1288/CH

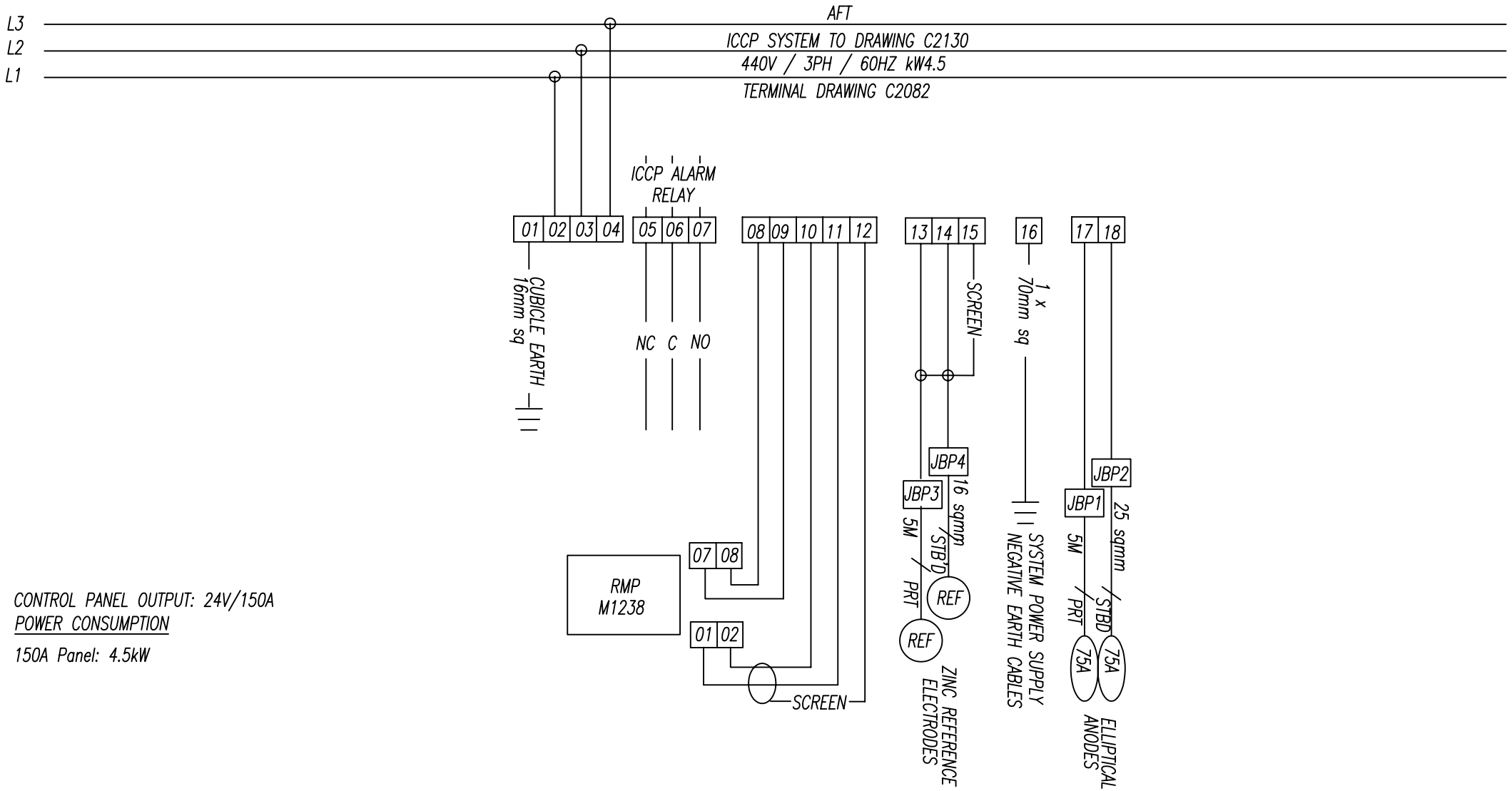
| ITEM / DESCRIPTION | SKETCH / WEIGHT | SUPPLY No. | POSN. No. | STOCK No. |
|---|---|---|---|---|
| MAIN POWER SUPPLY FUSES RATED TO PANEL OUTPUT. SEE SPECIFICATION FOR DETAILS. FUSES LOCATED IN BACK SECTION OF POWER SUPPLY UNIT. REFER TO TERMINAL LAYOUT DRAWING. |  | 2 PER PSU | BACK SECTION : PSU | TRANSFCONFUSE - ICCP |
| ANODE FUSES RATED TO ANODE OUTPUT. SEE SPECIFICATION FOR DETAILS. FUSE HOLDERS LOCATED IN BACK SECTION OF POWER SUPPLY UNIT. REFER TO TERMINAL LAYOUT DRAWING. |  FUSE TYPE: BARREL FUSE. DETAILS ON FUSE | 2 PER PSU | BACK SECTION : PSU | ANODE FUSE - ICCP |
| TRANSFORMER CONTROL, REMOTE & FAN SUPPLY FUSES LOCATED IN BACK SECTION OF POWER SUPPLY UNIT. REFER TO TERMINAL LAYOUT DRAWING<br><br>FUSE TYPE : 2A |  | 2 PER PSU | BACK SECTION : PSU | REMPOWER FUSE - ICCP |

C-SHIELD (ICCP)

CATHELCO LTD
MARINE HOUSE, 18 HIPPER STREET SOUTH,
CHESTERFIELD, DERBYSHIRE, S40 1SS, UK.

| DATE | REV | MODIFICATION |
|---|---|---|
| 09/07/04 | D | FUSE DETAILS CORRECTED |
| 13/10/03 | C | 'PER PANEL' NOTES ADDED |
| 29/8/03 | B | TITLE BLOCK MODIFIED |
| 15/8/97 | A | DRAWING PUT ON AUTOCAD |

| DATE | SCALE |
|---|---|
| 20:09:93 | NTS |
| DRAWN | CHECK |
| NKG | JRH |

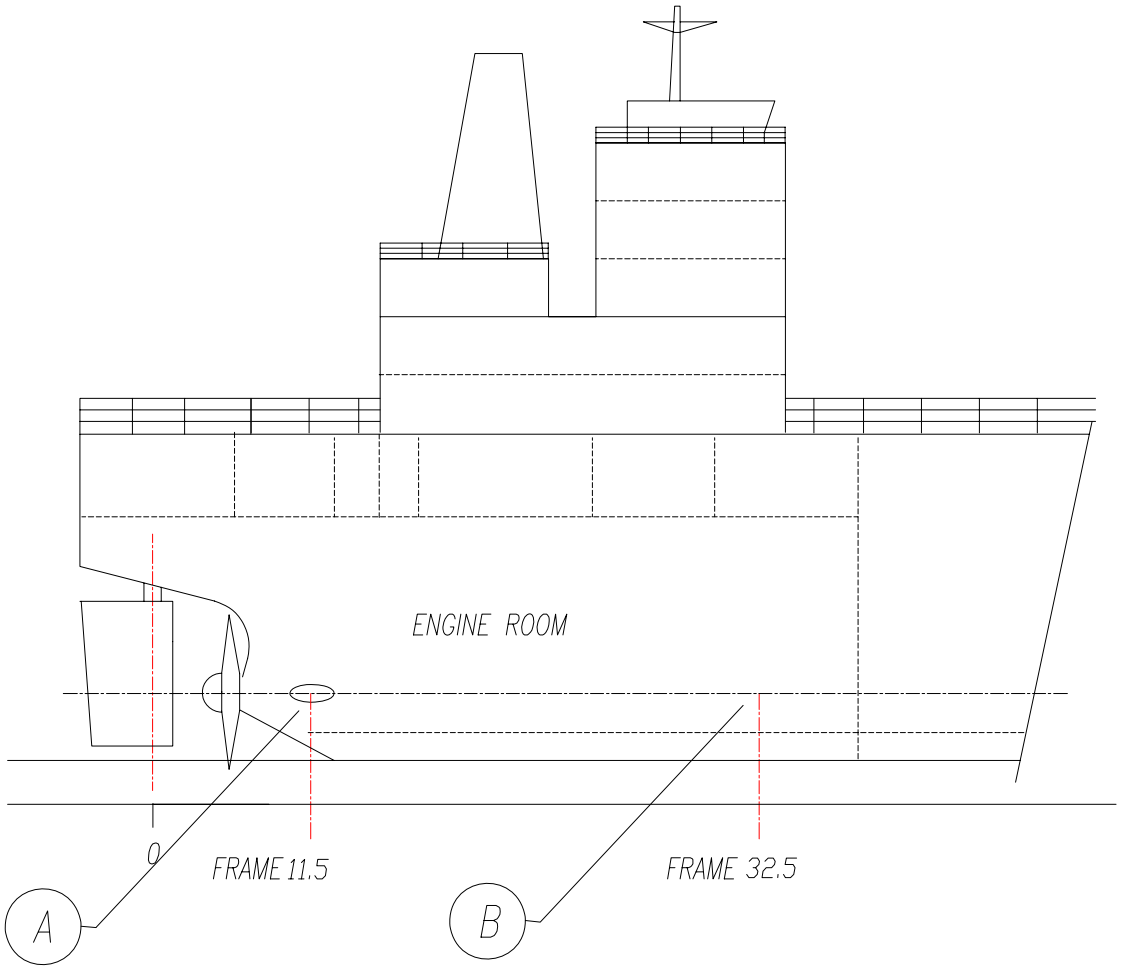



CONTROL PANEL OUTPUT: 24V/150A

POWER CONSUMPTION

150A Panel: 4.5kW

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| C-SHIELD (ICCP) | CATHELCO LIMITED<br>MARINE HOUSE, 18 HIPPER STREET SOUTH,<br>CHESTERFIELD, DERBYSHIRE, S40 1SS, UK. | | | | TITLE:<br>C-SHIELD SYSTEM WIRING DIAGRAM<br>JIANGSU SAENTI 565-DWT | PA NO:<br>CA 31973 | DATE:<br>27/02/07 | SCALE:<br>NOT TO SCALE |
| | | A | 05.05.06 | POWER CONSUMPTION ADDED | | DRAWN:<br>RJP | CHECK:<br>KS | DRG NO:<br>C2140 | REV<br>A |
| | | REV: | DATE: | MODIFICATION: | | | | | |




## KEY TO DRAWING ITEMS:

A — 75A RECESSED ELLIPTICAL ANODES
POSITION FRAME 11.5
AT A HEIGHT OF 2100 ABOVE B.L.

B — REFERENCE ELECTRODE ASSEMBLY
POSITION FRAME 32.5 POSITION
AT A HEIGHT OF 2100 ABOVE B.L.

C-SHIELD (ICCP)
CATHELCO LIMITED
MARINE HOUSE, 18 HIPPER STREET SOUTH,
CHESTERFIELD, DERBYSHIRE, S40 1SS, UK.

| REV: | DATE: | MODIFICATION: |
|---|---|---|
| | | |
| | | |
| | | |

TITLE: C-SHIELD ICCP AFT SYSTEM LAYOUT
JIANGSU SAENTI 5650DWT

| PA NO: | DATE: | SCALE: |
|---|---|---|
| CA31973 | 21/3/2007 | NOT TO SCALE |

| DRAWN: | CHECK: | DRG NO: |
|---|---|---|
| CAN | KAS | C 2103 |