Brisbane City

Brisbane Water

12th March 1998.

OPERATING MANUAL FOR:

KLEENHEAT GAS PTY LTD.
MOUNDED LPG VESSELS
BULWER ISLAND QLD.

CATHODIC PROTECTION SYSTEM

CLIENT:

WESFARMERS KLEENHEAT GAS PTY LTD.

PLAN VIEW

LEGEND:

- ANODEFLEX ANODE
- PERMANENT COPPER/COPPER SULPHATE REFERENCE ELECTRODE
- PERMANENT POTENTIAL MONITORING ELECTRODE
- CORROSION PROBE
- TEST BOX
- JUNCTION BOX
- EARTH ELECTRODE
- CATHODIC PROTECTION UNIT
- (2) ITEM NUMBERS, REFER TO MATERIAL SCHEDULE DRAWING 1932/DWG/06

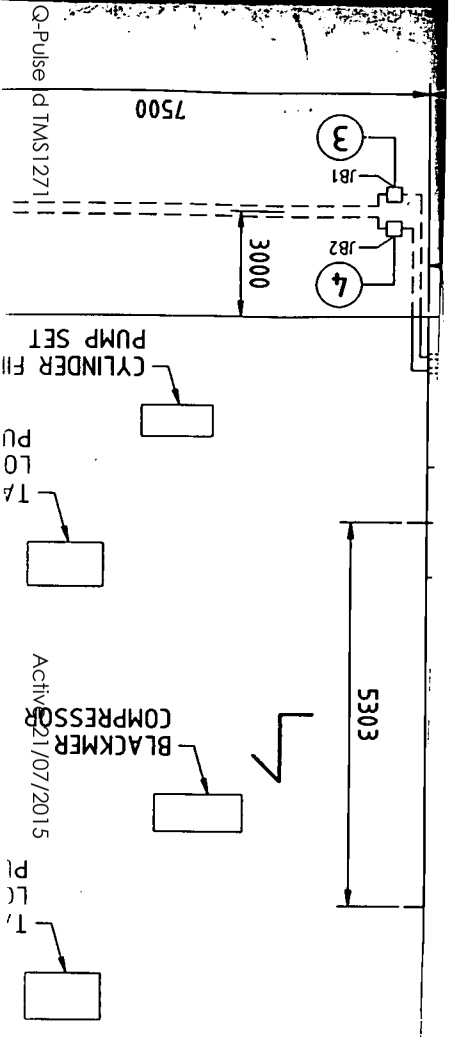
NOTES:

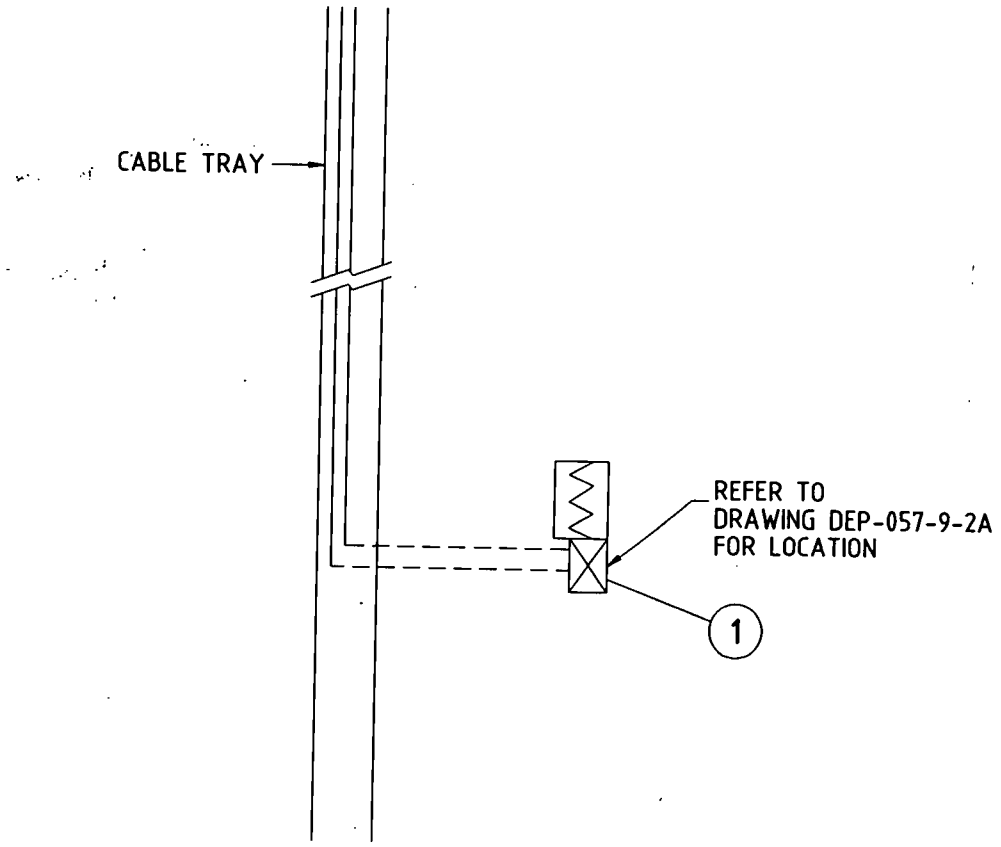
1. CABLES IN MOUND HAVE BEEN OMITTED FOR CLARITY.
2. CABLE TO EARTH ELECTRODE SHALL BE KEPT TO A MINIMUM AND FREE FROM KINKS.
3. FOR MATERIAL SCHEDULE REFER TO DRAWING 1932/DWG/06.
4. FOR COMPLETE DETAILS REFER TO DOCUMENT 1932/DS/01.
5. 100mm DIA. OPENINGS SHALL BE PROVIDED IN THE SIDE WALL FOR EARTHING CABLES.

1932/DWG/01

SOLOMON CORROSION CONTROL SERVICES P/L
22 Eskay Road Oakleigh South
Victoria 3167 Australia
Tel: (03) 9563 8665 Fax: (03) 9563 8744

WESFARMERS KLEENHEAT GAS PTY LTD
BULWER ISLAND QUEENSLAND
MOUNDED LPG VESSELS
CATHODIC PROTECTION SYSTEM
GENERAL ARRANGEMENT
PLAN VIEW





CAD FILE: 1932-01

DESIGN	H.K.	SCALE	N.T.S.
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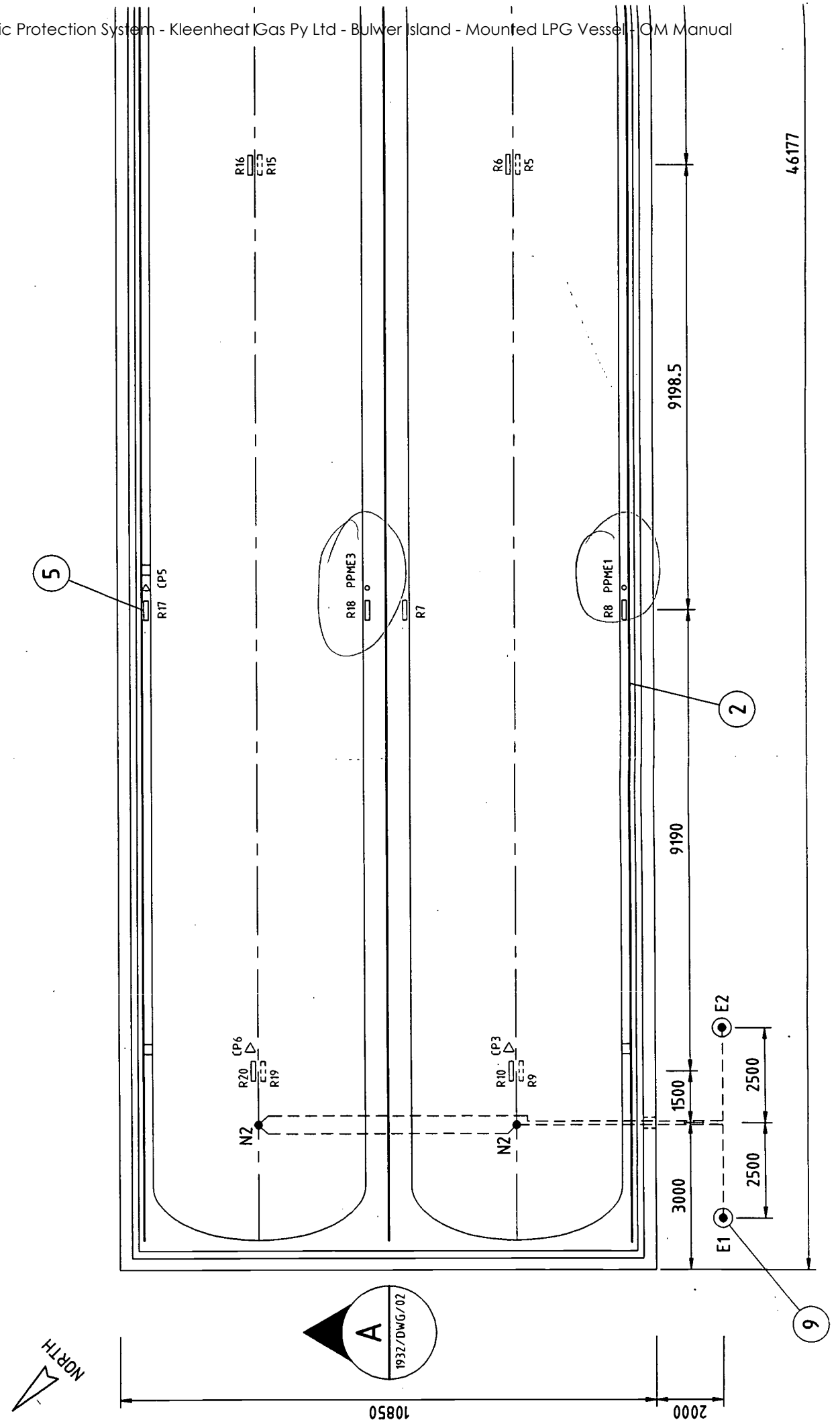
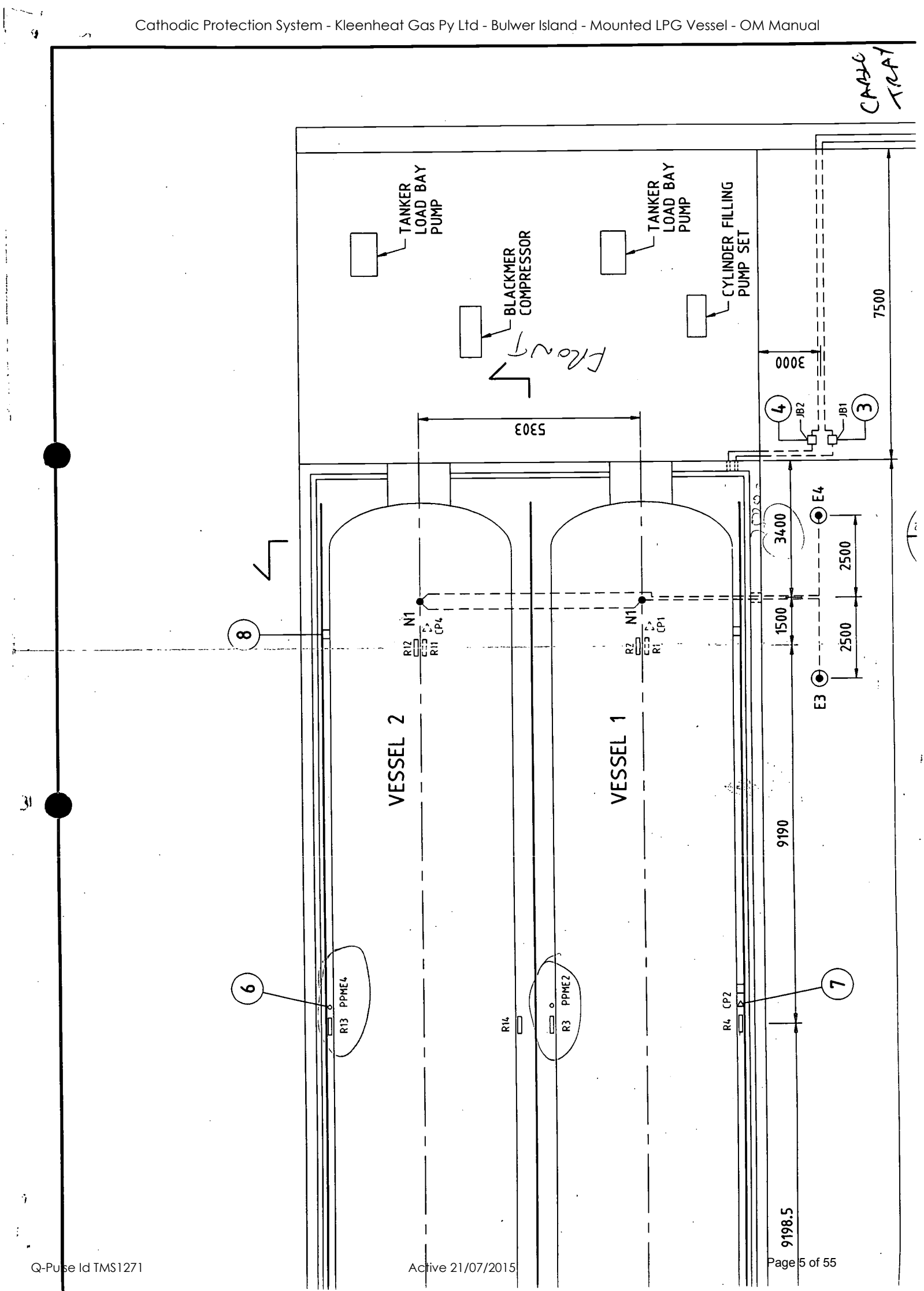
CHECKED	H.K.	PASSED	
APPROVED	P.C.		
DATE	11/6/96		


R16
R15
R6
R5
46177
9198.5
5
R17 CP5
R18 PPME3
R7
R8 PPME1
2
9190
CP6
R20
R19
CP3
R10
R9
E2
1500
2500
N2
N2
2500
3000
E1
9
A
1932/DWG/02
NORTH
10850
2000


CABLE TRAY
TANKER LOAD BAY PUMP
BLACKMER COMPRESSOR
TANKER LOAD BAY PUMP
CYLINDER FILLING PUMP SET
FRONT
7500
3000
5303
JB2
JB1
4
3
E4
E3
3400
2500
1500
2500
9190
9198.5
VESSEL 2
VESSEL 1
N1
R12
R11
CP4
N1
R2
R1
CP1
8
6
7
R13
PPME4
R14
R3
PPME2
R4
CP2

NOTES:

1. CABLES IN MOUND HAVE BEEN OMITTED FOR CLARITY.
2. CABLE TO ZINC EARTHING ELECTRODE SHALL BE KEPT TO A MINIMUM LENGTH AND FREE OF KINKS.
3. FOR MATERIAL SCHEDULE REFER TO DRAWING 1932/DWG/06.
4. FOR COMPLETE DETAILS REFER TO CATHODIC PROTECTION DESIGN DOCUMENT 1932/DS/01.
5. FOR LEGEND REFER TO DRAWING 1932/DWG/01.
6. SURGE DIVERTERS TO BE INSTALLED ACROSS INSULATING FLANGE AT CONNECTION N5 OF VESSEL V1 & V2.
7. 100mm DIA. OPENINGS SHALL BE PROVIDED IN THE SIDE WALL FOR EARTHING CABLES.

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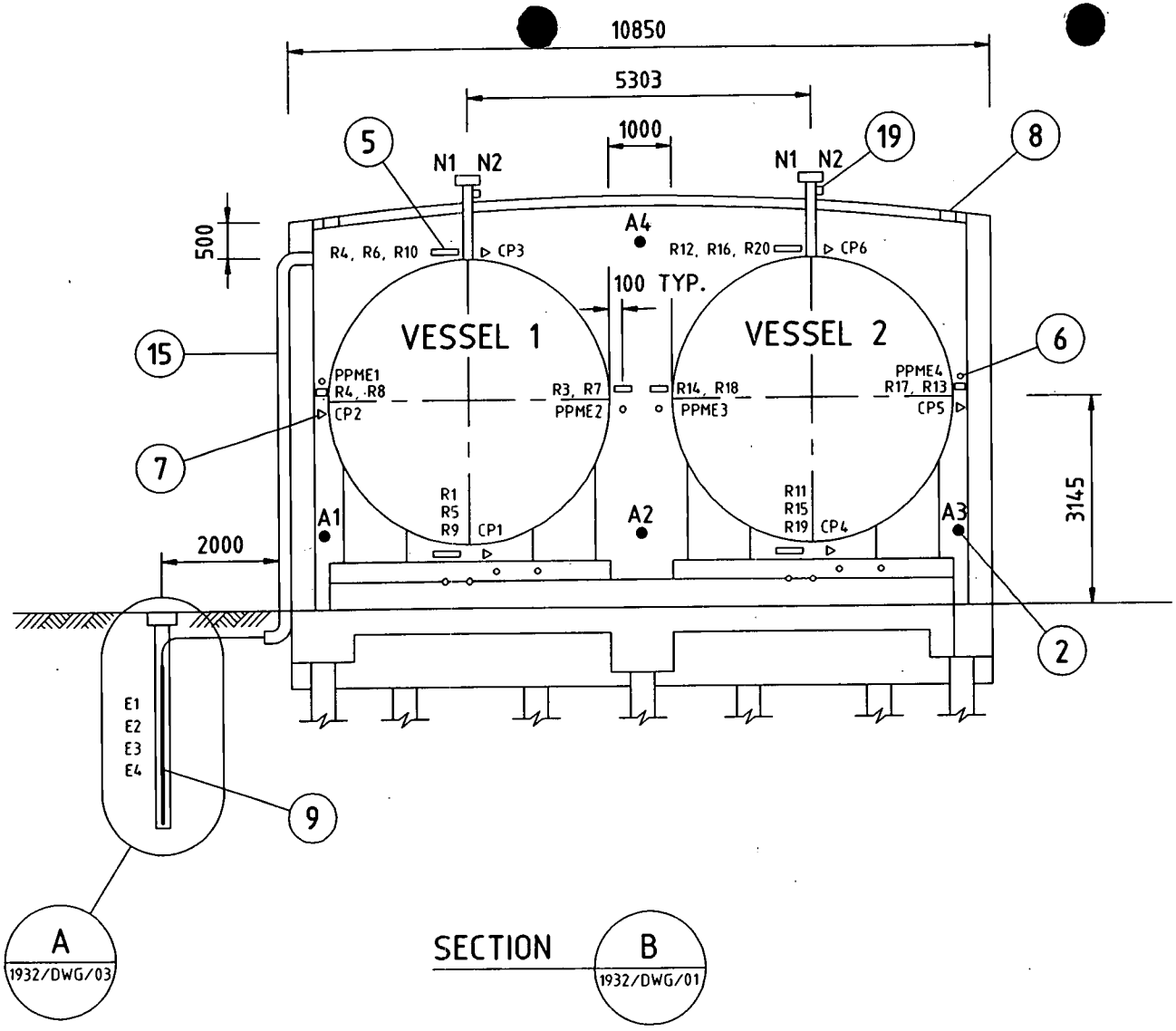
WESFARMERS KLEENHEAT GAS PTY LTD
BULWER ISLAND QUEENSLAND
MOUNDED LPG VESSELS
CATHODIC PROTECTION SYSTEM
GENERAL ARRANGEMENT
SECTIONAL VIEWS

DRAWING No.	1932/DWG/02
SHEET SIZE	A1
REVISION	0
SHEET 1 OF	1



REFER DETAIL A 1932/DWG/03

SECTION B 1932/DWG/01

CAD FILE: 1932-02

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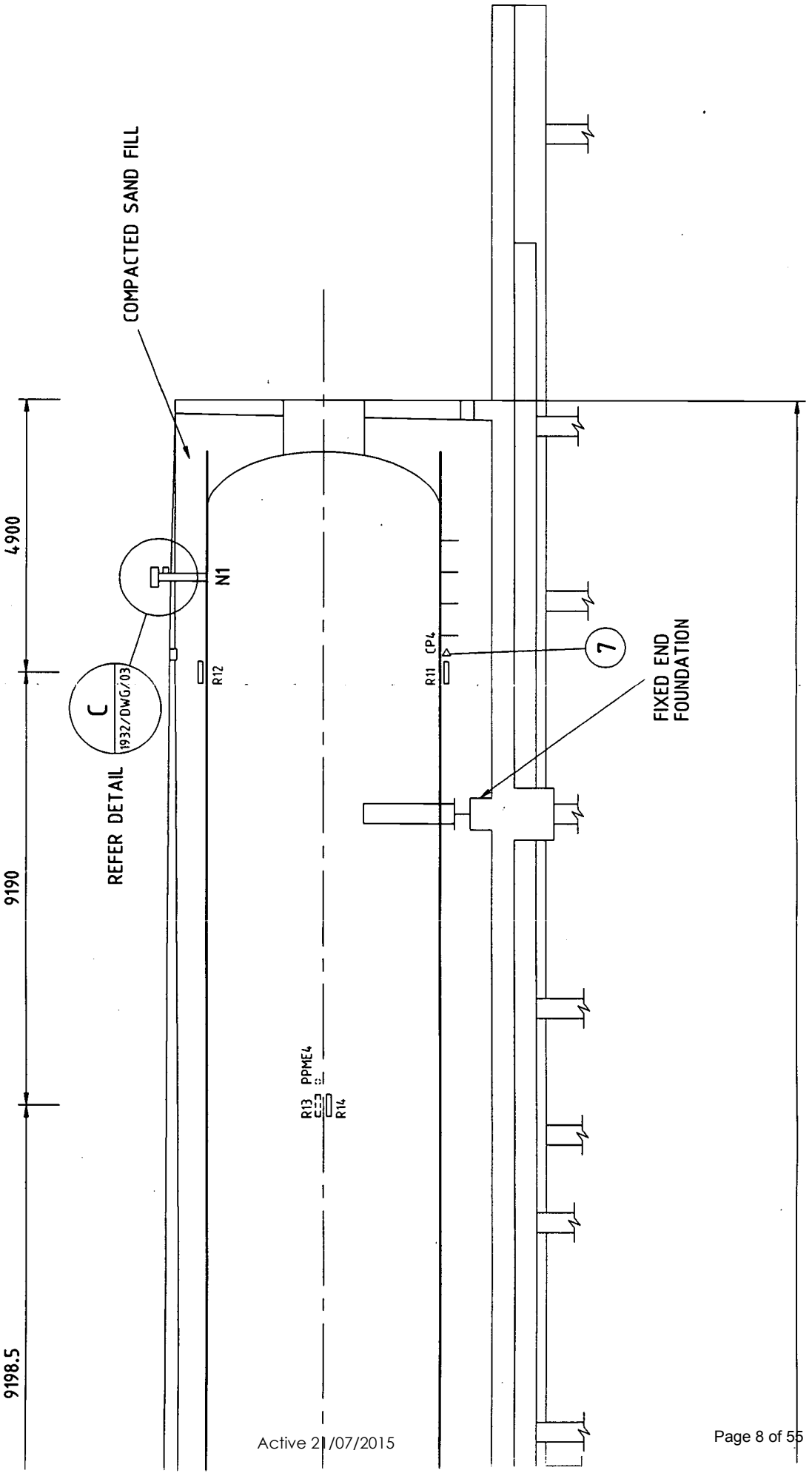
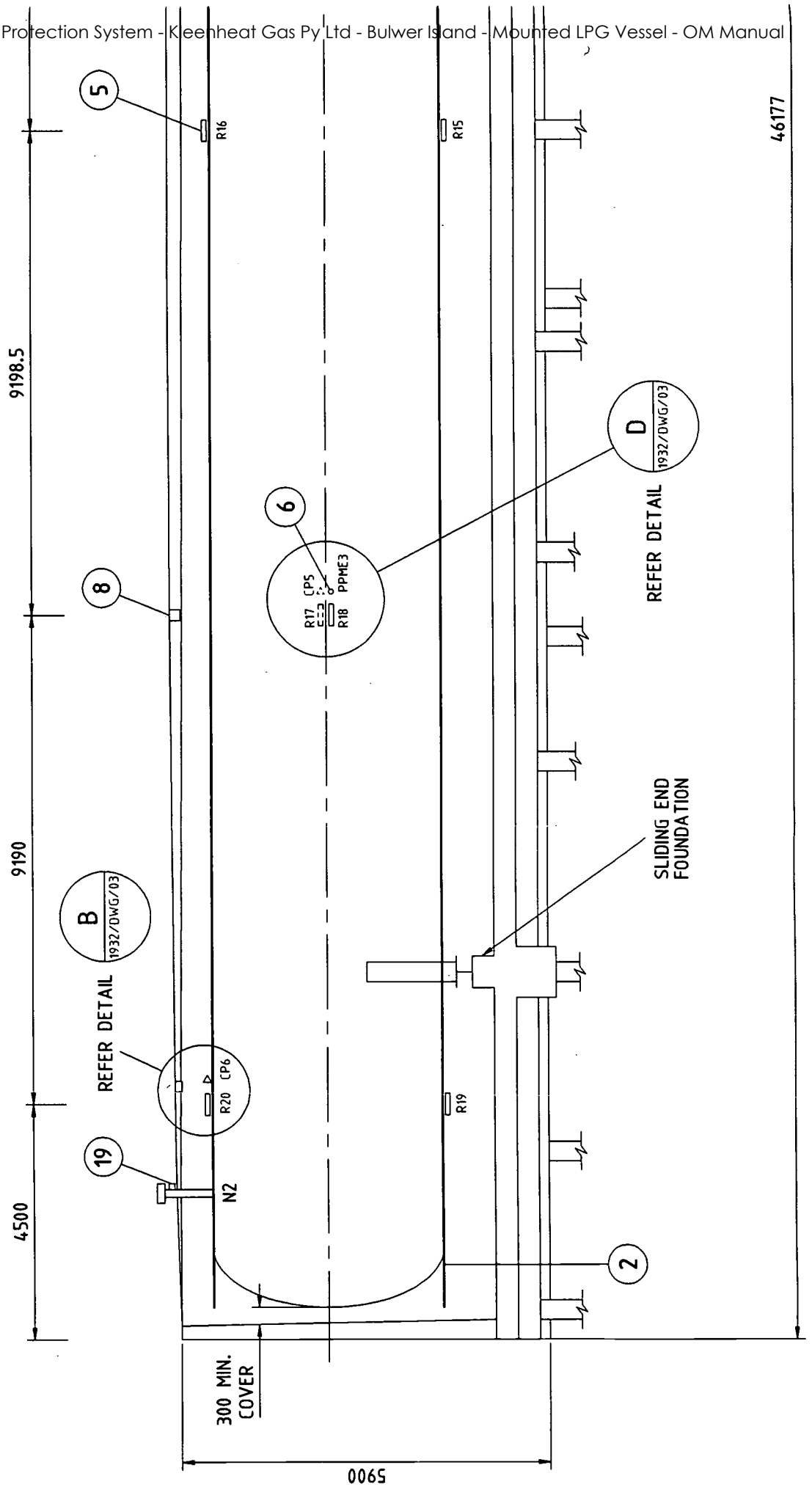
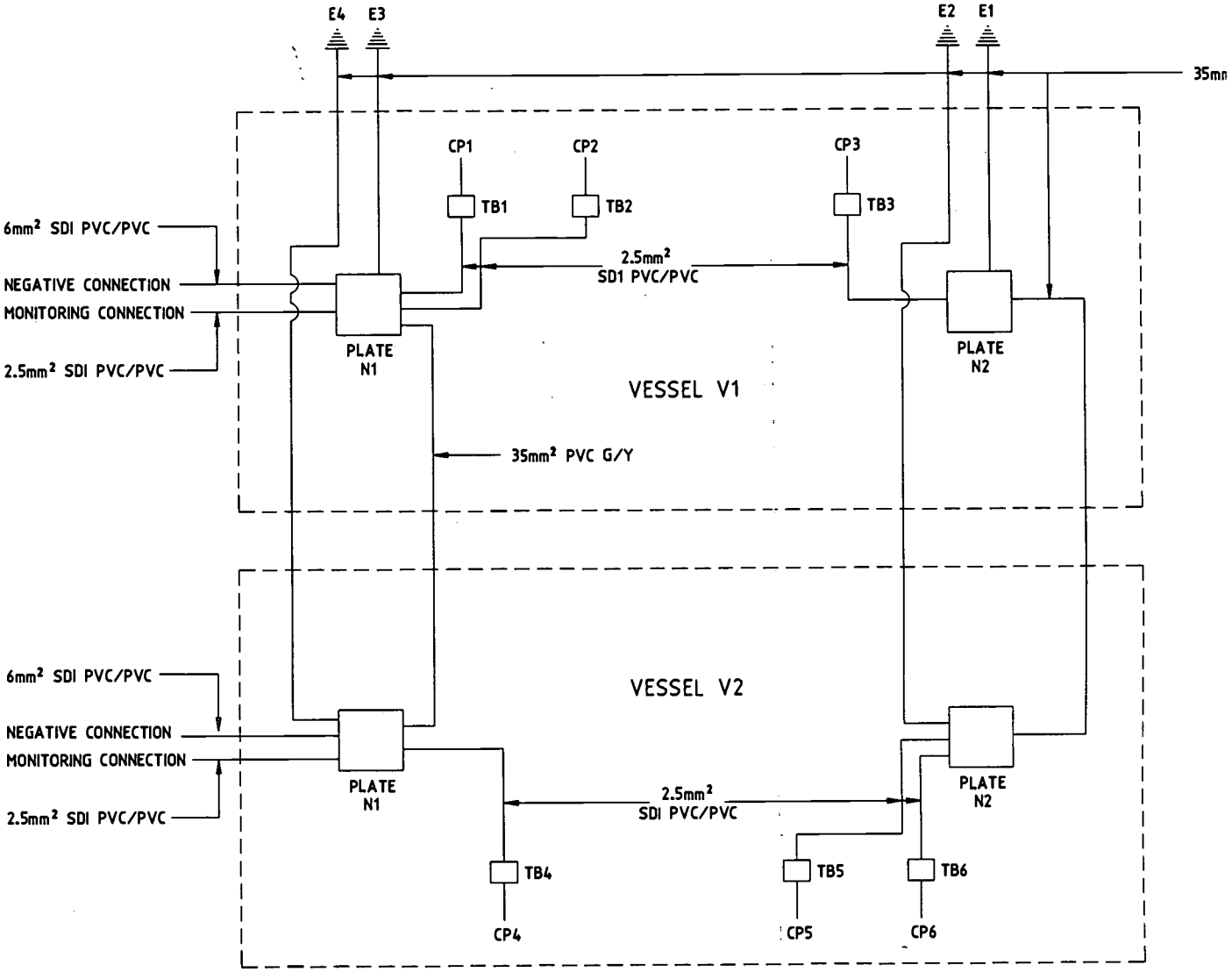
CHECKED	H.K.	PASSED	
APPROVED	P.C.		
DATE	11/6/96		


COMPACTED SAND FILL
4900
9190
9198.5
N1
R12
R11
CP4
7
FIXED END
FOUNDATION
C
1932/DWG/03
REFER DETAIL
R13
PPME4
R14
A
1932/DWG/01

SECTIO


5
R16
R15
46177
9198.5
8
6
R17 CP5
R18 PPME3
D
1932/DWG/03
REFER DETAIL
SLIDING END
FOUNDATION
9190
B
1932/DWG/03
REFER DETAIL
R20 CP6
R19
19
N2
4500
2
300 MIN.
COVER
5900

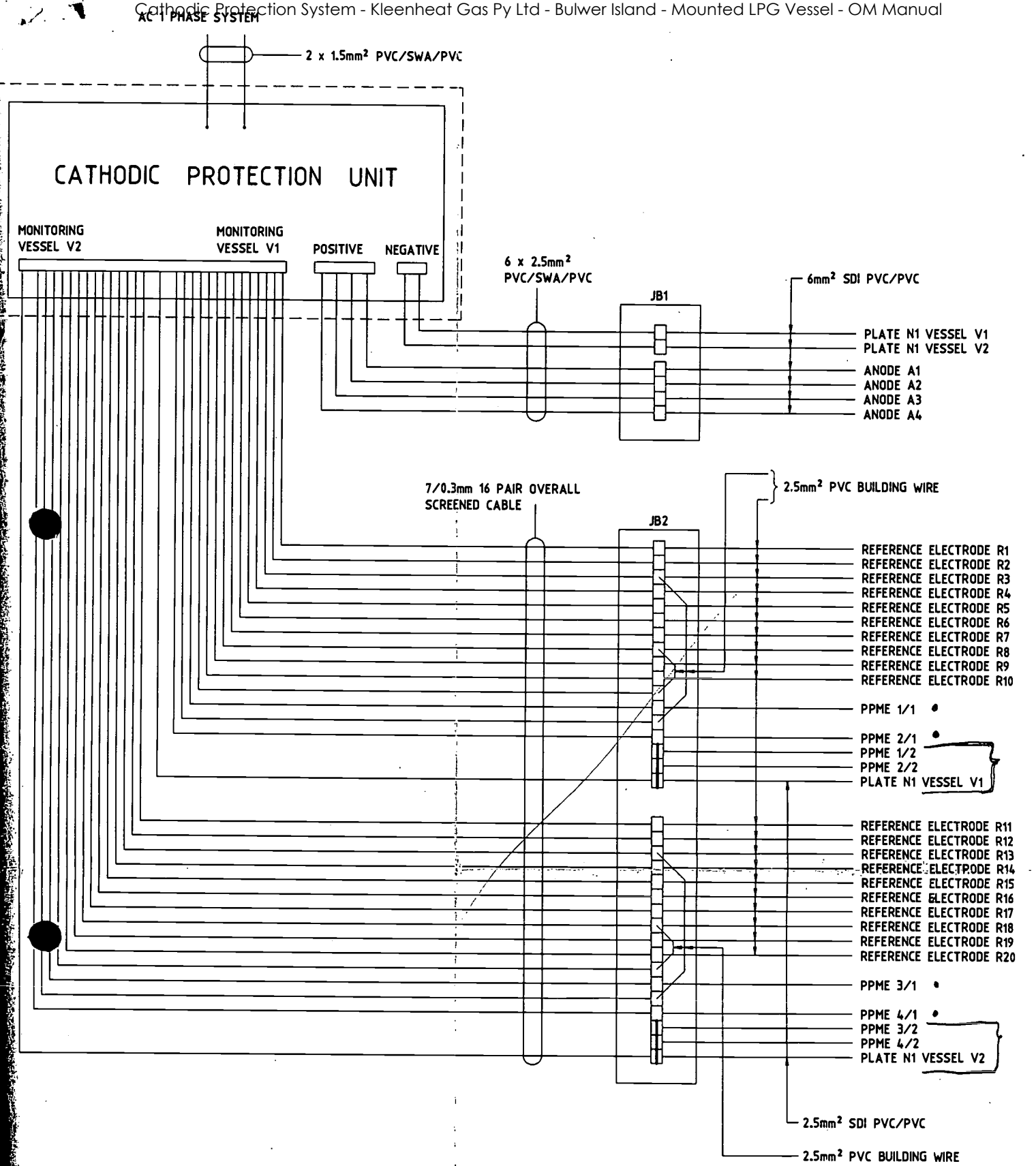


LEGEND:

CP1	CORROSION PROBE
TB1	TEST BOX
E1	EARTH ELECTRODE

~~DRWG~~

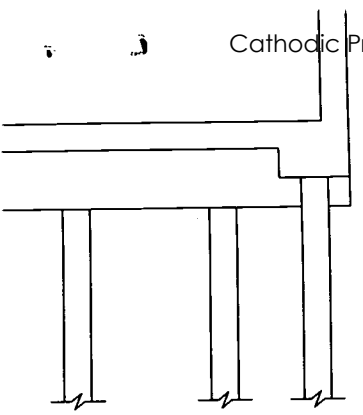
19321 DWG 03



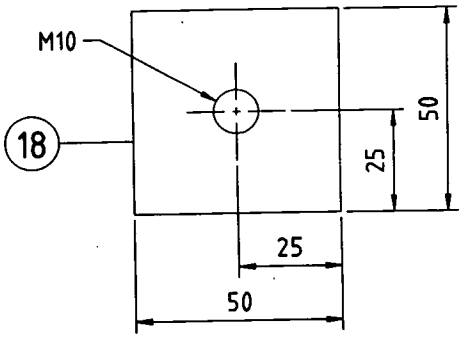
NOTES:

1. PPMES SHALL BE PROVIDED WITH 0.75mm² 2 CORE FLEXIBLE INTEGRAL CABLE.
2. REFER TO CABLE SCHEDULE FOR DETAILS.

DRWG 1932/DWG/03



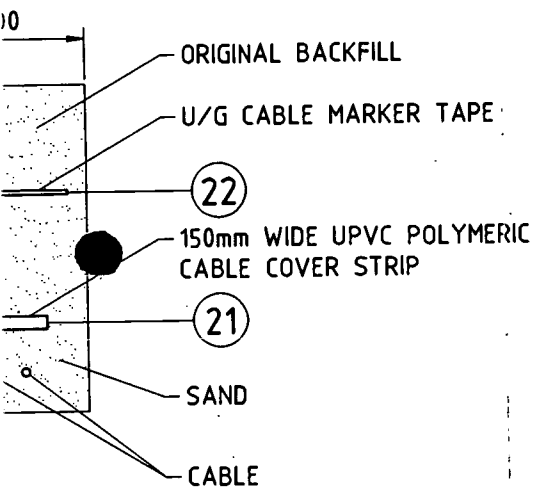
SURGE DIVERTER INSTALLATION



TION DETAILS

SURGE DIVERTER CONNECTION PLATE

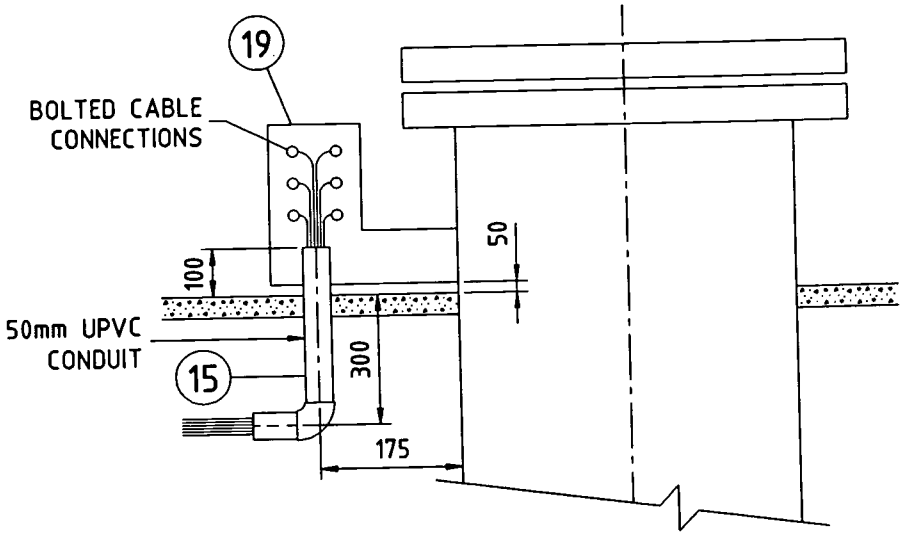
(THICKNESS: 3mm)



D CABLE
N DETAIL

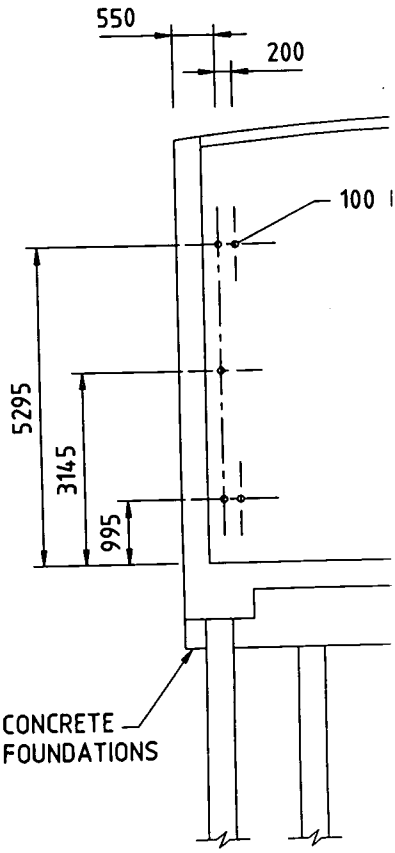
WESFARMERS KLEENHEAT GAS PTY LTD
BULWER ISLAND QUEENSLAND
MOUNDED LPG VESSELS
CATHODIC PROTECTION SYSTEM
INSTALLATION DETAILS

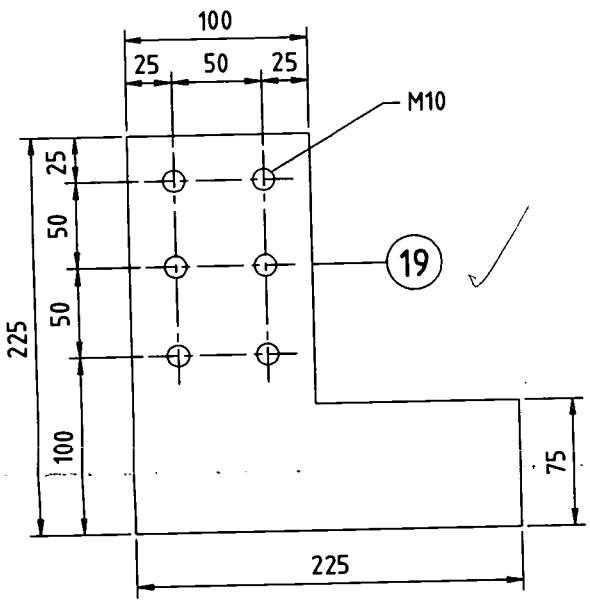
DRAWING No.	1932/DWG/03
SHEET SIZE	A1
REVISION	0
SHEET 1 OF	1



DETAIL C (1932/DWG/02) INSTALLATION OF

N1 & N2 CONNECTION

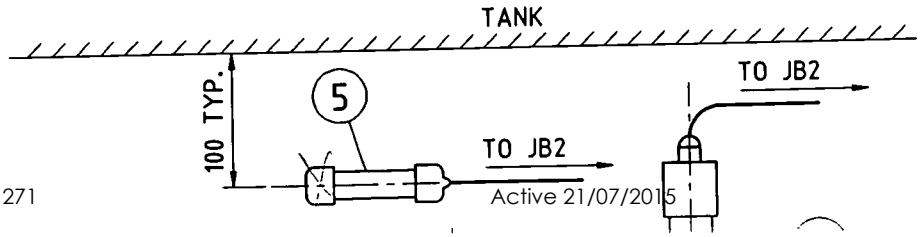


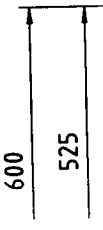


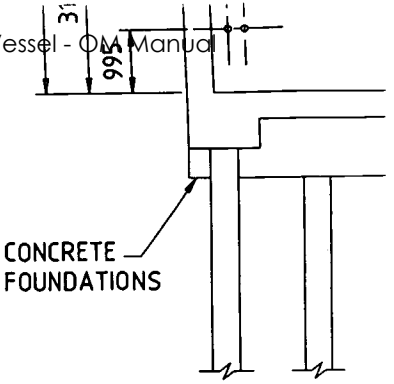
N1 & N2 CONNECTION PLATE

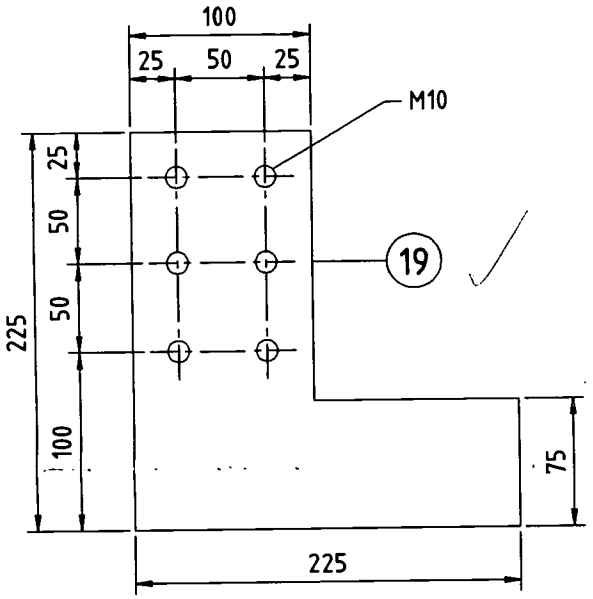
(THICKNESS: 6mm)

CAE
FRC





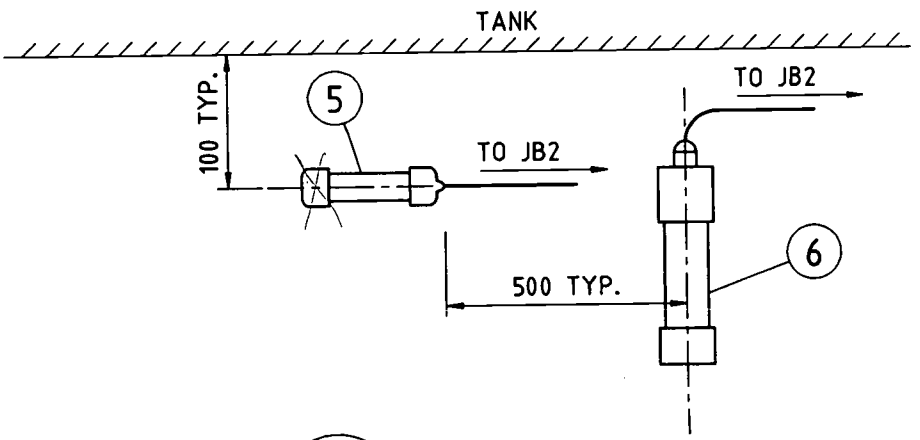


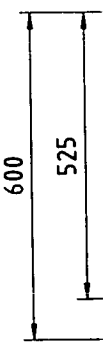


N1 & N2 CONNECTION PLATE

(THICKNESS: 6mm)

CA
FR



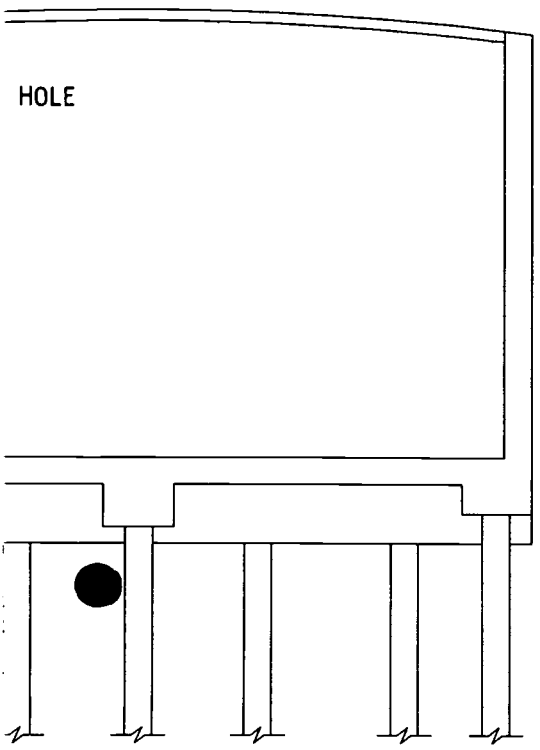


DETAIL D (1932/DWG/02) PPME INSTALLATION

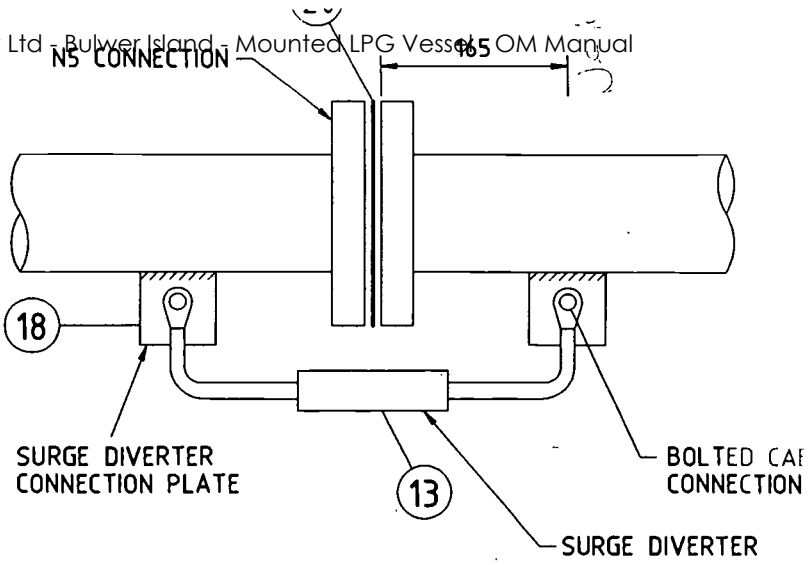
iN	H.K.	SCALE	N.T.S.
/N	M.B.	TRACED	
KED	H.K.	PASSED	
OVED	P.C.		
	12/6/96		

SCCS

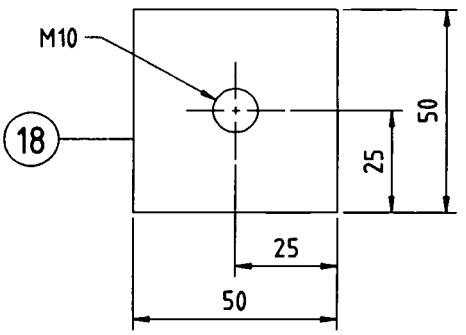
SOLOMON
CONTROL S
22 Eskay Roa
Victoria 3
Tel: (03) 9563 8665



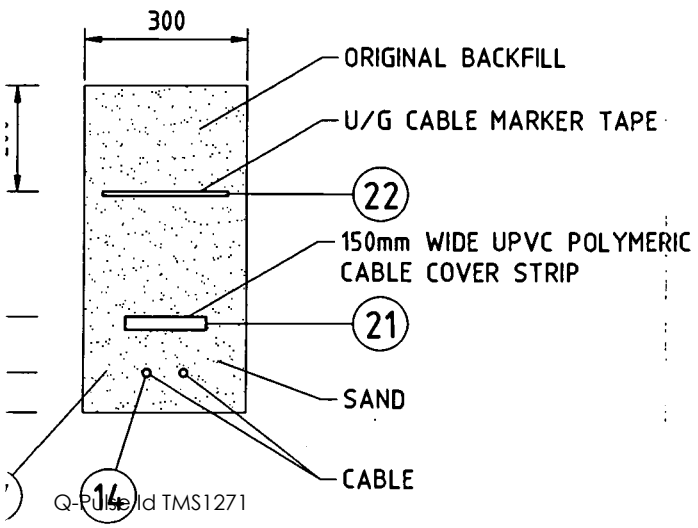
PENETRATION DETAILS
END



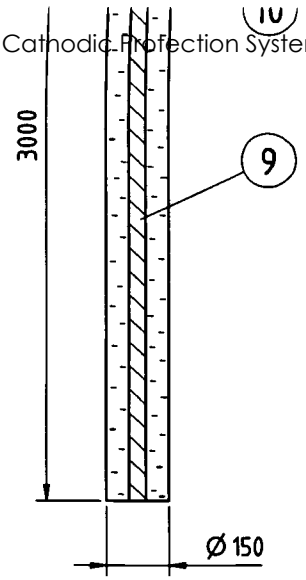
SURGE DIVERTER INSTALLATION

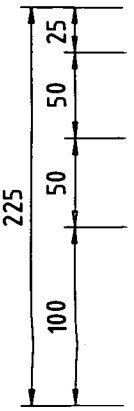


SURGE DIVERTER CONNECTION PLATE
(THICKNESS: 3mm)



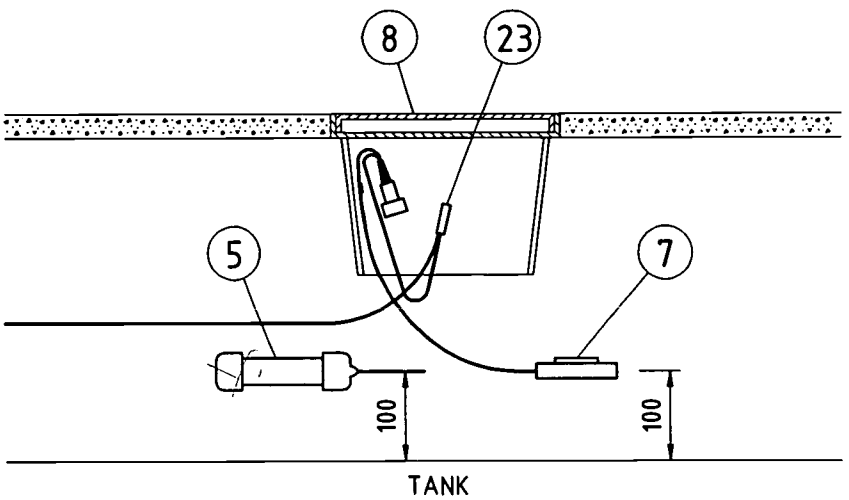
N1 & N2 (

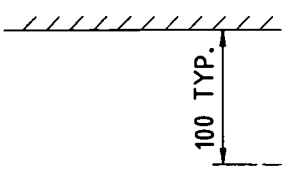




DETAIL A 1932/DWG/02 ZINC EARTHING ELECTRODE

N1 &





DETAIL B 1932/DWG/02 CORROSION PROBE TEST BOX

DETAIL

CAD FILE: 1932-03

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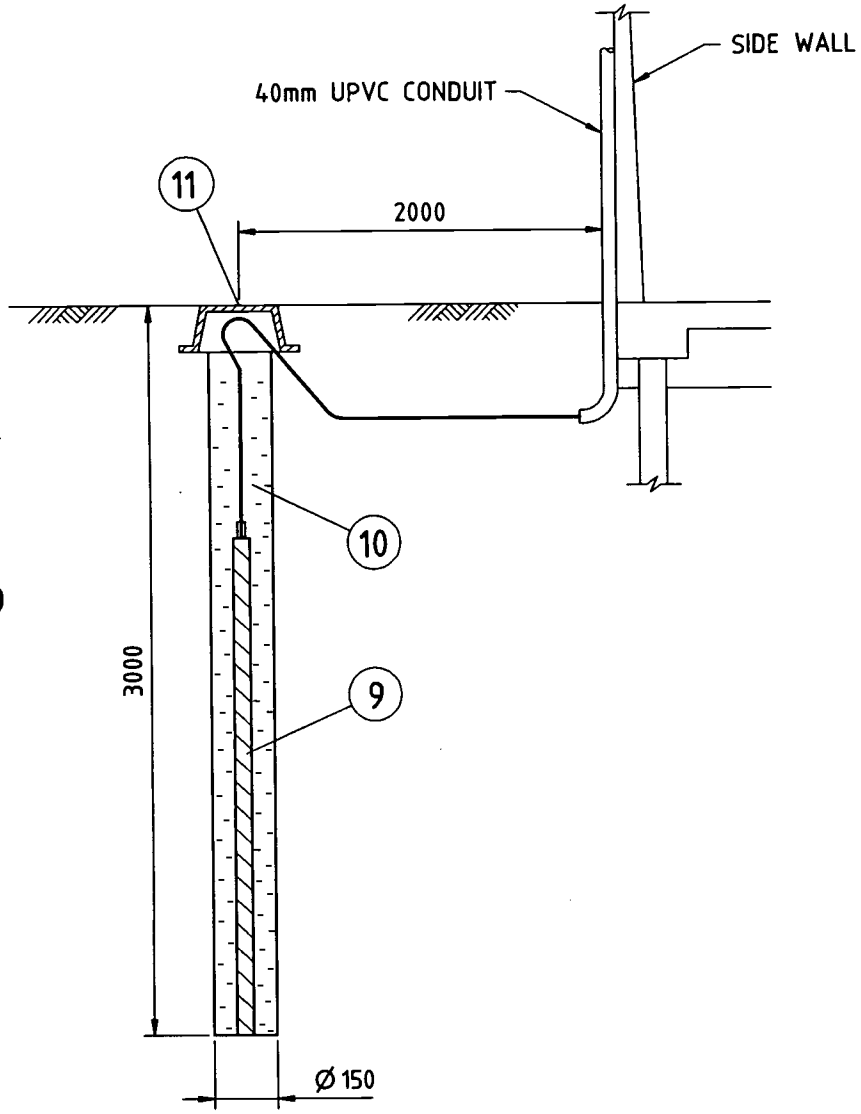
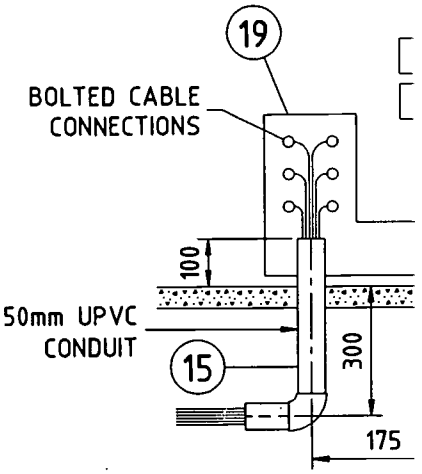
DRAWN	M.B.	TRACED	
CHECKED	H.K.	PASSED	
APPROVED	P.C.		

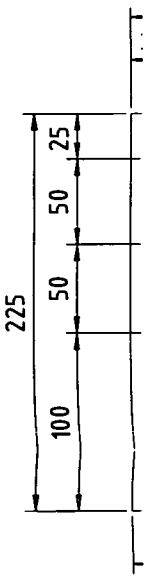


DETAIL A 1932/DWG/02 ZINC EARTHING ELECTRODE



DETAIL C 1932/DWG/02

N1 & N2 C(



N1 &

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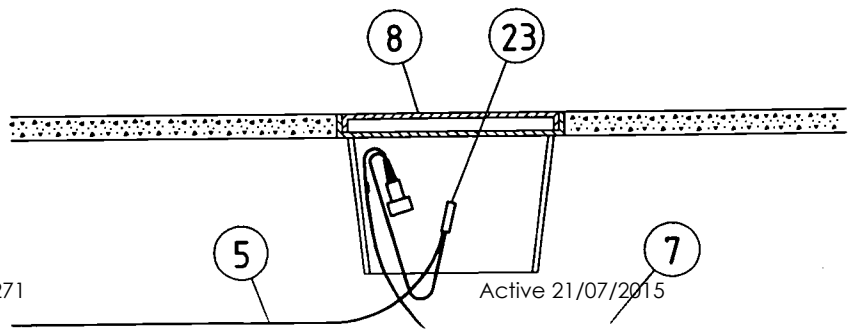
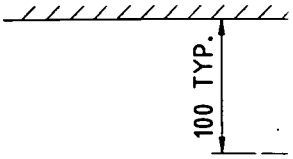
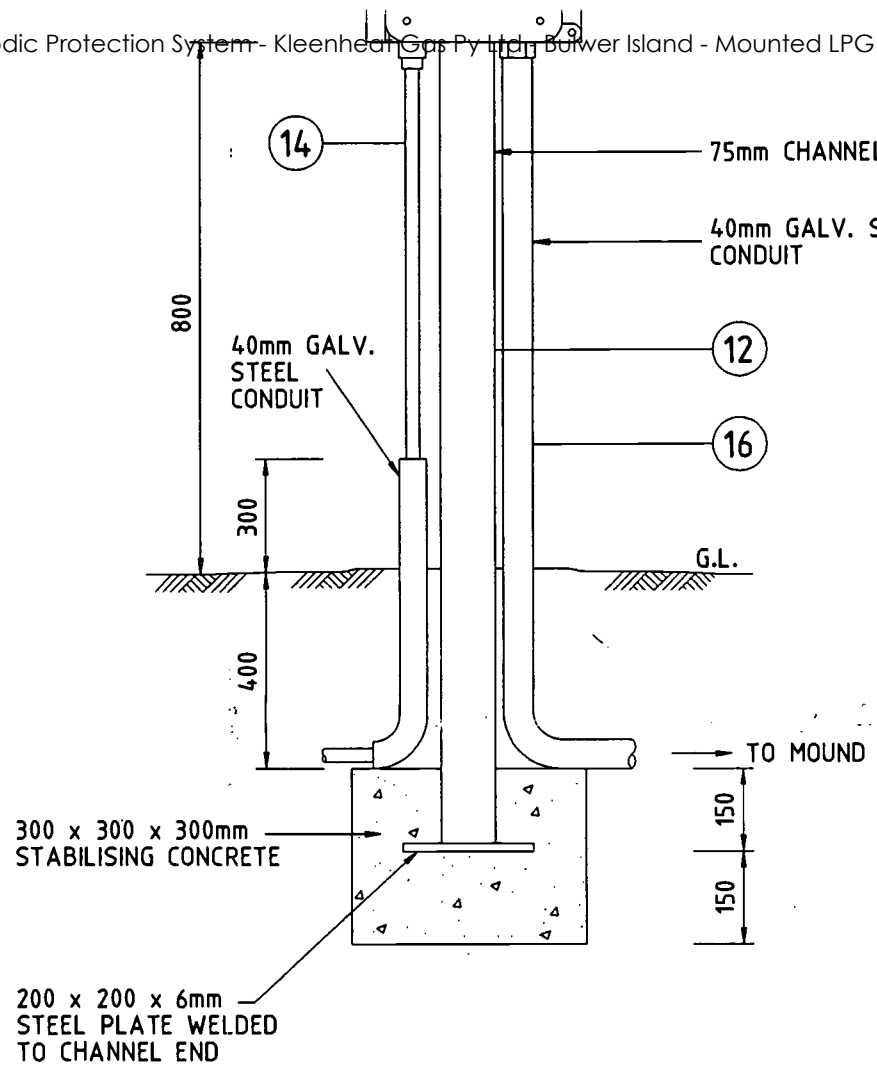
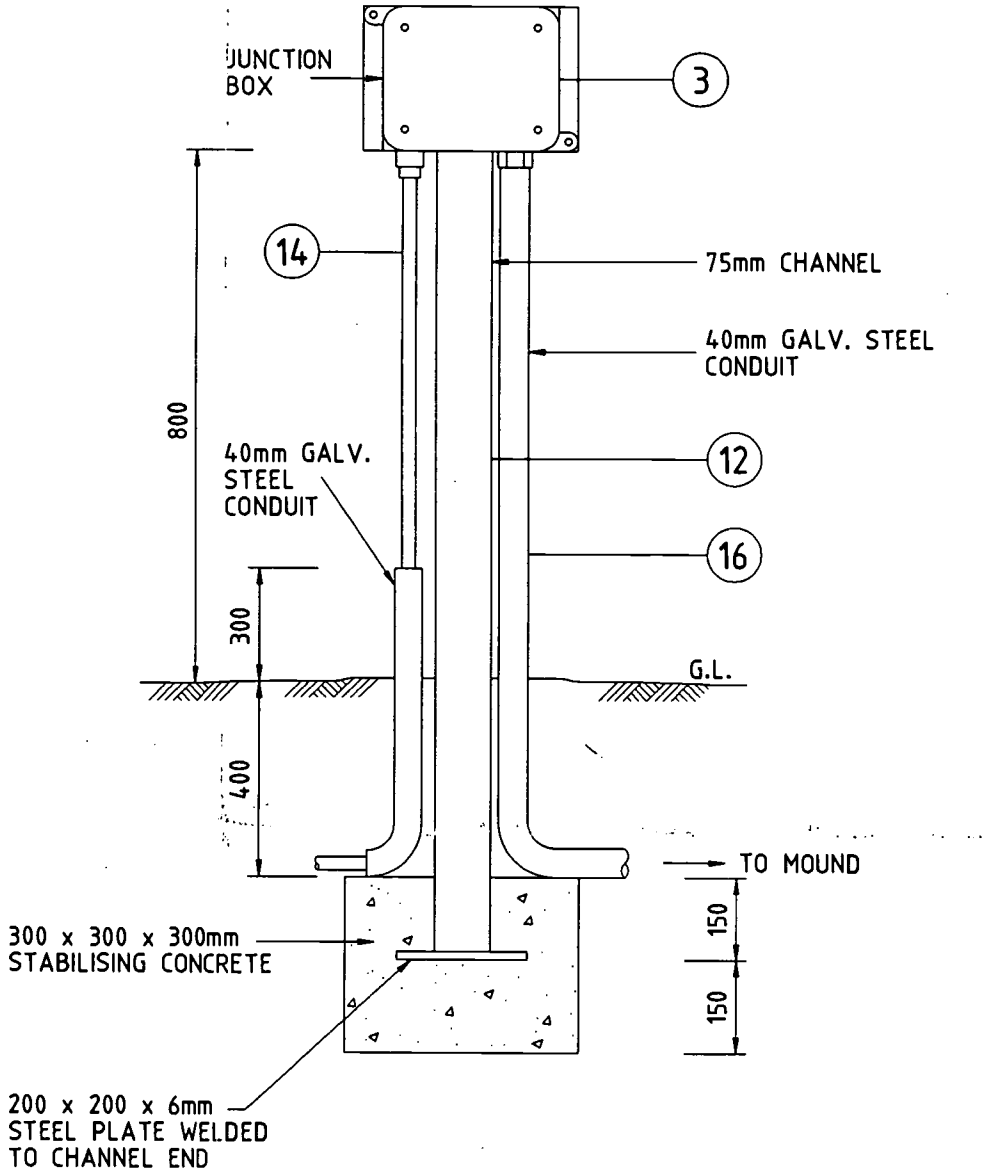




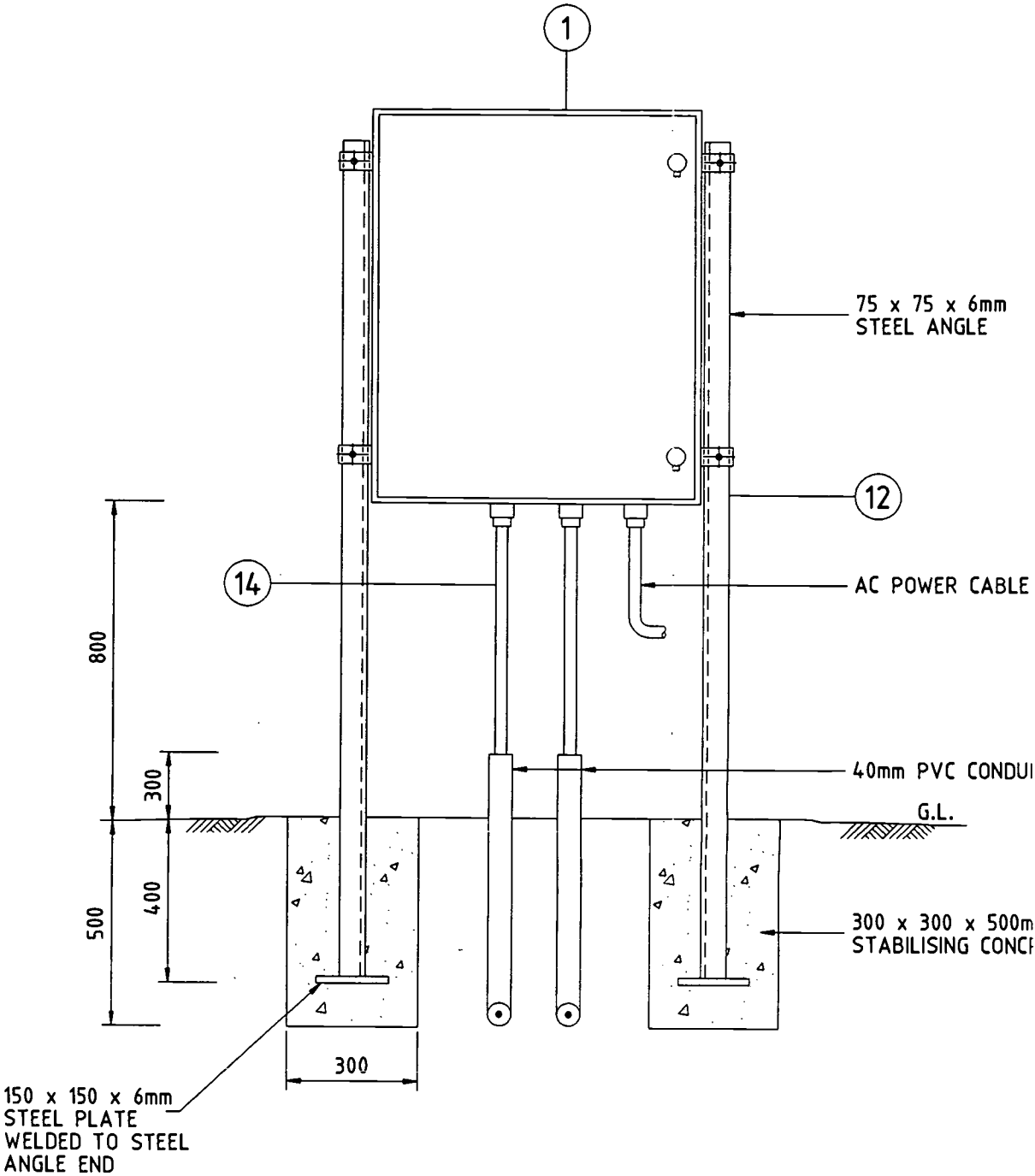


JUNCTION BOX JB1

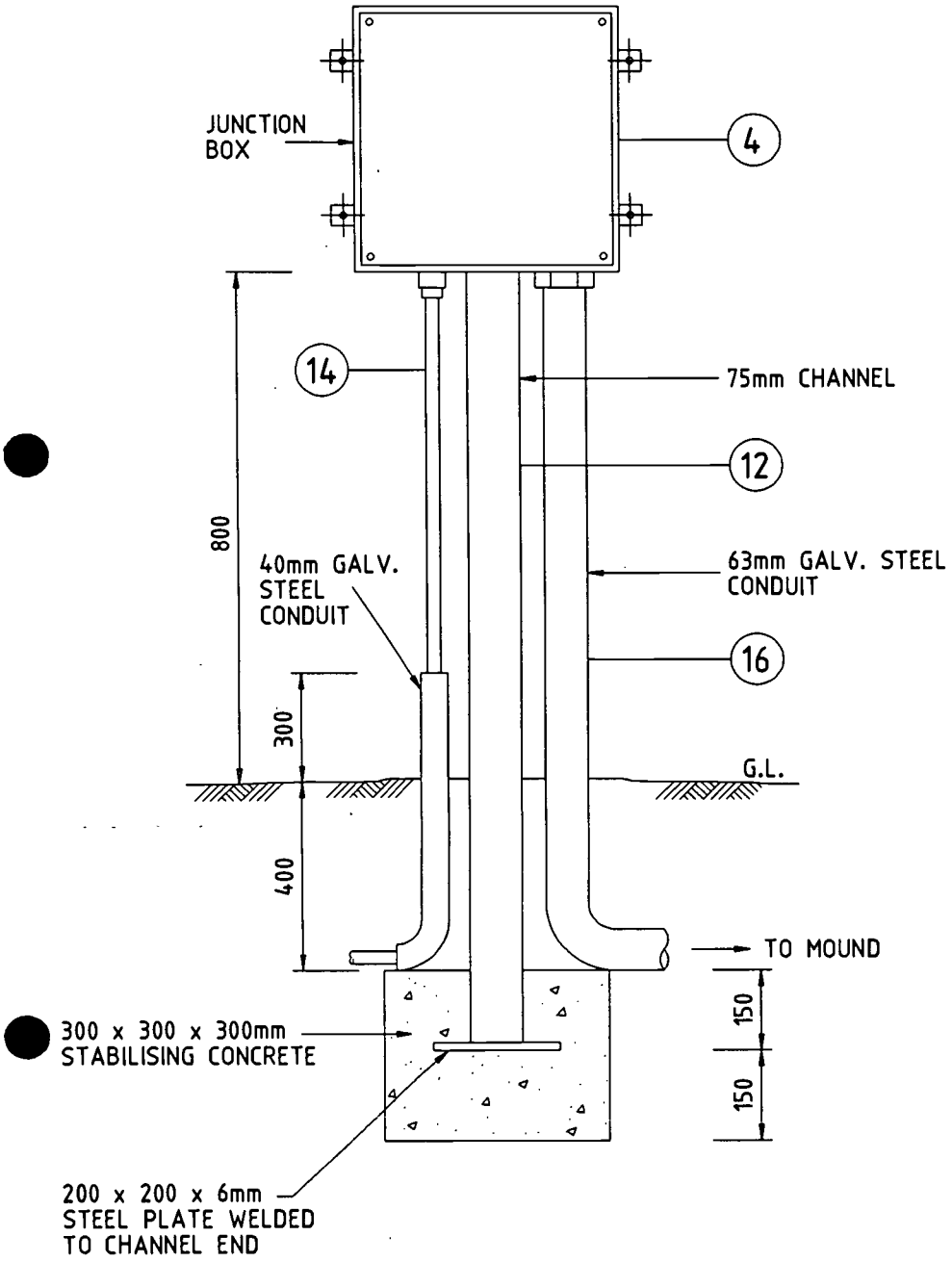
WESFARMERS KLEENHEAT GAS PTY LTD BULWER ISLAND QUEENSLAND MOUNDED LPG VESSELS CATHODIC PROTECTION SYSTEM TRANSFORMER UNIT AND JUNCTION BOX INSTALLATION	DRAWING No.	1932/DWG/05
	SHEET SIZE	A1
	REVISION	0
	SHEET 1 OF	1



JUNCTION BOX JB1



CATHODIC PROTECTION UNIT



JUNCTION BOX JB2

MATERIAL SCHEDULE

Item	Description	Qty	Remarks
1	30V, 10A DC output 240V, 50 Hz 1 phase transformer rectifier unit with monitoring facilities	1	
2	Anode (i) Anodeflex 1500 continuous anodes. (ii) Anodeflex end seals kits. (iii) Anodeflex in-line splice kits.	180m 4 4	Raychem
3	Junction box JB1 increased safety (Exe) type c/w terminals, entry holes and fittings	1	Crouse Hinds JBEC 221
4	Junction box JB2 increased safety (Exe) type c/w terminals, entry holes and fittings	1	Crouse Hinds JBE 331
5	Permanent copper/copper sulphate reference electrode c/w 15m cable tails	20	Borin Stelth 2 Model SRE-007-CUY
6	Permanent potential monitoring electrodes c/w cable tail	4	
7	E/R corrosion monitoring probes c/w cable tail	6	Cortest PR 1100
8	Corrosion probe test box	6	Everhard Industries
9	Zinc earth electrode 50 x 50 x 2000mm	4	
10	Chemical backfill for earth electrodes (25kg bag)	8	
11	Earth pit cover box	4	Gatic #714
12	Standpost for junction boxes and transformer rectifier unit	3	
13	Surge diverter	2	Critec IJP 230

Item	Description	Qty	Remarks
14	Cables (i) 2 x 1.5mm² with earth PVC/SWA/PVC cable (ii) 6 x 2.5mm² with earth PVC/SWA/PVC (iii) 7/0.3mm 16 pair overall screened cable (iv) 6mm² SDI PVC/PVC (read) cable (v) 6mm² SDI PVC/PVC (black) cable (vi) 2.5mm² SDI PVC/PVC (black) (vii) 2.5mm² PVC (white) building wire (viii) 35mm² G/Y earth cable	 5m 40m 40m 80m 50m 125m 600m 90m	
15	PVC conduit c/w fittings (i) 40mm (ii) 50mm (iii) 63mm	 As Required As Required As Required	
16	Galvanised steel conduit c/w fittings (i) 40mm (ii) 63mm	 As Required As Required	
17	Packing sand	As Required	
18	Surge diverter connection plate	4	
19	Cable connection plate	4	
20	Insulating flange kits class 300 (i) 100mm (ii) 80mm (iii) 50mm	 2 4 6	
21	UPVC polymeric cable cover strip	40m	
22	Cable marker tape	50m	
23	Miscellaneous including crimp lugs, cable glands, cable ties, insulating tape, nuts, bolts and washers, heat shrink sleeves, Denso primer petrolatum tape etc.	As Required	

PAD FILE: 1932-06

DESIGN	H.K.	SCALE	N.T.S.
DRAWN	M.B.	TRACED	
CHECKED	H.K.	PASSED	
APPROVED	P.C.		
DATE	18/6/96		

SOLOMON CORROSION CONTROL SERVICES P/L
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WESFARMERS KLEENHEAT GAS PTY LTD
BULWER ISLAND QUEENSLAND
MOUNDED LPG VESSELS
CATHODIC PROTECTION SYSTEM
MATERIALS SCHEDULE

DRAWING No. 1932/DWG/06

SHEET SIZE A3

REVISION 0

SHEET 1 OF 1

WESFARMERS KLEENHEAT GAS PTY LTD

BULWER ISLAND QUEENSLAND

MOUNDED LPG VESSELS

DESIGN, SUPPLY AND INSTALLATION OF CATHODIC PROTECTION SYSTEM

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1.0 INTRODUCTION

1.1 Solomon Corrosion Control Services Pty Ltd (SCCS) have been retained by Wesfarmers Kleenheat Gas Pty Ltd to provide the cathodic protection design and services for two (2) mounded LPG vessels proposed to be installed at Bulwer Island, Queensland.

1.2 This document details the design, materials schedule, materials specifications, installation drawings, testing and commissioning requirements for the proposed cathodic protection system.

2.0 APPLICABLE STANDARDS

The design, specifications, documents and drawings are in accordance with the following standards:

AS 2832 Guide to Cathodic Protection of Metals

AS 2430 Classification of Hazardous Areas

AS 1939 Degree of Protection Provided by Enclosures for Electrical Equipment (IP Code)

AS 3147 Approval and Test Specifications - Electrical Cables - Thermoplastic Insulated for Working Voltages up to and including 0.6/1kV.

3.0 SCOPE OF WORK

3.1 General

The design and documentation include the following:

3.1.1 Detailed design including calculations.

3.1.2 Materials schedule.

3.1.3 Materials specifications.

3.1.4 Installation specifications.

3.1.5 Installation drawings.

3.1.6 Testing and commissioning.

3.2 By Others

3.2.1 Provision of 240V single phase 50Hz AC power supply to the transformer rectifier unit.

3.2.2 All associated civil works which comprise of drilling 150mm diameter, 3 metre deep vertical holes for zinc earth electrodes, concreting of junction box and transformer rectifier unit stand posts, trenching for cables and conduits.

3.2.3 Installation of insulating flange kits supplied by SCCS.

3.2.4 Safe onsite storage for the cathodic protection materials.

3.2.5 Cranage facility if required for onsite unloading.

3.2.6 Welding of steel connection plates for cable attachments to the vessels and installation of surge diverters.

4.0 DESIGN PARAMETERS

The system design parameters are as follows:

4.1 Design life shall be 20 years.

4.2 The cathodic protection system shall be of impressed current type.

4.3 The monitoring system shall comprise of permanent copper/copper sulphate reference electrodes, permanent potential monitoring electrodes and electrical resistance corrosion probes.

4.4 The vessels shall be bonded together but isolated from other structures in contact with earth including copper earthing systems.

4.5 The tanks will be backfilled with clean sand having a resistivity no lower than 10,000 ohm-cm when dry, 5,000 ohm-cm when saturated with distilled water. The sand will be free from any sharp stones, clay or vegetation.

4.6 The vessels shall be earthed independently from the plant earth using zinc earthing electrodes.

4.7 Impressed current anodes shall be continuous anodes to provide uniform distribution of current and minimum resistance to the backfill.

4.8 The hold down bolts for the foundation plate shall be isolated from the steel reinforcement in the foundation.

4.9 The bullet shall have a high quality coating applied which shall be compatible with the cathodic protection system.

4.10 The transformer rectifier unit will be located not greater than 50 metres from the mound in a non-hazardous area.

5.0 PROTECTION CRITERIA

Protection criteria adopted for protection of vessels is in accordance with the Australian Standard AS 2832.2 - 1991, as given below:

(a) A negative polarised potential of at least 850mV relative to a saturated copper/copper sulphate reference electrode;

OR

(b) A minimum of 100mV of cathodic polarisation between the structure surface and a stable reference electrode contacting the electrolyte. The formation or decay of polarisation can be measured to satisfy this criteria.

Where possible, both the above criteria shall be satisfied.

To avoid detrimental effects on the external coating, cathodic protection 'off' potentials shall not be more negative than -1170mV versus $Cu/CuSO_4$.

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6.0 DESIGN CRITERIA AND CALCULATIONS

6.1 Design Criteria and Design Calculations

Design life	:	20 years
Sand backfill resistivity	:	21,000 ohm cm
Number of bullets	:	Two (2)
Surface area of the bullets	:	1263.8m^2
Coating efficiency	:	90%
Current density for bare area protection	:	25mA/m^2
Current required	:	126.38 x 25mA = 3.16A
Adding 20% for piping, earthing, saddles and hold down bolts etc.	:	0.632A
∴ Total current	:	3.16 + 0.632 = 3.792A ≈ 5A

Note: Initially the current requirement is likely to be extremely low with a good coating applied.

6.2 Anode Layout

Using continuous anodeflex 1500 anode:

Current output of anodeflex 1500 anode for a design life of 20 years	=	52mA/m
Length of anode	=	5000 ÷ 52
	=	96.15m

Using four (4) lengths of 45m each:

Total length of anode = 180m

Anode resistance = Ground factor x $\frac{\text{backfill resistivity (ohm cm)}}{1000}$

= $\frac{0.16 \times 21,000}{1000}$

= 3.36 ohms

Resistance of four (4) anodes in parallel:

= $3.36 \div 4$

= 0.84 ohms

6.3 Voltage Drop in Cables

Using 40m of 6 core x 2.5mm^2 cable between the transformer rectifier unit and the distribution junction box and 6mm^2 individual cable from the distribution junction box to the anodes and the negative connection to the vessels.

Voltage Drop in Positive Cable:

40m of 2.5mm^2 single conductor = $40 \times 7280 \times 10^{-6} \times 1.25$
= 0.364V

25m of 6mm^2 anode lead (longest) = $25 \times 3080 \times 10^{-6} \times 1.25$
= 0.1 volts

Voltage Drop in Negative Cable:

40 of 2.5mm^2 single conductor = $40 \times 7280 \times 10^{-6} \times 2.5$
= 0.728 volts

28m of 6mm^2 single conductor = $28 \times 3080 \times 10^{-6} \times 2.5$
(longest lead) = 0.22 volts

6.4 Transformer Voltage Requirement

	Transformer rectifier volts required	=	Volt drop through anodes + volt drop in cables + back emf
6.4.1	Volt drop through anodes	=	0.84 x 5
		=	4.2 volts
6.4.2	Volt drop in cables	=	0.364 + 0.1 + 0.728 + 0.22 volts
		=	1.412 volts
6.4.3	Back emf	=	2.0 volts
	Voltage required	=	4.2 + 1.412 + 2.0
		=	7.612 volts

Selecting 30V, 10A transformer rectifier unit.

6.5 Earthing Requirement

Using 50 x 50 x 2000mm zinc earth electrodes surrounded by gypsum/bentonite/sodium sulphate backfill, installed in 150mmØ x 3000mm deep vertical drilled hole in natural soil of resistivity 11000 ohm cm.

$$\text{Electrode resistance (R)} = \frac{\rho}{2\pi L}\left(\text{Ln}\ \frac{8L}{d} - 1\right)$$

Where:	R	=	Resistance in ohms		
	ρ	=	Resistivity of soil in ohm cm	=	11000 ohm cm
	L	=	Depth of chemical backfill column in cm	=	300cm
	d	=	Diameter of chemical backfill column in cm	=	15cm

By substituting the above values in the formula the electrode resistance is calculated as 23.8 ohm.

Using four (4) earth electrodes:

Combined earth electrode resistance	=	23.8 ÷ 4
	=	5.95 ohms

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7.0 SYSTEM DESCRIPTION

7.1 General

The cathodic protection system is an impressed current type. The design is based on the use of continuous anodes, evenly spaced around the bullet in the mound. Continuous anodes would provide an even spread of protection current.

This type of system also reduces the amount of current lost to foreign structures such as earthing systems and minimises the risk of interference effects.

30V, 10A transformer rectifier unit is utilised to provide power to the proposed cathodic protection system.

Protective current will be provided through the four (4) cores of 6 x 2.5m^2 PVC/SWA/PVC cable from the transformer rectifier unit to the distribution junction box (JB1) installed near the mound. From the distribution junction box (JB1) individual cables will distribute the current to the anodes. The current to the anodes shall be controlled by wire resistors installed in the transformer rectifier unit. This current will be picked up by the vessels' surface and returned to transformer rectifier unit via negative cables. Individual negative cables shall be installed from the vessels to the distribution junction box (JB1) and from distribution junction box (JB1) to transformer rectifier unit, two (2) cores of 6 x 2.5mm^2 PVC/JWA/PVC cable shall be utilised for the negative return current. With time a polarisation (protective) film will develop on the surface of the vessels.

7.2 Monitoring System

The monitoring system provided to monitor the effectiveness of cathodic protection system includes installation of twenty (20) permanent copper/copper sulphate reference electrodes, six (6) electrical resistance corrosion monitoring probes and four (4) permanent potential monitoring electrodes.

Cables from the reference electrodes and the permanent potential monitoring electrodes shall be terminated in the monitoring junction box (JB2). A multicore overall shielded cable shall be installed from the monitoring junction box (JB2) to the transformer rectifier unit for remote monitoring.

Cables from the electrical resistance corrosion probes shall be brought to corrosion probe test boxes installed on the top of the mound.

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7.3 Electrical Isolation

Vessels shall be electrically isolated from other structures. Double washer insulating flange kits shall be installed at the first flange for all offtakes from the vessels.

All shielding on instrumentation cable will be pulled back and left floating in the field.

7.4 Earthing System

Two (2) zinc earthing electrodes will be installed for each vessel external to the mound within vertical drilled holes and backfilled with a gypsum/bentonite/sodium sulphate backfill. The resistance of the earthing system shall be less than 10 ohms. Both the vessels shall be bonded together.

7.5 Surge Protection

Surge diverters shall be installed to mitigate sparking across insulating flange kits. One surge diverter per vessel shall be installed at connection N5. Surge diverter connection plates 3 x 50 x 50mm manufactured from mild steel shall be welded to pipes across the insulating flange for installation of surge diverters.

7.6 N1 and N2 Cable Connections Plate

Cable connection plates as per Drawing No. 1932/DWG/03 shall be welded to N1 and N2 risers of both vessels V1 and V2 for making cable connections to the vessels.

7.7 Cabling

Cables from the transformer rectifier unit to junction boxes will be laid directly in-ground or on the cable tray as per SAA wiring rules.

Cables from the junction boxes to the mound will be installed in PVC/steel conduits.

Cables within the mound will be laid directly in the sand.

Cables shall be terminated into junction boxes either through flame-proof cable glands or steel conduits.

8.0 MATERIAL SCHEDULE

Item	Description	Qty	Remarks
1	30V, 10A DC output 240V, 50 Hz 1 phase transformer rectifier unit with monitoring facilities	1	
2	Anode (i) Anodeflex 1500 continuous anodes. (ii) Anodeflex end seals kits. (iii) Anodeflex in-line splice kits.	 180m 4 4	Raychem
3	Junction box JB1 increased safety (Exe) type c/w terminals entry holes and fittings	1	Crouse Hinds JBEC 221
4	Junction box JB2 increased safety (Exe) type c/w terminals, entry holes and fittings	1	Crouse Hinds JBE 331
5	Permanent copper/copper sulphate reference electrode c/w 15m cable tails	20	Borin Stelth 2 Model SRE-007-CUY
6	Permanent potential monitoring electrodes c/w cable tail	4	
7	E/R corrosion monitoring probes c/w cable tail	6	Cortest PR 1100
8	Corrosion probe test box	6	Everhard Industries
9	Zinc earth electrode 50 x 50 x 2000mm	4	
10	Chemical backfill for earth electrodes (25kg bag)	8	
11	Earth pit cover box	4	Gatic # 714
12	Standpost for junction boxes and transformer rectifier unit	3	
13	Surge diverter	2	Critec IJP 230

8.0 Material Schedule continued

Item	Description	Qty	Remarks
14	Cables (i) 2 x 1.5mm² with earth PVC/SWA/PVC cable (ii) 6 x 2.5mm² with earth PVC/SWA/PVC (iii) 7/0.3mm 16 pair overall screened cable (iv) 6mm² SDI PVC/PVC (red) cable (v) 6mm² SDI PVC/PVC (black) cable (vi) 2.5mm² SDI PVC/PVC (black) (vii) 2.5mm² PVC (white) building wire (viii) 35mm² G/Y earth cable	 5m 40m 40m 80m 50m 125m 600m 90m	
15	PVC conduit c/w fittings (i) 40mm (ii) 50mm (iii) 63mm	 As required As required As required	
16	Galvanised steel conduit c/w fittings (i) 40mm (ii) 63mm	 As required As required	
17	Packing sand	As required	
18	Surge diverter connection plate	4	
19	Cable connection plate	4	
20	Insulating flange kits class 300 (i) 100mm (ii) 80mm (iii) 50mm	 2 4 6	
21	UPVC polymeric cable cover strip	40m	
22	Cable marker tape	50m	
23	Miscellaneous including crimp lugs, cable glands, cable ties, insulating tape, nuts, bolts and washers, heat shrink sleeves, Denso primer petrolatum tape, etc.	As required	

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9.0 MATERIALS SPECIFICATIONS

9.1 Transformer Rectifier Unit

9.1.1 Standards

All equipment and materials used in the manufacture of this rectifier shall comply with the requirements of the latest appropriate Australian Standards or Codes.

In particular, the latest revisions of the following standards and codes shall be observed:

AS2832.2-1991	-	Guide to Cathodic Protection of Metals Part 2: Compact buried structures.
AS3000	-	SAA Wiring Code.
AS2347	-	Power Transformers.
ASC320	-	Classification of Insulating Materials for Electrical Machinery and Apparatus.
AS1136	-	Switchgear and Control Gear Assemblies for Voltages up to 1000V AC.

9.1.2 Service Conditions

All equipment and materials supplied shall be suitable for operation in an outdoor marine environment under the following service conditions:

(i) Maximum ambient air temperature	-	45°C
(ii) Mean ambient air temperature over 24 hour period	-	35°C
(iii) Minimum ambient temperature	-	-5°C
(iv) Altitude not exceeding	-	1000 metres

9.1.3 Electrical Requirement

The unit shall be air cooled and have 240 volt ± 10%, single phase, 50 Hertz AC input and 0-30V, 10A DC output. The main AC incoming circuit shall be fitted with a moulded case circuit breaker of the appropriate rating.

An HRC fuse of appropriate size shall be installed in the negative of DC output.

The output shall be variac controlled over the complete design range and shall remain substantially constant at any setting for a constant load resistance.

The DC output shall be an AC ripple of less than 5% RMS at both full rated current and voltage conditions and at full rated current and 50% rated voltage conditions.

Analogue meters shall be installed to read output voltage and current. They shall have a full scale length of 70mm and a maximum overscale of 20% and a minimum accuracy of 2% or better.

Wiring within the cubicle shall be colour coded and numbered to allow easy infield tracing. Wiring shall be terminated using appropriate crimp lugs and rail mounted terminal blocks.

The polarity of the DC terminals and AC supply cables shall be clearly marked at the termination points.

The unit shall provide four (4) positive and two (2) negative outputs. Extra terminals shall be provided for the positives to inert wire resistors for control of positive current.

9.1.4 Labels and Markings

All circuit breakers, fuses, main AC & DC termination points, switches, meters and indicators shall be clearly labelled for easy identification.

A rating label shall be fixed to the inside of the door of the cubicle with the following lettering:

(i) Manufacturer's name and address
(ii) Date of manufacture
(iii) Rated AC input
(iv) Rated DC output
(v) Output ripple.

9.1.5 Surge Protection

Voltage surge diverters shall be installed for lightning protection. Metal oxide varistors shall be installed on input and output and gas filled suppressors on the output positive and negative poles.

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9.1.6 Interruption

The DC output shall be capable of cyclic interruption by an internally mounted static current interrupter which is capable of switching the full output current of the unit. The 'on' and 'off' interrupter time cycles shall be independently adjustable from 1 to 99 seconds.

9.1.7 Potential Monitoring Facilities

A facility for monitoring the "Instant Off" potential of the vessels and simulated coating defects shall be provided inside the transformer rectifier cubicle for 20 references and 4 simulated coating defects. Rotary selector switches shall be installed to select either of the two vessels and circuits for measurement of potential with respect to 10 references and 2 simulated coating defects for each vessel.

The facility shall have a potential measurement circuit with an input resistance of more than 10 meg ohms.

The potential shall be displayed by 3.5 digit LCD voltmeter to allow accurate readings across the entire voltage range.

9.1.8 Cabinet

The cubicle shall be dustproof and weatherproof offering protection to conform with IP56, constructed from 2mm zinc coated MS sheet and suitable for outdoor installation in marine environment. Paint finish shall be ultra violet resistance wet spray grey 631 to AS K185.

All nuts, bolts, screws or washers shall be of stainless steel. All bolted or screwed components shall be fitted with shake proof washers.

The transformer rectifier unit shall be wall or standpost mounted.

The rectifier shall be designed to incorporate a gland plate on the bottom of the unit.

The gland plate shall be fitted with a weatherproof gasket and shall be firmly fixed in position.

9.1.9 Alarm

The unit shall provide voltage free change over contacts (NC & NO) for initiating an alarm when the transformer rectifier unit output is zero.

9.1.10 Operation Instructions and Maintenance Handbook

The unit shall be supplied complete with three (3) operating manual/maintenance handbooks which shall include, in addition to the manufacturer's instruction the following data:

(i) A copy of the acceptance test data and certificate.

(ii) Drawings showing:

- Outline and GA
- Schematic Diagram

9.1.11 Testing

The rectifier shall be accepted subject to successful completion of approval testing. The unit shall be inspected and tested at the place of manufacture, at the option of the purchaser. The tests shall be carried out in the presence of the representative of the purchaser, or as directed and shall include the following:

(a) Insulation resistance test on the AC and DC circuits.
(b) Heat run test at full load.
(c) AC ripple content in the DC output.

9.1.12 Remote Monitoring Facility

Voltage and current output terminals shall be provided for remote monitoring. The transformer rectifier unit cabinet shall be able to accommodate the transducers and the transmitting hardware to be installed later by others.

9.2 Anode

The anode shall be Raychem's anodeflex 1500 polymeric anode. The conductive polymer is extruded over #6AWG copper conductor. The anode is wrapped in a porous woven jacket which is packed with a high performance petroleum coke breeze.

Nominal diameter	:	38.1mm
Recommended maximum design current output in soil	:	52mA/m
Minimum installation temperature	:	0°C

9.3 Junction Box (JB1)

The junction box shall be increased safety (Exe) Crouse-Hinds JBEC Marshalling box or approved equivalent.

Specifications:	Catalogue No:	JBEC 221
	Type of protection:	Exn
	Dimensions:	200 x 200 x 120mm
Standard Materials:	Body and cover:	cast copper free aluminium
	Cover screws:	stainless steel
Gasket:	Neoprene	
Standard finish:	Polyurethane grey.	

The junction box shall be complete with cable entries, cable glands, terminals and label as per details given below.

Cable entries	-	1 no. x 40mm
	-	1 no. x 25mm
Cable glands	-	1 no. suitable for 6 x 2.5mm^2 PVC insulated, PVC sheathed SWA copper conductor cable (OD 19.2mm).
Terminals	-	The junction box shall be complete with following sets of Klippon feed through terminals (type SAK 6N) including rail, end plate, etc. for termination of cables.
		1 set of 6 terminals.
Label	-	Junction box JB1.

9.4 Junction Box (JB2)

The junction box will be increased safety (Exe) Crouse-Hinds JBE Marshalling Box or approved equivalent.

Specifications:	Catalogue No:	JBE 331
	Dimensions:	300 x 300 x 150
Standard Materials:	Body and cover:	Mild street
	Cover Screws:	Stainless steel

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Gasket: Neoprene

Standard finish: Powder polyester coated.

The junction box will be complete with cable entries, cable glands and terminals as per details given below:

Cable entries - 1 no. x 25mm

- 1 no. x 63mm

Cable glands - 1 no. Suitable for 16 pair x 7/0.30mm PVC insulated, PVC sheathed, overall screened copper conductor cable (OD 16.9mm).

Terminals - The junction box will be complete with following sets of Klippon feed through terminals (Type SAK 2.5) including rails, end plate, base plate etc. for termination of cables.

2 sets of 15 terminals each with a shorting link for 3 terminals.

These sets be arranged in such a way as to allow adequate room for terminal of cables.

9.5 Copper/copper Sulphate Reference Electrodes

Stelth 2 Model SRE-007-CUY $Cu/CuSO_4$ reference electrode for underground service.

Size: 3.81cm diameter x 15.24 cm long ceramic tube with yellow protective caps.

Lead wire: 15m of #14 RHH-RHW yellow wire.

Stability: ± 10 millivolts with 3.0 microamps load.

Temperature range: 32° to 135° F (0° to +57.2° C)

9.6 Permanent Potential Monitoring Electrodes

The permanent potential monitoring electrode shall comprise of simulated coating defect 25mm in diameter. Each defect will be mounted in a PVC facility and connected to an integral cable tagged with an identification number.

Cable: 2 core x 0.75mm^2 PVC insulated flexible cord to AS 3191.

PPMEI	=	52m
PPME2	=	33m
PPME3	=	56m
PPME4	=	39m

Seal: Epoxy resin

9.7 Corrosion Probe

The corrosion probe shall be Cortest electrical resistance (E/R) underground probe PR 1100 or approved equivalent.

It shall have a flat strip sensing element of 0.25mm thickness made of carbon steel material (AISI 1018) and a separate grounding cable that allows a direct link to the structure.

The PR-1100 probes shall be complete with following lengths of cable:

CP1 and CP4	-	11.0m
CP2, CP3, CP5 & CP6	-	7.6m

Specifications:

Temperature rating	:	58° maximum
Pressure rating	:	100 PSI/0.7 MPa maximum
Seal material	:	Epoxy adhesive
Body material	:	Glass filled epoxy.

9.8 Corrosion Probe Test Box

The corrosion probe test box shall be Everhard Industries small meter/valve control box or equivalent.

It shall be injection moulded from high density, UV stabilised, black polyethylene.

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9.9 Zinc Earth Electrode

The zinc earth electrode shall comprise of steel cored zinc of 99.99% purity manufactured to AS 2239.

Specifications:	Dimensions:	50 x 50 x 2000mm
	Steel core:	12mm diameter

9.10 Earth Pit Cover Box

The earth pit cover box shall be of cast iron Gatic Product No. 714 or equivalent with a clear opening diameter of 152mm.

9.11 Surge Diverter

The surge diverter to be installed across insulating fittings shall be the CRITEC insulating joint protector (IJP 230) or equivalent.

The insulating joint protector shall consist of a heavy duty gas filled arrestor contained within an explosion proof brass housing. The brass housing is to be covered with a tough UV resistant insulating sheath and will be suitable for installation in explosive environments.

Specifications:

Rated DC breakdown voltage	:	230V
Breakdown voltage tolerance	:	± 15%
Surge breakdown voltage 1kV/us	:	<1000V
Arc voltage (conducting sate)	:	<20V
Insulation resistance (inactive state)	:	$>10^{10}$ ohms
Capacitance	:	<10pF
Rated impulse surge current (8/20us)	:	100kA
Lifetime	:	>10000 strikes
Dimensions	:	100mm (L) x 25mm (diameter)
Case material	:	Brass with insulating sheath
Lead length	:	2 x 250mm, 16mm^2 conductor
Terminals	:	8mm diameter (6mm static drain)
Static drain	:	450mm, 1mm^2 conductor

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9.12 Cables

All the cables shall be manufactured to relevant Australian Standards.

Cable type, size and lengths shall be as per Attachment 1.

9.13 PVC Conduit and Fittings

PVC conduit shall be HD rigid PVC conduit complying with AS 2053, colour shall be either UV stabilised grey or orange.

9.14 Galvanised Steel Conduit and Fittings

Galvanised steel conduit shall be manufactured to AS 2052 and shall have heavy protection for installation in salt laden atmosphere.

9.15 Insulating Flange Kits

The insulating flange kits shall comprise of following:

Flange Gaskets:

The flange insulation gaskets shall be neoprene faced phenolic, type E gaskets.

Insulating Washers:

The insulating washers shall be made of high strength phenolic and provide tough positive insulation at temperatures to +150°C.

Specifications:

Thickness:	3.2mm
Dielectric strength:	500V/mil
Compressive strength:	26,000 psi
Water absorption:	1.0% maximum
Maximum operating temperature:	+150°C

Insulating Sleeves:

The insulating sleeves shall be spiral wound mylar, have dielectric strength of 4,000 volts/mil and suitable for maximum operating temperature of 150°C.

9.16 UPVC Polymeric Cable Cover Strip

Polymeric cable cover strip shall be of a material equivalent to UPVC conduit complying with AS 2053 having a thickness not less than 3mm. The width of the strip shall not be less than 150mm.

9.17 Standposts

Standposts shall be of structural steel and shall be hot dip galvanised to AS 1650-1989 after the fabrication.

9.18 Cable Marker Tape

The cable marker tape shall be orange in colour and comply with AS 2648.1.

10.0 INSTALLATION SPECIFICATIONS

10.1 General

10.1.1 The work shall be carried out strictly in accordance with Kleenheat safety procedures.

10.1.2 No work shall be commenced without obtaining a work permit.

10.1.3 The cathodic protection system shall be installed in accordance with standards and codes as per Section 2.0 and the specific requirements in this section.

10.1.4 The installation of cathodic protection system shall be carried out by a trained and qualified personnel to ensure its compliance with drawings and specifications.

10.1.5 The installation of cathodic protection system shall be carried out in close co-operation with the other contractors working at site.

10.1.6 Proper storage arrangement shall be made at site to avoid damage and contamination of material.

10.2 Material Inspection

Inspection of all materials to be used in cathodic protection system shall be undertaken. Prior to installation, all material shall be examined as follows:

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10.2.1 Transformer rectifier shall be checked for visual damage, loose connections and components.

10.2.2 Anodes shall be checked for signs of handling abuse. Damaged anodes shall be repaired/replaced.

10.2.3 Junction boxes shall be checked for any visual damage and completeness of fittings such as cable glands, size and number of entries. Junction boxes to be installed in classified areas shall be checked for certification.

10.2.4 All the cables shall be carefully examined for insulation flaws, size, type and lengths.

10.2.5 Corrosion monitoring probes, permanent reference electrodes and permanent potential monitoring electrodes shall be examined for any visual damage and damage to the lead wires.

10.2.6 Miscellaneous material such as splice kits, corrosion probe test box, earth pit cover box, earth electrodes, surge protectors PVC conduit, galvanised conduit, cable glands etc. shall be checked for any visual damage, size and quantity.

10.3 Installation

10.3.1 Transformer Rectifier Unit

Transformer rectifier unit shall be installed so as to be easily accessible for maintenance and inspection. Care must be taken to avoid shock loading of the transformer rectifier unit as internal damage can occur.

The rectifier cabinet shall be separately grounded for safety.

Cable connections to the rectifier must be mechanically secure and electrically conductive. Before the power source is energised, it must be verified that the negative is connected to the structure to be protected and the positive is connected to the anodes.

10.3.2 Anodes

Anodeflex anodes shall be cut to the required lengths and provided with end seals and inline splices as per manufacturer's recommendations.

Anodes shall be installed at specified locations and to specified depths as per drawings. Care shall be taken so that lead wires and connections are not damaged

during backfill operations. Lead wire shall have enough slack to prevent strain. Anodes shall not be carried or pulled by the lead wire.

10.3.3 Junction Boxes

Junction boxes shall be located as indicated on drawings and shall be securely fixed in position. The cable entries to the junction boxes will be either through flameproof cable glands or steel conduits.

Steel wire armoured cables shall be terminated through flameproof cable glands and PVC/PVC cables shall be terminated through steel conduits. The junction boxes shall be earthed and connected to the nearest earth grid.

10.3.4 Cable Installation and Connections

All cable shall be laid as per drawings and AS 3000. Cables between transformer rectifier unit and the junction boxes shall be laid direct in the ground. UPVC polymeric cable cover strip shall be provided over the cable for mechanical protection. A cable marker tape shall be laid within the cable trench directly above the buried cable approximately 200mm below the finish surface of the ground for the entire length of the underground cable.

Cable entry conduits shall be installed as per drawings for cables entering or emerging from ground.

Cables from the junction boxes to the entry point to the mound shall be installed in galvanised conduit. All cables in the mound shall be laid directly in sand.

The cable connections to the vessels shall be as indicated on the drawings. The cable connections shall be made using cable lugs, stainless steel bolts, nuts and serrated washers. The electrical connection, shall be protected against corrosion using Denso mastic/tape.

Sufficient slack shall be left to avoid strain on all the wire and cables.

10.3.5 Electrical Resistance Probes

Prior to installation, the protective packaging shall be removed. The sand shall be fully compacted along the surface of the exposed element. The elements shall be aligned to face the same direction as the vessel surface. The cable connection to probe is an integral factory installed item. The multicore cable attached to the probe is provided with plug for electrical resistance measurement. A green single core cable is attached to the plug for making probe connection to the structure.

Both these cables are brought to the probe test box. The multicore cable with the plug shall be clamped onto the wall of the probe test box. The green single core cable shall be connected to 2.5mm^2 PVC/PVC single core cable in the probe test box as an extension for termination to the nearest connection plate.

10.3.6 Permanent Reference Electrodes, Permanent Potential Monitoring Electrodes

Permanent $Cu/CuSO_4$ reference electrodes and permanent potential monitoring electrodes shall be installed as per drawings. The lead wires shall be brought to monitoring junction box JB2. Sufficient slack shall be left to avoid strain on the lead wires.

10.3.7 Earthing of the Vessels

The earthing of vessels shall be carried out as per drawings.

10.3.8 Clean Up

The work area shall be restored to the original condition to the satisfaction of installation supervisor. The work area also includes locations used for access and storage of equipment and materials. Excess material as well as all scrap and debris shall be picked up and removed.

11.0 TESTING AND COMMISSIONING REQUIREMENTS

11.1 All testing and commissioning shall be performed by a fully qualified and experienced engineer and technician.

11.2 Commissioning and testing shall include the inspection and electrical measurement necessary to determine that protection has been established according to the applicable criteria and each part of the cathodic protection system is operating properly.

11.3 Commissioning shall include but not be limited to the following:

11.3.1 Visual examination of all system components, checking of all cable connections and polarity.

11.3.2 Installed anode resistance tests.

11.3.3 Continuity tests.

11.3.4 Isolation tests.

11.3.5 Transformer rectifier function tests.

11.3.6 Natural potential survey.

11.3.7 'On'/'Off' potential surveys

11.3.8 Interference tests and clearance from the electrolysis committee.

11.3.9 Corrosion probe monitoring tests.

11.4 Adequate time shall be allowed for polarisation of vessels before finally adjusting the protection levels.

11.5 A record of all tests shall be kept and a complete test record and report shall be submitted.

12.0 LIST OF DRAWINGS

The following drawings shall be considered as part of this document.

1.	Drawing No. 1932/DWG/01	Wesfarmers Kleenheat Gas Pty Ltd Bulwer Island Queensland Mounded LPG Vessels Cathodic Protection System General Arrangement - Plan view
2.	Drawing No. 1932/DWG/02	As above General Arrangement - Sectional views
3.	Drawing No. 1932?DWG/03	As above Installation details
4.	Drawing No. 1932/DWG/04	As above Electrical Schematic
5.	Drawing No. 1932/DWG/05	As above Transformer unit and junction box installation.
6.	Drawing No. 1932/DWG/06	As above Materials Schedule

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ATTACHMENT 1

CABLE SCHEDULE - Page 1 of 6

Cable Ref	Cable Route		Cable Details				Remarks
	Origin	Destination	Cores	Size (sq mm)	Length (m)	Cable Type	
1	Street light junction box	Cathodic protection unit	2	1.5	5	PVC/SWA/PVC	Incoming AC cable
2	Cathodic protection unit	Junction box JB1	6	2.5	40	PVC/SWA/PVC	
3	Cathodic protection unit	Junction box JB2	32	7/0.3	40	Overall screened	
4	Junction box JB1	Anode A1	1	6	14	PVC/PVC	Red
5	Junction box JB1	Anode A2	1	6	19	PVC/PVC	Red
6	Junction box JB1	Anode A3	1	6	23	PVC/PVC	Red
7	Junction box JB1	Anode A4	1	6	24	PVC/PVC	Red
8	Junction box JB1	Connection plate N1 Vessel V1	1	6	22	PVC/PVC	Black
9	Junction box JB1	Connection plate N1 Vessel 2	1	6	28	PVC/PVC	Black
10	Junction box JB2	Connection Plate N1 Vessel V1	1	2.5	22	PVC/PVC	Black
11	Junction box JB2	Connection Plate N1 Vessel V2	1	2.5	28	PVC/PVC	Black
12	Junction box JB2	Reference Electrode R1	1	2.5	7	Building wire	Extension to reference electrode lead wire

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ATTACHMENT 1

CABLE SCHEDULE - Page 2 of 6

Cable Ref	Cable Route		Cable Details				Remarks
	Origin	Destination	Cores	Size (sq mm)	Length (m)	Cable Type	
13	Junction box JB2	Reference Electrode R2	1	2.5	13	Building wire	Extension to reference electrode lead wire
14	Junction box JB2	Reference Electrode R3	1	2.5	17	Building wire	Extension to reference electrode lead wire
15	Junction box JB2	Reference Electrode R4	1	2.5	13	Building wire	Extension to reference electrode lead wire
16	Junction box JB2	Reference Electrode R5	1	2.5	25	Building wire	Extension to reference electrode lead wire
17	Junction box JB2	Reference Electrode R6	1	2.5	31	Building wire	Extension to reference electrode lead wire
18	Junction box JB2	Reference Electrode R7	1	2.5	40	Building wire	Extension to reference electrode lead wire
19	Junction box JB2	Reference Electrode R8	1	2.5	36	Building wire	Extension to reference electrode lead wire
20	Junction box JB2	Reference Electrode R9	1	2.5	42	Building wire	Extension to reference electrode lead wire

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CABLE SCHEDULE - Page 3 of 6

Cable Ref	Cable Route		Cable Details				Remarks
	Origin	Destination	Cores	Size (sq mm)	Length (m)	Cable Type	
21	Junction box JB2	Reference Electrode R10	1	2.5	48	Building wire	Extension to reference electrode lead wire
22	Junction box JB2	Reference Electrode R11	1	2.5	13	Building wire	Extension to reference electrode lead wire
23	Junction box JB2	Reference Electrode R12	1	2.5	19	Building wire	Extension to reference electrode lead wire
24	Junction box JB2	Reference Electrode R13	1	2.5	23	Building wire	Extension to reference electrode lead wire
25	Junction box JB2	Reference Electrode R14	1	2.5	19	Building wire	Extension to reference electrode lead wire
26	Junction box JB2	Reference Electrode R15	1	2.5	30	Building wire	Extension to reference electrode lead wire
27	Junction box JB2	Reference Electrode R16	1	2.5	37	Building wire	Extension to reference electrode lead wire
28	Junction box JB2	Reference Electrode R17	1	2.5	46	Building wire	Extension to reference electrode lead wire

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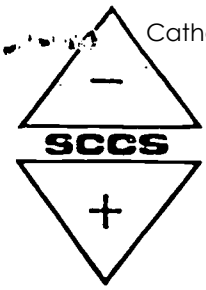
CABLE SCHEDULE - Page 4 of 6

Cable Ref	Cable Route		Cable Details				Remarks
	Origin	Destination	Cores	Size (sq mm)	Length (m)	Cable Type	
29	Junction box JB2	Reference Electrode R18	1	2.5	41	Building wire	Extension to reference electrode lead wire
30	Junction box JB2	Reference Electrode R19	1	2.5	47	Building wire	Extension to reference electrode lead wire
31	Junction box JB2	Reference Electrode R20	1	2.5	53	Building wire	Extension to reference electrode lead wire
32	Junction box JB2	Permanent potential monitoring electrode PPME1	2	0.75	52	Flexible cord	Cable is integral part of PPE
33	Junction box JB2	Permanent potential monitoring electrode PPME2	2	0.75	33	Flexible cord	Cable is integral part of PPE
34	Junction box JB2	Permanent potential monitoring electrode PPME3	2	0.75	56	Flexible cord	Cable is integral part of PPE
35	Junction box JB2	Permanent potential monitoring electrode PPME4	2	0.75	39	Flexible cord	Cable is integral part of PPE



ATTACHMENT 1

CABLE SCHEDULE - Page 5 of 6

Cable Ref	Cable Route		Cable Details				Remarks
	Origin	Destination	Cores	Size (sq mm)	Length (m)	Cable Type	
36	Corrosion Probe CP1	Test box 1	-	-	11	-	Cable is integral part of corrosion probe
37	Corrosion Probe CP2	Test box 2	-	-	7.6	-	Cable is integral part of corrosion probe
38	Corrosion Probe CP3	Test box 3	-	-	7.6	-	Cable is integral part of corrosion probe
39	Corrosion Probe CP4	Test box 4	-	-	11	-	Cable is integral part of corrosion probe
40	Corrosion Probe CP5	Test box 5	-	-	7.6	-	Cable is integral part of corrosion probe
41	Corrosion Probe CP6	Test box 6	-	-	7.6	-	Cable is integral part of corrosion probe
42	Test box 1	Connection plate N1 Vessel V1	1	2.5	9	PVC/PVC	
43	Test box 2	Connection plate N1 Vessel V1	1	2.5	19.5	PVC/PVC	