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Discipline

Engineering Standard – NSW

Category

Signalling

Title

Lightning and Surge Protection Requirements

Reference Number

SCP 04 – (RIC Standard: SC 00 17 00 00 SP)

Document Control

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About This Standard

The prime objective of this document is to specify the performance requirements for the lightning and surge protection of the signalling system so that the signalling system can meet its required availability using a cost effective level of maintenance, without a reduction in the safety of the signalling system.

Document History

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List of Amendments –

ISSUE	DATE	CLAUSE	DESCRIPTION
1.1		31/08/2004	Reformatting to ARTC Standard
1.2	14/03/2005	Disclaimer	▪ Minor editorial change ▪ Footer reformatted

Contents

1 Introduction

This Specification details the general requirements for Lightning and Surge Protection provided for ARTC's Railway Signalling systems.

The prime objective of this document is to specify the performance requirements for the lightning and surge protection of the signalling system so that the signalling system can meet its required availability using a cost effective level of maintenance, without a reduction in the safety of the signalling system.

The Appendices are provided as reference material. The Appendices detail a pre-existing approved method of achieving most of the required surge protection performance for average conditions.

2 Applicable Documents

2.1 International Standards

This Specification refers to the following international Specifications and Standards:

IEC 587-1994	Test methods for evaluating resistance to tracking and erosion of an electrical insulating material.
ANSI/IEEE C 62.4	Guide for Surge Voltages in low voltage AC power circuits - major feeder short branch circuit service panel (indoor)

2.2 Australian Standards

This Specification refers to the following Australian Standards:

AS 1768/1991:	Lightning Protection
AS 3000/1991:	Electrical Installations-Building, Structures & Premises

2.3 ARTC Specifications & Standards

This Specification refers to the following ARTC signalling standard Specifications and Standards:

1) Lightning/Surge Protection-Varistor/Arrestor Panel(VAP): Specification SPS 35.

2) Lightning/Surge Protection - Varistor Panel (VP): Specification SPS 36.

3) Lightning/Surge Protection-Power Inductor (PI): Specification: SPS 37.

4) Lightning Protection - Inductor/Varistor/Arrestor Panel (IVAP): Specification SC 091505 00 SP.

5) Lightning/Surge Protection-Line Protection Unit (LPU): Specification SPS 38.

6) Lightning/Surge Protection-Inductor/Diverter Panel(IDP): Specification: SPS 39

7) Circuit Design Standards SDS 25

3 Abbreviations & Definitions

Council (Supply Authority) Earth

Railway Electrical Supply Earth

Railway Electrical Supply Earth High Voltage

Earth Potential Rise

Diverter Panel Inductor/Diverter Panel

Inductor/Varistor/Arrestor Panel

Line Protection Unit

Load Cell Protector

Signalling Earth (same as S&CES)

Signals & Communications Earthing System Varistor/Arrestor Panel

Varistor Panel

Generic term for the process of Exothermic welding

The Infrastructure Owner, Australian Rail Track Corporation

A person, company or authority nominated by ARTC to make engineering determinations on ARTC's behalf.

The person, company or authority responsible for providing protection in accordance with this specification.

Electronic equipment	Electronic equipment is defined as equipment that has more than 5% of its electrical parts as electronic components. Electronic components are considered to be semi-conductor based devices, and capacitors.
Electro-mechanical equipment	Electro-mechanical equipment is defined as equipment that primarily contains inductors, electric motors, solenoids, relays, contactors, switches, resistors, etc.
Electrical equipment	Electrical equipment is considered to be either Electronic equipment or Electro-mechanical equipment. If there is any doubt as to the type of a particular item of equipment then it will be considered to be electronic equipment.
Protection earth	An earth provided for lightning and surge protection purposes.
Equipment earth	An earth provided to an item of equipment for shielding or purposes other than surge protection.
Location	A small building or protective enclosure inside which

	equipment is installed. The terms relay room, walk-in hut, bungalow, location case, equipment cupboard, trackside locations are types of location.
Main location	A critical location, or a location containing significantly more than the average quantity of equipment.
Transient earth clamp	Also known as a differential earth clamp. It is used to limit the potential difference between two separate earths.
Surge	A transient electrical overload condition due to external influences. A surge includes overloads and transient conditions due to lightning, power supply switching, and fault conditions appearing at interfaces.
Category A pulse	A test surge pulse as defined in AS 1768
Category B pulse	A test surge pulse as defined in AS 1768
Category C pulse	A test surge pulse as defined in AS 1768.

4 Railway Signalling Environment

4.1 General

The railway signalling environment consists of a large number of diverse types of equipment with complex interconnections spread out alongside a railway line, and housed in exposed equipment locations.

The railway line and the structures around the railway line tend to attract lightning strikes.

4.2 Safety

The Railway signalling system is a safety system. Care must be taken to ensure that the surge protection provided cannot create an alternative path between items of signalling equipment as this may cause a significant hazard to personnel and property.

The lightning and surge protection must be considered as part of the ‘fail-safe’ signalling system.

4.3 Equipment locations

Signalling equipment locations are situated adjacent to the railway tracks. They include brick or concrete buildings (relay room, huts, etc), and metal track-side cupboards. In the metropolitan area, these signalling equipment locations are fairly well protected against direct lightning strikes because of the 1500VDC overhead wire structure and 240VAC/2.2KV/11KV transmission lines. But extremely high surges can be experienced on the power supply feeders.

4.4 Types of Equipment requiring protection

Two general types of electrical signalling equipment require surge protection. In this specification these are termed electronic equipment and electro-mechanical equipment.

The electronic equipment requires a greater level of protection from surges than that required for the electro-mechanical equipment.

Some of the existing equipment and systems currently in use as part of railway signalling system are as follows. Note that these equipment types will vary as new technology is introduced.

Equipment	**Type**
DC Power supplies, linear	Electro-mechanical
DC Power supplies, switchmode	Electronic
Track monitoring systems: hot box detectors, dragging equipment	Electronic
Axle-counter systems	Electronic
Telemetry systems	Electronic
Computer Based Interlockings	Electronic
Event loggers	Electronic
Impulse track circuit transmitters	Electronic
Impulse track circuit relays	Electro-mechanical
Audio Frequency track circuit tuning units	Electronic
Audio Frequency track circuits (CSEE, ABB TI 21, WBS FS2500, WBS FS2600)	Electronic
AC and DC track circuits	Electro-mechanical
Coded track circuits	Electronic
Level crossing monitors, level crossing flashers	Electronic
Point machines.	Electro-mechanical
Colour light signal	Electro-mechanical
Train stops	Electro-mechanical
Cables (Telecommunications, power, data)	Electro-mechanical

4.5 Entry points for lightning and surges

In the railway signalling environment lightning and/or surges occur, enter, or are induced into the signalling system through one or several of the following:

- Power supply entry points 240VAC or 120VAC (derived from overhead 33KV/11KV/2.2KV transmission/distribution systems)
- 240VAC or 120V AC power supply aerial cables (in the country areas)
- 240VAC or 120V AC power supply cables
- Overhead 1500VDC traction wire structure in the electrified area
- rails and track connections into signalling equipment locations
- signalling control and indication circuit cables connecting to field equipment
- communication lines
- communication equipment on high masts
- ground as a result of Earth Potential Rise
- induction in power supply/communications/control wiring etc.

Typically the electrical insulation of wiring has a higher breakdown voltage than normal and therefore higher surge voltages can be propagated.

4.6 Power Supplies for Signalling Equipment:

Power supplies for signalling equipment typically have large tolerances from the nominal voltage. For example:

- The 120 volt AC signalling power supply varies from 108 to 132 volts.
- The 50 volt DC signalling power supplies are full wave rectified, and are not always filtered. These supplies are typically set at 55 volts but may vary from 48 to 60 volts. This results in up to 85 volts peak on the supply.
- The 24 volt DC signalling power supplies vary from 20 to 32 volts DC.
- The 12 volt DC signalling power supplies vary from 11 to 20 volts DC.

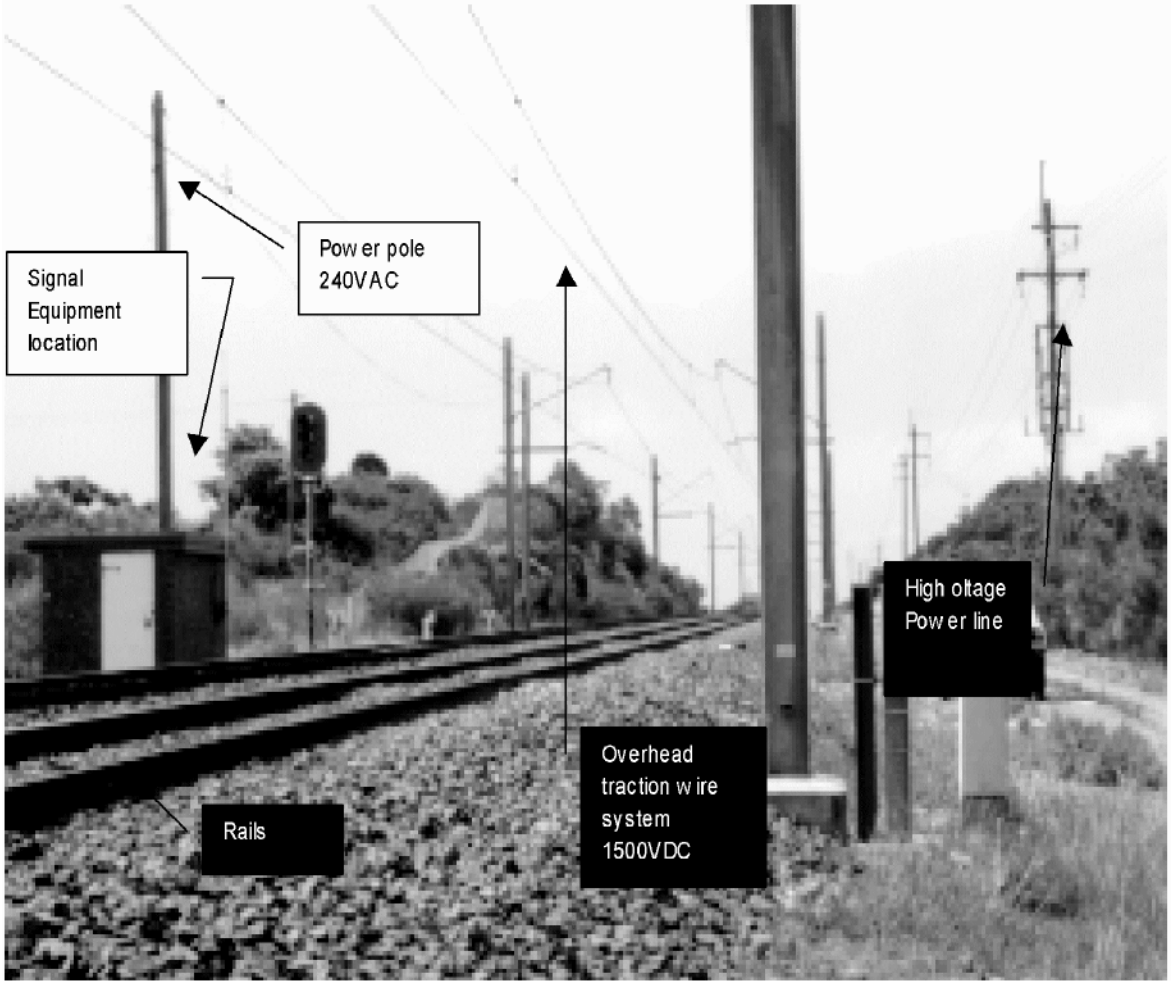
The main power supply distribution for signalling equipment is 120VAC50Hz and the supply is unearthed. The 120VAC supply is derived from 240VAC or 2.2KV(railway supply), or 11KV or 33KV Council supplies. In some locations there are alternate power sources such as motor generator sets, solar supplies, etc.

4.7 Earthing systems

Different earthing systems exist in the railway signalling environment. These earthing systems are; Signalling Earth, ARTC Electrical 240V Earth, ARTC Electrical HV earth, Council 240V MEN Earth, and Communications Earth.

4.8 Physical Structures

Typical signal equipment location illustrating the railway environment



The following physical structures exist in the railway signalling environment:

- The 1500VDC traction overhead wire structure in the electrified area (bounded by Lithgow on the Western line, Newcastle on the Northern line, Glenlee on the Southern line and Dapto on the South coast line)
- High communication masts adjacent to signalling locations where communication interfaces exists.
- High voltage and low voltage transmission and distribution lines.
- Power supply poles close to the signalling equipment locations.
- Signalling equipment locations at elevated and exposed areas

5 Required Protection Performance

5.1 General

The need for protection against power supply, and interface fault condition surges is essential in all cases.

The need for protection against lightning surges is essential unless the location provides an inherent zone of protection from lightning surges.

The lightning and surge protection provided shall comply with AS 1768 *Lightning Protection* including any recommendations and follow practices in the Appendices of AS 1768 unless varied by this specification.

It is the responsibility of the Supplier of the signalling system to ensure that the system is protected against lightning and surges so that the signalling system can achieve its required level of performance.

The surge protection equipment shall be rated for more than 150% of the intended interface load.

The surge protection equipment shall have an insertion loss of less than 1dB to valid signals for the interface during normal conditions.

The Signalling system surge protection shall, as a minimum, be provided as per the ARTC Circuit Design Standards SDS 25.

5.2 Safety

The surge protection equipment must not reduce the level of safety provided by the signalling system.

A Failure Modes And Effects Criticality analysis of the surge protection equipment and its proposed use is an accepted method of determining the affect of the surge protection on the safety of the signalling system.

The surge protection equipment shall present a low risk to personnel working near the surge protection equipment if a nearby lightning strike occurs.

The safety of personnel working on or near the surge protective equipment shall be considered when designing the layout of the surge protective equipment or the route for Earth conductors.

5.3 Life

The surge protection system shall have a design life such that it does not compromise the required life of the signalling system.

The surge protection system shall have a design such that items that only withstand a particular number of surge events or size of surge event are only required to be replaced once every two years on average.

5.4 Failure modes

The expected failure modes of the surge protection equipment must not prevent the protected equipment continuing normal operation if the protected equipment is still operational.

5.5 Earthing

The earthing shall maintain the required earth resistance and earth impedance for required life of the signalling system with no corrective maintenance required for the average installation. The expected level of corrosion, and electrolysis for the site shall be considered when choosing the earthing.

The earthing system shall have physical protection from activities that may be carried out in the vicinity and be vandal resistant.

The maximum value for Earth provided for surge protection for electrical equipment to be protected shall equal to or better than that nominated in the following table.

Equipment Type	**Earth Resistance**
Electronic Equipment installed inside locations	5 ohm
Electro-mechanical equipment installed inside locations	10 ohm
Electronic Equipment installed external to locations	20 ohm
Electro-mechanical equipment installed external to locations	50 ohm

Earth impedance for the earth connected at each item of surge protection shall be less than 10 times the nominated Earth Resistance when measured using earth impedance test equipment operating in the frequency range of 25KHz to 50KHz.

If an Earth Leakage detector is required at a location then a separate test earth shall be installed. The test earth shall have an earth resistance of less than 100 ohms.

Separate earths shall have a minimum physical separation of at least twice the length of the longest earth stake used.

5.6 Earth Potential Rise (EPR)

Earth potential rise due to a Category C surge pulse at the location shall be less than 430 volts.

Earth potential rise due to surges at adjacent locations or on different earth's shall be limited to 430 volts by the use of equi-potential bonding or transient earth clamp between the surge protection earth and the other earth.

A transient earth clamp shall be used to connect earth's provided for different purposes unless the owners of both earth's agree to equi-potential bonding of their earth.

The test earth for an Earth Leakage Detector shall be bonded to the protection earth using a transient earth clamp.

The earth for a Multiple Earthed Neutral shall be bonded to the protection earth using a transient earth clamp.

5.7 Surges

Each location or building shall withstand, without the normal operation of the equipment contained within it being degraded:

- more than 400 of each applicable type of Category C pulse on the power supply interfaces to the location.
- more than 100 of each applicable type of Category A pulse on each communications interface to the location.
- more than 100 of each applicable type of Category B pulse on all other electrical interfaces to the location.

when the surge is applied to the external interfaces of the location as both common mode and differential pulses.

Track-side equipment installed external to signalling equipment locations shall withstand more than 200 Category B pulses on all interfaces.

The protective action of the surge protection equipment in response to the nominated surges shall not cause circuit breakers to trip or fuses to 'blow'.

5.8 Acceptable Voltage or current at equipment

The following sub-sections define the maximum acceptable surges that may appear at the interfaces to the equipment when any of the surge pulses nominated in the *Section 5.7 Surges* occurs.

The rated voltage or current for an interface is to include the ratings for both differential mode and common mode voltages or currents.

In the case where the interface is an output only, the rated voltage or current for the interface will be the rated output voltage or current.

5.8.1 Electronic Equipment

Electronic equipment is considered to have three interfaces for the purposes of surge protection. They are the power supply, communications, and all other electrical interfaces. The communications interface only applies to telephone lines or data communications interfaces that comply with an International standard. The communications interface is not intended to include proprietary interfaces of a particular product, these are classified as “other electrical interfaces”.

Power supply interface

The voltage or current appearing at the interface to an item of electronic equipment shall not exceed 300% of the rated voltage or current for the interface.

The voltage or current appearing at the interface to an item of electronic equipment shall not exceed 200% of the rated voltage or current for the interface for more than 1mS.

The voltage or current appearing at the interface to an item of electronic equipment shall not exceed 150% of the rated voltage or current for the interface for more than 10mS.

Communications interface

The voltage or current appearing at the interface to an item of electronic equipment shall not exceed 1000% of the rated voltage or current for the interface.

The voltage or current appearing at the interface to an item of electronic equipment shall not exceed 400% of the rated voltage or current for the interface for more than 1 0 S .

The voltage or current appearing at the interface to an item of electronic equipment shall not exceed 150% of the rated voltage or current for the interface for more than 10mS.

All Other interfaces

The voltage or current appearing at any interface to an item of electronic equipment shall not exceed 1000% of the rated voltage or current for the interface.

The voltage or current appearing at any interface to an item of electronic equipment shall not exceed 400% of the rated voltage or current for the interface for more than 1mS.

The voltage or current appearing at any interface to an item of electronic equipment shall not exceed 150% of the rated voltage or current for the interface for more than 10mS.

5.8.2 Electro-mechanical Equipment

Electro-mechanical equipment is considered to have two interfaces for the purposes of surge protection. They are the power supply, and all other electrical interfaces.

Power supply interface

The voltage or current appearing at the interface to an item of equipment shall not exceed 500% of the rated voltage or current for the interface.

The voltage or current appearing at the interface to an item of equipment shall not exceed 200% of the rated voltage or current for the interface for more than 10mS.

The voltage or current appearing at the interface to an item of equipment shall not exceed 150% of the rated voltage or current for the interface for more than 100mS.

All Other interfaces

The voltage or current appearing at any interface to an item of equipment shall not exceed 1000% of the rated voltage or current for the interface.

The voltage or current appearing at any interface to an item of equipment shall not exceed 400% of the rated voltage or current for the interface for more than 10mS.

The voltage or current appearing at any interface to an item of equipment shall not exceed 150% of the rated voltage or current for the interface for more than 100mS.

5.9 Cables

Buried cables shall be provided with the means to mitigate the effects of ground surge currents.

Mitigation of ground surge current effects has two purposes. Firstly to protect the cables from damage, and secondly to reduce the level of surge that may be induced in the cable.

One established means of mitigating the effect of ground surge currents is the provision of an earthed stainless steel drain wire 300 mm below ground level, and 300 mm above the cables.

5.10 Maintainability

Surge protection equipment shall be able to be tested without disruption to the operation of the equipment being protected.

Equipment that is not readily accessible for maintenance purposes shall not contain parts that require preventative maintenance or periodic inspection to check correct operation.

The surge protection equipment's Mean Time To Repair for failures shall be 10 minutes or less for one person and 95% of all failure repair tasks shall be completed in less than 20 minutes. These times do not include travelling time, but do include fault diagnosis time.

Preventative maintenance required to maintain correct performance of the surge protection equipment shall not increase the maintainers workload by more than 10%.

6 Proof of Performance

The supplier shall produce and submit a technical report on the performance of the proposed surge protection. The technical report must detail how the performance criteria will be met (to the ARTC General Manager ISP or nominated Signalling representative's satisfaction) for the particular site or sites with the nominated equipment and installation practices.

The technical report is also to consider any special needs for the particular installation due to site aspects or equipment aspects.

Surge protection equipment and its usage shall be approved as part of ARTC's Type Approval process.

APPENDIX A : Earthing

General

Earthing systems (dependant on the type of system to be protected) shall be installed in accordance with the relevant drawings in Appendix H.

These Earthing systems shall be referred to as the S&C Earthing System (S&CES) and shall not be directly connected to any other earthing system installed by Electrical Authorities or others.

All different Earthing systems (namely the Electrical 240V Earth, ARTC Electrical HV earth, Council 240V Earth, Signalling Earth, Communications Earth, etc.) shall be bonded together by using transient earth clamps.

Facilities shall be provided to periodically test these transient earth clamps. Preferably these devices are to be installed inside the equipment room so that these devices can be tested.

Separation between the Signalling Earth of the S&C Earthing System and other Earthing systems shall be greater than 5 metres.

Earthing systems shall be designed for the effective operation of surge protection equipment.

To achieve this the earth connections shall be made as short and straight as practicable with large radius bends.

Earth conductors and unprotected cables shall not be run in parallel in close proximity with other cables. The clearances shall be as detailed in the section on Running of Earth Conductors in Main Locations and Track-Side Locations. Earth leads may cross signalling cables at right angles to each other as applicable.

All Earthing equipment and material other than the approved types shall be subject to approval before installation.

Design of S&C Earthing System

The design of the earthing systems will be dependant on the type of system to be protected and the value of Earth resistance required at the location.

Equipment used for Earthing shall be as specified in Appendix D and also in Appendix F.

The procedure for achieving the specified earth resistance and installation of S&C Earthing system is in accordance with the Measurement of Earth Resistivity section.

Earth Resistance - Main Locations

Main locations are considered to be points where Signalling 120V AC power supply originates. Earth resistance at main locations shall be less than 5 ohms.

Earth Resistance/Track-side Locations

Track-side locations are other cupboards or huts that contain the signalling equipment. Earth resistance at track-side locations with electronic equipment shall be less than 5 ohm; otherwise it shall be less than 10 ohm.

The information in following Sections shall also be taken into consideration in designing the S&C ES.

Earth Connection Leads

The earth leads used at various stages shall be as follows

Earth Electrode - Main Busbar : 7/1.7mm (Green & Yellow) PVC insulated cable

Main Busbar - Subsidiary Busbar: 2x7/1.7mm(Green & Yellow) PVC insulated cable

Main and Subsidiary Earth Busbars

The incoming Earth leads shall be individually terminated on a copper busbar. This busbar shall be referred to as the Main Earth Busbar. The minimum dimensions of Main and Subsidiary Earth Busbars shall be 150x30x6mm. The earth wire (or terminating lug) shall be installed in direct physical contact with the busbar plate.

All equipment Earths and surge protection Earths shall be connected wherever possible directly to the Main Earth Busbar making it a single Earth system or if totally impracticable, to Subsidiary Earth Busbars which in turn are connected by duplicated 7/1.7 green and yellow P.V.C. insulated earth cables to the Main Earth Busbar. These connecting earth cables are to be run in orange conduit set into the floor of the signalling equipment building.

Running of Earth Conductors in Main Locations and Track-side Locations.

The typical arrangement shall be in accordance with drawings listed in Appendix H. The incoming Earth leads are to be run in 25mm orange conduit set into the floor of the relay room and at least 300mm away from the signalling, power and communications cable entries.

Earthing conductors or cables that do not have surge protection shall not be run in the same conduit as the signalling conductors, or parallel within 300mm, as far as practicable.

In all cases the earth conductors are to be run with a minimum of bends. The minimum radius for a bend is 150mm.

Connection of Earth Conductors to Earth Electrodes

Earth conductors shall be bonded to earth electrodes by exothermic welding which shall be referred to as "Cadweld Bonds".

Alternatively a cast copper clamp connection may be used.

The earth electrode connection shall not be buried and shall be located so as to be readily accessible for inspection purposes. The connection must be protected from burial by being enclosed in a pit fitted with an approved lid with the strength to suit the physical position (i.e. truck axle loads in access roads). Easy removal of the lid, for inspection without disturbing the pit, is required.

Earthing of Racks and Equipment Housings.

All racks and equipment housings shall be earthed to the Main or Subsidiary Earth Busbars.

All surge protection equipment shall be grouped together in close proximity to the Main Earth Busbar or Subsidiary Earth Busbar and be physically isolated from other signalling equipment.

The minimum size of Earthing conductors shall be 7/0.85 (exception being for earth connection on "LSJK" Transient Barrier where 2.5sqmm wire is used). The conductor insulation shall be green and yellow P.V.C. and shall be run in orange conduit. The conduit shall be set into the floor of the location for new locations.

Measurement of Earth Resistance

a) The earth resistance shall be measured at the S&CES Main Earth Busbar or each separate Earth system using an approved earth resistance meter. Each local earth system is to be tested independently. (i.e. all interconnecting trench cable route Earths disconnected.)

b) The Earth probes on the earth resistance meter shall be connected such that a line drawn between them is at right angles to the railway line.

c) Where (2) cannot be achieved due to physical limitations of a site, unusual earth potential voltages or due to any other difficulty arising, approval shall be obtained for an alternate method of determining the earth resistance.

The procedure for installation of the S&CES.

8) Take measurements of Earth resistivity at the site. (refer *Measurement of Earth Resistivity)*

9) Determine the number of Earth stakes needed, from the Table below, to obtain the required Earth resistance. The Table stated hereunder shall be used as a guideline to determine the initial installation of earth stakes.

Table 1.1 - EARTHING ARRANGEMENTS (NUMBER OF EARTH STAKES)

Earth Resistivity Range	**R=5 ohms** **Length of Earth Stake**			**R=10 ohms** **Length of Earth Stake**		
(Ohm.cm)	**2m**	**4m**	**6m**	**2m**	**4m**	**6m**
0000 to 1000	1	NR	NR	1	NR	NR
1001 to 1700	2	1	NR	1	NR	NR
1701 to 2000	2	2	1	1	NR	NR
2001 to 2300	3	2	1	2	1	NR
2301 to 3000	3	2	2	2	1	NR
3001 to 3400	4	2	2	2	1	NR
3401 to 4000	4	3	2	2	2	1
4001 to 5000	CS	3	2	3	2	1
5001 to 5500	CS	3	3	3	2	2
5501 to 6000	CS	4	3	3	2	2
6001 to 7000	CS	4	3	4	2	2
7001 to 7500	CS	CS	3	4	3	2
7501 to 8000	CS	CS	4	4	3	2
8001 to 10000	CS	CS	4	CS	3	2
10001 to 14000	Cs	CS	CS	CS	4	3
14001 to 15000	Cs	CS	CS	CS	CS	3
15001 to 20000	Cs	CS	CS	CS	CS	4
20001 & over	Cs	CS	CS	CS	CS	CS

NR = Not Required

CS = Consult ARTC GM ISP or nominated Signalling representative.

However Earth stakes shall not be installed exceeding or less than the following limits.

	Location	Earth Resistance (ohms)	Required Number Minimum	Required Number Maximum
1	Track-side units at Matching/Tuning Units	10	1 x2m	1 x4m
2	Locations without electronic equipment	10	2x2m	4x2m
3	Locations with electronic equipment	5	4x2m	4x4m
4	Main Locations(power supply entry points)	5	4x2m	6x4m

When installing multiple Earth stakes the minimum separation between Earth stakes shall be twice the length of the longer Earth stake.

Where the maximum number of earth stakes does not achieve the required value for earth resistance, consult ARTC GM ISP or nominated Signalling representative.

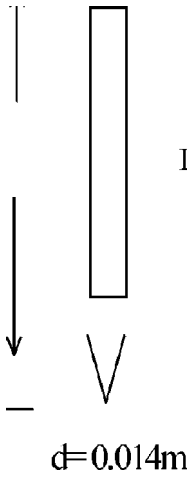
Measurement of Earth Resistivity

Earth Resistivity shall be measured as outlined in AS 1768/1991: Lightning Protection.

Some Earth Resistance meters provide the facility to measure earth resistivity directly.

If only the earth resistance measurement facility is available, the following relationship may be applied to calculate the earth resistivity.

$$R = \frac{\rho}{2.75\,L} \log_{10} \frac{4L}{d}$$



Where, R - Earth Resistance in ohms

ρ - Earth Resistivity (Ohm-metre)

L - Depth of the electrode inside soil in metres

d - Diameter of electrode in metres

Earth Electrode in Rocky Area/Earth Enhancing Compound

Soil Resistivity is generally high in dry and rocky areas and also difficult to drive earth rod into the rocky soil. In such areas holes shall be drilled for earth stakes.

To ensure maximum contact between the earth stakes and the surrounding earth, the hole shall be filled with earth enhancing compound to improve the earth conductivity.

Relay Room Earth Schematic

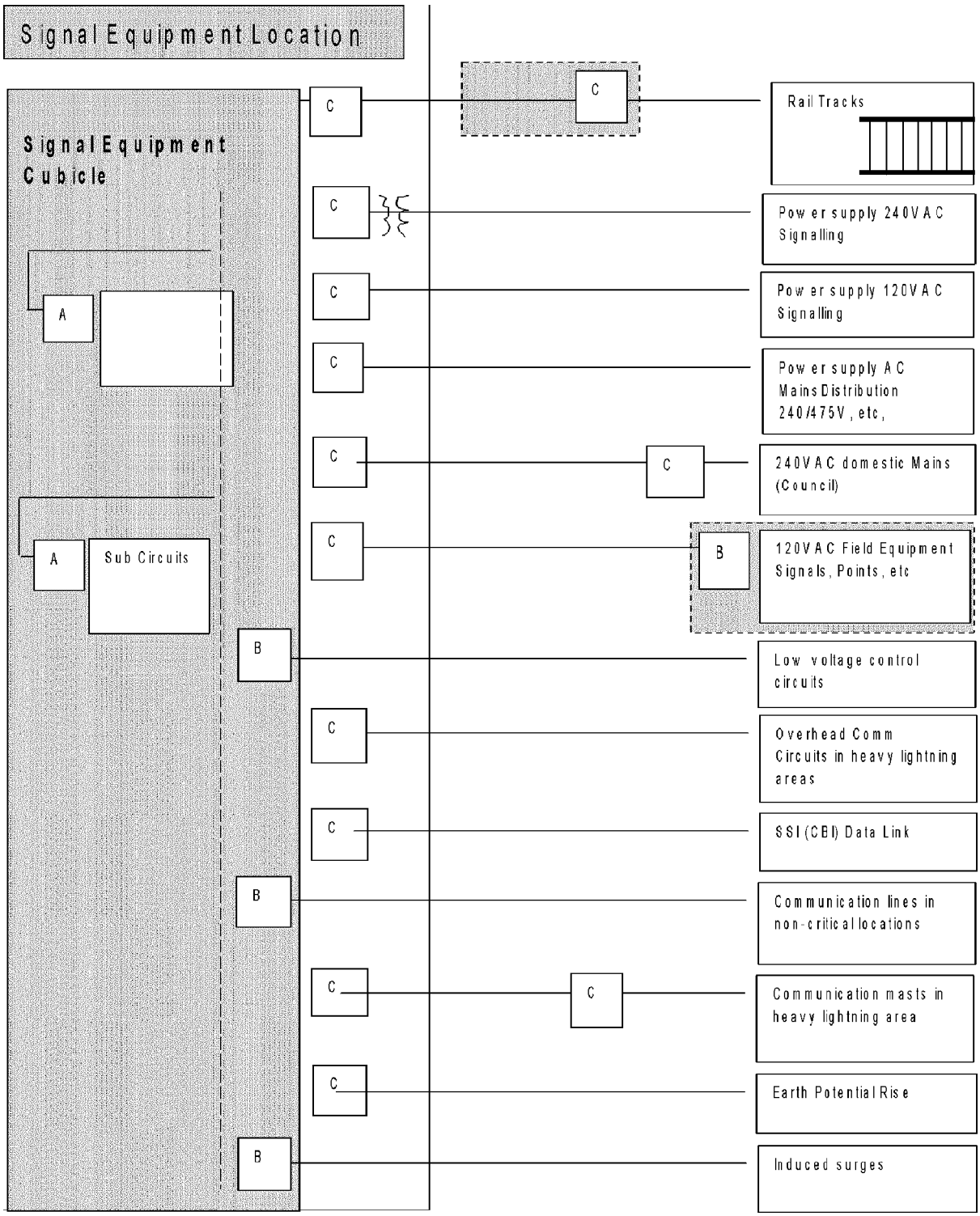
a) Foundation drawings for Relay Rooms or Walk-in huts, submitted for approval shall include details of all Earthing conduits.

b) For every signalling location the supplier shall attach to the Lightning/Surge protection test report a dimensioned layout sketch of the `as-built' Earthing arrangements. This shall show Earth conductors, conductor sizes, conduits, Earth electrodes and electrode lengths, main and subsidiary Earth busbars, and transient earth clamps. It shall indicate S&C Earth, Earth Leakage Detector test Earth, and any EE or Council Earth.

APPENDIX B : Expected Exposure Of Equipment Interfaces

Surge Category	Discharge Pulse	Equipment interface
Category C	70KA, 8/20us or 10/350us	Tall communication antennas in heavy lightning area close to signalling equipment locations.
	70KA, 8/20us	Some power supply entry points in hilly open areas that have a history of serious lightning damage, and critical installations.
	60KA, 8/20us	Power supply entry points 240VAC 50Hz,
	40KA, 8/20us	Power supply entry points(locations) 120VAC 50Hz
	20KA, 8/20us or 20KA, 10/350us	Open Wire Line, lines
	20KA, 8/20us	Some field equipment
	20KA, 8/20us	Track circuit input cables at track-side locations
	60KA, 8/20us	Power supply entry point (Council 240VAC)
	40KA, 8/20us	Power supply distribution to field locations(120/240/415V, etc)
	20KA, 8/20us	SSI Data Links through LDT, external communication circuits
Category B	3KA, 8/20us or 6kV, 1.2/50	Sub circuits. Field equipment
	3KA, 8/20us or 6kV, 1.2/50	SSI Data Links (installations not exposed to lightning)
	3KA, 8/20us or 6kV, 1.2/50	Low Voltage control circuits
Category A	6KV, 200A	Final equipment or devices, Sub-circuits

APPENDIX C : Lightning Protection for Railway Signalling



Represents lightning protection equipment suitable for protection against the nominated Category of surge as detailed in AS 1768

APPENDIX D: Lightning/Surge Protection Equipment

All the designs of surge protection systems or equipment other than the ones specified, require type approval. The let through voltage of surge protection equipment for each item of equipment to be protected shall be taken into consideration.

Types of Equipment

The following types of surge protection equipment are permitted to be installed as applicable. Alternate devices that are superior in performance than the ones specified are acceptable for consideration. These alternate devices shall meet the application requirements in terms of the performance requirements and are acceptable subject to Type Approval

Arrestors & Arrestor Holders Two Terminal Arrestors

The two terminal arrestor shall be the Type #1 Arrestor as specified in Appendix-F with breakdown voltage of 350V rms.

Arrestor holder for above shall be "Sankosha" type Arrestor holder or an approved equivalent type.

Three Terminal Arrestors

The three terminal arrestors shall be as follows:

Type#2 - with breakdown voltage of 290Vrms; and

Type#3 - with breakdown voltage of 700Vrms.

The octal-pin socket for the above shall be "Sankosha" GT-3P, "Omron" PF 083A, or an approved equivalent type. Terminations shall be on the front side of the base.

Varistors

Suitable varistors approved for the application considering the signal application voltage and surge current capability.

Diverters

Diverters shall meet the application requirements.

Diverter Panels(DP)

Diverter Panels have been designed to install inside the switchboards on Council 240VAC incoming supplies.

Inductor/Diverter Panels (IDP)

This provides the primary level of lightning/surge protection on signalling power supply feeders, usually installed on 240 Volt AC side. The IDP shall be as specified in Specification SPS 39.

Inductor/Varistor/Arrestor Panel (IVAP)

This provides secondary protection (or primary if IDP is not installed). The IVAP shall be as specified in Specification SC 091505 00 SP.

Varistor/Arrestor Panel (VAP)

This provides secondary protection on power supply feeders. The VAP shall be as specified in Specification SPS 35.

Varistor Panel (VP)

The Varistor panel shall be as specified in Specification SPS 36.

Line Protection Unit (LPU)

LPU's shall be used to protect data communication lines (or voice communication if required). The LPU shall be as specified in Specification SPS 38

Load Cell Protector

Load Cell Protectors shall be used to protect Load cells and weight indicating/reporting systems. This unit shall be as specified in Appendix F.

Earthing Equipment

The following components are approved for use in Earthing and surge protection systems.

	Item	**Type No./(part#)**	**Manufacturer/ Supplier**
1	Earth Electrode Clad 14mm dia. length 2m	Stainless steel grade 316; Type STE1420	Electrical Equipment Ltd - ALM Division
2	Earth Electrode Clamp	Type: EP 01	- " -
3	Earth Electrode Coupling	Type: SCT 15	- " -
4	Earth Electrode Driving Head	Type: DHT 15	- " -
5	Earth Electrode Star Driving Point	Type SDP 15T	- " -
6	Earth Enhancing Compound	Earth Rite Compound	- " -
7	Cable untinned PVC insulated annealed copper	Single core 7/0.85 or larger, Yellow/Green	- " -
8	Earth Cable stainless steel, 2mm dia. solid conductor single strand	Grade 304	Atlas Steel(Aust) P/L

Current Ratings and Selection of Panels

Current ratings of IDP and IVAP panels shall be selected for

a) the continuous rating of the supply transformer (on the supply side of the switchboard), or

b) the distribution circuit breaker rating (on the load side of the switchboard).

Where the required rating exceeds the standard range of panels, a custom-designed panel, generally in accordance with the specification, shall be submitted for approval by ARTC GM ISP or nominated Signalling representative.

APPENDIX E :Systems Protection Supply Mains

Where the signalling equipment location derives its power from a council or railway 240 Volt mains, surge Diverters shall be mounted, subject to the approval of the supply Authority, on the 240 Volt side of the transformer and earthed to the 240 Volt system earth.

For incoming 240V Council power a Diverter Panel (DP) shall be installed on the Council meter box. The Diverter panel shall be Council approved as well as ARTC type approved. When a Diverter Panel (DP) is installed an IDP is not required to be installed.

The Supplier shall be responsible for obtaining the approval of the relevant electricity authority. When approval cannot be obtained from the relevant electricity authority, the Supplier shall advise the ARTC GM ISP or nominated Signalling representative in writing, of the reasons given for the rejection of the installation of the Diverters.

Where approval cannot be obtained to install the Diverter on the 240 Volt mains then an IDP shall be installed on the 120 Volt side of the supply transformer. Typical connection arrangements are shown in drawing M08-837.

If the Transformer is mounted on the service pole the IDP shall be mounted at the base of the service pole 3 metres above ground level in a housing and earthed in accordance with the drawing M08-827.

An IVAP shall be installed within the location immediately after the IDP or, where the IDP is externally mounted, immediately after the entry point. It shall be earthed to the SE as shown in drawing M08-837.

Outgoing 120 Volts Signalling Distribution Mains: Line wires from Main Locations

At the load location on a linewire run, where a pair of linewires enters the location, only one set of protection units as defined in the following section is required.

If the outgoing linewires are not the same pair of linewires as the incoming linewires and location equipment is connected to the outgoing linewires, then a second set of protection units shall be installed for each pair of line-wires.

The same arrangement shall be installed as stated in the following section. In this case, looking from the exit point of the line-wire, the IDP where installed shall be mounted first and then the IVAP.

Incoming 120V Signalling Distribution Mains: Line Wire to Main Locations

a) An IDP shall be installed where 50Hz AC signalling circuits or track circuits are installed.

b) The IDP shall be mounted at the base of the service pole and earthed in accordance with the drawing M08-827.

c) In case the linewire enters the location directly (not through cable) then the IDP can be installed within the location at the entry point.

d) An IVAP shall be installed immediately after the IDP.

e) The IDP and IVAP shall be positioned as close as practical to the entry point to the location.

f) They shall be earthed to the Signalling Earth point.

g) In locations where an IDP is not installed an IVAP shall be installed, and the fuse base should be bridged with a shorting link (see Drawing M08-838).

120 Volts Signalling Distribution Mains: (Cables In Main Locations)

An IVAP for each incoming and outgoing cable shall be installed. The IVAPs should be positioned as close as possible to the entry/exit point in the location and earthed to the signalling earth.

At the load location on a mains cable run, where the cable loops into and out of the housing (location cases) only one IVAP is required, between the main terminals and the location equipment.

The fuse base of the IVAP shall be bridged with a shorting link.

Outgoing 50 Volts DC Supply - Main Locations

The same level of protection shall be provided as in the section on 120 Volts.

120V Signalling and 50VDC Supply at Track Side Locations

One VAP shall be installed in the location for each supply. The incoming cable or cables should be connected directly to the VAP terminals if possible, otherwise the connecting cables between the incoming terminals and the VAP should be as short and straight as practicable.

For track-side equipment with electronic equipment, an IVAP shall be installed as in drawing M08-836.

The VAP shall be grounded to the Signalling Earth.

When the VAP is used to protect a 50V supply, the varistors on the VAP shall be replaced with appropriately rated varistors and the VAP labeled appropriately.

Protection of Signalling Circuits - Aerials.

Single switched circuits entering or leaving a location shall be protected by arrestors type#1 connected between Line and Earth as shown in the drawing M08-815.

Double switched circuits entering or leaving a location shall be protected by a three terminal arrestor type#2 tied across the line and the earth as shown in the drawing M08-815.

Protection of Multi-core Cables

Separate protection will not be required on each individual signalling circuit in multi-core signalling cable. However an arrestor type #1 shall be installed between the copper "shield" tapes or drain wires in the cable and earth at each end of the cable run. Separate arrestors shall be provided at each end of each multi-core cable.

Local Signalling Cables - An arrestor type # 1 shall be installed between the Copper Shield or drain wire and Earth at the equipment location end of the cable. If no earth is available for a shield arrestor at the equipment end then the shield is to be extended via 7/0.85 Green/Yellow PVC wire and terminated on a separate unused terminal within the local equipment. For cables between local equipment where no Earth are available, both ends of each shield shall be terminated as above.

Protection of Track Circuits

As a minimum track circuit protection shall be as per the ARTC Circuit Design Standards SDS 25 unless otherwise specified, terminal and arrestor layout for the following track circuits shall be in accordance with drawing M08-818.

At track circuit cable entry points to equipment locations improved protection is needed.

DC Track Circuit :

Relay end and track feed locations shall be protected by installing surge arrestor type #2 as shown on the drawing M08-816.

AC Track Circuit :

Protection of 50Hz AC track circuit equipment shall be in accordance with drawing M08-817.

Busbar Protection in Signalling Equipment Locations

Varistors with appropriate ratings shall be installed across all busbars, considering the no load voltage of power supply units and the manufacturing tolerances for breakdown voltage of Varistors.

Wherever there is a doubt, varistors with higher breakdown voltages shall be proposed for approval.

Wiring to Varistors shall not be run in ducting containing other wiring.

Varistors shall be mounted on fireproof hardware clear of any combustible materials. Minimum wiring size to Varistors shall be 7/0.85mm Blue PVC. Varistors are to be connected as close as practical to the power cables connections to the busbar

TDM and FDM Telemetry Line Protection.

Communication Lines

TDM and FDM Telemetry equipment should be protected from surges coming through the communication lines by means of a Line Protection Unit (LPU). The LPU shall be installed before the communication line terminates at the TDM/FDM equipment and near the Main Earth Busbar so that the earth connection can be made as short and straight as practicable.

The communication line connected to the terminals "Line" and "Equipment" on the LPU, shall not be laid with the other cables. They shall be separated from other cables by at least 30mm.

Power Supply

A Varistor Panel VP-20KA shall be installed in the input power supply line irrespective of type of supply voltage connected to the equipment.

Both the LPU and VP-20KA shall be earthed to the Signalling Earth.

Line wire Protection.

For 1 Km either side of the main signalling equipment location an overhead ground wire of 7/1.04mm bare copper cable should be placed 1.2 meters above the top cross arms and shall be earthed at every second pole with an earth at the lead-in pole and end pole.

Should steel poles be used, the overhead ground wire shall be further earthed to the pole. The earthing shall be as per the drawing M08-827.

Cable Protection.

Location to Location

A shielding wire of 2.0mm diameter stainless steel cable shall be buried 300mm below the surface and a minimum of 300mm above all cable runs for the full extent of the cable runs.

When back filling, the soil around the earth wire shall be thoroughly rammed and compacted.

In DC electrified areas, to avoid electrolysis, the shielding wire shall have a break (outside the extremity of any local cable run) of 10 meters midway between the two locations. The shielding wire shall be connected to the earth busbar at each location. At the midway break each end of the shielding wire shall be terminated on its own individual earth electrode offset 2 metres from the main cable trench.

Where buried cable route changes to GST the shielding wire shall extend through the trough laid in with the cables. If an insulated section in the GST is required the shielding wire shall be broken and each end terminated against the vertical side of the GST so as not to bridge the insulation piece.

Where buried routes pass under the railway tracks (ULX), under road crossings (URX) or under creek crossings (UCX) the trench shielding wire shall be installed within a separate conduit extended to maintain 300mm clearance to the buried cables on either side.

Location to Track-Side Equipment

A shielding wire shall also be buried over the signalling cable from signalling equipment location to all types of trackside equipment. One end of this wire shall be connected or cadwelded to the track side equipment earth electrodes and the other end to the busbar inside the location case (Refer drawing M08-826). Each shielding wire shall be labelled for clear identification.

When back filling, the soil around the earth wire shall be thoroughly rammed and compacted.

Re-enterable Cable Routes, Local or Main (GLT or GST)

Shielding wires shall be installed in the same manner as for buried cable routes taking care not to bridge any insulated sections of GST. (Termination in GST to occur at the last mechanical joint bolts prior to the insulated section)

Protection of Axle-Counter Equipment

Protection of axle-counter equipment shall be done in accordance with manufacturer's recommendations and additional protections as follows:

Axle-Counter central equipment

Shall be protected by varistors with appropriate ratings arranged in "Delta" arrangement (as in VP-20KA panel). The equipment should also be protected from surges emanating through the data communication line, by installing an LPU on the line before it terminates on the Distribution Frame.

Track-side equipment

Trackside equipment shall be protected by varistors with appropriate ratings arranged in "Delta" arrangement (as in VP-20KA panel) and mounted as a card inside the vandal proof cover.

Earthing

Earthing shall be installed in accordance with Appendix A. Trackside locations shall be done similarly. In case of electrified 25KV AC 50 Hz traction areas, a 70 sqmm bare, buried copper cable shall connect from the earth busbar in main equipment location hut to the track-side location earth busbar.

Protection of Weighbridge Equipment

Protection of Load Cells & Weight Indicating Equipment

Load Cell Protector type "CRITEC" LCP-01 or an approved equivalent shall be installed on the load cell cables as close as practical to each Load Cell.

The same device shall be used to protect the weighbridge indicator, which shall be installed on the Load Cell extension cable as close as practicable to the weight indicator.

Protection of Data Communication Lines

Line Protection Units shall be installed between the modem and communication line.

Power Supply for Weighbridge Equipment

The weighbridge equipment shall also be protected from surges induced on the power supply. IVAP-15A/240V panels shall be installed at Weighbridge Equipment Location hut as detailed in the sections for 120 volts distribution.

Earthing

Earthing shall be as laid down in Appendix A. The Earth resistance shall be less than 1 ohm.

Earth electrodes up to 6 metre length shall be installed in bored holes and filled with earth enhancing compound.

An Earth busbar shall be provided at the weighbridge hut. Earth cables shall be extended from the earth electrode, which is closest to the pit. (For new installations of weighbridges an earth busbar may be installed within the weighbridge pit).

An "Equi-potential Earth" may be provided by connecting the Earth terminals of load cells together.

Protection of Stand-by Power plants (Motor/Alternator sets)

Each motor/alternator standby set shall be provided with an Earth busbar within the unit. Earth electrodes 2x2m shall be installed to form the earthing system (the frame and the enclosure if applicable shall be connected to the Earth busbar).

If the Motor/Alternator stand-by set is installed external to the equipment hut two Earth wires (7/1.7 G/Y PVC) shall interconnect the Main Earth Busbar in the equipment room and the busbar of the unit.

A typical earthing arrangement shall be as detailed in drawing M08-833.

Earthing of Motor/Alternator sets, rated other than 120V AC, shall be done in accordance with AS 3000 and ARTC standards and which shall in this case be referred to as EE.

Solid State Interlocking/Computer-Based Interlocking protection

Solid State Interlocking equipment protection shall include:

- Primary power supply protection for both normal and emergency supplies
- Secondary power supply protection
- Protection against EMI and electro-static effects
- Protection against traction system harmonics
- Data Link protection

The protection arrangements shall be as per the ARTC Circuit Design Standards SDS 25.

Protection of Equipment Operating on 240V AC 50Hz (Unprotected supplies)

Whenever there is a necessity to operate equipment on 240V AC 50Hz at signal equipment locations, it is necessary to make sure the 240V AC supply is protected against lightning/surge protection. Wherever there is a doubt a commercially available approved surge suppression/filter shall be installed.

APPENDIX F : Lightning Protection Equipment

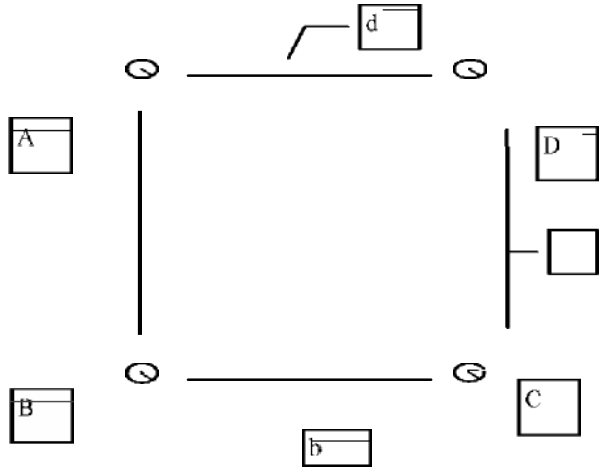
	Description	Remarks /Issue Unit
1.	Arrestor, "Sankosha" type Y08JSZ-350D	(Type#1)
2.	Arrestor Holder, "Sankosha" type AT	
3.	Arrestor, "Sankosha" type 3Y20-290GT	(Type#2)
4.	Arrestor,"Sankosha" type 3Y20-700GT	(Type#3)
5.	Base, octal to suit non-vital relays & Arrestor "Sankosha" GT type, "Omron" PF083A or Equivalent	
6.	Cable, 7/0.85 PVC Green & Yellow	meter
7.	Cable, Stainless Steel 2 mm (Approx. 3036M)	75Kgcoil
8.	Earth Electrode 2 m x 14 mm Dia. Stainless Steel	
9.	Earth Electrode Clamp, Cast Copper 14 mm	
10.	Earth Electrode Coupling	
11.	Earth Electrode Driving Head	
12.	Earth Electrode Star Driving Point	
13.	Earth Enhancing Compound (Earth-rite compound or an equivalent)	
14.	Line Protection Unit	
15.	Panel Diverter (DP-240V)	
16.	Panel, Inductor/Diverter Panel (IDP-50A)	
17	Panel, Inductor/Diverter Panel (IDP-100A)	
18.	Panel, Inductor/Varistor/Arrestor Panel (IVAP-50A)	
19.	Panel, Inductor/Varistor/Arrestor Panel (IVAP-100A)	
20.	Panel, Varistor/Arrestor (VAP)	
21.	Varistor, Siemens SIOV B32K150 or "National" ERZC32EK241 (20KA, for 120V bus)	
22.	Varistor, SIOV S20K17(5KA, for 12V bus)	
23.	Varistor, SIOV S20K30 (5KA,for 24V bus)	
24.	Varistor, SIOV B32K75 (20KA ,for 50V bus)	
25.	Varistor,SIOV B60K150 (60KA, for 120V bus)	

	Test Equipment	
26.	Earth Tester type YEW 3235 or equivalent	
27.	Lightning Arrestor/Varistor Tester	

APPENDIX G : Surge Protection Installation Test Report

Area/District: Location : Km : Project :

Earthing arrangement



Sketch of earthing arrangement

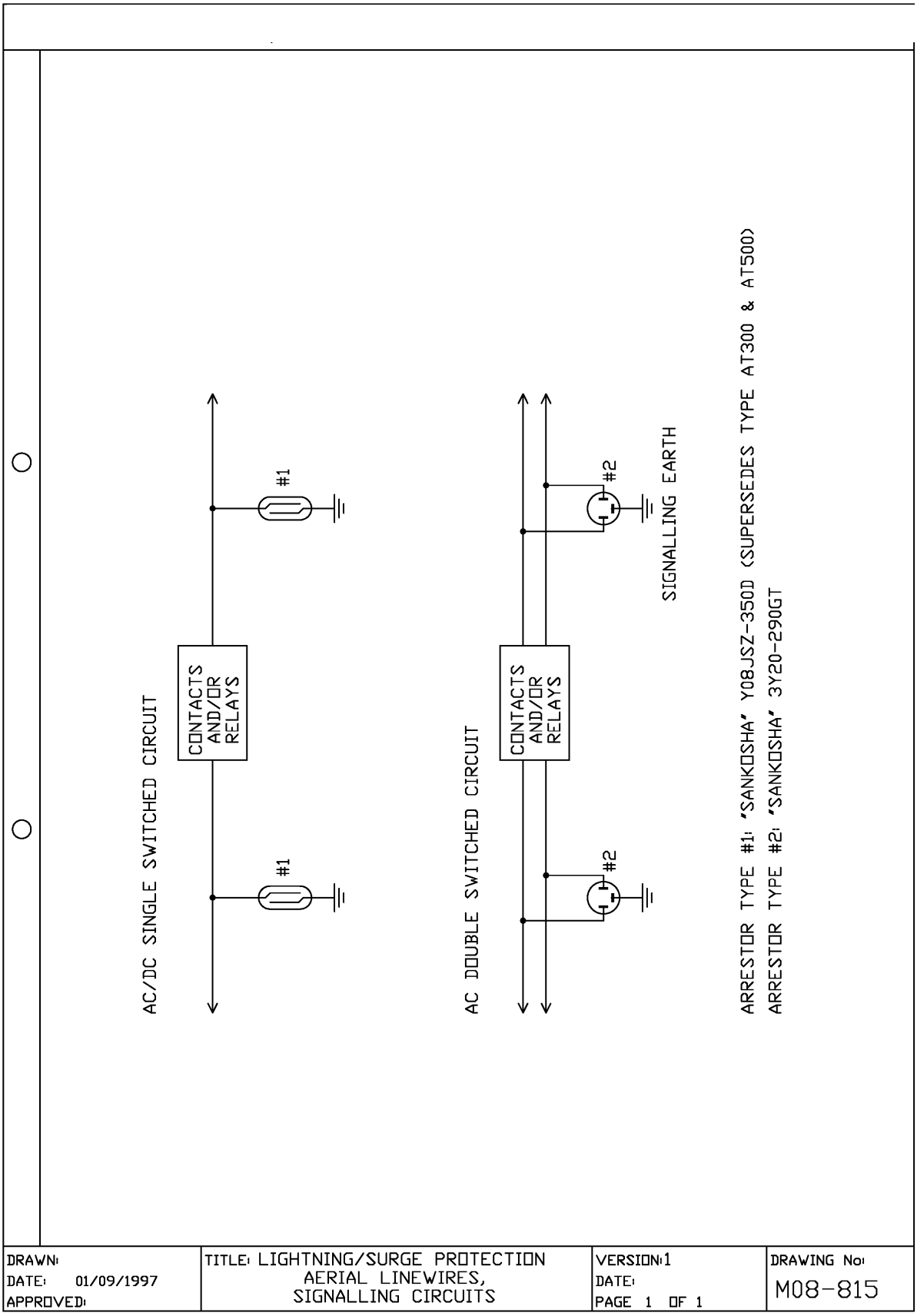
Earth Stake Length	Earth Leads (2mm SS or 7/1.7Cu)
A=	a=
B=	b=
C=	c=
D=	d=

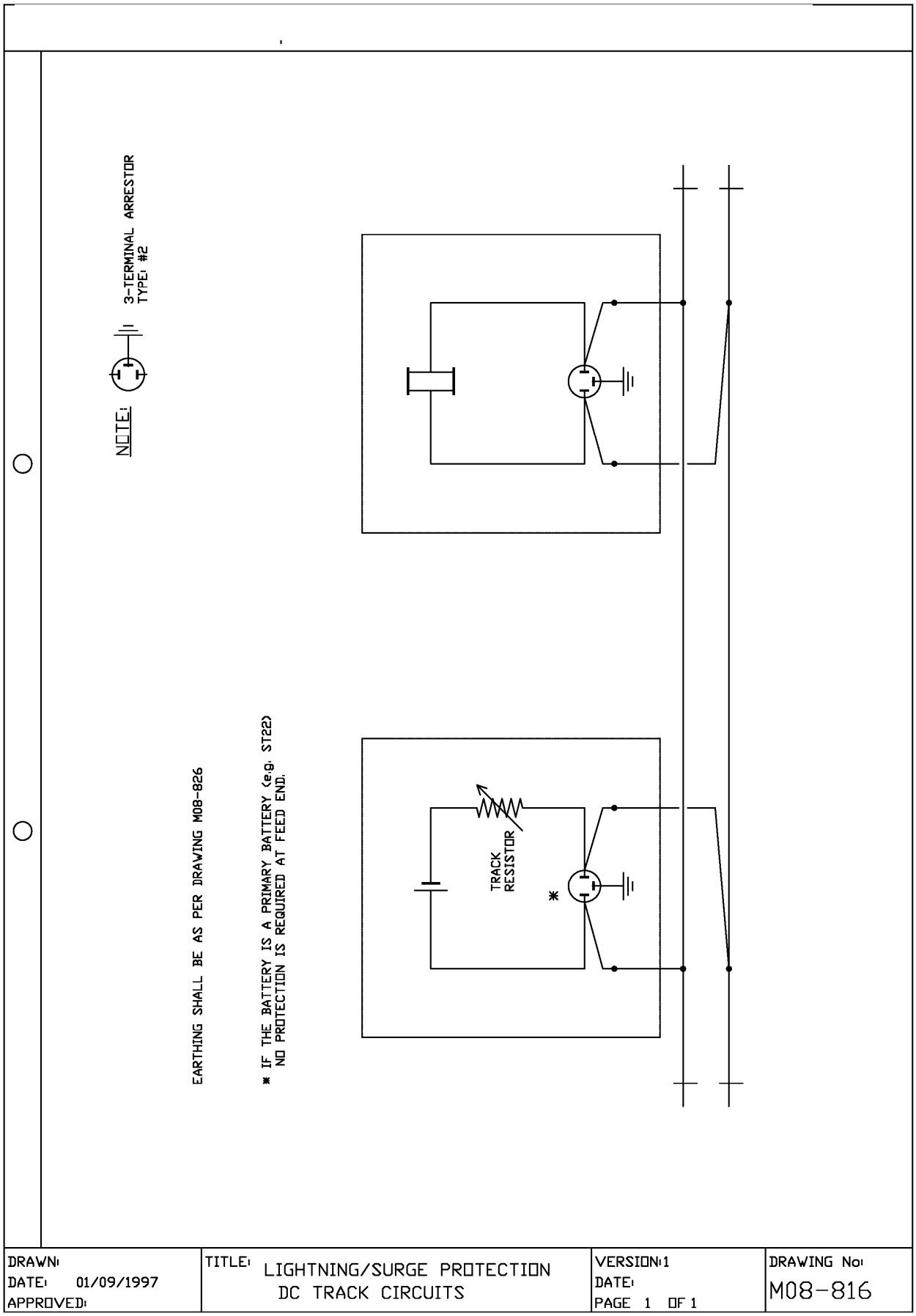
Continuity tested?	Yes/No
Earth Resistivity (measured or calculated reading)	=…. Ohm.cm
Condition of soil(Marshy/wet/moderate/dry/rocky)	
Earth Resistance (1) -tested at Earth Busbar/Electrode Earth Resistance (2)	= Ohm =
Earth Resistance at main earth busbar(with all earths connected)	= Ohm
Remarks (material, practices, specification deviations, etc.): Name of Supplier: Representative: Signature: Date: / /	

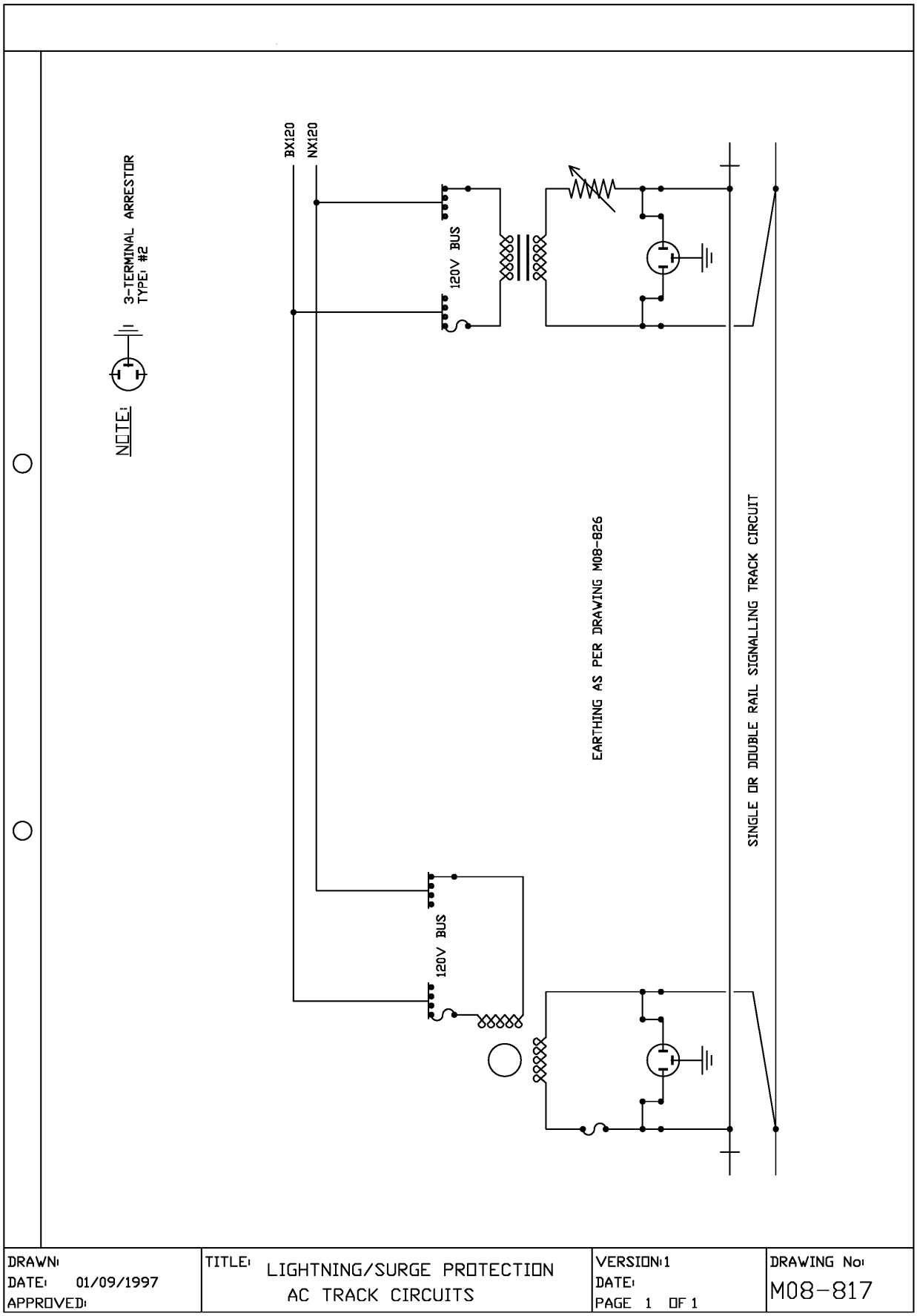
Inspection & testing of lightning protection installation		
Physical and mechanical inspection	(OK/Remarks)	
Protective equipment tested	(OK/Remarks)	
Continuity test of earth conductors	(OK/Remarks)	
Earth Resistance at Main Busbar (verified or witness tested) (Y/N)		
Signature of ARTC Corridor Manager or nominated Signalling representative:		Date: / /
Name/Title:		

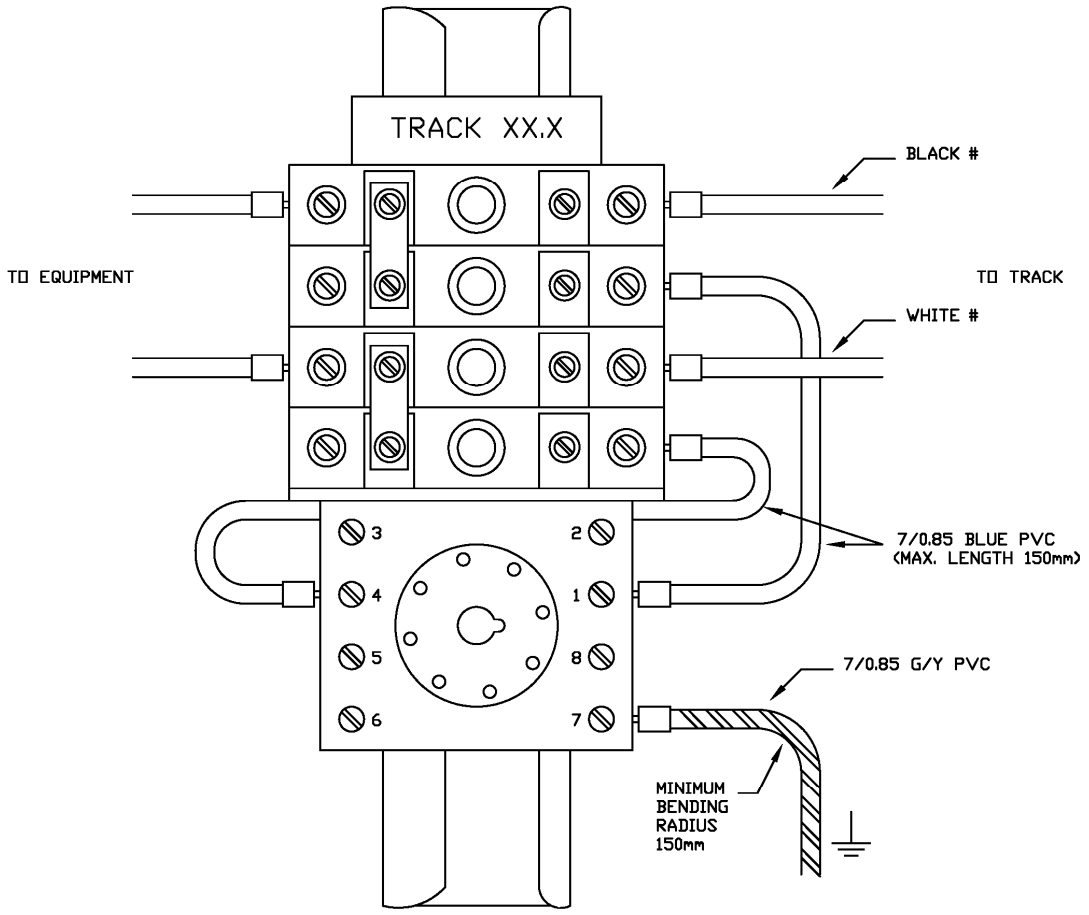
APPENDIX H : DRAWINGS

Protection of Aerial line Wires, Signalling Circuits	M08-815
Protection for DC Track Circuits	M08-816
Protection for AC Track Circuits	M08-817
Track Circuit Protection- Terminal & Arrestor layout	M08-818
Earthing Arrangement for track-side cupboards	M08-826
Earthing arrangement for overhead ground wires	M08-827
Typical layout of Relay Room, Part A	MO8-831/A
Typical layout of Relay Room, Part B	M08-831/B
Layout of Level Crossing Equipment hut	M08-832
Preferred layout of relay room with Motor/Alternator set	M08-833
Preferred layout of relay room with dual transformer supplies 240/415/2KV/11KV	M08-834
Signalling Power Supply - General Arrangement	M08-836
Signalling Power Supply - Configurations	M08-837
Signalling Power Supply - Protection of secondary of supply transformer	M08-838





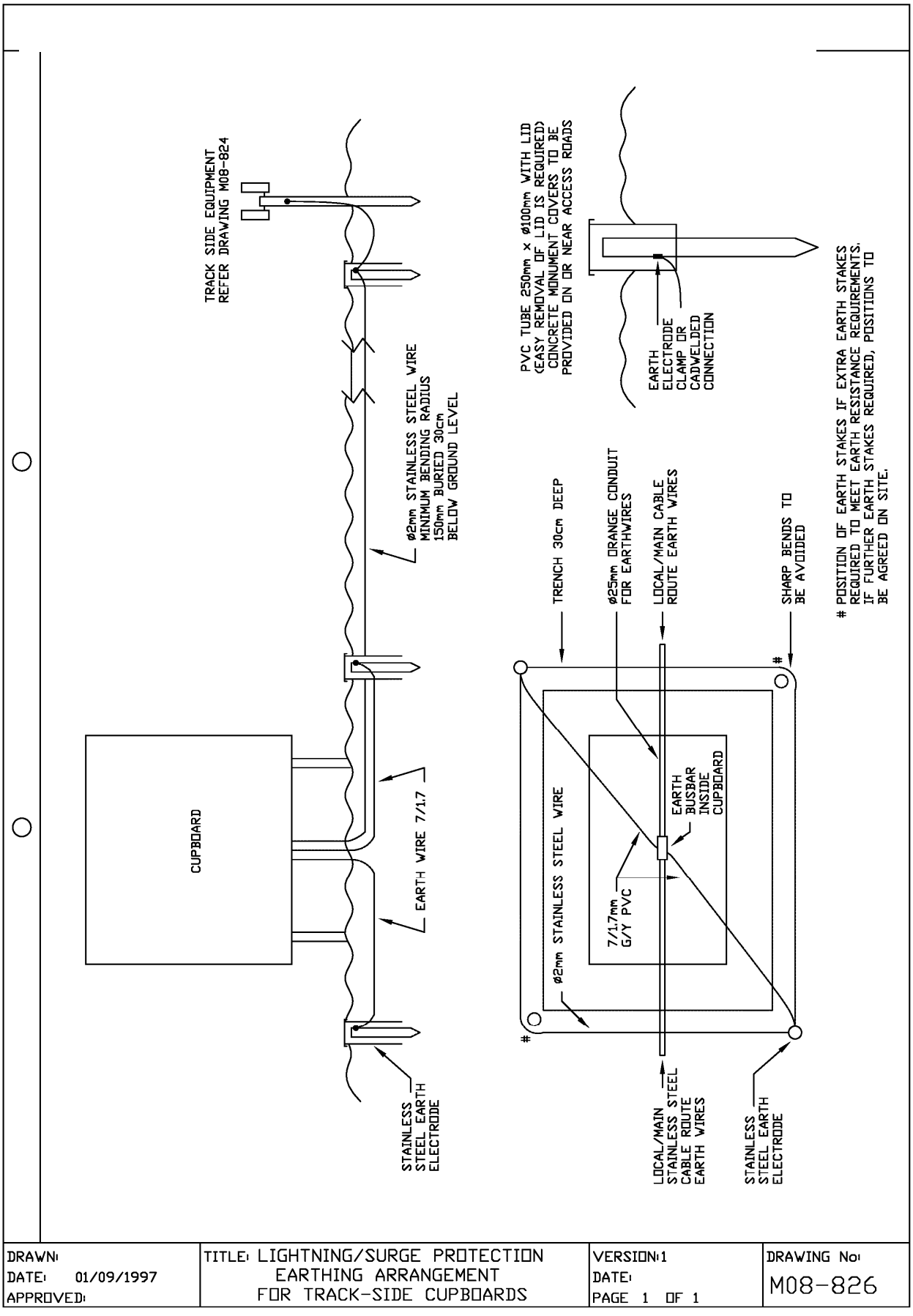


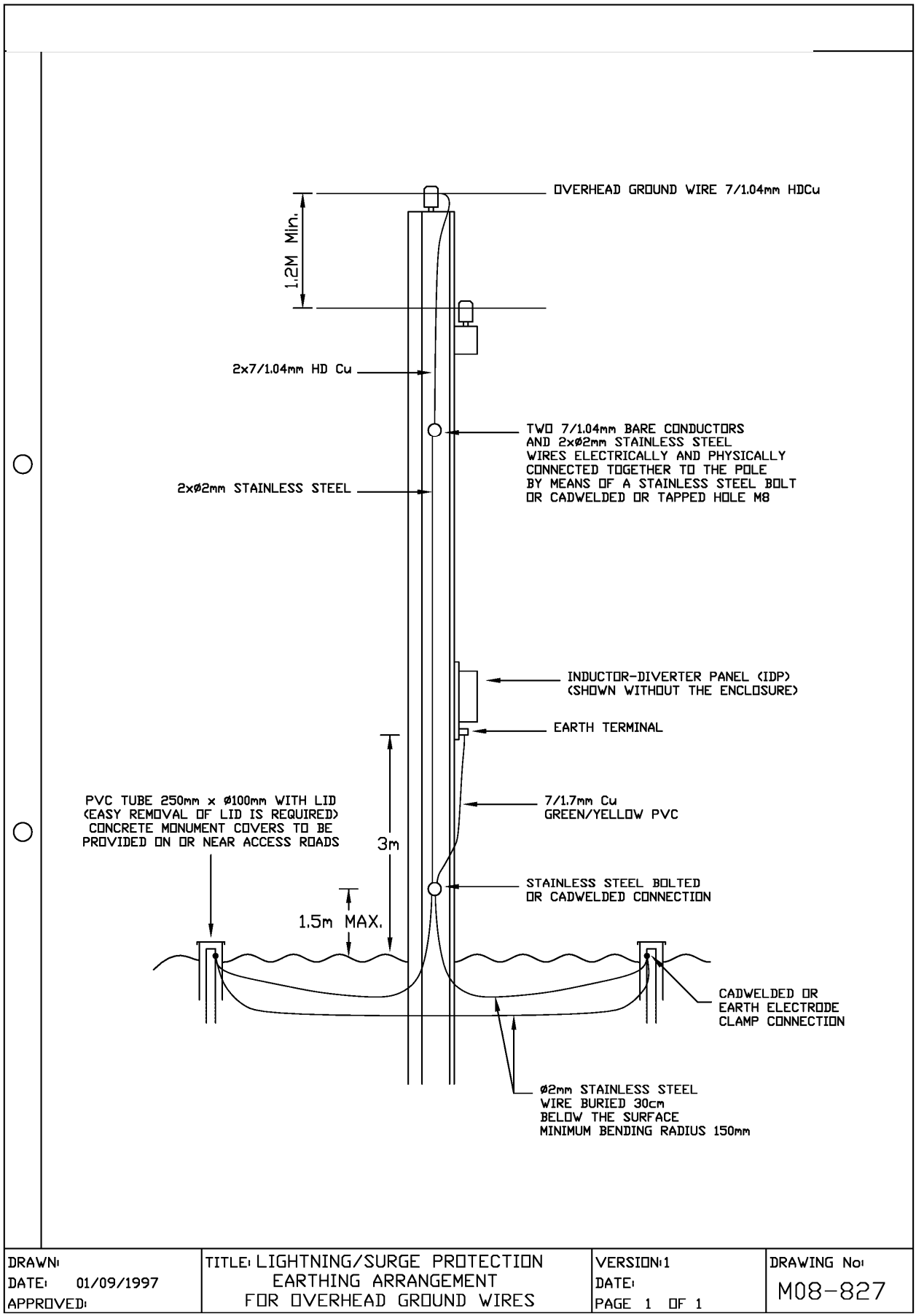


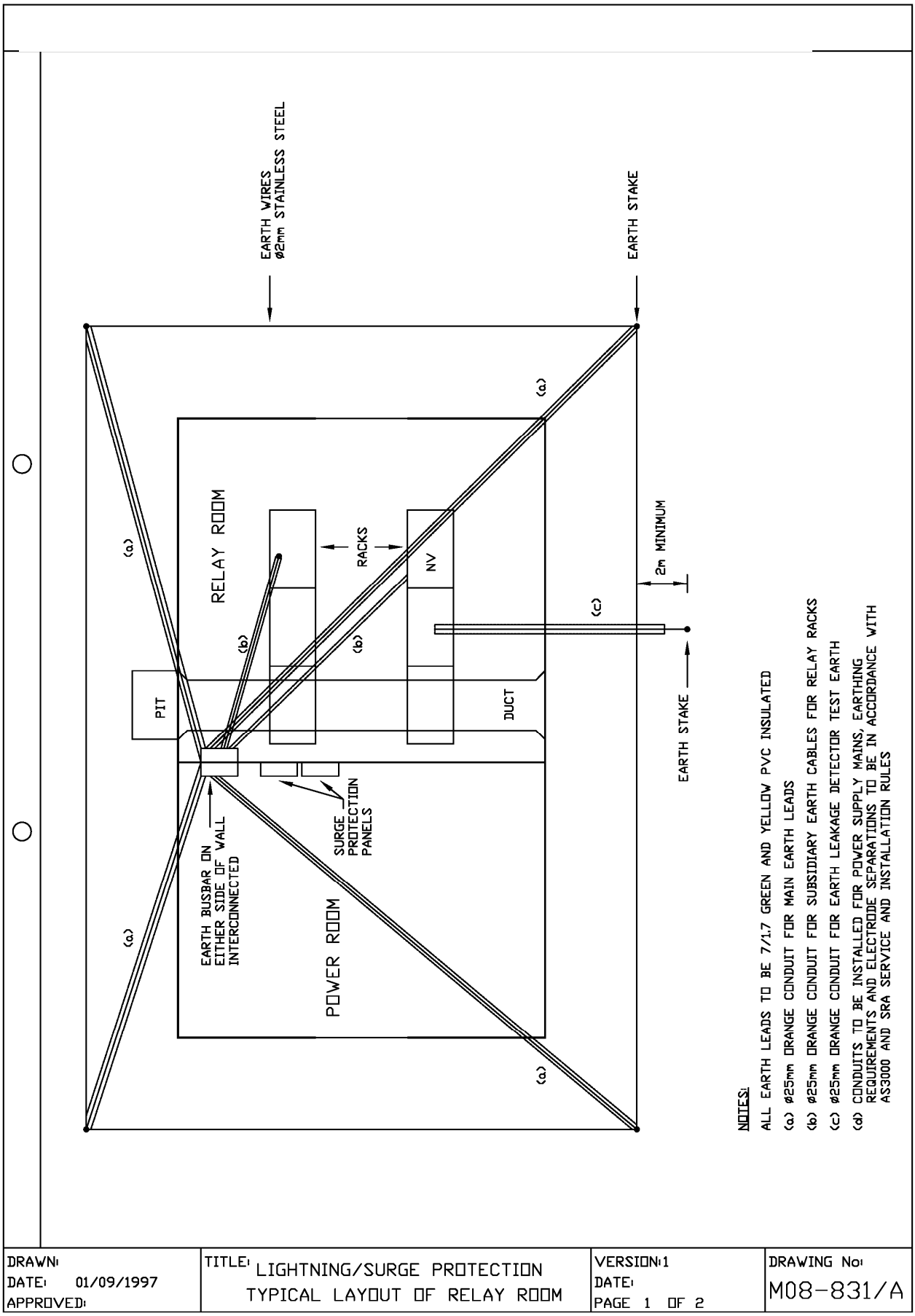
TERMINALS – KLIPPON SAK C10
ARRESTOR BASE – OMRON PF-083A

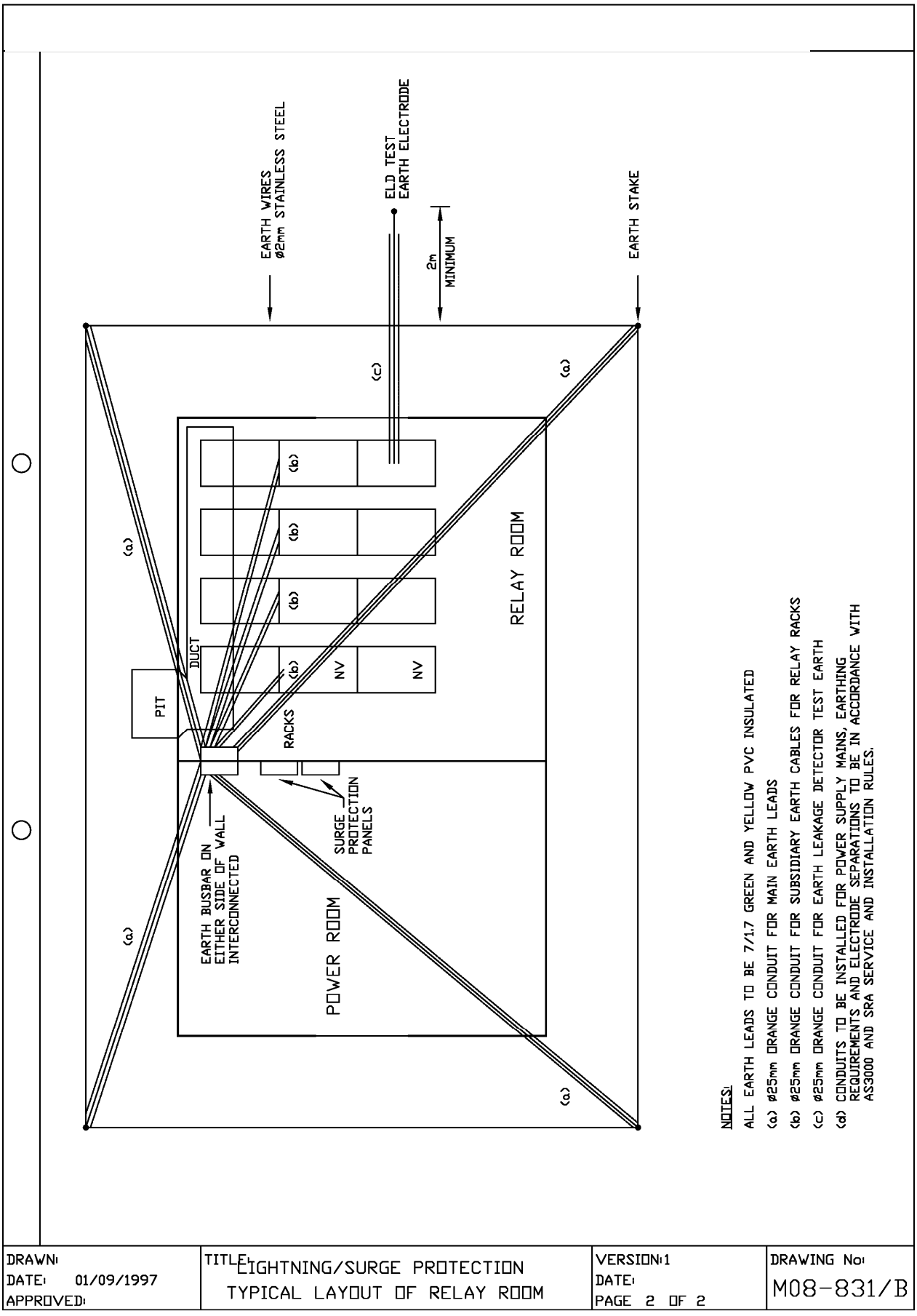
CORE COLOURS WHERE APPLICABLE

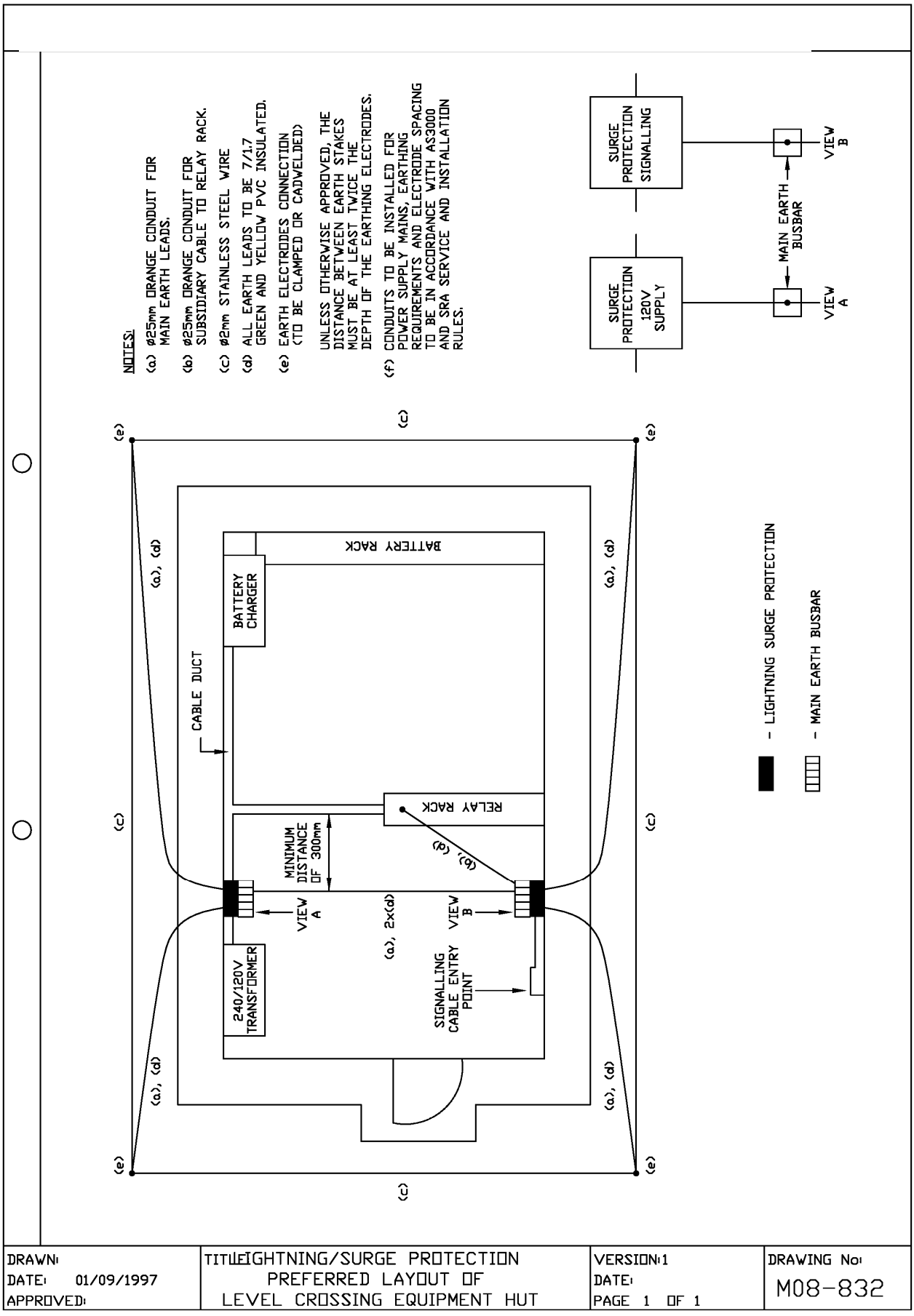
DRAWN: DATE: 01/09/1997 APPROVED:	TITLE: TRACK CIRCUIT SURGE PROTECTION TERMINAL AND ARRESTOR LAYOUT	VERSION: 1 DATE: PAGE 1 OF 1	DRAWING No: M08-818

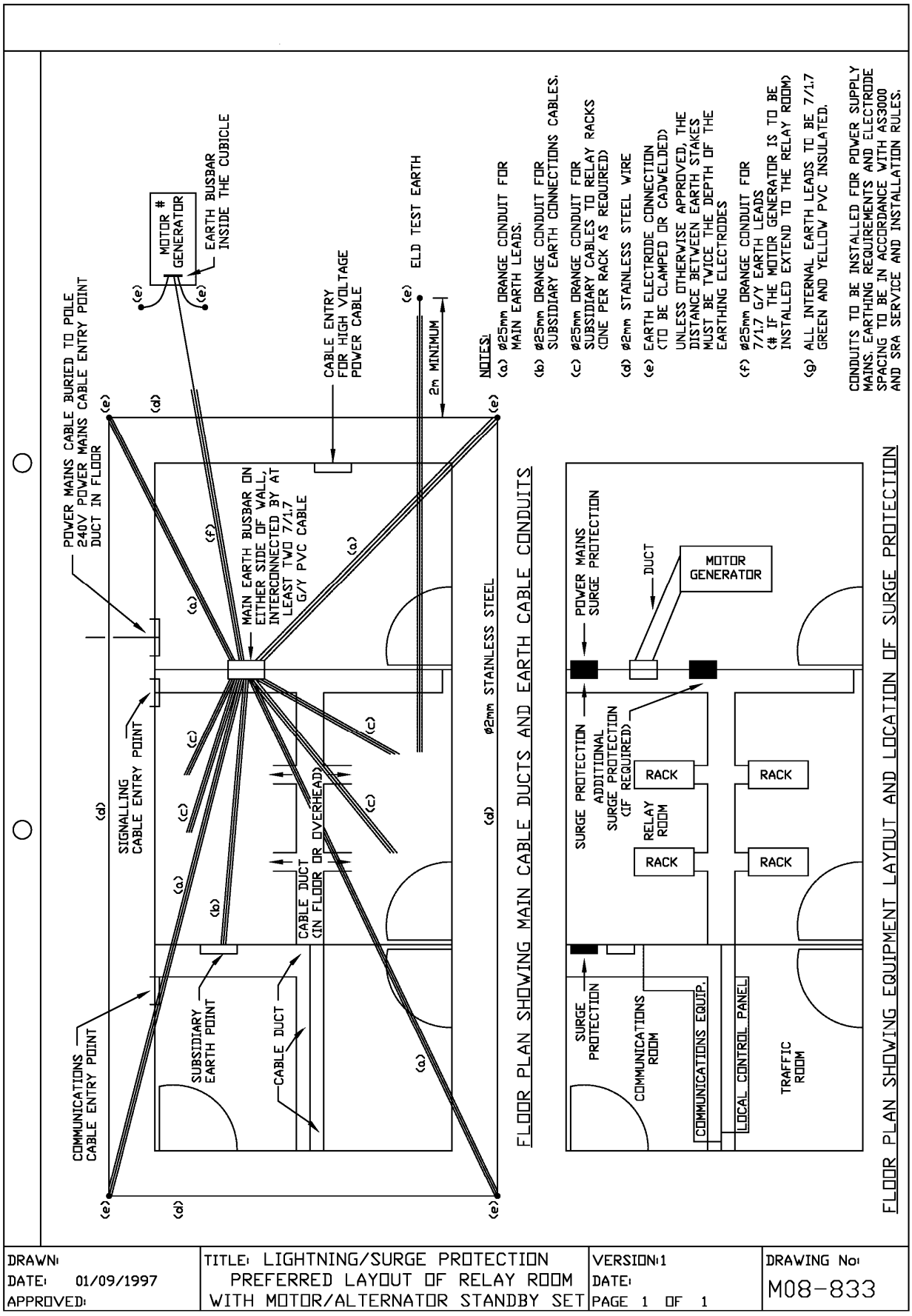


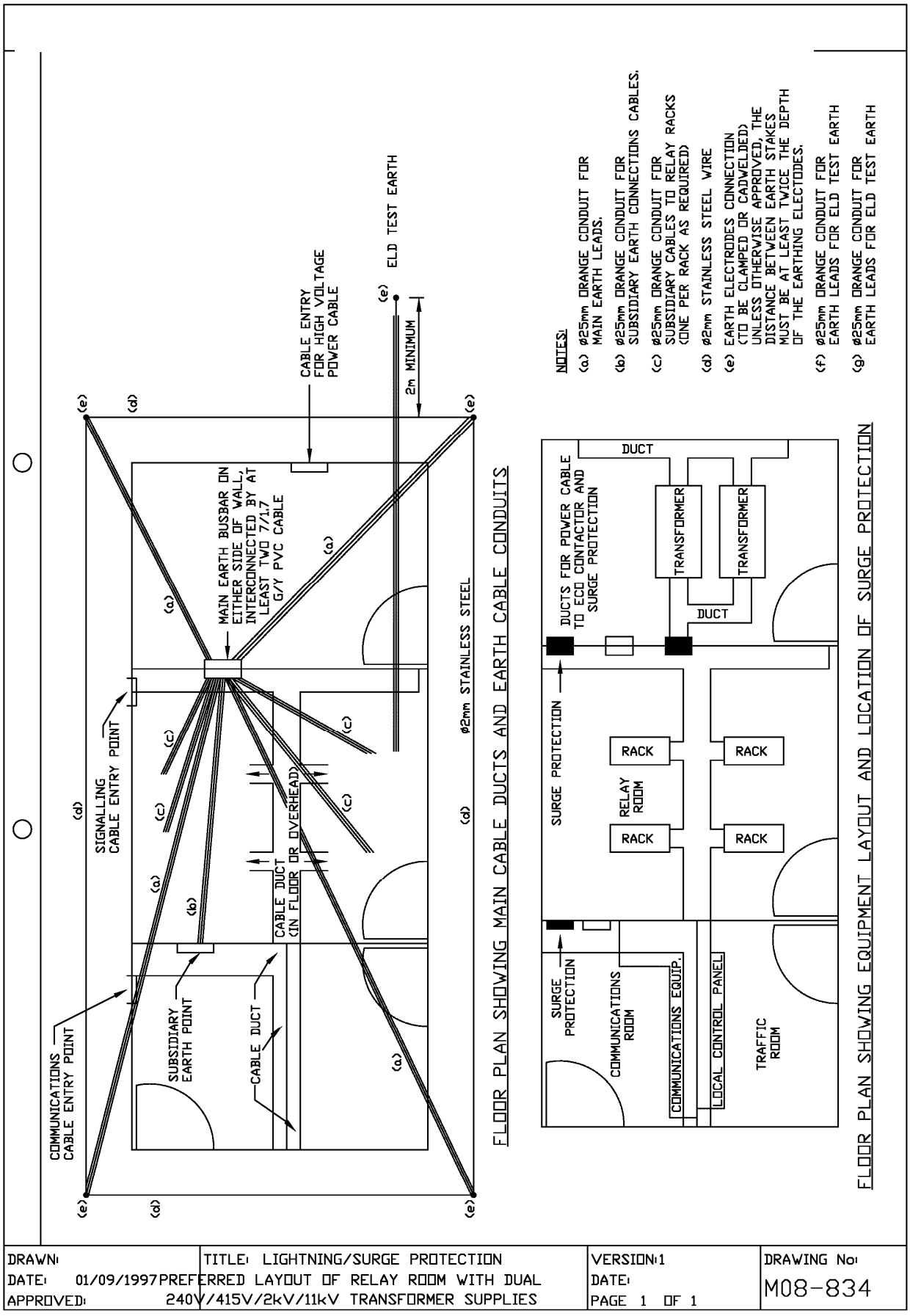


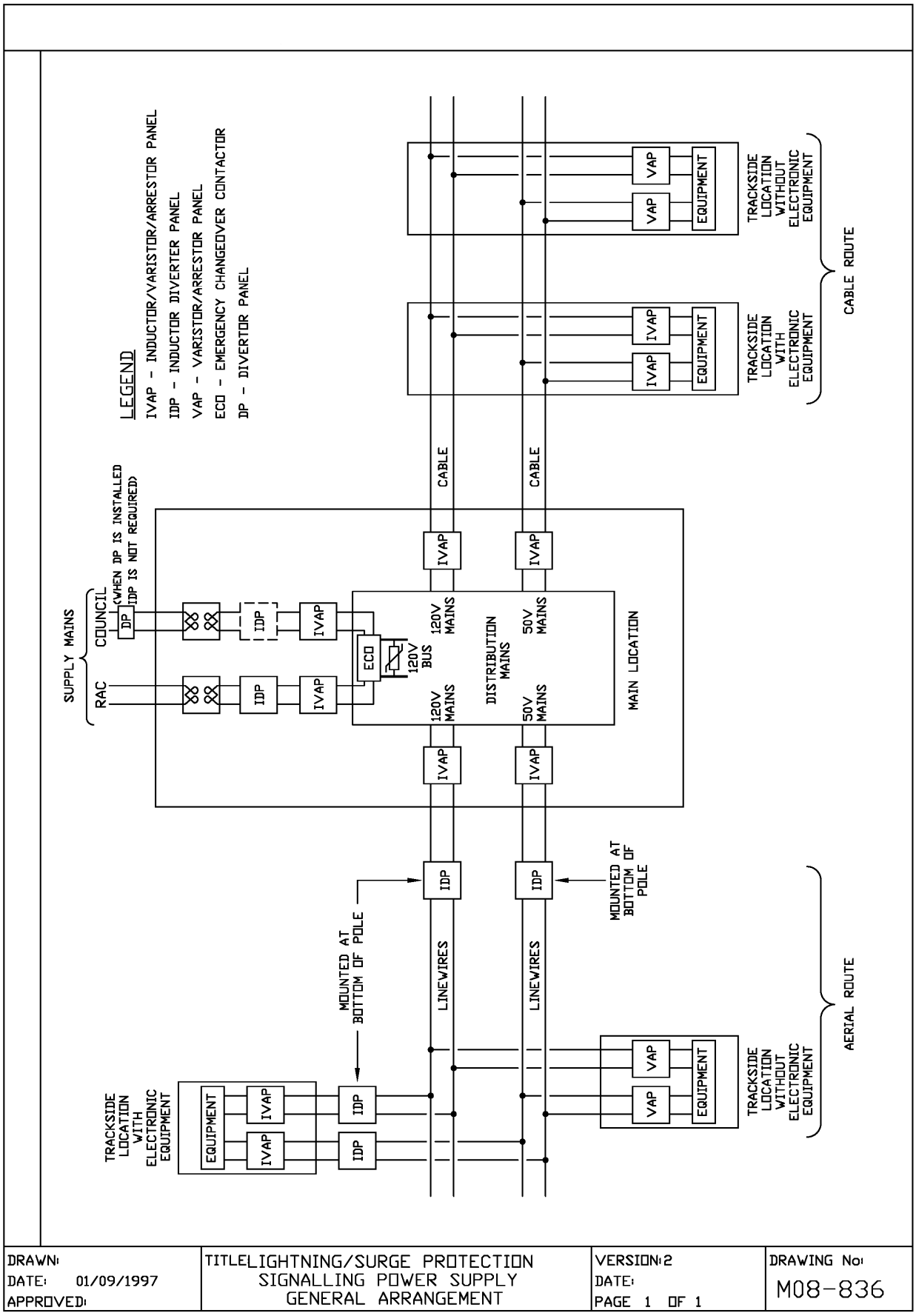


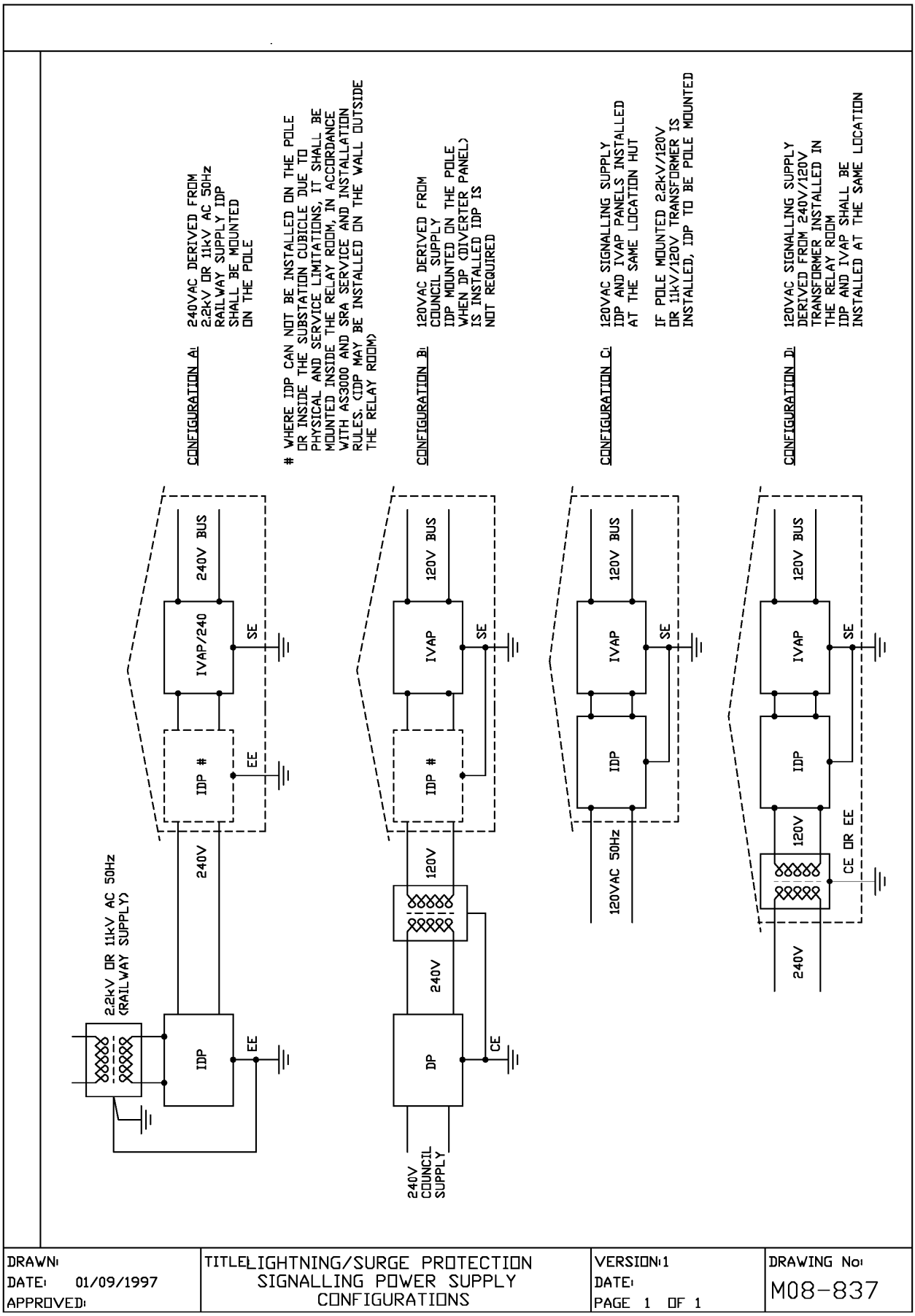






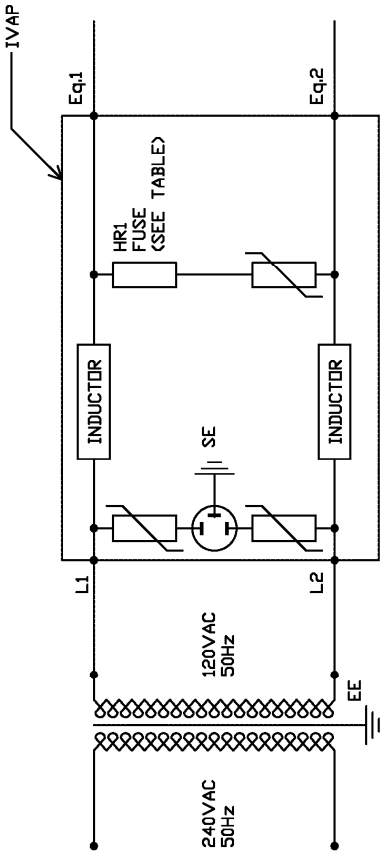






MAINS TRANSFORMER RATING kVA	FUSE RATING
1.5	4A
3.0	10A
ABOVE 3.0	20A

FUSE TO BE REPLACED WITH A SHORTING LINK WHEN IVAP (AND IDP) IS NOT FED FROM SUPPLY TRANSFORMER.



DRAWN: DATE: 01/09/1997 APPROVED:	TITLE: LIGHTNING/SURGE PROTECTION PROTECTION OF SUPPLY TRANSFORMER	VERSION: 1 DATE: PAGE 1 OF 1	DRAWING No: M08-838