

UNCLASSIFIED

Lightning and surge protection – general requirements

Telecommunications

Document information

HPRM Ref: D/18/54033

Approval Date: 31/07/2018

Review Date: 31/07/2019

Security class: Unclassified

UNCLASSIFIED

Document review and approval record

Version	Change/review details	Author or reviewer	Date of review/update	Approver	Date authorised and accepted
1.0	First Issue	John Berti	26/06/2018	Leon Qu	31/07/2018

Amendment record

Version	Date	Description
1.0	26/06/2018	First Issue as TS-ST 038: Standard VRIOGS 012.7.9 Rev A taken over by VicTrack incorporated into VicTrack format in its entirety.

Document owner

Name	Title	Date
Kathryn Shoolman	Manager Infrastructure Design	31/07/2018

Document Author

Name	Title	Date
John Berti	Manager Standards & Specifications	31/07/2018

Document Endorsers

Name	Title	Date
NA	NA	NA

Approval Authority

Name	Title	Date
Leon Qu	Acting Group Manager Engineering	31/07/2018

UNCLASSIFIED

DISCLAIMER

© VicTrack 2018

This document is reviewed periodically and new editions are published. It is important that readers use only the current document published on VicTrack's document management system portal.

This document is not, nor should it be relied on as a substitute for, professional engineering design expertise or any other professional advice.

Nothing in this document diminishes the responsibility of designers and constructors for applying the requirements of any applicable law or standard.

Reviews and Amendments

This document should be reviewed every one (1) year by the Group Manager Engineering or amended as appropriate if the nature of operations changes significantly.

Contents

1. Conventions	5
2. Definitions	6
3. Scope and general	8
3.1. Scope.....	8
3.2. Application	8
3.3. Background	8
3.4. Occupational health and safety	8
3.5. Safety.....	8
4. Signalling Equipment.....	10
4.1. Equipment locations	10
4.2. Entry points for lightning and surges	10
4.3. Physical structures	10
5. Types of equipment requiring protection.....	11
5.1. Electronic equipment.....	11
5.2. Electro-mechanical equipment	11
5.3. Equipment Types.....	12
6. Lightning and surge protection	13
6.1. General.....	13
6.2. Design life.....	13
6.3. Failure modes.....	13
6.4. Segregation	13
6.5. Surge zones	13
7. Earthing protection	15
7.1. Maintainability.....	15
8. References.....	17
Appendix A – Earthing Equipment.....	18
Appendix B Lightning protection equipment.....	19
Appendix C Earthing arrangements for apparatus boxes and relay rooms.....	20
Appendix D Earthing arrangement for multiple apparatus boxes	21

1. Conventions

- 1) Words or phrases that appear capitalised out of context are defined within the Definitions section of this VRIOG Standard.
- 2) The word “**Shall**” is to be understood as mandatory.
- 3) The word “**Should**” is to be understood as non-mandatory i.e. advisory or recommended.
- 4) Uncontrolled Standards may not be referenced within the VRIOG Standards. These include former PTC Standards, Franchisee Standards, Franchisee Subcontractor Standards and Infrastructure Lessee Standards.
- 5) Controlled Standards, including Australian Standards and other VRIOG Standards, may be referenced but only if:
 - i) The referenced item cannot be adequately explained with an amount of text that could not reasonably be inserted into the body of the Standard.
 - ii) The reader is not referenced to another Controlled Standard necessary for the item to be adequately explained i.e. one document link only.
 - iii) The referenced document is a Figure or table and could not reasonably be included in the appendices of the Standard.
- 6) The format employed in the VRIOG Standards is compatible with Australian Standards, and will be used from this point on.
- 7) The numbering system for the VRIOG Standards is chronologically sequential from the point of introduction, and is not based on any form of interpretive system.
- 8) The VRIOG Standards contain engineering information necessary to operate a safe Railway. VRIOG Standards will not contain any information that can be construed as a work instruction, procedure, process or protocol. This information forms the basis of each individual entity’s Safety Accreditation Certification, and, as such, is outside the scope of VRIOG Standards.

2. Definitions

Terminology	Definition
Accredited Rail Operator (ARO)	A Rail Infrastructure Manager or Rolling Stock Operator who is accredited under Part 5 of the Rail Safety Act 2006.
Application for Variation of Accreditation	<p>An application to the Safety Director by an Accredited Rail Operator for variation of its accreditation due to the Accredited Rail Operator proposing to make change to or to the manner of carrying out, accredited rail operations that may reasonably be expected:-</p> <ul style="list-style-type: none"> • To change the nature, character and scope of the accredited rail operations; or • To not be within the competence and capacity for which the Accredited Rail Operator is accredited.
CBI	Computer Based Interlocking
Constructor	Person or organisation undertaking supply, construction, manufacturing, installation, testing or commissioning works under this specification.
Designer	The legal entity undertaking the design work in this standard.
DOT	Department of Transport
Earth Potential Rise	The increase in electrical potential of an earthing electrode, body of soil or earthed structure, with respect to distant earth, caused by the discharge of current to the general body of earth through the impedance of that earthing electrode or structure.
Earth Resistance	The resistance of the LPZ to the general mass of earth, as measured from a test point.
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.
Electronic equipment	Electronic equipment is defined as equipment that has more than 5% of its electrical parts as electronic components. Semi-conductor based devices and capacitors are considered to be electronic components.
Electro-mechanical equipment	Electro-mechanical equipment is defined as equipment that primarily contains inductors, electric motors, solenoids, relays, contractors, switches, resistors, etc.
EPR	Earth Potential Rise
Fail Safe	A design philosophy which results in expected failures maintaining or placing the equipment in a safe state.
GST	Galvanised Steel Toughing

UNCLASSIFIED

Terminology	Definition
Location	A small building or protective enclosure inside which equipment is installed. The terms relay room, walk-in hut, location case, equipment, track-side locations are types of location.
Lightning Protection Zone	With respect to the lightning threat, a zone may be defined, inside of which is sensitive equipment. Extra protection is applied at the zone boundary to minimize the risk of damage to equipment inside the zone.
LPZ	Lightning Protection Zone
Main location	A critical location, or a location containing significantly more than the average quantity of equipment.
MTTR	Mean Time To Repair
Rail Infrastructure Manager	A person who controls Rail Infrastructure.
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.
SPU	Surge Protection Unit
System	The system is defined as the product as a whole being supplied under the specific contract. The system may consist of a number of sub-systems which form the complete system.
Type Approval	Considerations of form, fit and function under specified conditions to approve equipment suitability for use within VRIOG infrastructure. (Refer to VRIOG standard "Standard for Signalling Design and Documentation VRIOG 012.1, Clause 4.2)
UPS	Uninterruptible Power Supply
VRIOG	The Victorian Rail Industry Operators' Group comprising the following members:- VicTrack V/Line Passenger Metro Trains Melbourne Yarra Trams Australian Rail Track Corporation (ARTC) Public Transport Division of the Department of Transport (PTD)
VRIOGS	Victorian Rail Industry Operators Group Standards.

Table 1. Terminology

3. Scope and general

3.1. Scope

This Standard provides guideline and performance requirements for earthing, lightning and surge protection provided for railway signalling systems within Victoria Railway Network.

3.2. Application

Unless otherwise specified, the earthing, lightning and surge protection components/equipment used in a signalling system shall be Type Approved by the ARO.

Refer to Appendix A and B of this specification for the lists of approved components/equipment. These lists are not exclusive. Alternate devices shall meet the application requirements in terms of the performance requirements and must be Type Approved by the ARO.

The Designer of the signalling systems shall provide the signalling systems design in accordance with the requirements stated in this specification.

It is the responsibility of the Designer of the signalling system to ensure that the system is protected against lightning and surge so as to minimise damage to the signalling equipment and that the signalling system can achieve its required level of performance.

3.3. Background

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 structure around the railway line tend to attract lightning strikes.

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

3.4. Occupational health and safety

The Designer and Constructor shall comply with the Victorian “Rail Safety Act 2006”, the “Occupational Health and Safety Act 2004” and the “Occupational Health and Safety Regulations 2007”.

If they are based overseas, they shall comply with a recognised international equivalent.

3.5. Safety

The railway signalling system is a safety system.

UNCLASSIFIED

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.

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

A “Failure Modes and Effects Critically Analysis” of the surge protection equipment and its proposed use is an accepted method of determining the effect 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.

4. Signalling Equipment

4.1. 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 location cases.

In the metropolitan area, these signalling equipment locations are fairly well protected against direct lightning strikes because of the 1500V DC overhead wiring and structures. But extremely high surges can be experienced on the power supply feeders.

4.2. Entry points for lightning and surges

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

- Power supply entry points 240V AC or 110V AC (derived from overhead high voltage transmission/distribution system)
- 240V AC or 110V AC power supply aerial cables (in the country areas)
- 240V AC or 110V AC power supply cables
- Overhead 1500V DC 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 EPR
- Induction in power supply/communications/control wiring etc.

4.3. Physical structures

All physical structures in the railway signalling environment shall comply with the Australian Standard "Lightning Protection" AS 1768.

5. 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.

5.1. 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”.

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.

The voltage or current appearing at the interface to an item of electronic equipment shall not exceed the rated voltage or current for the interface for more than the values given for the durations shown in the following table.

Interface	=<1ms	>1ms	>10ms
Power supply	300%	200%	150%
Communications	1000%	400%	150%
All other	1000%	400%	150%

Table 2. Rated voltage duration of exposure for electronic equipment

5.2. 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.

Electro-mechanical equipment is defined as equipment that primarily contains inductors, electric motors, solenoids, relays, contractors, switches, resistors, etc.

The voltage or current appearing at the interface to an item of electro-mechanical equipment shall not exceed the rated voltage or current for the interface for more than the values given for the durations shown in the following table.

UNCLASSIFIED

Interface	=<1ms	>1ms	>10ms
Power supply	500%	200%	150%
All other	1000%	400%	150%

Table 3. Rated voltage duration of exposure for electro-mechanical equipment

5.3. Equipment Types

Some of the existing equipment and systems currently in use as part of railway signalling systems are as follows:- (Note: These equipment types will vary as new technology is introduced)

Equipment	Type
AC and DC track circuits	Electro-mechanical
Audio frequency track circuit tuning units	Electronic
Audio frequency track circuits (CSEE UM71, WBS FS2500, WBS FS3000)	Electronic
Axle counter systems	Electronic
Cables (Telecommunications, power, data)	Electro-mechanical
Coded track circuits	Electronic
Color light signal (mostly LED based)	Electronic
Computer based interlocking	Electronic
DC Power supplies, linear	Electro-mechanical
DC Power supplies, switch mode	Electronic
Event loggers	Electronic
Impulse track circuit relays	Electro-mechanical
Impulse track circuit transmitters	Electronic
Level crossing monitors, level crossing flashers	Electronic
Point machines	Electro-mechanical
Telemetry systems	Electronic
Track monitoring systems : hot box detectors, dragging equipment	Electronic
Train stops	Electro-mechanical

Table 4. Equipment types

6. Lightning and surge protection

6.1. General

- a) Lightning and surge protection shall be installed to all signalling equipment in accordance to the equipment manufacturer's specification and with these Australian Standards:-

Australian Standard	Name
AS 3000	Wiring Rules
AS S009	Installation Requirements for Customer Cabling
AS 1768	Lightning Protection

Table 5. Australian standards for lightning and surge protection

6.2. Design life

- b) The surge protection system shall have a design life such that it does not compromise the designed life of the signalling system.
- c) 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 2 years on average.

6.3. Failure modes

- d) The expected failure modes of the surge protection equipment must not prevent the protected equipment continuing normal operation if the protection equipment is still operational.
- e) When a surge protection device breaks down due to a surge event, the failure of the device shall be readily identified.

6.4. Segregation

- f) Surge protected wiring shall be segregated from non-surge protected wiring to prevent coupling of surges between the wiring. Earth wire is to be considered as non-surge protected wiring.
- g) The amount of segregation shall be suitable for the expected level surge on the non-protected wiring.

6.5. Surge zones

Typical surge protection schemes are based on dividing the equipment installations into zones.

Each zone defining the possible level of surge that could occur in the zone from a protected zone by using surge protection filters on the entry to the zone, and physical separation of the zones.

UNCLASSIFIED

The surge protection zones defined in Australian Standard “Lightning Protection” AS 1768 are targeted towards physical protection of buildings.

Surge protection equipment supplier defined zones vary from one supplier to another.

The zones are defined as:-

Zone	Definition
Internal	Protected wiring within the location
Zone A	External wiring that originates in another equipment room
Zone B	External wiring that originates at a ground level source
Zone C	External wiring that originates from an above ground source

Table 6. Surge zones

Zone C has the highest exposure to surges, and internal zone has the least exposure to surges.

Surge protection devices are rated as Category A, B, or C with the appropriate category device fitted on the zone boundary.

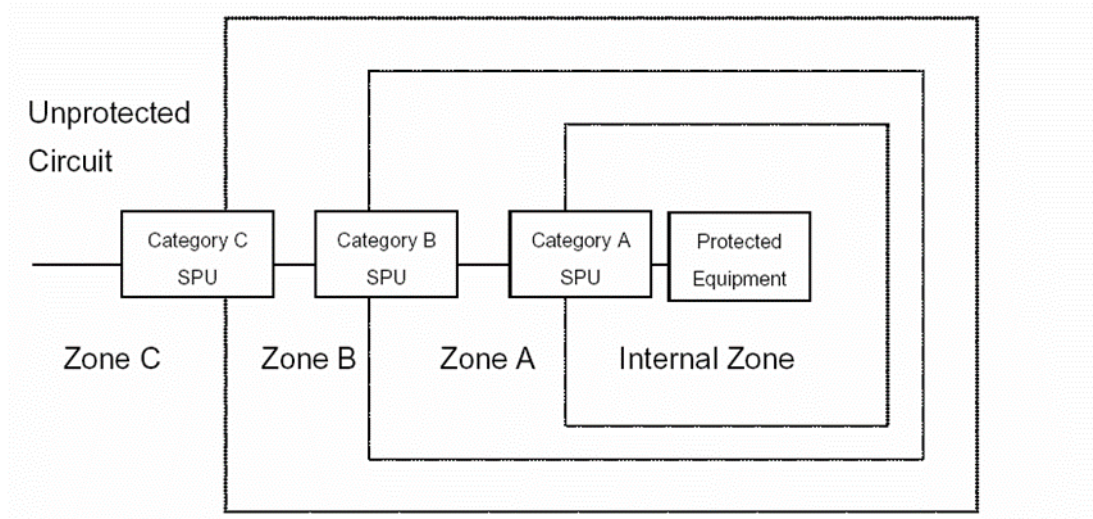


Figure 1. Relative category ratings

7. Earthing protection

- a) For the requirements of earthing for signalling apparatus protection, refer to VRIOG Standard "Specification for Signalling Supply, Construction and Installation" VRIOGS 012.2, Section 18.
- b) The earthing of equipment boxes shall be installed in accordance to the drawings shown on Appendix C and D of this specification
- c) The earthing for CBI signalling equipment shall be installed in accordance with the requirements stated in this specification and in accordance with the CBI equipment manufacturer's specification.
- d) 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 system.
- e) The earthing system shall have physical protection from activities that may be carried out in the vicinity and be vandal resistant.
- f) The maximum value of earth resistance provided for surge protection for electrical equipment to be protected shall be equal to or lower than that nominated in the following table.

Equipment Type	Earth Resistance
Electronic equipment installed inside locations	5Ω
Electro-mechanical equipment installed inside locations	10Ω
Electronic equipment installed external to locations	75Ω
Electro-mechanical equipment installed external to locations	150Ω

Table 7. Maximum value of earth resistance provided for surge protection

- g) 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 25 kHz to 50 kHz.
- h) 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 100Ω.
- i) Separate earths shall have a minimum physical separation of at least twice the length of the longest earth stake used.

7.1. Maintainability

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

UNCLASSIFIED

- b. Equipment that is not readily accessible for maintenance purposes shall not contain parts that require preventative maintenance or periodic inspection to check correct operation.
- c. The surge protection equipment's MTTR 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.
- d. Preventative maintenance required to maintain correct performance of the surge protection equipment shall not increase the maintainers' workload by more than 10%.
- e. For more details regarding maintainability refer to Australian Standard "Dependability Management" AS 60300.

8. References

The following Australian and International Standards have been used and referenced for the preparation of this standard:-

No:	Ref No:	Title
1.	AS 1768	Lightning Protection
2.	AS 3000	Wiring Rules
3.	AS S009	Installation Requirements for Customer Cabling
4.	AS 60300	Dependability Management
5.	IEC 60587 - 2007	Electrical insulating materials used under severe ambient conditions – Test methods for evaluating resistance to tracking and erosion
6.	IEEE C62.41.1 - 2002	Guide on the Surge Environment in Low-Voltage (1000V and less) AC Power Circuit
7.	VRIOGS 012.1	Standard for Signalling Design and Documentation
8.	VRIOGS 012.2	Specification for Signalling Supply, Construction and Installation
9.	VRIOGS 012.7.10	Lightning and Surge Protection – Varistor- Arrestor Panel (VAP)

Table 8. Referenced documents

Appendix A – Earthing Equipment

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

No:	Item	Type No/Part No
1.	Earth Electrode Clad 14mm dia. length 2m	Stainless steel grade 316; Type STE 1420
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 conductor	Single core 16mm ² Yellow/Green
8.	Earth Cable stainless steel, 2mm dia. solid conductor single strand	Grade 304

Table 9. Components approved for use in earthing and surge protection systems

Appendix B Lightning protection equipment

The following equipment is approved for use in lightning protection.

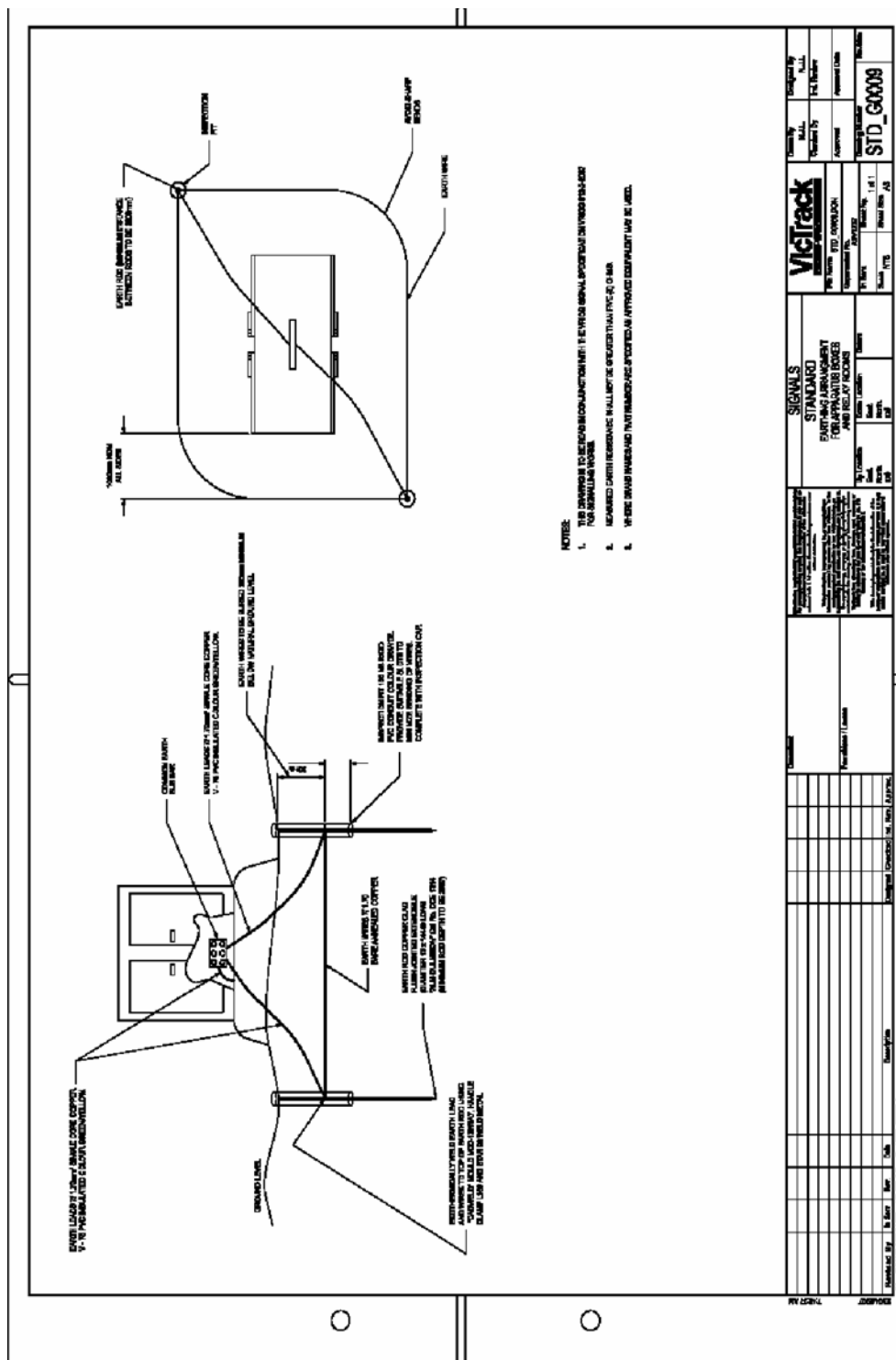
No:	Item
1.	Cable, 7/0.85 PVC Green & Yellow
2.	Cable, Stainless steel 2 mm (Approx. 3036M)
3.	Earth electrode 2 m x 14 mm Dia. Stainless steel
4.	Earth electrode clamp, Cast copper 14 mm
5.	Earth electrode coupling
6.	Earth electrode driving head
7.	Earth electrode star driving point
8.	Earth enhancing compound (Earth-rite compound or an equivalent)

Table 10. Equipment approved for use in lightning protection

For the list of approved varistor and arrestor use within Victorian Railway Network, refer to VRIOG Standard "Lightning and Surge Protection – Varistor and Arrestor" VRIOGS 012.7.10, Appendix A.

The use of any other type of lightning protection equipment will require type approval by the ARO.

Appendix C Earthing arrangements for apparatus boxes and relay rooms



		STANDARD FOR APPARATUS BOXES AND RELAY ROOMS		STD_G0009	
Approved By: [] Checked By: [] Drawn By: [] Date: []	Approved Date: [] Approved By: [] Checked By: [] Drawn By: [] Date: []	Project Name: [] Project No: [] Revision: [] Issue: []	Revision: [] Issue: [] Date: []	Revision: [] Issue: [] Date: []	Revision: [] Issue: [] Date: []

Appendix D Earthing arrangement for multiple apparatus boxes

