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Response to Australian Association of Live Steamers Code of practice Electric Systems for Miniature Locomotives

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Executive Summary

A sub committee of our club has been set up to consider this important and extensive document. Our analysis has included consideration of the draft clause by clause, investigation and inspection of real locomotives in search of details that should be included in the code, consideration of electrical fundamentals and research into Standards and other materials. We identify some matters as being especially critical – one relating to a safety problem that we believed would be cause by the draft as written, and one relating to a possible misleading of the reader about electrical fundamentals. These have been discussed separately from the clause by clause analysis.

Introduction.

The Box Hill Miniature Steam Railway Society Inc. (hereinafter called the "Box Hill Club") , being a member of the Australian Association of Live Steamers, supports the endeavours to introduce a Code of practice for Electric Systems for Miniature Locomotives.

The Box Hill Miniature Steam Railway Society runs a dual gauge (5 and 7 1/4 inch) Railway with about one and a quarter kilometre of main line. The railway is laid out on prototypical principles, and design features such as line of sight for signals only cater for a driver located in or immediately behind his loco. We thus do not have experience with locos that are operated from the rear of a train by way of a tether or radio link. Our comments will therefore not extend to that sort of operation.

We are pleased to take the opportunity to offer comment.

We have some experience with electric traction. Our Club owns a battery electric locomotive, and a member owned petrol electric loco joins this in regular revenue earning service together with diesel hydraulic and steam locos.

1.2 Scope of our contribution.
We have worked through the draft document, and made comments where called for clause by clause. We have also found the need to make comments on potential content: that is comment that does not relate to any clause in the draft.

We also have a contribution to make on how the proposed code can fit in to the model railway scheme of things.

Suggest change in Top-Level structure

In planning how to best propose that the code be brought into effect, we see a need for a family of Codes of Practice. For this reason, we suggest that the title of the proposed code be changed to

"Code of practice – Electric Systems for Miniature Locomotives Part 1. Safety."

We envisage other codes in the family. For example in this submission we assemble some material that might be gathered in a different part:
"Code of practice – Electric Systems for Miniature Locomotives Part 2 Wiring Practice"
Material that might form a useful guide for the beginner such as that gathered in the excellent submission by Neil Graham.
Perhaps there should be a part that acts as an introduction to all the other parts. In this case, perhaps the introduction should be Part 1. Then the Draft Code under consideration would have a different number. The numbering of the parts can be selected on merit, without any urging from us.

Legal Aspects

There seems to be concern about legal status.
Quote from the draft:

"AALS does not have any legal powers to be able to prohibit what people do"

This is not the point for a builder who will look to the Code. Assured compliance with the Code will be taken as establishing "Best Practice", and "Due Diligence" and will potentially be used as a defence against a charge of negligence. Thus the Code will have legal implications even if the Code writers desire that this would not be so.

A word on legal implications.
What follows is the situation as understood by members at Box Hill who have filled places in their careers that qualify them to make informed comment. For simplicity, a person who might modify equipment will be referred to as a "modifier".

Two Types
There are two types of legal implications that can come into play when some equipment is built and used.

The first is that there are legislative requirements to be met by the manufacturer, modifier, and the operator.

Second, when Standards or Codes of practice are written, they come to represent accepted practice. If a party suffers damage and seeks legal recourse, then the manufacturer, the modifier, or the operator can cite compliance with Standards or Codes of Practice as part of his case to demonstrate that due care has been taken: that is that there has not been negligence.

This second factor means that a Code of Practice, once published, has legal implications even if it does not touch on any matter that is covered by any existing law or regulation.

A manufacturer and a modifier are treated differently by law makers and regulation and Standard writers.

Generally, a manufacturer is held to account for the result of his work. There is a very wide scope for how he might order his efforts to result in the product. ***If a product is to be sold***, there are Standards that the product must meet, and often other Standards which dictate what tests must be performed to establish compliance with the first lot of Standards. The usual process is that the product will be designed and prototyped by engineers. Prototypes are tested, and when found compliant, the manufacturing is handed over to a production department. Generally, it is the responsibility of the production department to make units that are faithful copies of the units that passed the testing. There are generally no requirements that the actual production work be done by a person with any particular qualification or accreditation. It is the character and the quality of the product at the end of the line that matters: not what goes on in the production process.

If a product is made by an owner-builder, then the Standards for good practice apply, but the Standards for accreditation do not apply. There has been a continuously growing population of "home made" electronic equipment since the very first days of radio. The people who make electronic equipment at home do not have to submit their efforts for testing by any accredited testing authority. The wise home constructor will use the requirements that are imposed on industry as a guide. If the equipment owner can show that he has taken just as much care with respect to safety matters as the care that is mandated for the mass-producer, then he is in a good position to argue that he is not negligent and has taken all due care about the safety of people who operate or come near the equipment.

There is a problem when home made equipment is sold. The cost of design compliance for a manufacturer would exceed the cost of a single unit by a large factor. Compliance testing is not practical for a “one off”. This must be regarded as an ill-defined area. One solution when buying home made equipment is to modify it heavily, so that it becomes a new product in which the old product was only used as a component. Then the new owner takes full responsibility for safety compliance.

When deciding on every little detail of a product, the manufacturer has all details at his disposal. He thus knows all about the context for any potential change. This is not so when equipment is modified after sale, however. In this case the modifier does not have all the manufacturing information. He has to use other guidelines. He has to be qualified to take those guidelines into account. This is the class of person who is said to “work on” equipment in State government regulations.

To clarify this distinction with an example. Let us say that a manufacturer is to improve an air conditioner by fitting an enhanced thermostat. The engineers will design the change. If required, they will have a prototype built and sent off to an independent laboratory for Standards accreditation. Once those steps are taken, new work instructions will be drawn up and issued to the factory. Possibly stock units to the old design will be drawn from the store and modified in the factory. These modifications will be carried out by factory workers according to the work instructions. The factory workers will not be required to have any qualifications at all as far as any legislative agency is concerned.

However, if the old pattern air conditioner is already installed in a home, and the owner wants the upgrade, it might be necessary that this be done by a licensed electrician. He will not have the benefits of factory management and the work instructions that the factory worker has. He has to overcome these deficiencies with an understanding of the implications of what he does and the regulations that apply to his work. What he does is what constitutes “working on the equipment”.

If a grommet is required where a wire is passed through a panel, the factory worker will find instructions for installing the grommet. On the other hand, the electrician will install the grommet or a bush because he understands the requirement for it. The electrician's accreditation is the owner's guarantee that he does have sufficient understanding.

When an owner builder wires up his own locomotive, this is not “working on it” in this legal sense.

Classification of Voltages

It is stated in the Draft Code (In the Red Box) That:

"It is essential for the correct application of this Code that the above explanation and scope of Extra Low Voltage (ELV) and Low Voltage (LV) is clearly understood.",

However the drafters seem to misunderstand the correct application and scope of these terms.

What follows is the most critical and important point in this submission. The use of these names for these voltage ranges, is not only being taken out of context, **BUT IT IS DANGEROUS**. We ask locomotive designers to apply Fail Safe principles. The very same principles should be applied in the design of the wording of the code.

Here is a table representing the classification of voltages in three different contexts.

Context	**Usages of names for Voltage Classifications**
Consumer Electronics	**LT = Low Tension**. A voltage low enough to not cause an electric shock **HT = High Tension.** A voltage high enough to cause an electric shock. Potentially more dangerous than the electricity mains, as no protection is provided by the Earth Leakage Breaker. (Also sometimes called "**B+**" from the days when this came from the "B Battery" **EHT = Extra High Tension**. Voltage higher than High Tension. Particularly applicable to equipment with cathode ray tubes. "**Mains Voltage**". Although the voltage was often less than the HT in the equipment, it was classified separately. Protected by Earth Leakage Breaker, but has high current capability – can cause nasty burns as well as electric shock.
Alerts for the General Public	**High Voltage** – A voltage high enough to cause an electric shock. Finds application on the label on the rear cover of consumer equipment: "**Danger High Voltage – No User Serviceable parts inside**" (Have you ever seen a warning label that has "Danger Low Voltage"?) **Low Voltage** – A voltage that is not high enough to cause an electric shock. Members of the public know that they can handle torch batteries, phone batteries, lantern batteries and the like without danger of electric shock. The very design of these components, with bare terminals, conveys the low danger. The more adventurous members of the general public might learn the effect of placing the terminals of a nine volt battery on their tongue.
Electric Vehicles	High Voltage: Is defined in UNECE Regulation No. 100 **Uniform provisions concerning the approval of vehicles with regard to specific requirements for the electric power train** **Contains the definition at Clause 2.17** "High Voltage " means the classification of an electric component or circuit, if its working voltage is > 60 V and ≤ 1500 V DC or > 30 V and ≤ 1000 V AC root mean square (rms) **(Note: Of all the definitions seen, this one, by way of its authoritative context, seem to be most applicable to miniature locomotives.)**

Whatever words (and thresholds) are chosen in the code, there are consequences if these are misunderstood. The consequences are different for different word choices. Here is a matrix plotting the consequences of the actions of a naïve Code interpreter.

	Code written according to AS3000	Code written to UNECE Regulation 100
Observer sees wire labelled "low voltage"	Observer thinks wire is safe and grabs it	Observer thinks wire is safe and grabs it
Observer sees wire labelled "high voltage"	Observer thinks wire is unsafe and does not touch	Observer thinks wire is unsafe and does not touch

It is evident that in this matrix, that the orange cell represents an observer error. This error could result in the death of the observer. There is no corresponding dangerous outcome to an observer response to wire label in the column for Code of Practice written to UNECE Regulation.

It is established practice in the development of safety related documentation that safety is MORE IMPORTANT than the correct following of words in their established usages. An example is the use of the invented word *flammable* in preference to the actual established English Language word *inflammable*. This deliberate error has been introduced because of fear that the "in"prefix in inflammable means "not". (It does not mean that.)

We are lucky. All we have to do is choose the voltage classification system from the most applicable Standard (Electric Vehicles). We do not have to invent any ad hoc term to do the safe thing.

We believe that if voltage is to be classified, then the definitions of classes must be in a "Definitions" section.

One safe strategy might be to avoid descriptive words altogether.
If there is concern that there is some ambiguity in that the words "high" and "low" mean different things in different contexts, then new definitions could be established thus:

AALS Electrical Code of Practice Voltage Class 1
and
AALS Electrical Code of Practice Voltage Class 2

There could be a note indicating how these voltage classes correspond to designations in other Standards contexts.

Reference Material
See Wikipedia entry "High Voltage" at https://en.wikipedia.org/wiki/High_voltage

Where you will find "In automotive engineering, high voltage is defined as voltage in range 30 to 1000 VAC or 60 to 1500 VDC.

This cites UNECE regulation No 100 (revision 2, 12 August 2013) at
http://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/2013/R100r2e.pdf

The World Forum for Harmonization of Vehicle **Regulations** is a working party (WP.29) of the

Sustainable Transport Division of the United Nations Economic Commission for Europe (**UNECE**). It is tasked with creating a uniform system of **regulations**, called **UN Regulations**, for vehicle design to facilitate international trade.

This regulation is headed:

"UN Regulation No. 100
Uniform provisions concerning the approval of vehicles with regard to specific requirements for the electric power train"

It has the definition at Clause 2.17:
"High Voltage means the classification of an electric component or circuit, if its working voltage is > 60 V and ? 1500 V DC or > 30 V and ? 1000 V AC root mean square (rms)."

We probably need a clause to cover the case where faithful reproduction of warning signs on a prototype dictates wording that is not provided for in the Code. Might I suggest that if a cubicle cover carries a warning that is prototypical but not in accordance with the code, then immediately behind that cubicle cover (out of sight of the model admirer) there could be a compliant warning.

Colour Codes for Wiring

The Draft Code has:
"6.10 Consideration shall be given to having all LV traction wiring coloured orange. "
This is meaningless. It does not fall into the two categories of influence that are available to the Code writers. These are "shall" and "should". (The word "shall is used, but that applies to consideration: not to any feature of the locomotive.)

In a legal case (Imagine a person has been electrocuted touching a terminal inside a junction box that is not orange) the builder can state.
"I gave consideration to having all LV wiring coloured orange, and decided against it."
In this respect his loco would comply with the current draft.
If he has made a dated note at the time that that consideration was given, in his design notes notebook, he can prove that his loco complies.

What about something like this:
There shall be some visible indication of the status of wiring in each conduit or grouping or sheath. This shall be done by colour coding, or by some means that is just as visible as colour coding such as indelible identification with written labels. If colour coding of wiring is used then table XX.XX shall apply.
(There follows table that assigns various colours to wires of different functions)

This removes the element of "wishy washy" from the code. The word 'shall" is used, so there is a clear line between compliance and non-compliance, yet the builder who wants to use a bunch of cable that he has which is not orange, is not prevented from doing so.

We note that some heavy cables such as welding cables (heavy cable with high temperature insulation) is coloured orange. This is likely to find its way into traction circuits carrying 24 or 48 volts or so.

Earth Leakage Device

Here is a quote from the Draft Code:

"All low voltage systems shall be designed and constructed to be double insulated from the locomotive frame. An earth leakage device shall be provided to detect faults to frame."

The expression "earth leakage device" is not a generally used term in electrical engineering. It is used in a few instances to identify what is normally known by any of several names:
Earth Leakage Circuit Breaker
Residual Current Device

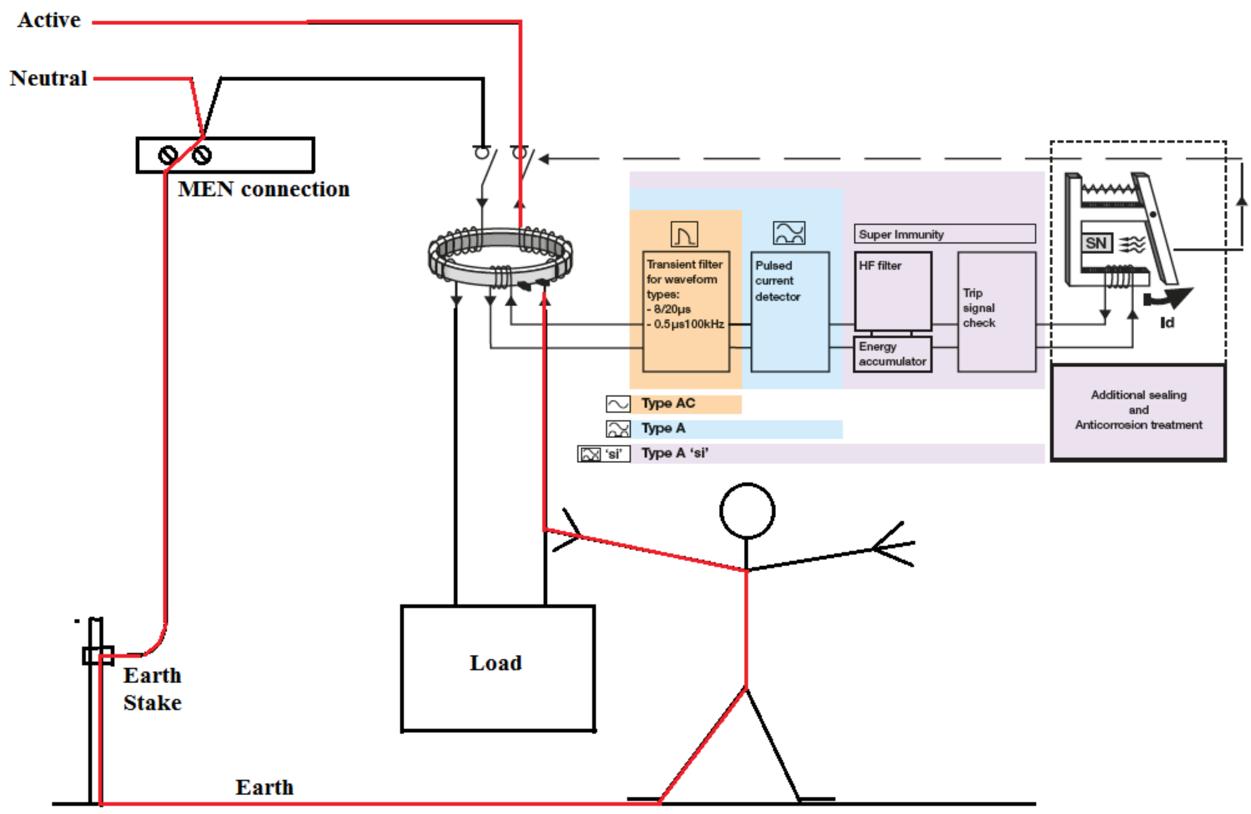
Schneider Electric at: https://www.schneider-electric.com.au/en/faqs/FA243467/
ask "What is the definition of the Earth Leakage Device?", but then go on with a spiel about RCDs. (This is a good summary.)

The term "Earth leakage Device" is very close to "Earth leakage Circuit Breaker" , but seems to be distinct. Let us assume that "Earth Leakage Circuit Breaker" is meant.

In this case the two sentences from the Draft Code quoted above **ARE CONTRADICTORY**.

IF " All low voltage systems shall be designed and constructed to be double insulated from the locomotive frame", THEN AN EARTH LEAKAGE CIRCUIT BREAKER **WILL NOT WORK..**

Schneider Electric have a diagram of the internal parts of an Earth Leakage Circuit Breaker on their web site. I have copied this, and added the essential external circuits for this to work.



The "Earth Leakage" path (which in this case is provided by a stick-figure person) can be traced from mains Active, through one coil in the balanced toroidal transformer, through the person to

Earth. Then through the wire from the Earth Stake to the MEN point in the building main switchboard. The connection between the Earth and the Mains Neutral (at the MEN point, and at other points in the supply network) is essential for closing the circuit for the fault current to flow. It will be noticed that the fault current path (red) passes through only one side of the toroidal transformer. This is what causes the imbalance and the tripping of the breaker.

Of course, if the application is a locomotive, and not a house, the chassis can stand in for the "Earth".

In systems in which power circuits are isolated from the chassis, such as full size EMD diesel electric locos, protection against a fault to earth is provided by a "Ground Fault Relay" which works on completely different principals. A "Ground Fault Relay" can be devised to work on DC or AC, which is not possible with a core balance residual current device.

Ground fault Relays have been used in electric fork trucks as well.

We note that in the submission from DVR, it is assumed that the draft document expression "earth leakage devices" means "Residual Current Devices. The DVR writers are concerned about the applicability of these with frequency and waveforms that are different from those encountered in building wiring. It seems to us that the waveform shape is of no concern, as the combination of the two quoted sentences has to be removed from the draft anyway.

Proposed Requirements of Code that do not relate to particular clauses in the Draft

Test Examinations of Locomotives

We conducted inspections on three seven and a quarter inch gauge locomotives, all in revenue service on our club railway. One battery Electric, One Petrol Electric, and one diesel hydraulic. We inspected them as if we were checking them for compliance and accreditation against some future formality. As we noted each detail, we assessed whether that detail should be covered by a code. The following are some of the points that were noted.

* Interlocking 1. Throttle to be in the "zero" position before the reverser can be moved.
* Interlocking 2. For locomotives with internal combustion engine and electric start, it must bot be possible for the locomotive to be moved by the action of the starter. (starter to be inoperative unless driver controls in a safe state)
* Any contactor that can be opened to break contact current in a locomotive with a petrol engine, to have a snubber circuit on the contacts to eliminate sparks.
* Ergonomics. Size and actuating force of controls to be commensurate with their function. An accidental knock is not to be able to open the throttle. (Electronics "volume control" pot as throttle)
* Live terminals to be covered where a metal object placed on the dash board can cause a short circuit.
* Instruction labels not to use "nick names" for key functions where misunderstanding could be dangerous
* Sound card not to include horn sounds that occur when driver has not actuated loco horn.
* Insulated wire to be properly tied up and not draped on items which might become hot.
* Unknown internal circuits of proprietary controller not to be relied on to provide fail-safe features.

Other Requirements

- Selection of temperature rating of electrical insulation.
- Prohibit us of solder to consolidate strands in screw terminals

SECTION 2. CLAUSE BY CLAUSE REVIEW OF DRAFT

An editable version of the draft has not been available to us, so what follows is a copy of the text taken from the .pdf. This does not preserve the formatting of the published draft. Note that the table has been copied as a picture.

Comments are in colour.

1.
GENERAL

1.1
This Code of Practice is intended to cover minimum safe operating requirements of affiliated societies operating miniature railways as non commercial hobby operations.
1.2
This code is in accordance with the Aims and Objects as detailed in the Australian Assoc iation of Live Steamers Constitution.
1.3
With changes to Amusement Device Legislation in various States of the Commonwealth and the trend for self regulation by industry and business in general the need for a high standard of competency in construction and operation what about design? is required.

2.
CONTEXT

2.1
This Code of Practice for Electric Systems for Miniature Locomotives should be read in conjunction with:
2.1.1
AALS Code of Practice:- Operation of Miniature Railways, Road Vehicles and Plant;
2.1.2
AALS Code of Practice:- Interoperability and Safety of Miniature Railways, Road Vehicles and Plant;
2.1.3
AALS Code of Practice:- Training of Operators and Attendants of Miniature Railways, Road Vehicles and Plant;
2.1.4
AALS Code of Practice:- Gas Firing of AMBSC Boilers;
2.1.5
AALS Code of Practice:- Gas Firing in Small Models ; and
2.1.6
AMBSC Boiler Codes parts 1, 2, 3 and 4;
2.1.7
AS 3533 - 2009 Amusement Rides and Devices;
2.1.8
AALS Constitution;
2.1.9
AALS Standing Orders.
UN Regulation No. 100
Uniform provisions concerning the approval of vehicles with regard to specific requirements for the electric power train

3. DEFINITIONS

3.1
For definitions used within AALS Codes of Practice, see the AALS Code of Practice: Operation of Miniature Railways, Road Vehicles and Plant

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4.
SCOPE

4.1
This Code of Practice applies for the building of miniature locomotives which utilise electric systems for operating by an AALS affiliated society in the presence of the public. Locomotive systems may include the power supply, control system, traction system and accessories, any or all of which may be electric, or electric in conjunction with internal combustion, mechanical, hydraulic or other types of systems.
4.2
The intention of this Code of Practice is to provide information about the design, construction and operation of the electrical systems of a miniature locomotive to ensure safety for the user or maintainer, and the general public.
4.3
This Code of Practice will also provide AAL S affiliated club executives information regarding these systems should their members wish to pursue this method of locomotive type and establish safe practice to allow visiting members from other AALS affiliated clubs to operate their equipment.
4.4
This code will consider equipment operation at extra low voltage (ELV) which is not exceeding 50v AC or 120v ripple-free DC, and low voltage (LV) which is above ELV and not exceeding 1000v AC or 1500v DC. In the case of low voltage (LV) equipment this code shall only consider equipment operating up to common industrial voltages (i.e. 415v AC, or 480v DC)
Note: Some jurisdictions consider voltages in excess of 25v AC and 60v DC to be hazardous, even though still ELV

IMPORTANT

It is essential for the correct application of this Code that the above explanation and scope of Extra Low Voltage (ELV) and Low Voltage (LV) is clearly understood. Most battery electric drives built by model engineers are Extra Low Voltage (ELV). The typical electrical supply to houses, etc. is Low Voltage (LV).

4.5
This code does not consider battery packs or combinations of batteries with nominal voltage greater than 48v DC. Why not? Why shouldn't a builder who strips equipment from a 72 volt fork lift be able to use it?
4.6
This Code of Practice applies to a miniature locomotive that operates within 2½ inch gauge to 7¼ inch gauge railways, and is used for public passenger hauling, or is used on the same tracks at the same time as public passenger hauling.
4.7
Due to the rapid change in battery technology, this code is not able to specify practical details for all the various types of batteries that may be utilised now or in the future.

Consequently it is a requirement on the designer and builder to adopt the general safety provisions provided for in this code, and to comply with the manufacturers recommendations for installation and operation of such equipment within the safety context.

4.8

Systems may be electro-mechanical or electronic in nature. A simple electro-mechanical system (i.e. one that uses relays which have a predictable failure mode) may be used to provide fail safe functionality in an otherwise electronic system.

4.9

Review definition?

This code uses the concept of failsafe. Failsafe is a specific design philosophy that when applied to a system results in any failure of or within that system having a safe outcome. Specifically certain equipment may be considered to have reliable and predictable failure modes such that

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they may be designed into a system that produces safe outcomes. Generally such systems require an application of energy to progress to a less safe state (e.g. a higher speed) while a failure will result in the removal of energy, and the equipment thus stopping. In recent radio control systems, the term 'failsafe' has also been used to describe a programmable facility that can respond to a loss of communication between the controller and remote unit. Such facilities are usually set, as a minimum, to remove traction power. However the unit is not necessarily considered failsafe ~~in the traditional sense.~~ as defined in railway practice.

Perhaps we need a more snappy definition. This definition will be quoted frequently in the fraternity, and needs to be quotable in nature, and memorable and clear to those with a short attention span. It will be used for judging design features against very often.

Wikipedia on “Fail Safe”
https://en.wikipedia.org/wiki/Fail-safe

A **fail-safe** in engineering is a design feature or practice that in the event of a specific type of failure, inherently responds in a way that will cause no or minimal harm to other equipment, the environment or to people.

Proof of safety is achieved by a detailed analysis of the outcomes of all the various failures of each and every component in the system. Failure Mode and Effects and Criticality Analysis (FMECA) is a technique used in producing a proof of safety. Such analysis becomes increasingly complex as systems become larger and have increased numbers of components. It is recognised that formal and comprehensive proof of safety of systems on miniature locomotives are unlikely to be able to be produced by designers and builders of miniature locomotives used in a hobby environment. Consequently this code will largely consider any control systems that uses electronic components to have an unpredictable failure mode and that such a system would need to be supported by a simple series system which provides the level of safety required or an additional independent system that guarantees the reliability of a stop command.

Where an all electronic arrangement with safety implications is used in industry then that system would need to comply with AS/IEC 61508 Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems. It is not anticipated that hobbyists will be familiar with these standards nor would suppliers to this hobby so this code attempts to provide guidance to achieve ~~a degree of equivalence~~ compliance.

Risk exposure if not complying with Standard?

There are other risks that may need consideration and a risk assessment of the overall system shall be conducted by the designer to ensure any hazard is designed out. This code will list some of these potential hazards.

4.10

The principal safety issue this code addresses is the ability to bring a locomotive to a stand in a reliable way. Thus the safety requirement is to be able to cut traction power and wherever possible, apply brakes reliably upon demand of the operator. (This document refers to this as an Emergency Override. It could take a number of forms).

The Emergency Override shall be easily accessible to the driver. Other hazards include the risk of explosion, burns, fire and electric shock or electrocution.

~~4.11~~

~~Commercial builders of genuine model equipment will have their own standards and compliance regime to which their products are built in order to conform to legislated Work, Health and Safety Requirements and electrical regulations and are thus exempt from the design and construction requirements of this Code. However it is recommended that migration to this Code occur wherever its requirements are greater than those currently being used by manufacturers.~~

It is difficult to see a rationale for exempting commercial built equipment from this code. If commercial equipment does not meet the requirements of this code and is exempt, then it is not compliant. If it does not meet the requirements and is not exempt then it is still not compliant. All the exemption achieves is to deny the commercial manufacturer the opportunity to be compliant. Why should the owner of a purchased commercially made locomotive be denied the opportunity to claim compliance to this code? A locomotive that is to be sold will have to meet other requirements as well. See “Legal Aspects” above.

Delete 4.11

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5. BATTERIES

SAY that there is no such thing as a “sealed battery”.

5.1

Batteries shall be securely mounted to the vehicle.

5.2

Adequate ventilation shall be provided for batteries that gas or have the potential to emit gas so that such gas may freely escape. This includes valve regulated (often erroneously called “sealed”) batteries.

The design of battery compartments shall ensure that any escaping gas is not channelled to an area that may contain a means of ignition.

5.3

Wet batteries shall have a means to prevent the escape of electrolyte in the event of an accident.

5.4

All batteries shall have an isolation device close to the battery. This isolation can be by switch or by removal of a battery lead, in smaller models. The isolation device shall be easily accessible.

5.5
Batteries shall be mounted clear of any heat sources.

5.6
A fuse or circuit breaker shall be provided close to the battery , but external to the battery compartment if a separate compartment is provided, to limit current under fault conditions.

5.7
Battery terminals shall be shrouded with a robust cover. Thermoplastic shall not be used for battery terminal shrouds.

5.8
When some battery types are on charge and floating explosive and corrosive !!!???? (What is corrosive? Oxygen or hydrogen?) gasses are
discharged. This is a serious and dangerous ~~explosive~~ explosion hazard. Measures must be taken to
charge in very well ventilated areas (do not put cover over loco!) as an electrical contact opening at the time of battery float can be an ignition source. It is ~~recommended~~ required that battery changing take place in a secure well ventilated area away from ignition sources.

5.9
When an onboard charger is provided, switching shall be provided to isolate the ELV system when charging, and conversely to isolate the charger when the locomotive is in use. (To what purpose?)

6.
ELECTRICAL SYSTEMS

Common Requirements

6.1
All wiring shall be insulated or protected from short circuit and held clear of hot or moving parts. What about bus bars?
Bus bars and bare terminals covered by a cover that one needs a tool to open.

6.2
Care shall be taken that wiring insulation shall be rated for the application
Insulation must have a suitable voltage rating for the service, have the appropriate temperature rating, and be robust in the face of scuffing or contact with sharp edges.

and the size of
conductor is consistent with the current it is expected to carry as well as any fault current ~~levels~~. Provide cable size requirement.

6.3
Circuit breakers used on DC systems shall be of a type suited for DC use at the voltage applied.

6.4
Connectors for wiring between vehicles shall be shrouded to avoids accidental short circuits What is wrong with insulation within the connector body?
I think that the authors mean that connector have a connector body, and not be bare terminals..

6.5
Any inclusion of a low voltage on board battery charger shall have the locomotive frame connected to the mains earth
I have a problem with this. Mains earth is a dangerous voltage. A connection to mains earth might interfere with track circuits.

and the ELV system shall be isolated from the batteries when charging.

Why?
It should preferably not be able to operate the locomotive when attached. On board chargers shall not be used while people are on or in the equipment. The presence of an on board charger does not place the locomotive into the Low Voltage category, as the low voltage equipment cannot be used while it is operating.
Rethink? What is this all about?
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Requirements for Systems Operating at Voltages within the LV Range
6.6
All low voltage systems shall be designed and constructed to be double insulated from the locomotive frame. An earth leakage device shall be provided to detect faults to frame. The above two requirements are mutually contradictory. “earth leakage device” not the name of anything. An earth leakage breaker requires a connection between the current carrying wiring and earth (in AS3000 context, this is the MEN point.) What is required in these circumstances is a “Ground Relay (as in full size diesel loco practice). See “Earth Leakage Device” (above). The
locomotive shall not be operated while ever a fault to frame exists. A test button shall be provided to test the effectiveness of the earth leakage device. (This is an IT standard type electrical configuration).(what does this mean?)
6.7
There are to be
~~All low voltage systems shall ensure there are~~ no accessible terminals, or touch points in low voltage circuits ~~within the locomotive~~. Enclosed terminals shall be used. Any bare terminals shall be shrouded, such that removal of the shroud is only possible by the use of a tool
.
6.8
ELV and LV systems within the one locomotive shall be separated as far as possible. Double insulation shall be provided on the ELV wiring (either by wiring sheath or insulated ducting) where it runs close (<50mm) to LV wiring.

Circuits which themselves use ELV voltages, but which are essentially connected to LV circuits (such as gate drive for MOSFETs or IGBTs, or SCRs) are considered to be part of the LV circuit.
6.9
ELV systems powered from a LV source shall be provided with an isolated power supply to ensure that faults within the LV system such as short to chassis cannot ~~propagate into the~~ give rise to excessive voltage on the ELV system.

Drafting note: It is understood that in a case where the ELV system is powered by an isolated supply from an LV system, a fault that causes the LV system to fail (either directly, or because some protective device has tripped) then the supply for the ELV system will have (of necessity) failed. In such a case, circuits in the ELV system will not be relied on to provide any safety features (such as power for breaker shunt trip) for the LV system.

6.10
~~Consideration shall be given~~ Are these words “Consideration shall be given” supposed to be by way of a drafting note? A detail has to be mandatory or recommended or left out. Just mandating considering of something doesn't say anything. to having all LV traction wiring in an orange coloured sheath.~~ orange.~~

On locomotives in which there are both LV and ELV wiring, all wiring shall be clearly labelled or colour coded to indicate which category it belongs to.

6.11
No LV wiring shall be accessible in the driver's area. (note: apostrophe in previous sentence is in blue)
6.12
On board LV generators shall not be used to power external equipment unless the generator is compliant with AS2790-Electricity Generating Sets. Any single or three phase outlets on the generator shall not be able to connect to external devices. Previous sentence contradicts the one before.
6.13
Some jurisdictions may require LV electrical work to be performed by an appropriately competent or licensed person. Need to resolve this before releasing this document.
I do not believe that it is true. The Builder shall ascertain the specific requirements for their State or Territory.

7. CONTROL SYSTEMS
7.1
Locomotives of 5 inch gauge or larger with the capacity to haul more than one carriage (as indicated in the matrix) shall have a key switch, control box disconnect facility or other arrangement which can be used to immobilise the locomotive against unauthorised use when unattended. It shall not be possible to drive the locomotive with the key, control box or other arrangement removed.
7.2
Irrespective of the method of control, a n accessible, simple, robust and reliable method shall be provided to be able to bring the locomotive to a stand. (Brakes?)
7.3
“The system” (What is “the system”?) shall be designed to failsafe principles.
Any broken wire, defective terminal, defective relay, broken switch or the like shall tend to bring the locomotive to a stand. Need to revise. Some wires are not safety related. Not appropriate to disable loco if some irrelevant wire is open circuit. Very difficult to arrange circuitry to disable loco if the wire from the headlight switch to the headlight goes open circuit whilst the headlight is switched off.

7.4
Where an electronic control system is provided, compliance with 7.3 can be achieved by providing an independent, reliable and robust method (such as an 'Emergency Override'

switch) to bring the locomotive to a stand in the event of a malfunction.
No it can't!!
7.5
The operator may be remote from the locomotive by use of a control box attached to the

end of page 8

locomotive by a lead, or by radio control. The method of control does not alter the need to comply with 7.4
.
7.6
Where a remote control system (either by tether or radio) is used, the independent system required in 7.4 may also be an electronic system provided it is totally independent from the main system and the likelihood of any common failure modes is remote. Such dual systems shall be prove d operational at all times the locomotive is in use. (i.e. both systems are required to be operational to operate the locomotive). This ensures that in the event of failure of either system, the alternate system is available to bring the locomotive to a stand. An analysis shall be made of such an arrangement to demonstrate it provides the safety benefits of a fail safe system through a duplicated system of high reliability.
7.7
Interlocking of controls may be required (see Matrix) where the locomotive is capable of hauling more than one carriage . Such interlocking should consider the selection of direction only when the locomotive is at a stand, or a very slow speed, and when the throttle is off, or is attached externally to a battery charger.
7.8
Only one locomotive shall be controllable from the controller at a time, unless the units are coupled and connected as multiple units. Similarly any locomotive shall only be controllable from a single controller at any one time.
7.9
Where the driver is seated on a vehicle separate ~~to~~ from the locomotive, provision of an automatic shut down in the event of the driver's vehicle becoming unattached is highly desirable It is highly undesirable to introduce categories such as “highly desirable”. in locomotives which can haul more than one carriage ('Breakaway Control'). The shut down shall disconnect traction power.
7.10
Disconnection or loss of a controller or the control function (either tethered or radio) shall result in a shut down of traction power, and ~~if possible,~~ the application of brakes.
In the case of radio control, a loss of the radio link shall shut down traction and~~, if possible~~ apply the brakes, when applied to a locomotive that can haul more than one carriage .IT IS POSSIBLE!
7.11
Consideration of the inclusion of dead man control or a driver detector should be given for all locomotives that can haul more than one carriage. Allow Vigilance Control, but impose some restrictions.
7.12
An indicator light shall be provided on the control panel to show when the power is active.
7.13
When utilising a remote control (wireless) system, builders are encouraged to consider a **quality system** (In the context of a code of practice, “quality system” has a meaning that is different from that required here. Choose other words.)
https://www.safetyculture.com.au/international-standards-organisation-iso/quality-

management-system-as-nzs-iso-9001-2016/?gclid=Cj0KCQjwxbzdBRCoARIsACzIK2kT3v58IiKV5xEPyINTjGNYmBVxagfvjCxdV54faK7HklPuzDDtI08aAoE6EALw_wcB
with robust components and ~~proven~~ proved reliability. Means of ensuring the transmitter cannot be dropped while the train is operating should be implemented (e.g. use of a lanyard).
7.14
The required application of various hazard reduction controls is shown on the requirements matrix.

end of page 9

Requirements Matrix for Hazard Reduction on Miniature Locomotives with Electric Systems

	Small Non passenger hauling loco or vehicle	Small passenger hauling loco.	Major 5 inch or smaller 7.25 inch gauge passenger hauler .	Large 7.25" gauge passenger hauler.
Requirement				
Emergency Override (7.1)	Not Required	M	M	M
Power On Light (7.12)	Not Required	M	M	M
Battery Isolation Device (5.4)	M	M	M	M
Battery Fuse or CB (5.6)	M	M	M	M
Key Switch (7.1)	Not Required	R	HR	M
Interlocking of controls (7.7)	Not Required	R	HR	M
Breakaway control (7.9)	Not Required	R	HR	HR
FailSafe used with Remote Control (7.10)	R	R	HR	M
Dead Man control (7.11)	Not Required	Not Required	R	HR

R-Recommended HR-Highly Recommended M-Mandatory N.B. Having a higher level of requirements implementation is always satisfactory.

Not Required - While this requirement is not specifically considered there is no restriction on its implementation.

Definitions:

Small non passenger hauling loco or vehicle: A 2.5" gauge or 3.5" gauge model that may haul one carriage. Such models are not capable of public passenger hauling. They are characterised by being light weight and generally simple in their systems, and use small batteries, although they may be radio controlled. They are considered low risk due to their very low mass.

Small passenger hauling loco: Typically a 4 wheel type battery powered model capable of hauling 1 carriage. Potentially capable of hauling 1 public passenger and 1 driver. They may use 1 battery or perhaps 2 small ones. These are considered low risk due to their low power and speed and low mass.

Major 5 inch or smaller 7.25inch gauge passenger hauler: These locomotives can haul 2 or more passenger cars and can be used for public passenger hauling. They have a larger mass, usually use 2 (or more) batteries, and are often provided with some brakes as part of the locomotive.

Large 7.25 inch gauge passenger hauler: This category is for large (sometimes narrow gauge) prototypes of substantial mass.

Note: I have had to include a photo of page 10 here, as it was impractical for me to recover the table from the pdf.
The term “Dead man Handle” is well known and understood. Perhaps it should be in the definitions. The term “Dead Man control” introduces ambiguity in being different. How is it supposed to be distinct from “Dead Man Handle”. Is “Dead man Control” supposed to cover “vigilance control” (“VC”) as well as “Dead Man Handle”? I want to promote the option of VC for reasons of authenticity.
Add a “Brakes” row to the table.
end of page 10

8. PROOF OF SAFETY, TESTING AND CERTIFICATION

8.1

All Electronic Systems: All 5 inch gauge or larger locomotives that can haul more than one carriage, and is equipped with an all electronic control system in accordance with Section 7.6 shall have their safety methodology (What is this? Perhaps "Design for Safety Method" is meant.) analysed and the results documented as a proof of safety. The analysis may be conducted by the designer, builder or owner. The Proof of Safety shall incorporate a Failure Modes and Effects Analysis, a test plan that demonstrates the effectiveness of the safety systems , and the system shall be tested in the presence of an independent witness who will countersign the proof of safety document.

Many loco owners and builders will need help with this. many would not know where to start.

8.2

Low Voltage Systems: Any locomotive built with a LV power system shall be certified by a competent electrical engineer or a qualified supervisor electrical to be in compliance with this code of practice. This certificate will be valid for 5 years from the date of inspection and will be void if substantial changes are made to the LV equipment or installation

.

(See sample template in Appendix 1)

.

9. OPERATION

9.1

The charging of batteries that gas shall be carried out clear of steam locomotives, steaming bays and other areas where an ignition hazard may be present.

9.2

Consideration shall be given by Societies ~~in regard to~~ to require a fire extinguisher being carried on trains.

This might be a good idea, but doesn't seem to belong here.

9.3

The potential of a remote control system could provide a means for a driver to be seated at a different location rather than traditionally at the front of the train. Societies shall consider the hazards and advantages that this may present and ensure suitable operating procedures are in place for any variation to normal operation.

9.4

The battery shall be isolated whenever work is being done on the system, except for testing purposes only.

10. NON EXHAUSTIVE LIST OF HAZARDS

The following list are hazards that may be present and are presented as an aide–mémoire in consideration of the various factors that the design will need to accommodate.

10.1

Electrical systems

Electric shock

Explosion or fire from gassing battery

Acid burn

Hazards of alternative battery technology (eg LiPo) not understood.

Overheating of wiring with risk of fire

Explosion from vaporizing conductor on fault current.

Petrol vapour ignited by contactor arc.

end of page 11

Relay/contactor jams in energised position.

Switch breaks.

Short circuiting of connections or terminals.

10.2

Control System

More work required here. An introductory paragraph explaining how the obligation to provide a fail safe design bears on the control system might be good. Maybe that would go in 7.0

Uncontrolled acceleration.

Need to point out in the appropriate place that electrical safety is not the only factor to consider in over current protection. The over current protection would be required to trip if full battery voltage were suddenly applied to traction motors, for instance.

Broken switch or control device (including blown fuse, defective servo, defective power supply, unsuitable receiver location)
Broken or defective tether cable to controller.
Loss of radio link for radio control
Unit becomes out of range.
Interference to radio link
(by another operator)
Operator drops controller (radio or tethered)
Drivers car (with or without) controls becomes disconnected from locomotive
Remote unit
flat battery.
Inadvertent control of wrong locomotive
Inadvertent movement when setting direction.
On board and remote control units simultaneously active.
Driver in different position in train.

11. AMENDMENTS TO THIS CODE

11.1 First approved issue <Date>

end of page 12

APPENDIX 1

Sample Certification Letter for Low Voltage Locomotives.

CERTIFICATION OF LOW VOLTAGE MINIATURE LOCOMOTIVE

IN ACCORDANCE WITH THE
AALS CODE OF PRACTICE FOR ELECTRIC SYSTEMS FOR MINIATURE LOCOMOTIVES.

I certify that the following locomotive:
Type of Locomotive: Gauge:
Builders Name:
Builders Address:
Date of Commissioning:
Owners Name:
Owners Address:

has been inspected by me and is in accordance with the mandatory requirements of the AALS Code of Practice for Electric Systems for Miniature Locomotives Section 6 in respect of a locomotive with a low voltage system.

Signature:
Name of Electrical Engineer or Qualified Supervisor (Electrical):
Certificate Number:
Address:
Date:

Section 3. Establishing a context for the proposed Code of Practice – Electrical Systems for Miniature Locomotives

When (if) the proposed code of practice is endorsed by AALS, what role is it expected to play in the scheme of things? We believe that some context needs to be established to bring the Code to a level of usefulness that reflects the work that has been put in to it.

We envisage a situation where the Code could play a role in the determination of the level of safety for accredited locomotives so that clubs could use this to establish whether it is safe to run the loco on the club's track. The similarity of this aim to the situation that AALS has achieved with steam locomotive boilers. Maybe the the administrative structure around the accreditation and actions of club boiler inspectors can be used as a guide. This might not be easy, as it might not be as straightforward to find and appoint Electrical inspectors with a standing similar to that of the existing boiler inspectors.

The difficulty of achieving this is demonstrated by looking at the wording that defines Boiler Inspector appointment, and how it might be modified to suit the electrical case.

APPENDIX 1 - AALS Electric Traction Inspector Qualifications
A1.1 ACCEPTABLE QUALIFICATIONS FOR APPOINTMENT AS AN AALS Electric Traction INSPECTOR
A1.1.1 A person holding a tertiary qualification issued by an accredited university, college, ~~or government agency~~, in electrical or electronic engineering and at least five years experience in the design or testing or manufacture of electronic and electrical equipment of similar complexity to a locomotive with electric traction. ~~such qualification being in a field related to the design, testing, and operation of pressure vessels, or;~~

A1.1.1 A person holding a trade or technician qualification tertiary ~~qualification issued by an accredited university, college, or government agency~~, in electrical or electronic engineering and at least five years experience in the design or testing or manufacture of electronic and electrical equipment of similar complexity to a locomotive with electric traction.

Should we provide for the autodidact (self-taught)?

Should some familiarity with railway practice be required?

~~A1.1.2 A competent model boiler constructor who shall possess the following criteria to be eligible;~~
~~a) A minimum educational qualification of a NSW Higher School Certificate, or equivalent, or a trade certificate, or higher qualification, and~~

~~b) A minimum of three years membership of an AMBSC registered society, and~~

~~c) The successful construction of at least one miniature boiler, and~~

~~d) A minimum of two years experience in the practical operation of miniature boilers, and~~

e) Two current ~~boiler~~ inspectors to act as referees to attest to the satisfactory quality of

workmanship of the nominee inspector

We believe that many clubs might have difficulty finding a suitable candidate for “Club Electrical Inspector”. In an attempt to address this, we suggest that the electrical inspector's task might be simplified by providing a detailed check list. It is much less demanding of the electrical inspector's understanding of the issues that matter, if he finds them listed on a check list.

This gives rise to the idea of a separate code.
“Code of Practice – Good Electrical Wiring.”

We do not suggest that the word “Safety” appear in the title of this particular Code. The reason for this is, that the inspector has to be immune from criticism from an applicant who might claim that a particular matter does not have safety implications for his particular loco.

Suggested matter to include in a “Good Wiring Practice” Code

Wire Sizes

The loco owner should have the opportunity to justify a particular wire size in a specific application. However, a table could be provided to use as a default.

Wire size to be determined by prospective fault current – not working current.

C.S.A.	Current carrying capacity
mm^2	A
1.0	11
1.5	14.5
2.5	20
4	26
6	34
10	46
16	61
25	80
35	99
50	119

Wire Types

Stranded wire to be used. This does not mean electricians "building wire" with 1 mm strands. The strand thicknesses are to reflect the need to have wiring that will not exhibit fatigue failure from vibration.

This table mentions UL. A suitable international one would suit better.

Flexible Cables and Cords

Tri-Rated

105°C 600/1000 V

Anixter Number	Nominal Conductor Area	Nominal Conductor Stranding	Nominal O/D	Approximate Weight	UL Style Number
	mm^2	#/mm	mm	kg/km	
TRI-0005-##	0.5	16/0.2	2.6	12	1015
TRI-0007-##	0.75	24/0.2	2.8	15	1015
TRI-0010-##	1.0	32/0.2	3.0	18	1015
TRI-0015-##	1.5	30/0.25	3.3	23	1015
TRI-0025-##	2.5	50/0.25	3.7	34	1015
TRI-0040-##	4.0	56/0.3	4.4	50	1015
TRI-0060-##	6.0	84/0.3	5.1	71	1015
TRI-0100-##	10	80/0.4	6.9	123	1028
TRI-0160-##	16	126/0.4	8.6	207	1283
TRI-0250-##	25	196/0.4	10.5	303	1283
TRI-0350-##	35	276/0.4	11.9	412	1283
TRI-0500-##	50	396/0.4	14.4	607	1284
TRI-0700-##	70	360/0.5	16.7	837	1284
TRI-0950-##	95	475/0.5	19.0	1080	1284
TRI-1200-##	120	608/0.5	20.5	1280	1284

= colour, -01 = white, -02 = black, -03 = red, -04 = green, -05 = yellow, -06 = blue, -07 = brown, -08 = orange, -09 = grey, -10 = violet, -12 = pink, -60 = green/yellow. etc.
Other colours available upon request.

For more technical information see page 2:50.

Check List for Locomotive Inspections

Notes.

1. The item number in this document are only recording order of entry. It is proposed that the item numbers be replaced with a more systematic numbering as a proper structure emerges.
2. A dash "-" in the Complies column indicates that this column does not have to be filled in for this line.
3. Some of this wording can be changed once a "definitions" section is expanded, and the defined

words can then be used without ambiguity or further explanation.

Item No.	Requirement	Complies (Write "Y" if the loco under inspection complies)
1	**All Locomotives with Electric Circuits**	-
1.11	All wires are to have a cross sectional area suitable to support the prospective fault current (NOT the normal operating current)	
1.12	All conductors are to be solid bus bars rigidly supported, or stranded wires supported at suitable intervals to minimize movement.	
1.13	All wire sizes are to be in accordance with the default wire size table unless the documentation for the locomotive carries design notes to justify the selection of a different wire size.	-
1.14	Default wire size table is used throughout	
1.15	Special design documentation provided to support wire size selection.	
1.16	Tubes used as conduits are to have flared ends, or ends bushed with a soft material to prevent wire insulation chafing	
1.17	All terminals shall be shrouded and covered. The covering shall be either: Insulating, in which case the shrouding or covering may be close to or in intimate contact with the terminal, or In the form of a box made of metal, in which case the box is to be rigid and so placed that it will not be pushed in and make contact with the terminal in the case of a derailment and roll-over, and to be spaced from the terminal with a spacing that takes into account: (a) the voltage) and (b) the mechanical requirements.	
1.2	**Physical location of wiring and physical support.**	-

Item No.	**Requirement**	**Complies** (Write “Y” if the loco under inspection complies)
1.21	Wiring is tied together in a wiring harness (loom) with cable ties or other means, or is inside solid or flexible conduit. All flexible conduits are attached at frequent intervals so as to be firmly located.	
1.22	Where wiring is accessible to those not involved in maintenance (driver, say) then lacing together in a wiring harness will not be relied on, and the wiring is to be provided with mechanical protection (conduit, flexible conduit, spiral binding (which is not spiral: it is helical) etc.	
1.23	Where any wire enters a terminal, it is to be tied to other things nearby (other wires or structural supports), so that if it becomes disconnected from its terminal, it cannot then reach any other terminal, or any other conducting items that could have a dangerous or destructive effect.	
1.24	Spade lugs are not used to support the weight of wiring.	
1.3	**Protection against over currents**	-
1.31	Protection against over currents can take two forms: (F1) A device is wired in series (fuse or breaker) that will go open circuit if excessive current flows for a period approaching that where damage could be done. Where protection type F1 is used, it is necessary to show that the circuit is capable of providing the current required to open circuit the protective device. (There is no point installing a 10A fuse on a power supply that can only provide 1A) (F2) Circuit arrangements are such that the current cannot exceed a safe level. (An example is a shunt generator. If shorted, the supply to the field is removed, and the generator will only have residual field. The short circuit current might be less than the operating current. In the locomotive, all circuits are protected by suitable sized type F1 protection, or with adequately documented type F2	

Item No.	Requirement	**Complies** (Write "Y" if the loco under inspection complies)
	protection.	
1.32	Items such as fuse assemblies that have a cover over the fuses to protect them, shall also have a cover over any bare terminals if these are exposed when the loco is in normal operation. (Drafting note: A case is recorded where a driver places spectacles on the dash board of a loco, and the frame shorted the chassis (panel) to the unprotected side terminals of a fuse assembly that had a lovely cover to protect the fuses.)	
1.4	**Connection of a Low Current Branch Circuit to a heavy Current circuit.**	-
1.41	Where a low current branch circuit which passes in amongst other wiring is connected to a heavy current circuit, then the connection is to be made with wire sized the same as the heavy current circuit, and circuit protection (fuse or breaker) is to be provided at the point where the run starts in lighter wire.	
1.42	Where a low current circuit is connected to a heavy current circuit, and it is inconvenient or electrically contra-indicated to provide fuse protection (e.g. sense wire from a shunt to a meter), then light wire may be used for the low current circuit provided that: (a) it is segregated from other light current wiring, and (b) it is heavily armoured and protected so that accidental damage to the insulation and a subsequent short circuit has a probability that is reduced to negligible proportion.	
1.43	Connections to a shunt will be in accordance with the proper Kelvin connection.	
1.5	**Failsafe**	-
1.51	Failsafe design used throughout and claims to failsafedness are supported by the engineering documentation.	

Item No.	Requirement	Complies (Write "Y" if the loco under inspection complies)
1.52	If proprietary modules are used of unverifiable failsafe status, then they are to be surrounded by other circuitry that will provide the failsafe feature. (e.g. If a wheel chair controller is used as a traction controller and the fail safe status with respect to switching MOSFET meltdown cannot be verified, then external circuitry is to be used to disconnect power from the controller in the case of a failure. Drafting note. Is it required that power be disconnected automatically, or that appropriate action by the driver can be required to come into play?	
1.6	**Controls to be accessed in an emergency**	-
1.61	Any and all controls that might need to be accessed in an emergency are to be placed so that they are: (a) readily accessible when the locomotive is in the normal position, and (b) readily accessible when the locomotive is derailed and is lying on its side (either side) Controls are accessible	
1.7	**Access to Electrical Equipment**	-
1.71	The locomotive is designed and laid out to provide easy access to all electrical equipment for maintenance and repair	
1.8	**Documentation**	-
1.81	The locomotive documentation includes neatly and logically laid out circuit diagrams to provide for easy access to the information required. (Drafting note. To test this, the inspector is to locate some item or terminal point on the loco and then attempt to locate it on the circuit diagram. He is then to choose some point on the circuit diagram and attempt to locate it on the loco. The loco has clear and accessible circuit diagrams THAT ARE CORRECT	
1.82	Any design aspects that have been chosen by ad hoc design, rather than by selecting from tabulated data in this code, are	

Item No.	Requirement	Complies (Write "Y" if the loco under inspection complies)
	to be supported by design documents to that the inspector can quickly and verify their veracity.	
1.9	**Provision for use by various drivers**	-
1.91	Controls are to conveniently and logically located	
1.92	Controls are to perform expected and logical functions, either following prototype practice, or the engineering practice of the technology used in the model.	
1.93	Warning notices are to be pertinent, obvious in meaning, and are to refer to items by names that will be known to drivers.	
1.94	If auxiliary circuits are required to be operated for proper and safe operation of the locomotive, then the locomotive is to be prevented from being driven unless the required circuits are active. (drafting note. If the 12 volt supply on S318 is not on, then there is no power to the brakes air compressor. Easy to prevent traction power unless the 12 volt supply is enabled.)	
1.95	Controls are to be of a nature that befits their purpose. Action is not to be too heavy to cause drive fatigue, or so light that a careless bump can change the control setting. (Drafting note: volume control put with a radio knob is not suitable for a throttle.)	
1.A	**Consideration of People Other than the Driver**	-
1.A1	The locomotive is to be fitted with a horn.	
1.A2	The sounding of a horn (the making of the sound of a horn sounding) is to be under the control of the driver at all times, and not part of the function of any system designed to provide prototypical sounds.	
2	**Locomotives with Electric transmission**	-
2.1	The locomotive has electric transmission.	

Item No.	Requirement	**Complies** (Write "Y" if the loco under inspection complies)
2.2	The control performing the function of "reverser" is to have a "mid" position that falls between the "Forward" position and the "Reverse" position. When this control is in the "Mid" position, no traction power can be applied.	
2.3	There is to be an interlock between the control performing the function of "throttle", and the control performing the function of "reverser.	
2.4	If the "throttle" is in any position other than "zero power", then the function of the reverser cannot be changed.	
2.5	The locomotive has a mechanical interlock which prevents the reverser being moved when the throttle is off "zero".	
2.6	The locomotive has an electrical interlock that prevents a change in the reverser from having any effect if the throttle is not on "zero".	
2.7	When the "throttle" is in position "zero" there is to be no transmission of power to the wheels.	
3	**Locomotives with Internal Combustion Engines**	-
3.1	**Electric Starter** If the locomotive is equipped with en electric starter motor that is wired to a battery as in automotive practice, then the starter heavy current circuit will be exempt from over current protection requirements as specified in 1.31, but the insulation on this circuit will be robust, and all terminals are to be covered, or placed where accidental short circuit is extremely unlikely. This provision acknowledges the fact that operators and maintenance people have expectations of requirements for care based on automotive experience.	
3.11	Any isolating switch in an electric starter motor circuit is to have its terminals covered by an insulating cover if they are exposed in an area that can be accessed without a tool, or without removing cabinet covers. If a starter battery is also used to provide power to other circuits, then the other circuits are to be connected to the starter circuit at one place only. The connection to the starter	

Item No.	Requirement	Complies (Write "Y" if the loco under inspection complies)
	circuit is to go immediately to a fuse or other circuit protection. The wire from the starter circuit is to be as short as possible and is to be robustly protected.	
3.12	**Protection of Wiring from Hot Parts** All wiring is to be segregated from and protected from exhaust systems and other hot parts.	
3.2	**Locomotive with a Petrol Engine**	-
3.21	High Tension (spark Plug) leads are exempt from requirements of the code that specify insulation and protection according to voltage. (Drafting note: It is recognized that: (a) although the voltage on spark plug leads is high, the energy is low. (b) If the spark plug lead wiring follows good internal combustion engine practice, it will be recognized for what it is, and maintenance and driving personnel will treat it with appropriate respect.) Engine spark plug leads follow accepted internal combustion engine good workmanship practice.	
3.22	Proximity of spark plug leads to dangerous items. (drafting note: although an electric shock from a spark plug might not be dangerous, an involuntary sudden movement might put a person in danger.) Spark Plug leads are not placed so that a person receiving an electric shock from them is then likely to make an involuntary movement and place a body part: (a) in the way of dangerous electrical terminal(s) (b) in the way of dangerous mechanical parts (e.g. fan) (c) in contact with dangerous hot parts such as an exhaust manifold or exhaust pipe. Spark plug leads are not located near dangerous parts.	
3.23	Petrol tanks, petrol lines and petrol handling apparatus are to be in a well ventilated location, and in particular there is to be a path below these for any heavier-then-air vapour to find its way out of the locomotive (to the ground or track)	
3.24	No contactors or other devices with current carrying contacts are to be placed where petrol vapours can accumulate in	

Item No.	Requirement	**Complies** (Write “Y” if the loco under inspection complies)
	instances such as a spill during tank filling.	
3.25	On a locomotive with a petrol engine, all contacts that carry a current heavy enough to draw a spark, are to: (a) be built into the design so that the contact can only change state when the current is not flowing, or (b) have a snubber circuit attached to the contacts so that the formation of a spark is prevented. documentation to support the snubber design is required. Heavy current contacts comply.	
4	**Locomotives with Internal Combustion Engines and Electric Transmission-**	-
4.1	The locomotive has an internal combustion engine and electric transmission	
4.2	If the control that performs the “throttle” function works the engine directly, it is to be also equipped with a switch to detect the “zero” position for control interlocking and other purposes.	
4.3	The starter switch is to be interlocked with the traction controls so that the starter can only be operated when: (a) the throttle is in the “zero” state, and (b) the reverser is in the “mid” position. Starter interlock complies	
5	**Batteries**	-
5.1	Batteries are to be fixed in place in the locomotive with fixings strong enough to hold the batteries in the event of a locomotive roll-over.	
5.2	The locomotive frame and body in the vicinity of battery terminals is to be strong enough and rigid enough that it cannot be pushed in and make contact with the terminals in the event of a locomotive roll over.	

Item No.	Requirement	Complies (Write “Y” if the loco under inspection complies)
5.3	Battery terminals are to be covered with an insulating shroud made of thermosetting plastic or similar material. (That is, won't melt if overheated or in a fire.) If a battery terminal is connected to the locomotive chassis, then this terminal will be exempt from this requirement.	