*******DRAFT for APPROVAL******

AUSTRALIAN ASSOCIATION OF LIVE STEAMERS

CODE OF PRACTICE

Electric Systems for Miniature Locomotives

ELECTRIC SYSTEMS

Document control

This document consists of the following sections with the version dates shown.
Sections 1 to12, dated 4 December 2017:
This document consists of 13 pages (including cover).

Authoring, Consultation and Approval

This document was produced by the Australian Live Steamers Safety Committee, a committee of the Australian Association of Live Steamers Limited ABN 81 107 882 404 (AALS) For the registered office refer to the AALS Reference document.

Any feedback is to be forwarded to:
Secretary
Australian Association of Live Steamers Ltd.
Contact details are available on the AALS website. www.aals.asn.au

This Code of Practice for Electric Systems for Miniature Locomotives was approved at the AALS Annual Convention in <Location> on <Date>.

About this code

This Code of Practice has been compiled by the Australian Association of Live Steamers for use by Member Societies so that a minimum standard of competency can be achieved by their Society Members.

By adopting the requirements and procedures outlined in this code the Association and its Member Societies recognise their obligation to provide a safe environment for visiting public and members alike which will be engendered at the many operating locations throughout Australia.

Distribution and change

The AALS maintains the master for this document and publishes the current version on the AALS website www.aals.asn.au

Any changes to the content of this publication will also update this control page. The control page defines the current version of this document. Changes to this document are approved by vote by the member Society's of the Association in accordance with the Association's Constitution and Standing Orders.

Disclaimer

This document has been produced for use by the member Societies of the Australian Association of Live Steamers. Use by others for any purpose is at the user's risk.

Contents

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 Association 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 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.

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.

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 AALS 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 greater than 48v DC.

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 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

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.

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.

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.

5. BATTERIES

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. 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.

5.8 When some battery types are on charge and floating explosive and corrosive gasses are discharged. This is a serious and dangerous explosive hazard. Measures must be taken to charge in very well ventilated areas as an electrical contact opening at the time of battery float can be an ignition source. It is recommended 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.

6. ELECTRICAL SYSTEMS

Common Requirements

6.1 All wiring shall be insulated and held clear of hot or moving parts.

6.2 Care shall be taken that wiring insulation shall be rated for the application and the size of conductor is consistent with the current it is expected to carry as well as any fault current levels.

6.3 Circuit breakers used on DC systems shall be of a type suited for DC.

6.4 Connectors for wiring between vehicles shall be shrouded to avoids accidental short circuits.

6.5 Any inclusion of a low voltage on board battery charger shall have the locomotive frame connected to the mains earth and the ELV system shall be isolated from the batteries when charging. 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.

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 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).

6.7 All low voltage systems shall ensure there are no accessible terminals, or touch points 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.

6.9 ELV systems powered from a LV source shall be provided with an isolated power supply to ensure faults within the LV system cannot propagate into the ELV system.

6.10 Consideration shall be given to having all LV traction wiring coloured orange.

6.11 No LV wiring shall be accessible in the drivers area.

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.

6.13 Some jurisdictions may require LV electrical work to be performed by an appropriately competent or licensed person. 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, an accessible, simple, robust and reliable method shall be provided to be able to bring the locomotive to a stand.

7.3 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.

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 a 'Emergency Override' switch) to bring the locomotive to a stand in the event of a malfunction.

7.5 The operator may be remote from the locomotive by use of a control box attached to the

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 proved 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 the locomotive, provision of an automatic shut down in the event of the drivers vehicle becoming unattached is 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.

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.

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 with robust components and proven 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.

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.

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 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.

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 a fire extinguisher being carried on trains.

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.

Relay/contactor jams in energised position.

Switch breaks.

Short circuiting of connections or terminals.

10.2 Control System

Uncontrolled acceleration.

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>.

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: