AALS - Electric Traction and Control Systems for Miniature Locomotives.

Comments 1-23 submitted and evaluated 9 October 2017 on draft dated 12 May 2017.

Comments 24 on are for consideration following the 2018 AALS Meeting on draft dated 4 December 2017.

No.	By Whom	Clause No.	Clause	Comment	Review Assessment	Proposed Update
1	David Lee	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.	Is the forward - neutral - reverse switch considered acceptable?	Yes, this is hardwired switch.	Nil
2	David Lee	6.3	Circuit breakers used on DC systems shall be of a type suited for DC.	When working for Cutler Hammer i was told that the DIN breakers for LV were also suitable for ELV DC. Just wondering how true this is. I think I have 32A on GM9 (400w) and 50A on GM13 (600w) both 24vdc	Comment only.	Nil
3	David Lee	7.1	Locomotives of 5 inch gauge or larger	My loco does not have a	Removal of the hardwired	Locomotives of 5 inch gauge

			with the capacity to haul more than one carriage shall have a key switch which is to be used to immobilise the locomotive against unauthorised use when unattended. It shall not be possible to drive the locomotive with the key removed.	key. It has a toggle switch located under a cover. The loco cannot be operated if the control box is not plugged in!	control box is the equivalent to removing a key. There may also be other methods. Proposed to review wording to permit this.	or larger with the capacity to haul more than one carriage 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.
4	David Lee	7.7	Interlocking of controls is 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.	Little confused!! Matrix says HR for 5" and M for 7.25". This statement say is required. My loco is a hybrid of electronic and relay and does not have the interlocking suggested.	Slight rewording proposed.	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.
5	David Lee	7.12	An indicator light shall be provided on the control panel to show when the power is active.	What about a voltmeter?? My loco does not have a light, only a voltmeter. The loco has number lights when they are switched on and a sound card irrespective of the control box being plugged in.	The user would need to full understand the purpose of the voltmeter. It may not in itself be an obvious indication of the immovability of the loco. A clearly marked light is seen as simple and non	Nil

					confusing, and thus no change is proposed.	
6	David Lee	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.	Is there a proforma for this Proof of Safety. Is it just a tick against the matrix?	A proforma is not possible as each system is likely to be unique and thus the safety analysis will be different. A future guideline may be issued to clarify how this may be achieved.	Nil
7	David lee	10.1	(List of Hazards)	Not sure which section this fits into. Mosfets shorted in on mode. Similar to relay jammed. Probably fits with uncontrolled acceleration??	There are a large number of electronic component failures that could result in uncontrolled acceleration. These are causes of 'uncontrolled acceleration' which covers the whole range without having to be specific.	Nil
8	Zac Lee	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.	Had a read of that code, Just have a couple of comments about it. i think not being able to have the systems earthed to the	There is no restriction to using the loco frame of ELV systems for current return, only LV systems.	No change.

			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).	frame is going to put a few existing locos out, and also its very unnecessary. in our cars etc we run 12 -48V systems through the frames at unto 200AMPS without any issues. it just seems to over complicate the design of doing this as simple as possible. Secondly and I don't mean any disrespect here. I think the idea of having to have an electric code. and the way things are going i guess a compliance ticket with our electric/petrol engines? is a bit ridiculous... Regards, Zac		
9	Mike Crean	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.	**Line 2** insert the following line after ripple-free DC *or 70v DC non filtered 3 phase rectification and 85v DC non filtered single phase rectification.* **Line 3** 1000v AC. *Note 630v AC W.A. electrical codes.* **Line 4** (i.e. 315v AC, *Note up to 440v AC in W.A.)* **Line 6** ELV *in practice most*	A query on this was sent to Mike Crean and response as follows: Hi Warwick, I have put some comments after your queries in your email. **I think I can understand most of your comments, however I am intrigued by your mix of DC and AC ripple voltages you have added to the LV definitions. Can you provide more detail on**	Nil

				miniature locomotive ELV traction systems do not operate above 50v DC	**why you think these should be mentioned (especially the 70 and 85)?** *The voltages were only an indication of ELV DC voltage levels expected when an automotive alternator using single or three phase rectification and is run up without filtering or load. In hindsight this is not going to happen in our application as there will always be a Capacitive, Resistive or Inductive load on the alternator when it is exited via the field coil. Therefore M1 and other related references can be omitted.* **I have taken the view so far to only specify the LV limits as per AS3000 otherwise we can get into all sorts of arguments about what is a safe level and I just want to adopt a simple definition with a solid basis. I did note it could be different in some jurisdictions which is a rider to confess the**	

					code cannot address all the varieties and it is up to the builder / designer to determine what is acceptable in their State. I suspect they don't complicate it with ripples because (in my understanding) the peak DC should not exceed 120v, and that covers it. *It is great to see the Safety Committee putting together a guide for electric traction vehicles related to our hobbies.* If I can be of any further help pleas do not hesitate to contact me.	
10	Mike Crean	4.5	This code does not consider battery packs greater than 48v DC.	battery packs greater than 48v DC. *or float voltages greater than 57v DC*	As this is well within the ELV definition, no change is proposed.	Nil
11	Mike Crean	4.8	Systems may be electro-mechanical or electronic in nature. A simple electro-mechanical system (ie one that uses relays which have a predictable failure mode) may be used to provide fail safe functionality in an otherwise electronic system	electronic system *and should employ soft start techniques for traction motors.*	This is a advantage only possible with an electronic system. It does not impact the safety of the system, and is just one of many features that could be designed into the system on which the code is silent, as it would be difficult to predict what	Nil

					they all may be..	
12	Mike Crean	5.1.2	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.	means of ignition. *Please note 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 open air cage well away from other buildings and structures.*	Proposed to further emphasise these hazards by the addition of clause 5.1.8	Include 5.1.8 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.
13	Mike Crean	5.1.6	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.	Fault conditions. *except high current starting circuits. It is impractical to limit current in these circuits. Battery isolation switches must isolate these and all other circuits connected to the batteries. Change over switching should be used with on board battery chargers, isolating the locomotive ELV system when on charge and isolating the charger*	More investigation and comment required on availability of suitable breakers. Include requirement 5.1.9 for changeover switches when using on board chargers? ***Further Review*** Is there any hazard here if this is not done?	Include 5.1.9 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.

				when the locomotive is in use.		
14	Mike Crean	6.5	Any inclusion of a low voltage on board battery charger shall be completely isolated from the locomotive frame and other systems (other than the battery) and 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.	shall be *where a LV connection is made to an on board charger the charger must be earthed to the locomotive frame via the mains earth and the locomotive ELV system must* be isolated from the batteries while charging.	Agreed loco frame needs to be earthed.	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.
15	Mike Crean	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.	Line 3 wiring. *ELV DC systems can use the locomotive frame as the negative return path. This is the method used by automotive manufacturers.*	There is no restriction to this. The quoted clause is LV only. I think he may be suggesting that on an LV loco it is still possible to use the loco frame for the return on the ELV. As we have specified an ELD	Nil

					from LV to frame to detect faults, use of the frame as an ELD return would interconnect the systems under a fault condition. As the ELV would not be designed to tolerate LV, this is a potentially unsafe situation. (Note that the ELD has to have a connection anyway to be able to sense a fault) Consequently this is undesirable. *** Consider Further***	
16	Mike Crean	7.7	Interlocking of controls is 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.	comply with 7.4. *use of some radio frequencies is not desirable due to interference from cellular mobile devices. Some of these frequencies are the 2.4 GHz band and in particular 802.11 devices.*	This is a quality item. It may be included in a future guideline, but does not affect the hazards already identified.	Nil
17	Mike Crean	P10. Item 4	(Hazard/ Control Matrix)	Battery fuse or CB on low current circuits. High current circuits such as starting motors fuse or CB protection is impractical.	See item 13 above.	Nil??
18	Mike Crean	P10. Item 6	(Hazard/ Control Matrix)	Interlocking of controls requires more definition	The interlocking is given in item 7.7: Interlocking of	Nil

				within the document.	controls is 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. No further clarification is required?	
19	Mike Crean	P10. Item 7	(Hazard/ Control Matrix)	Breakaway control requires detailed definition within the document.	Covered in Clause 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 and mandatory in locomotives which can haul more than one carriage ('Breakaway Control'). The shut down shall disconnect traction power. No further clarification is	Nil

					required?	
20	Mike Crean	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).	qualified supervisor *W.A. rules state that all work must be carried out by a licensed electrical contractor and certified by same. See attached W.A. regulations 4A. (2) (a) last two lines.*	This may apply in other States too. Suggest it is up to the builder to ascertain the particular States' requirements.	Add new clause 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.
21	Mike Crean	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	Line 2 may be present. *Please note when some battery types are floated at charging voltages, 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.*	See item 12 above. Covered by new 5.1.8	
22	Mike Crean	10.2	(List of Control System Hazards)	Line 7 Loss of radio link for radio control *use of some radio frequencies is not desirable due to interference from cellular mobile devices. Some of*	See item 16 above.	Nil

				these frequencies are the 2.4 GHz band and in particular 802.11 devices. Line 11 (by another operator) *same as above.*		
23	Mike Crean	6.12	On board LV generators shall not be used to power external equipment unless the generator is compliant with AS2790 - Electricity Generating Sets.	*Where an off the shelf LV generator is used other external devices should not be able to be connected via the single phase or three phase GPO.*	Agreed. Additional wording to be added.	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.

Comments 24 on are for consideration following the 2018 AALS Meeting on draft dated 4 December 2017.						
No.	**By Whom**	**Clause No.**	**Clause**	**Comment**	**Review Assessment**	**Proposed Update**
24	Michael Moyse SASMEE	6.10	Consideration shall be given to having all LV traction wiring coloured orange,	*There is already a colour code for single and three phase AC wiring under LV regulations and using only one colour for wiring would prove very difficult in testing and fault finding.* *The colour code is:* *Red or Brown = Active* *Black or Blue= Neutral* *The colour code for 3 phase wiring is:* *Red=Active for phase 1* *White =Active for phase 2* *Blue=Active for phase 3* *Black= Neutral* *In all single or three phase wiring, the green / yellow colour is used for earthing.*		
25	Michael Moyse SASMEE	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	*In South Australia any LV power system that is commissioned will have an "Electrical Certificate of Compliance" completed by the person who has completed the testing of the electrical work 1) Registered Electrical*	***Refer section 6.13 which states**:* 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	

			made to the LV equipment or installation. (See sample template in Appendix 1).	*Worker or Contractor / Authorised Person. The electrical work can be completed by the builder and then tested/commissioned by a person who holds the appropriate license. This "Electrical Certificate of Compliance" is for all low voltage installations. This is an observation regarding certification by a "Competent Electrical Engineer"or a "Qualified Supervisor Electrical". There is a possibility that both these types of people would not hold the appropriate licence. All electricians in South Australia will hold either a "Registered Licence" or a "Contractors Licence".*	State or Territory. ***The design report adds:*** Not all States or Territories have the same electrical work requirements. While this code is National, designers and builders need to ensure LV work conforms to the requirements in their State or Territory.	
26	Unknown			*Parts of the Design Report should have been included in the code.*		
27	Unknown			*If LV is allowed locomotive should have a tilt switch for isolation.*		
28	Unknown	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)	*The upper voltage limit of the Code in 4.4should be much more prominent.*		

			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).**			
29	Unknown	4.5	This code does not consider battery packs greater than 48v DC.	*Battery packs (4,5) should be up to 120V so we can utilise increasing availability of electric car batteries*		
30	Unknown	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	*Section 4.9 is too much waffle and should be in plain English*		

			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.			
31	Unknown	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.	*Commercial builders (4.11) should not be exempt, specially for passenger carrying equipment*		
32	Unknown	5.9?		*(Section 5) Most modern chargers are temperature controlled, sensor operated, and can stay connected.*		
33	Unknown	6		*All LV wiring must be multi-stranded and at least triple insulated*		

34	Unknown	5 & 6		*Rubber grommets should be specified where wiring passes through metal panels, specially for LV*		
35	Unknown	6		*LV system should have switching to reduce current when body panels are opened*		
36	Unknown	7.3		*(7.3) Steam locos have no failsafe, why should electrical be different*		
37	Unknown	7.6		*Remote control systems (7.6) should never be used on passenger carrying trains.*		
38	Unknown			*Finding electrical trades people to sign off will prove extremely difficult unless wired by themselves or other qualified person*		
39	Unknown			*Document should include table of wire sizes and colour coding*		
40	Unknown			*Document should include information on fuses and fuse types*		
41	Unknown			*Examples of circuits (eg. Curtis) would be very helpful.*		
42	Peter Nixon Tweed Valley			*There are some good points and some bad points. However there are too many bad points for this code to be put in place at*		

				this time.		
43	Peter Nixon Tweed Valley			*The writing is confusing, not in plain English and contains many important errors.*		
44	Peter Nixon Tweed Valley			*We believe that ELV (voltage not exceeding 50vAC or 120v DC) is entirely adequate for the hobby. LV and HV are not to be permitted as they present dangers that ordinary members will not understand.*		
45	Peter Nixon Tweed Valley			*The code is too broad in its concept and should be limited to locos with electric drive systems. General safety of electrical fittings on ALL types of locos, could be added as an annex.*		
46	Peter Nixon Tweed Valley	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	*On board chargers with a lead for overnight charging by LV (household) leads should only be permitted if double insulated and designed to be left connected to battery. (Earthed chassis are neither desirable nor recommended).*		

			equipment cannot be used while it is operating.			
47	Peter Nixon Tweed Valley			*Fuses, circuit breakers and isolators should be described and recommendations made as fit for use.*		
48	Peter Nixon Tweed Valley	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.	*On board gen sets are not to be fitted to locos . An advisory as to gen sets on maintenance wagons is to be offered.*		
49	Peter Nixon Tweed Valley	7		*Check the facts on failsafe removal of power on locos fitted with regenerative braking.*		
50	Peter Nixon Tweed Valley	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.	*Radio, mobile phones and remote computers may not be used when carrying passengers.*		
51	Peter Nixon Tweed Valley	8.1		*Establish who shall be responsible for compliance in a club situation.*		

END

Excerpt from the *Electricity (Licensing) Regulations 1991 (Western Australia)*

[Regulation 3 amended in Gazette 23 Dec 1994 p. 7134;

6 Sep 1996 p. 4410-11; 24 Mar 2000 p. 1639-40; 19 Apr 2005

p. 1296; 31 Dec 2007 p. 6492-3, 6537 and 6538-9; 10 May

2011 p. 1667; 17 May 2011 p. 1813-14; 13 Apr 2012 p. 1652.]

4A. Term used: electrical work

(1) In these regulations —

electrical work means —

(a) work —

(i) on electrical machines or instruments; or

(ii) on an electrical installation; or

(iii) on electrical appliances or equipment,

to which electricity is supplied or intended to be supplied at a nominal pressure exceeding 50 volts alternating current or 120 volts ripple free direct current; and

(b) work comprising an assessment of an electrical installation to ensure that the installation and any work done on the installation complies with the requirements of these regulations.

(2A) However the definition of ***electrical work*** does not include work on components of a motor vehicle, as defined in the Road Traffic Act 1974 section 5(1), that operate on direct current.

(2) For the purposes of the definition of ***electrical work*** it is immaterial —

(a) whether or not the thing on or in relation to which the work is performed is part of, or is connected to or to be connected to, any distribution works or private generating plant; and

(b) where work is performed on or in relation to any appliance, whether or not electricity is supplied or may be supplied to the appliance through an electric plug socket or socket outlet.