AALS - Electric Traction and Control Systems for Miniature Locomotives.

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

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. **Roger:** This would be OK if the reversing switch physically switches power to the motors. It would not be good enough if it only switches control functions which then switch relays or electronics – as most modern systems do **Warwick**: Its Ok if the switch activates relays wired in a fail safe configuration, which is a requirement of using it for the Emergency.	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	Comment only. **Roger:** In my experience typical AC rated domestic breakers work reliably on ELV DC systems **Warwick**: The issue is the greater power dissipation	Nil

				(600w) both 24vdc	with DC then AC. It doesn't state AC breakers are not suitable, just that they need to be suitable for the application.	
3	David Lee	7.1	Locomotives of 5 inch gauge or larger 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.	My loco does not have a key. It has a toggle switch located under a cover. The loco cannot be operated if the control box is not plugged in!	Removal of the hardwired control box is the equivalent to removing a key. There may also be other methods. Proposed to review wording to permit this. **Roger:** I agree, though a key does provide greater security.	Locomotives of 5 inch gauge 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. **Roger:** Matrix review advisable. I don't think interlocking should be diluted. **Warwick:** This was a disconnect between the words and matrix fixed in the previous issue. The matrix is now predominant and is based on the hazard levels in the risk assessment. Most non electronic control would	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.

					not have this feature.	
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 confusing, and thus no change is proposed. **Roger:** Concur. Voltmeter indicates that power is potentially available but not that the system is active.	Nil
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. **Roger:** I think we might be able to come up with something that checks off against key requirements. **Warwick:** I did issue a draft on this, but it is for the future at this stage.	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. 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).	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 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	There is no restriction to using the loco frame of ELV systems for current return, only LV systems. **Roger:** The LV versus ELV confusion raises its ugly head again. Warwick: This was addressed by the inclusion of the red warning box.	No change.
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)	**Line 2** insert the following line after ripple-free DC *or 70v DC non filtered 3 phase rectification and 85v DC non*	A query on this was sent to Mike Crean and response as follows: Hi Warwick, I have put	Nil

			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.	*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 miniature locomotive ELV traction systems do not operate above 50v DC*	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 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. **Roger:** The fact that the	Nil

					code does not consider packs above 48V does not mean that people can't use them. If higher voltage packs are used in future then the code might be updated at that time. **Warwick :** See item 29 below for more recent comment and action.	
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 they all may be..	Nil
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*	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

				changing take place in a secure open air cage well away from other buildings and structures.		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 when the locomotive is in use.*	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? **Roger:** Circuit breaker rating selection covers this No problem to use CB's as battery isolation switches either, but not ideal as the overall system isolation/power cut-off switch. An alternative to changeover switching is a plug and socket arrangement such that the unit can only be configured for charge or run at any time.	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.

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. **Roger:** Consider optional double isolation and test and tag. **Warwick:** See Item 32 and 46 below for latest comment and action.	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 from LV to frame to detect faults, use of the frame as an ELD return would interconnect the	Nil

					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. **Roger:** No it's not ☺	Nil
18	Mike Crean	P10. Item 6	(Hazard/ Control Matrix)	Interlocking of controls requires more definition within the document.	The interlocking is given in item 7.7: Interlocking of controls is required (see Matrix) where the locomotive is capable of hauling more than one	Nil

					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 required?	Nil
20	Mike Crean	8.2	**Low Voltage Systems:** Any locomotive built with a LV power system shall be certified by a competent electrical	qualified supervisor *W.A. rules state that all work must be carried out by a licensed*	This may apply in other States too. Suggest it is up to the builder to ascertain	Add new clause 6.13: Some jurisdictions may require LV electrical work to be

			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).	*electrical contractor and certified by same. See attached W.A. regulations 4A. (2) (a) last two lines.*	the particular States' requirements. **Roger:** I suspect applies to all states. **Warwick** : Agree. However States differ! See Item 29 below for further update.	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 these frequencies are the 2.4 GHz band and in particular 802.11 devices.* Line 11 (by another operator) *same as above.*	See item 16 above.	Nil

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.

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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.*	**Roger:** I stand to be corrected but seem to recall that these are preferred colours only and that the only colour that cannot be used for active is green due to it being reserved for Earth. However, best to stick to Red/White/Blue for 3 phase etc, and red/brown and black/blue for single phase as these are the COMMONLY used colours. Orange isn't standard for anything. **Warwick:** The intent was to have sheaths or ducts coloured orange, similar to the requirement that LV cables use orange conduit, or flexible cable sheaths be orange. It is also noted that not all LV wiring may be 3 phase. For example, brushless DC motor technology. AS3000 does not mandate colours for multi phase	Replace 6.10 with the following: **Wiring for 3 phase systems are recommended to use red/white/blue colours for the phases. Consideration shall be given to using Orange colour to identify LV wiring sheaths or ducts**.

					wiring except that it shall not be green/yellow however does make recommendations in Table 3.4. The situation being dealt with here is not fixed wiring for which AS3000 (or other wiring installations) is directly applicable. NCOP 14 (Electric Vehicle Guidelines) Section 2.7 requires all hazardous voltage cables to be coloured orange. Individual wires may then be partly sleeved with red or black. Orange is also prescribed for LV wiring coverings eg. AS3000 Figure 3.9 and S009-2013 Table 1 where Orange denotes AC mains power.	
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 made to	*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 Worker or Contractor / Authorised Person. The electrical work can be completed by the builder and*	***Warwick: 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 State or Territory.	Replace first sentence with the following: **Any locomotive built with a LV power system shall be certified by a competent electrical engineer (where permitted under legislation) or otherwise by a State licensed electrical**

			the LV equipment or installation. (See sample template in Appendix 1).	*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".*	***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. The requirements in each state differ, as do the terms for the licensed person. Where there is no State requirement for a licensed person, then an Electrical Engineer is suitable as being competent to compare the installation to the Code. Licensed persons may only have experience for fixed installations. The clause does use NSW terms. Contractors in NSW are not necessarily electrical qualified as they need to employ a qualified supervisor. Proposed to make the clause more generic.	**tradesman, to be in compliance with this code of practice.**
26	Unknown			*Parts of the Design Report should have been included in the*	**Warwick**: The code is intended to be concise to	Nil

				code.	be easy to read. Additional information in the Design Report provides a basis for the code requirement. While this provides traceability and explanation as to the intent of the clause, it is not necessary for the code itself. Without knowing the actual parts to be transferred it is not possible to assess further.	
27	Unknown			*If LV is allowed locomotive should have a tilt switch for isolation.*	**Warwick:** All wiring is insulated and protected as are terminals and the issue of LV does not in itself create any additional hazards in derailment.	Nil
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) 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.	*The upper voltage limit of the Code in 4.4 should be much more prominent.*	**Warwick:** The red box provides additional visibility of the need to correctly understand ELV and LV limits. The actual context is difficult to make much more prominent.	Bold text the voltages, LV and ELV wording in clause 4.4 See proposed format changes shown at the end of this document.

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

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*	**Warwick:** See comment in Item 10 above. The code does not address other batteries either such as LiPo etc. There is currently insufficient experience in such new technology. A future update could be made when clearer.	Nil
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 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	*Section 4.9 is too much waffle and should be in plain English*	**Roger:** Maybe we could dumb it down **Warwick:** The intent of this clause is explanatory and is to ensure that readers understand that there are two descriptions of the term fail safe, and that the proof of safety (i.e. failsafeness) of electronic systems is governed by international standards which would be beyond the intent of this	Clause to be broken up and better presented in sections in the document. See proposed format changes shown at the end of this document.

			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		hobbyist application. It is within this context that these code requirements exist. We can try and retain these aspects but present it better.	

			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*	**Roger:** Speaking as a Commercial Builder I don't have a problem complying with the code other than when I would apply a superior level of protection and/or safety. I suggest that Commercial Builders should comply to the Code or to superior standards. **Warwick:** The AALS has no powers to compel anyone to comply with its requirements. Club members follow the codes as a requirement of affiliation and to show they have safety standards in place. This clause is provided to make it clear what the legal situation actually is.	Nil

32	Unknown	5.9?		*(Section 5) Most modern chargers are temperature controlled, sensor operated, and can stay connected.*	Refer also to Item 14 & 46. **Roger:** Maybe, but not globally true. **Warwick**: It is not possible to predict the type of charger that is to be used. If the unit is plugged into mains power the it is a requirement of AS3000 that all exposed metal work be earthed. It is agreed that this requirement is not necessary if the charger is double insulated. It is not clear the impact of back feeding into a charger so disconnection is preferred.	See Item 46.
33	Unknown	6		*All LV wiring must be multi-stranded and at least triple insulated*	**Roger:** Sounds a bit knee jerk. How does this compare to general standards for mobile LV equipment? **Warwick:** There are no requirements in AS3000 etc for triple insulation of LV wiring (except in swimming pools) only as separation from other wiring systems. This code adopts those industry	Nil

					standards as adequate for this situation. While multi strand wiring is good practice, and may be included in a guideline of good practice, it is not in itself a mandatory safety requirement.	
34	Unknown	6.1	All wiring shall be insulated and held clear of hot or moving parts.	*Rubber grommets should be specified where wiring passes through metal panels, specially for LV*	**Roger:** True. Something I would do without thinking but then I have the background so worth adding. **Warwick**:Add additional sentence to cover chaffing hazard.	Include additional sentence: **Clause 6.1 Where wring passes through panelling or frame members additional protection shall be provided to avoid chaffing or damage to the wiring.**
35	Unknown	6		*LV system should have switching to reduce current when body panels are opened*	**Roger:** Worth consideration. **Warwick**: This requirement would prevent testing and fault finding. All wiring is insulated and protected as are terminals and the removal of the body panels does not in itself create a hazard.	Nil
36	Unknown	7.3		*(7.3) Steam locos have no failsafe, why should electrical be different*	**Roger:** Just because one technology does not permit a specific safety feature does not mean that one that does should be prevented from doing so. Points more to the lack	Nil

					of safety in steam locos rather than anything else, though I am minded of fusible plugs to prevent boiler explosion. **Warwick:** Steam locos have directly mechanically connected controls. These are operated by hand. There are separate controls for the regulator, brake etc. Similarly a remote control unit has a lever or knob that is operated by hand. However they have an electronic link between the knob and the actual relay performing the control. This link is prone to failure which can affect all controls simultaneously. Additionally the failure may be 'wrong side' and result in power on. Such failures may have no warning. using such equipment may have the operator remote from the locomotive so they are not in a position to take any direct action on the device itself. Accordingly	

					these hazards produce a risk that needs to be controlled.	
37	Unknown	7.6		*Remote control systems (7.6) should never be used on passenger carrying trains.*	**Roger:** I think we've covered this by requiring driver at the front and Safety Cut-Off switch. I can see growing interest out there in radio controlled MU operation. **Warwick:** The code acknowledges that there are remote methods for control. Providing they are safe, the code does not prohibit their use. The necessary requirements for safe operation (as identified in the risk assessment) are requirements of this code.	Nil
38	Unknown			*Finding electrical trades people to sign off will prove extremely difficult unless wired by themselves or other qualified person*	**Roger:** Fair comment in some cases, but most clubs would have an electrician amongst their membership. Only applies to LV anyway and at least for now that is rare n our hobby. **Warwick:** Noted. Persons undertaking the design and construction of complex variable frequency drives are likely	Nil

					to be knowledgeable about such systems and have experience and contacts in the industry.	
39	Unknown			*Document should include table of wire sizes and colour coding*	**Roger:** This is up to individual designers and their own design analysis. My company, Mini Train Systems, has it's own colour code and cable ratings but would not expect another manufacturer or hobbyist to comply with it. **Warwick**:It is not possible to predict all the possible configurations of equipment that could be constructed to this code. The code is there to prescribe safety requirements. It is not a detailed design guide. The code does require that equipment and wiring be appropriately rated. Details of wiring and ratings etc could be provided in a future guideline should such information be provided.	Nil
40	Unknown			*Document should include information on fuses and fuse types*	**Roger:** The Code is not an engineering design manual.	Nil

					Warwick: It is not possible to predict all the possible configurations of equipment that could be constructed to this code. The code is there to prescribe safety requirements. It is not a detailed design guide. The code does require that fuses and fuse types be suitable and appropriately rated. Details of fuses etc could be provided in a future guideline should such information be provided.	
41	Unknown			*Examples of circuits (eg. Curtis) would be very helpful.*	**Roger:** Beyond the scope of the Code I think, though a block diagram might be useful. **Warwick:** It is not possible to predict all the possible configurations of equipment that could be constructed to this code. The code is there to prescribe safety requirements. It is not a detailed design guide. The code does require that circuits be fail safe where they perform a safety function. Details of circuits	Nil

					etc could be provided in a future guideline should such information be provided.	
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.*	Comment only. **Roger:** Peter's comments while well-meaning do urge the code to restrict the experimental nature of the hobby rather than ensure that experimentation is done safely. Wasn't the British "Model Engineer" magazine initially called "Model Engineer and Experimental Electrician"?	Nil
43	Peter Nixon Tweed Valley			*The writing is confusing, not in plain English and contains many important errors.*	**Warwick:** Comment only. Clause 4.9 to be reformatted.	Reformat 4.9 See proposed format changes shown at the end of this document.
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.*	**Warwick:** The AALS does not have any legal powers to be able to prohibit what people do. As LV locomotives exist this code is intended to ensure that such locomotives are safe. It is the responsibility of clubs to operate safely under their States legislation, and thus it is their prerogative as to whether to permit such	Nil

					locomotives or not. It is not clear why ordinary members will not understand LV risks. All houses, etc are supplied with LV and operate all household appliances. LV locomotives would be fully enclosed and operators or passengers would be unaware of the type of drive within. There is no intention to have any HV systems.	
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.*	**Warwick:** The code only addresses the safety issues of the electric systems. The ELV requirements are very brief but essential as LV locomotives are also likely to contain such equipment.	Nil
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	*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).*	Refer also to Item 14 & 32. **Roger:** See my earlier comment on Double Insulation. **Warwick:** It is not possible to predict the type of charger that is to be used. If the unit is plugged into mains power the it is a	Amendment as follows: "....Any inclusion of a low voltage on board battery charger **(unless double insulated)** shall have the the locomotive frame connected....."

			board charger does not place the locomotive into the Low Voltage category, as the low voltage equipment cannot be used while it is operating.		requirement of AS3000 that all exposed metal work be earthed. It is agreed that this requirement is not necessary if the charger is double insulated.	
47	Peter Nixon Tweed Valley			*Fuses, circuit breakers and isolators should be described and recommendations made as fit for use.*	**Roger:** Not out of the question but this is not a Design Document as such **Warwick**: It is not possible to predict all the possible configurations of equipment that could be constructed to this code. The code is there to prescribe safety requirements. It is not a detailed design guide. The code does require that the various equipment be suitable and appropriately rated. Details of suitable components could be provided in a future guideline should such information be provided.	Nil
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	*On board gen sets are not to be fitted to locos . An advisory as to gen sets on maintenance wagons is to be offered.*	**Roger:** Advisory is a good idea. **Warwick**: It is not clear why such a restriction is warranted. Any LV system is likely to have an IC engine powering an	Nil.

			connect to external devices.		alternator which is in effect an on-board gen set. ELV locomotives may also exist in this configuration. Having the generator on an adjacent wagon introduces the issue of power cables between vehicles, which as currents and/or voltages increase, are a less desirable feature.	
49	Peter Nixon Tweed Valley	7		*Check the facts on failsafe removal of power on locos fitted with regenerative braking.*	**Roger:** Power removal on regen locos MUST cause loss of regen braking as well as in a fault condition regen circuits may produce drive instead. Backup braking in the form of a mechanical brake on the driver's car is or should be required. **Warwick**: This is a matter for the design of the locomotive. The code requirement is not changed in that power must be disconnected when that control is initiated.	Nil
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	*Radio, mobile phones and remote computers may not be used when carrying passengers.*	See also 37 above. **Warwick:** The code acknowledges that there	Nil

			a lead, or by radio control. The method of control does not alter the need to comply with 7.4.		are remote methods for control. Providing they are safe, the code does not prohibit their use. The necessary requirements for safe operation (as identified in the risk assessment) are requirements of this code.	
51	Peter Nixon Tweed Valley	8.1		*Establish who shall be responsible for compliance in a club situation.*	**Roger:** Do we need or want the equivalent of a Boiler Inspector for electrical systems? **Warwick:** Each Society is responsible for its operations through its Board of Directors. The AALS cannot dictate how each society operates as it is responsible to the various State bodies for company law and Work Health and Safety. Thus it is up to the Society's Board to determine how they police their responsibilities. The code does require any ongoing compliance. It is only for new and altered locomotives.	Nil

Proposed reformat of certain clauses below:

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).

4.9 This code uses the traditional concept of failsafe which 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 vehicle 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 it may not have a predictable state during failure.

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.

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.