

Risk Assessment for AALS Code of Practice for

Electric Systems for Miniature Locomotives

The Code considers miniature locomotives from 2½ inch gauge to 7¼ inch gauge. As the mass and speed of these vary considerably so does the potential for uncontrolled energy. In order to match appropriate controls to the hazards, the mass is accommodated by breaking the locomotive types into 4 categories as follows:

Typical Mass	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.
Loco Mass	10-20kg	20-50kg	50-200kg	>150kg
Train Mass	~100kg	~300kg	~1500kg	>2500kg
Speed	5km/h	8km/h	12km/h	Up to 20km/h
Energy (joules)	96	740	8333	38580
Relative Hazard Increase for the train mass shown.	1	8	86	400

Energy is directly related to the mass and the square of the velocity viz; $0.5M*V^2$. The potential result of a loss of control is derailment, overspeeding on curves and collision.

Additional hazards are related to electricity (shock), chemical (acid) and heat (burns).

The basis of this hazard assessment is to equate electric drive locomotives to a steam equivalent except where a safety improvement can be gained at low cost or inconvenience due to the greater functionality of electric systems. This is a requirement of "As low as reasonably practicable" where any easily gained safety benefit is considered to be mandated unless shown to be impractical or out of proportion to the benefit.

While the following risk assessment describes the general risk reductions as a worse case across the hazards, the actual application is in accordance with the matrix in the code where specific controls are matched to the energy of the loss of control. Thus the major hazard controls are focussed on the larger 5 inch and 7.25 inch gauge operations.

This risk assessment is based on AS4360 methodology. details of the scoring etc are at the end of this document.

Hazard	Likelihood	Consequence	Control	Additional Requirement	Likelihood	Consequence	Notes	Residual Risk
10.1 Electrical System								
Electric shock	Likely	Major 19	Ensure LV system isolated from chassis. Use double insulation. Provide IT system. Include ELD.	Colour LV wiring distinctively. Physically separate LV wiring from ELV. Shrouded terminals.	Unlikely	Minor 5		Lethal shock can now only be achieved through a direct connection with active and neutral.
Explosion or fire from gassing battery	Unlikely	Minor 5	Include operational control in Code for charging battery.	Vent battery area.	Very unlikely	Minor 4	Only small quantities of gas produced. Common risk for motor vehicles in operation (hot engine adjacent).	Experience suggests very unlikely.
Acid burn	Likely	Minor 7	Secure battery. Enclose/control spillage.		Very unlikely	Minor 4	Most batteries designed to minimise this.	Experience suggests very unlikely.
Hazards of alternative battery technology (eg LiPo) not understood	Likely	Moderate 13	Make user aware of need to consult manufacturers requirements.	Batteries are to be intended for traction or vehicular usage for any equipment where a	Likely	Minor 7	An unknown created due to evolving technology.	Could rise in time, currently low. Most likely in the smaller

resulting in fire.				person is mounted on the battery holding vehicle				models-less energy.
Overheating of wiring with risk of fire.	Likely	Minor 7	Rate wiring to suit situation.		Unlikely	Minor 5	Includes voltage and current. More likely under fault conditions.	Generally no impact to passengers.
Relay/contactor jams in energised position	Unlikely	Moderate 9	Use quality equipment with predictable failure mode.		Very unlikely	Moderate 8	Relays have a high probability of achieving a predictable failure mode.	Unlikely failure simultaneous with other loss of control.
Switch breaks.	Likely	Moderate 13	Use failsafe wiring configuration. Emergency override.		Likely	Minor 7	Common failure.	Negligible
Short circuiting of connections or terminals	Likely	Minor 7	Shrouding of terminals, double insulation of LV wiring.	Battery isolator provided.	Likely	Minor 7	Usually occur due to a mechanical failure or interference.	Generally no impact to passengers.
10.2 Control System								
Uncontrolled acceleration (all causes)	Likely	Moderate 13	Emergency Override provided. Failsafe wiring configuration.		Unlikely	Minor 5	The emergency override is provided but it requires the driver to activate it. The 'minor' rating is due to this uncertainty otherwise it would be negligible.	All instances of uncontrolled acceleration (from any cause) is mitigated by the emergency

								override facility.
Broken switch or control device (including blown fuse, defective servo, defective power supply, unsuitable receiver location)	Likely	Moderate 13	Emergency Override provided. Failsafe wiring configuration.		Unlikely	Minor 5	The emergency override is provided but it requires the driver to activate it. The 'low' rating is due to this uncertainty otherwise it would be negligible.	All instances of uncontrolled acceleration (from any cause) is mitigated by the emergency override facility.
Broken or defective tether cable to controller.	Very likely	Moderate 14	Emergency Override provided. Failsafe wiring configuration.		Unlikely	Minor 5	The emergency override is provided but it requires the driver to activate it. The 'low' rating is due to this uncertainty otherwise it would be negligible.	All instances of uncontrolled acceleration (from any cause) is mitigated by the emergency override facility.
Loss of radio link for radio control	Very Likely	Moderate 14	Emergency Override provided. Failsafe wiring configuration. Use 'failsafe' function in receiver.	Quality radio control equipment.	Unlikely	Minor 5	The emergency override is provided but it requires the driver to activate it. The 'low' rating is due to this uncertainty otherwise it would be negligible. However using a radio with an internal 'failsafe' would instantly protect this, on the basis that a parallel Rx failure is	All instances of uncontrolled acceleration (from any cause) is mitigated by the emergency override facility.

							unlikely.	
Unit becomes out of range.	Very Likely	Moderate 14	Emergency Override provided. Failsafe wiring configuration. Use 'failsafe' function in receiver.	Quality radio control equipment.	Unlikely	Minor 5	The emergency override is provided but it requires the driver to activate it. The 'low' rating is due to this uncertainty otherwise it would be negligible. However using a radio with an internal 'failsafe' would instantly protect this, on the basis that a parallel Rx failure is unlikely.	All instances of uncontrolled acceleration (from any cause) is mitigated by the emergency override facility.
Interference to radio link (by another operator)	Unlikely	Moderate 9	Emergency Override provided. Failsafe wiring configuration. Use 'failsafe' function in receiver.	Quality radio control equipment	Unlikely	Minor 5	The emergency override is provided but it requires the driver to activate it. The 'low' rating is due to this uncertainty otherwise it would be negligible. The likelihood of this is very low.	All instances of uncontrolled acceleration (from any cause) is mitigated by the emergency override facility.
Operator drops controller (radio or tethered)	Almost certain	Moderate 18	Emergency Override provided. Failsafe wiring configuration.	Operator should use lanyard to retain control unit.	Unlikely	Minor 5	The emergency override is provided but it requires the driver to activate it. The 'minor' rating is due to this uncertainty otherwise it would be insignificant.	All instances of uncontrolled acceleration (from any cause) is mitigated by the emergency override facility.

Drivers car (with or without) controls becomes disconnected from locomotive or driver loses controller.	Very likely	Moderate 14	Emergency Override provided. Failsafe wiring configuration.	Operator should use lanyard to retain control unit. Breakaway control.	Unlikely	Minor 5	Coupling standard uses retaining pins.	Removal of driver from control is dependent on coupling integrity. Breakaway control is an additional safeguard.
Remote unit flat battery.	Very likely	Moderate 14	Emergency Override provided. Failsafe wiring configuration. Use 'failsafe' function in receiver.	Quality radio control equipment.	Unlikely	Minor 5	The emergency override is provided but it requires the driver to activate it. The 'low' rating is due to this uncertainty otherwise it would be negligible. However using a radio with an internal 'failsafe' would instantly protect this, on the basis that a parallel Rx failure is unlikely.	All instances of uncontrolled acceleration (from any cause) is mitigated by the emergency override facility.
Inadvertent control of wrong locomotive	Unlikely	Moderate 9	Emergency Override provided. Failsafe wiring configuration. Use 'failsafe' function in receiver.	Quality radio control equipment.	Unlikely	Minor 5	The emergency override is provided but it requires the driver to activate it. The 'low' rating is due to this uncertainty otherwise it would be negligible. However using a radio with an internal 'failsafe' would instantly protect this, on the basis that a parallel Rx failure is unlikely.	All instances of uncontrolled acceleration (from any cause) is mitigated by the emergency override facility.
Inadvertent	Very	Minor	Emergency Override	Interlocking of	Unlikely	Minor	The emergency override is	Requires

movement when setting direction.	likely	11	provided.	controls provided.		5	provided but it requires the driver to activate it or to back off the throttle. The 'low' rating is due to this uncertainty otherwise it would be negligible.	driver response to adjust control.
On board and remote control units simultaneously active.	Likely	Minor 7	Emergency Override provided. Failsafe wiring configuration.	Quality radio control equipment.	Unlikely	Minor 5	The emergency override is provided but it requires the driver to activate it or to back off the throttle. However the likelihood of this fault is very low.	All instances of uncontrolled acceleration (from any cause) is mitigated by the emergency override facility.
Driver in different position in train.	Almost certain	Minor 12	Acknowledge potential change	Societies to assess risk and put procedures in place.	Unlikely	Minor 5	Societies are not good at pre-empting these issues.	Issue likely to be precise positioning visibility of front of train ahead.

.Compiled by Warwick Allison 12 May 2017

RISK ASSESSMENT MATRIX

To assist employers and employees to assess areas of Occupational Health & Safety in your business we have provided the following Risk Assessment Matrix:

LIKELIHOOD	CONSEQUENCE				
	Insignificant No injuries, low financial loss	Minor First aid, property or environmental damage up to \$2,500	Moderate Any lost time injury, short term temporary disability (under 1 month), property or environmental damage \$2,500 to \$25,000	Major Lost time injury longer than 2 weeks, long term temporary disability (over 1 month), property or environmental damage \$25,000 to \$250,000	Catastrophic Fatality, permanent disability, property or environmental damage over \$250,000
	A	B	C	D	E
5 Almost Certain Is expected to occur in most circumstances	10	12	18	21	25
4 Very Likely Could happen regularly	6	11	14	20	24
3 Likely Might happen at some time	3	7	13	19	23
2 Unlikely Could happen but only rarely	2	5	9	16	22
1 Very Unlikely Could happen, but probably never will	1	4	8	15	17

RISK ASSESSMENT	MANDATORY ACTION
1-5	Maintain integrity of existing controls, monitor and review effectiveness.
6-9	Action plan to be developed, time frame established. Interim controls may be needed.
10-17	Action plan to be developed and hazard controlled within one month.
18-25	Stop work, do not re-start until hazard controlled.

Matrix sourced from AS/NZS 4360:1999 Risk Management

END