Department of Natural Resources, Mines and Energy

Recognised standard 19

Design and construction of mine roads

August 2019

Coal Mining Safety and Health Act 1999

Queensland Government

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This publication has been compiled by the Mines Inspectorate, Mines Safety and Health, Department of Natural Resources, Mines and Energy.

Recognised standards

This document is issued in accordance with PART 5—RECOGNISED STANDARDS and Section 37(3) of the *Coal Mining Safety and Health Act 1999.*

PART 5 - RECOGNISED STANDARDS

71 Purpose of recognised standards

A standard may be made for safety and health (a “recognised standard”) stating ways to achieve an acceptable level of risk to persons arising out of coal mining operations.

72 Recognised standards

(1) The Minister may make recognised standards.
(2) The Minister must notify the making of a recognised standard by gazette notice.
(3) The chief executive must keep a copy of each recognised standard and any document applied, adopted or incorporated by the recognised standard available for inspection, without charge, during normal business hours at each department office dealing with safety and health.
(4) The chief executive, on payment by a person of a reasonable fee decided by the chief executive, must give a copy of a recognised standard to the person.

73 Use of recognised standards in proceedings

A recognised standard is admissible in evidence in a proceeding if—
(a) the proceeding relates to a contravention of a safety and health obligation imposed on a person under part 3; and
(b) it is claimed that the person contravened the obligation by failing to achieve an acceptable level of risk; and
(c) the recognised standard is about achieving an acceptable level of risk.

PART 3- SAFETY AND HEALTH OBLIGATION

37. How obligation can be discharged if regulation or recognised standard made

37(3) …. if a recognised standard states a way or ways of achieving an acceptable level of risk, a person discharges the person’s safety and health obligation in relation to the risk only by—
(a) adopting and following a stated way; or
(b) adopting and following another way that achieves a level of risk that is equal to or better than the acceptable level.”

Where a part of a recognised standard or other normative document referred to therein conflicts with the *Coal Mining Safety and Health Act 1999* or the *Coal Mining Safety and Health Regulation 2017*, the Act or Regulation takes precedence.

This recognised standard is issued under the authority of the Minister for Natural Resources, Mines and Energy.

[Gazetted 9 August 2019]

Contents

1 Purpose

This Recognised Standard is designed to assist mine management and workers at coal mines in meeting their obligations by stating ways to achieve an acceptable level of risk to persons arising out of coal mining operations that shall be included in a coal mine safety and health management system for the design and construction of mine roads.

2 Scope

This Recognised Standard applies to the design and construction of all mine roads in surface coal mines, including surface areas of underground coal mines, in the state of Queensland.

3 Introduction

Vehicle interaction is recognised as a principal hazard in surface coal mines in Queensland, and a principal hazard is a hazard that has the potential to cause multiple fatalities.

Statistics show that a large percentage of the high potential incidents and serious accidents reported by surface coal mines are related to vehicle interaction, and uncontrolled movement of vehicles. A number of these events have resulted in fatalities. In some cases the investigation of these incidents have identified that the design and construction of the road has been a causal factor of the event occurring. Therefore, it is recognised within the coal industry that designing and constructing mine roads to a recognised standard will assist mines in achieving an acceptable level of risk associated with the movement and interaction of vehicles.

4 Definitions

Safety berm	A Safety berm which may also be referred to as a berm, safety bundwall, bundwall, bund, or windrow, is a triangular or trapezoidal shaped mound of earthen material used to redirect wandering vehicles and/or to absorb some of the impact energy if a vehicle hits them. They are a standard safety feature on a haulroad, dump crest, pit wall crest or other areas where a vertical drop or collision hazard exists.
Median/centre safety berm	A median/centre safety berm is a safety berm that is placed along the centreline of a roadway to separate and/or define traffic flow.
Light vehicle roads	Light vehicle roads are roads that are used by light and medium vehicles for access around the perimeter of the pit, within pit areas and on the surface.
Permanent haul roads	Permanent haul roads are major arterial roads used by haul trucks and the majority of mine traffic.
Pit haul roads	Pit haul roads are roads that are used by haul trucks and other mine traffic in and around pit areas including, in pit haul roads and ramps, bench roads, dump roads and ramps, etc.
Roadway	The part of a road intended for vehicles, in contrast to the pavement or verge.
Delineator	Markers erected to define the edge of the running surface of a road
Bollards	High visibility thick posts or segregation barriers installed where vehicles interface with surface infrastructure e.g. buildings, structures, service corridors, etc. and/or ground level or underground hazards such as covered sumps, soak wells, and drains not designed to support the weight of vehicular traffic.
Mobile plant (MP)	Means plant capable of being moved under its own power. Examples are draglines, shovels, excavators, and off highway mining trucks.

Light vehicles (LV)	Vehicles up to 4.5 tonnes gross vehicle mass.
Medium vehicles (MV)	On highway type vehicles greater than 4.5 tonnes gross vehicle mass. Typically refers to buses with more than 11 seats, light trucks, mobile cranes, crane trucks, service trucks, water trucks, explosive trucks, prime movers and multiple combination trucks.
Vehicles	The collective group of mobile plant, medium vehicles and light vehicles.
Super-elevation	Super-elevation is the cross gradient applied to switchbacks, corners and curves. It allows a vehicle taking a corner to counteract the 'centrifugal' forces by directing the vehicle weight towards the centre of the curve, much like a velodrome.
Grade	The gradient on a ramp is the grade line profile along the road centre line. It is measured from the horizontal, +ve representing up grade and –ve representing down grade.
Shoulder	Road edge that is not considered the running surface for vehicles
SISD	An abbreviation for safe intersection sight distance
SSD	An abbreviation for safe stopping distance
OEM	An abbreviation for original equipment manufacturer
SSE	An abbreviation for site senior executive
OCE	An abbreviation for open cut examiner

5 Road types

5.1 Primary haulroad

Means a main haulage road constructed for use over an extended period for mobile plant to move overburden, coal and waste material. It may include permanent sections of coal haulage ramps. An extended period of time is the life of a particular pit or mining area.

5.2 Secondary haulroad

May include some sections of ramp haulroads, in pit haulroads, and bench and dump roads which are generally made redundant with the advance of the pit or mining area.

5.3 Primary access road

These are roads generally used over an extended period of time by light and medium vehicles. An extended period of time is the life of a particular pit or mining area.

5.4 Secondary access road

These are roads used by light and medium vehicles over a short period of time, and are normally made redundant with the advance of the pit or mining. Typically these are access roads into draglines, drills, blasting areas, pumps, pipelines, highwall crests, exploration, mine boundary etc.

6 Mine road construction

Mine roads should be designed and constructed to provide:

- well-drained and stable base layers capable of supporting the weight of traffic
- a hard and smooth running surface utilising materials that minimise skidding and dust generation.

The following elements should be considered to determine the required road construction process and construction profile:

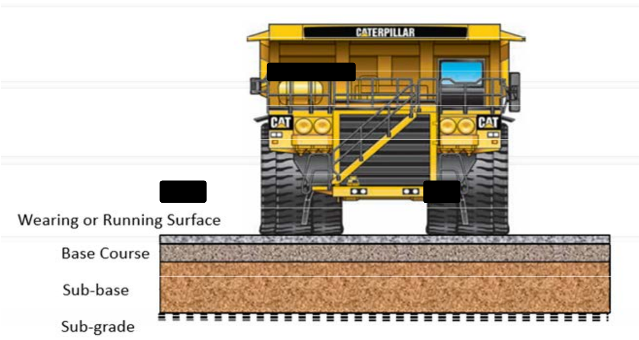
- The road type as detailed in section 5, and more specifically the:
  - Expected lifespan of the road
  - Primary purpose of the road
  - Frequency of usage of the road.
- The vehicles that are expected to use the road and the design road speed.
- The mobile plant available for constructing the road.
- The material available for constructing the road.
- The geometric design parameters for the road.
- The time of year (or expected weather conditions) that the road is expected to be constructed.
- The time of year (or expected weather conditions) that the road is expected to be used and road maintenance processes such as expected watering practices.

For primary haulroads, industry recognised pavement designs processes should be used to ensure the road profile is adequately designed to suit the material selected and vehicle wheel loading.

Survey control should be utilised when constructing mine roads, particularly primary roads, to ensure the construction process conforms to the required engineering and geometric design specifications.

Primary roads may be considered as structures in their own right, composed of the following typical construction profile:

- sub-grade
- sub-base
- base course
- wearing or running surface.



6.1 Sub-grade

The sub-grade is the native level under which the road profile is established. For primary roads, the sub-grade will consist of either native material or compacted cut and fill with the effective stiffness or bearing capability of the sub-grade determining the magnitude of pavement deflection (flexure) under truck loading and therefore the required road construction profile required above to support the weight of traffic.

6.2 Sub-base

The sub-base typically constitutes the majority of a haulroads strength. For Primary haulroads the sub-base should be composed of sufficient rigid material capable of bearing the weight of haulage traffic. The thickness and construction process of the sub-base is dependent on the bearing capability of the sub-grade, the bearing capability of the material utilised and the weight of vehicles expected to use the road. The following elements should be utilised as a general guideline for sub-base construction:

- Sub-base thickness selection is dependent on the strength of available material. The material should typically be composed of coarse and dry material with a lump size <400mm.
- Sub-base material should be placed in layers with adequate compaction of each layer occurring.
- The sub-base should be roughly shaped to suit the profile of the final running surface, i.e. start forming the cross fall and road geometry at this stage.
- Road side drainage works should be commenced during this construction stage.

6.3 Base course

The base course is the platform for the wearing or running surface. It is a supplementary layer usually composed of better quality and high bearing capacity material to increase the thickness of the pavement when sub-grades are weaker. For primary haulroads the following elements should be utilised as a general guideline for base course construction:

- Base course thickness selection is dependent on the strength of available material. The material should typically be composed of the best rocky material with a lump size <250mm.
- Base course material should be free of plastic material such as clays and carbonaceous materials.
- Base course material should be placed in layers no thicker than 300mm with adequate compaction of each layer occurring.
- The base course should be shaped to suit the design road geometry profile of the final running surface.
- Road side drainage works should be established during this construction stage.

6.4 Wearing or running surface

The wearing or running surface provides the layer upon which mobile plant will operate. The wearing or running surface material selection and construction process should provide a hard and smooth surface with an appropriate friction co-efficient value whilst minimising dust generation. Expected road watering practices and the requirements of s129 of the Coal Mining Safety and Health Regulation 2017 (Qld) shall be considered when determining the material and construction process.

The following elements should be utilised as a general guideline for wearing or running surface construction:

- The wearing or running surface may be designed to provide for periodic replacement over time.
- The wearing or running surface thickness should generally be 200mm dependent on the strength of material available.
- The particle size (or grading), moisture content, and drainage of the wearing or running surface are key elements in maintaining the surface in good condition.
- Avoiding wearing or running surface failures (e.g. surface corrugations, pot holing, excessive dust generation and loose or slippery materials) requires both strong particles (to limit crushing under the tyre loading) and a strong surface, in which individual particles cannot be easily pulled out of the surface matrix. This is generally achieved by using a “well graded” material with a small quantity of cohesive fines and moisture, to assist in binding the surface together.

In dry climates a comparatively fine surfacing material with not less than 5% fines is desirable to effectively retain moisture, and lead to better binding characteristics.

- In a wet climate a wider grading range, tighter fines limits of not more than 10% and harder material is required to provide wearing course strength and to resist softening.
- High levels of compaction should be used to firmly lock particles together.
- The final design road geometry profile shall be achieved at the completion of this construction stage.
- Design of the road wearing/running surface shall take into consideration vehicle tyre specifications (rubber composition, tread pattern, TKPH, tyre dispensations etc.). Further guidance is in *Recognised Standard 13 Tyre, wheel and rim management.*

6.5 Design of structures

For the design of structures such as bridges, concrete or corrugated steel (ARMO CULVERTS):

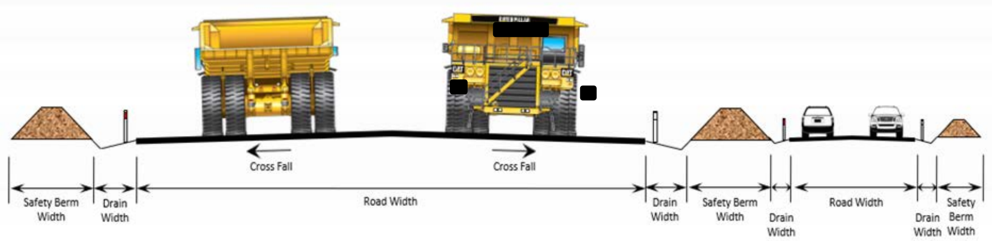
- Structure will be designed in accordance with acceptable engineering design principals and standards.
- Design of structures shall take into account the relevant stream and overland flows for the expected design life.
- Attention to be paid to the design of water flow structures to minimise ponding and the risk of scouring that may affect the road construction.

7 Road widths

Mine roads shall be designed and constructed to accommodate the operating width of the largest vehicle regularly using the road. The following shall be utilised to determine the required road width for various road types:

- Single lane roadways – 1.5 x vehicle operating width
- Double lane roadways – 3.5 x vehicle operating width.

Road width is the useable running pavement clear of guideposts, drains and safety berms. An example of a typical double lane roadway schematic for a haul road and an access road is as follows:



Where road width cannot be achieved an assessment of risk shall be undertaken to determine controls that manage the hazard to an acceptable level of risk (e.g. specifying give way requirements, speed restrictions, installation of narrow road signage highlighting the road width hazard etc.).

Where roadways are separated for extended lengths by a median/centre safety berm or other physical barrier then those segments of roadway shall be considered single lane segments and single lane roadway width criteria applied accordingly.

The operating width of a vehicle is the maximum width of the vehicle during normal operation, and is taken as the width of the outer extremities of the vehicle (for example mirror to mirror, rock deflector to rock deflector).

8 Crossfall/camber

Primary roads shall, and secondary roads should, be constructed to ensure the surface shape of the roadway supports water run-off from the road surface without adversely affecting the drivers steering control or increasing tyre wear. Cross fall or camber is the cross road gradient perpendicular to the road direction. Consideration should be given to:

- road gradient
- expected rainfall
- wearing surface material
- OEM vehicle specifications.

Cross fall on mine roads should vary between 1.0% and 4.0% depending on the above criteria.

In applications where tyre wear may be an issue (e.g. long hauls), cross fall on loaded lanes should be kept to a minimum.

9 Road alignment (horizontal and vertical curvature)

All haulroads and primary access roads shall, and secondary access roads should, be designed and constructed with the following alignment criteria:

- Curves (horizontal and vertical) should have the largest radius possible.
- Curvature should be smooth and consistent.
- Tight curves should comply with OEM minimum turn radius requirements.
- Horizontal compound curves (i.e. where the radius changes significantly through the curve) shall not be used (refer to **Figure 1** below).

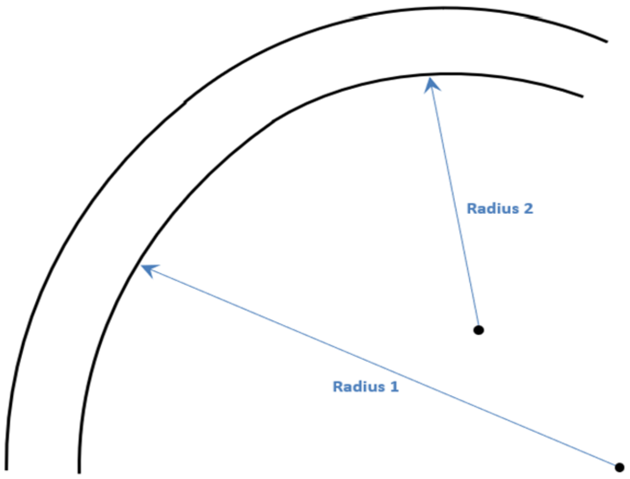


Figure 1. Compound curve

- Horizontal reverse curves (i.e. a curve in one direction subsequently followed by a curve in the opposite direction - refer to **Figure 2** below) should typically be separated by a minimum straight section of road:
  - 60km/hr – minimum straight length – 36m
  - 40km/hr – minimum straight length – 24m
  - 20km/hr – minimum straight length – 12m.

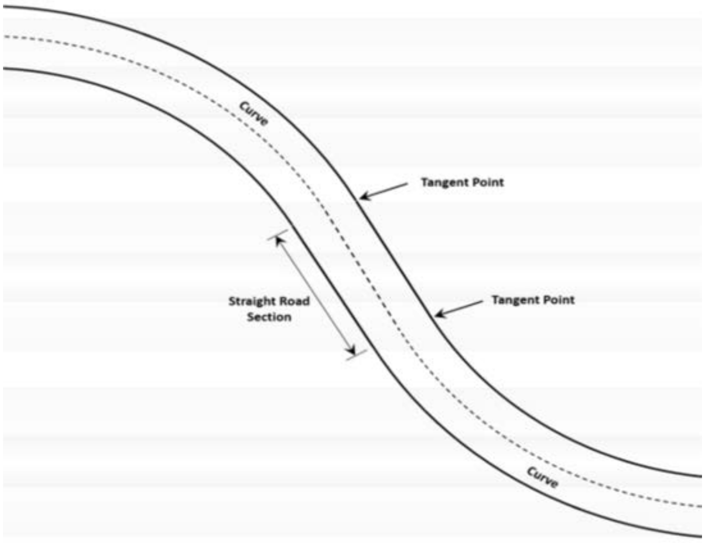


Figure 2. Horizontal reverse curve

- Horizontal and vertical curves should complement each other:
  - horizontal curves at the crest of vertical curves should be avoided as sight distance is generally restricted and it is difficult for drivers to perceive curves in such a situation.
  - sharp horizontal curves should be avoided at the base of ramps or long sustained downhill grades as vehicles are typically at their highest speeds at these locations.
- Switchbacks should have the largest radius possible and be placed on flat sections of the ramp. They should not be placed on grade as the inside curve may exceed design gradient parameters.

10 Superelevation

All haulroads and primary access roads shall, and secondary access roads should be designed and constructed with superelevation and/or speed restrictions on all horizontal curves.

Typically, superelevation rates of 2% - 6% suit most mine road applications, rates above 6% shall not be used. The application of negative superelevation (adverse cross fall) should be avoided.

The following tables detail recommended superelevation rates, curve radius and speed relationships:

Table 1* – Curve radius for desired speed and superelevation rates:

Speed (km/hr)	Superelevation rate						
	-2% ** (adverse cross- fall)	1%	2%	3%	4%	5%	6%
	Curve radius						
10	10 m	18 m	9 m	6 m	5 m	4 m	3 m
20	39 m	73 m	36 m	24 m	18 m	15 m	12 m
30	89 m	164 m	82 m	55 m	41 m	33 m	27 m
40	157 m	291 m	145 m	97 m	73 m	58 m	48 m
50	246 m	454 m	227 m	151 m	114 m	91 m	76 m
60	354 m	654 m	327 m	218 m	164 m	131 m	109 m
70	482 m	890 m	445 m	297 m	223 m	178 m	148 m
80	630 m	1,163 m	581 m	388 m	291 m	233 m	194 m

* Note: a) Coefficient of side friction 0.2
b) Maximum superelevation 0.06m/m

** Note: a) Although adverse cross fall should be avoided, situations may arise where the adoption of adverse cross fall may be necessary
b) For adverse cross fall, coefficient of side friction 0.1

Table 2 – Superelevation rates for desired speed and curve radius:***

Speed (km/hr)	Curve radius												
	50 m	75 m	100 m	125 m	150 m	175 m	200 m	250 m	300 m	350m	400 m	450 m	500 m
	Superelevation rate												
10	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
20	1 %	1 %	1 %	1%	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
30	3 %	2 %	2 %	1 %	1 %	1 %	1 %	1 %	1 %	0 %	0 %	0 %	0 %
40	6 %	4 %	3 %	2 %	2 %	2 %	1 %	1 %	1%	1 %	1 %	1 %	1 %
50	9 %	6 %	5 %	4 %	3 %	3 %	2 %	2 %	2 %	1 %	1 %	1 %	1 %
60	13 %	9 %	7%	5 %	4 %	4 %	3 %	3 %	2 %	2 %	2 %	1 %	1 %
70	18 %	12 %	9 %	7 %	6 %	5 %	4 %	4 %	3 %	3 %	2 %	2 %	2 %
80	23 %	16 %	12 %	9 %	8 %	7 %	6 %	5 %	4 %	3 %	3 %	3 %	2 %

*** Note: a) Coefficient of side friction 0.2
b) Maximum superelevation 0.06m/m
c) Red shaded areas represent superelevation rates above 6% that shall not be used

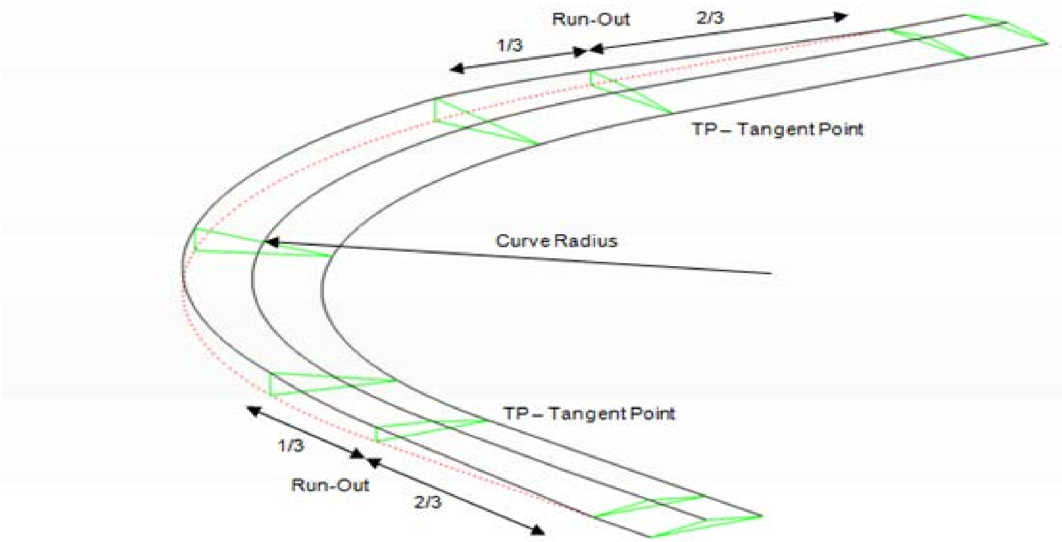
Run-out shall be applied to enable the smooth transition from the straight roadway cross slope section into the superelevated curve section. Run-out assists a driver in the safe manoeuvring of a vehicle into and out of a curve. Run-out lengths vary with design speed of the curve and the total change in cross slope. Run-out is applied such that 1/3 of run-out length occurs in the curve and 2/3 run-out length before the tangent point of the curve (in the straight section). The following table details total run-out length, for the speed and absolute change in cross slope:

Absolute change in	Speed						
	20 km/hr	30 km/hr	40 km/hr	50 km/hr	60 km/hr	70 km/hr	80 km/hr

cross slope	Run out length						
1 %	4 m	5 m	7 m	8 m	10 m	10 m	10 m
2 %	8 m	10 m	13 m	16 m	19 m	19 m	19 m
3 %	12 m	15 m	19 m	24 m	28 m	28 m	28 m
4 %	16 m	20 m	25 m	31 m	37 m	37 m	37 m
5 %	20 m	24 m	32 m	39 m	46 m	46 m	46 m
6 %	24 m	29 m	38 m	47 m	55 m	55 m	55 m
7 %	28 m	34 m	44 m	54 m	64 m	64 m	64 m
8 %	32 m	39 m	50 m	62 m	73 m	73 m	73 m
9 %	36 m	43 m	57 m	70 m	82 m	82 m	82 m
10 %	40 m	48 m	63 m	77 m	91 m	91 m	91 m

To illustrate the application of run-out, assume a road is designed for 30km/hr and has a normal cross fall of 3% to the left. The roadway has a curve to the right that requires a super-elevation of 4% to the right. The absolute change in cross slope is 3%+4%=7%. From the above table, the run-out length required is 34m (comprising 10m in the curve and 24m before the tangent in the straight).

Superelevation and run-out schematic:



11 Grade

Mine roads shall be designed and constructed with grades that conform to the following specifications:

- Grades should typically not exceed 10% (1:10).
- An assessment of risk shall be undertaken to identify controls for managing design grades exceeding 10 % so the level of risk is at an acceptable level.
- OEM vehicle operating specifications shall not be exceeded.

Use vertical curves to ensure a smooth transition from one grade to another.

Ensure that grades are kept as constant as possible (avoid unnecessary grade changes).

Ensure grades at, or near intersections (particularly within the sight distance envelope of an intersection) are kept as flat as possible, (refer to Section 13.1).

12 Shoulder control/drainage

12.1 Shoulder control

Mine roads shall be designed and constructed to address the risk of a vehicle accidently leaving the roadway. Where a roadside hazard exists such as a vertical drop-off (>0.5m) along the road edge or a steep or sustained shoulder grade steeper than 1V to 4H ratio a suitable safety berm (or other physical barrier) shall be established in the affected area.

Shoulder design can have a significant impact on the structural performance of a haulroad pavement along the outside edge of the roadway. Ensure that sufficient strength and bulk is incorporated in the shoulder design to minimise lateral pavement failures along the edge of roadways.

12.2 Drainage

Mine roads should be constructed with adequate roadside drainage to ensure water is removed from the running surface and away from the road.

Poor road side drainage and water ingress into structural layers of a roadway is a common cause for mine road pavement failures.

Where designated floodways cross roadways (as either low level crossings or culvert crossings) the road base (and outlet locations in the event of a culvert crossing) should be constructed with suitable material to withstand significant erosion in the event of water flowing over the roadway.

Ensure that roadside drainage complies with site environmental requirements and where applicable:

- establish erosion and sedimentation controls as part of the roadside drainage system
- ensure scour protection is provided at outlet locations.

Provision should be made for water to be directed off the road edge via drainage breakthroughs in the safety berms or grader run outs.

13 Intersections

13.1 Intersection design

In general, intersections should be designed and constructed so they are as simple as possible. Intersections are to be designed in accordance with the following criteria:

- Intersecting roads shall be at 90° (+/- 5°) to each other. 'Y' intersections shall not be used and treatments shall be applied to ensure roads intersect at 90° (+/- 5°).

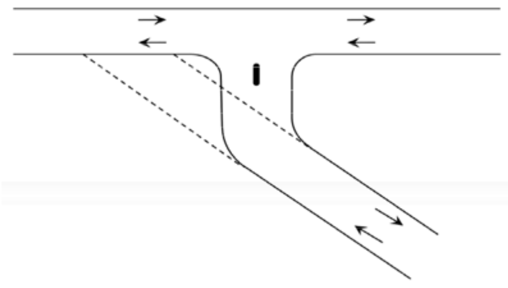


Figure 3. 'Y' intersection treatment example

- 'T' intersections should be utilised where possible.
- '+' intersection shall only be used when absolutely necessary, where multi-leg treatments (refer to **Figure 4** below) are not feasible and with a risk assessment approved by the SSE.

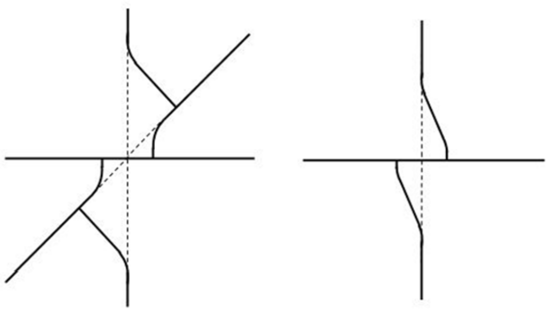
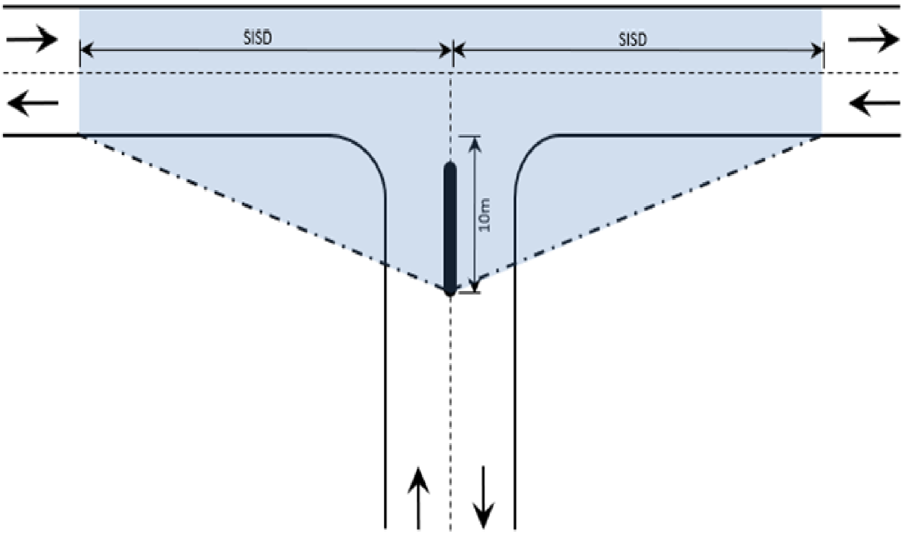


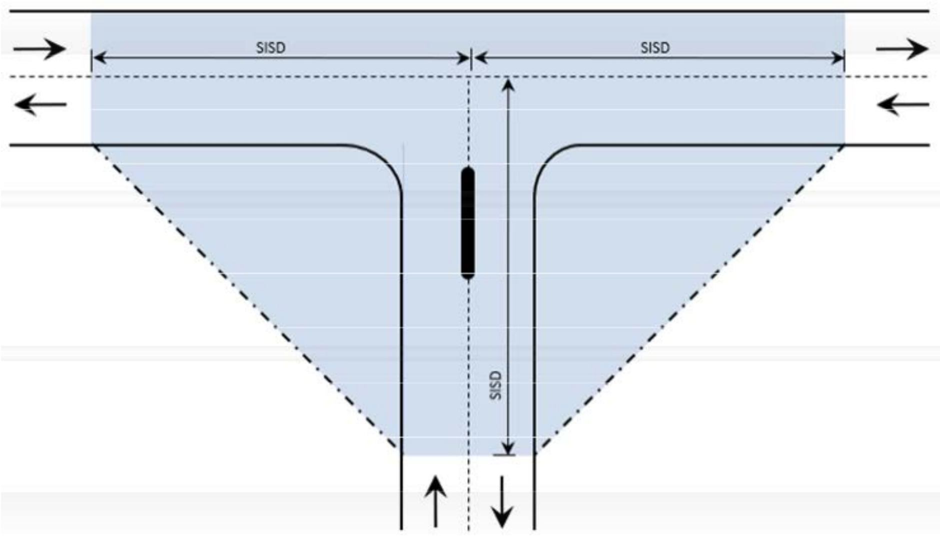
Figure 4. ***Multi-leg treatment examples***

- Complex intersections (intersection of more than 2 roads) shall not be used.
- Intersections within close proximity to each other shall be separated by a 70m centre-line to centre-line offset.
- Where roads intersect at the base of ramps a flat spot of at least 25m should be provided as a level braking zone. Similarly, where roads intersect at the top of ramps priority should be given to vehicles coming up the ramp or a flat spot of at least 25m provided, particularly if there is a requirement for vehicles to stop at the top of the ramp.
- Intersections shall be positioned and designed to maximise sight distance on approach and throughout the intersection.
    - Sight distance shall be measured for the driver eye height of the lowest vehicle using the road (e.g. utilise 1.5m for a light vehicle) to largest vehicle with the longest stopping distance (e.g. truck)
    - Consideration shall be given to sight distance in both the horizontal and vertical planes and if required controls e.g. speed restriction shall be adopted to achieve safe intersection sight distance (SISD) requirements

- o The following diagram details the intersection sight distance envelope requirements for a sign controlled intersection:



o The following diagram details the intersection sight distance envelope requirements for a hierarchy/priority rules controlled intersection:



o The following table details typical minimum SISD requirements at various speeds:

Speed	
(km/hr)	Safe intersection sight distance (SISD)*
10	10m
20	30m
30	50m
40	70m
50	90m
60	110m
70	145m

***** Note: Values are based on the following:

a) Coefficient of friction (CoF) 0.4 (dry mine road), speed reduction of min 10km/hr required to achieve wet road CoF of 0.2

b) 2.5sec driver reaction time, 0.5sec brake activation time & 1.5sec SSD to SISD conversion factor

c) No allowance for grade effects

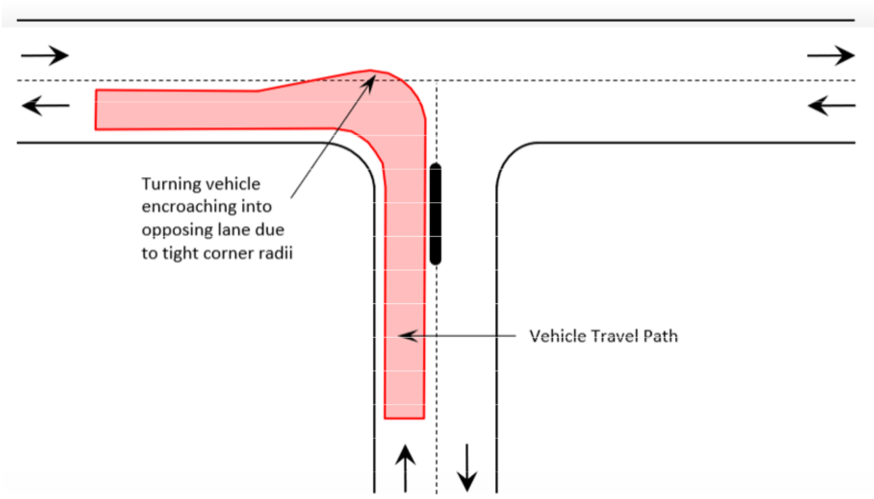
d) SSD formula as follows:

$$\text{Stopping distance} = \tfrac{1}{2} g t^2 \sin\theta + v_o t + \left(\frac{(g t \sin\theta + v_o)^2}{2g(U_{\min} - \sin\theta)} \right)$$

where;

g	=	acceleration due to gravity (m/s^2)
t	=	driver reaction AND brake activation time (s)
Θ	=	grade of road (degrees) positive downgrade
U_{min}	=	coefficient of friction tyre-road
v_o	=	vehicle speed (m/s)

- Turning radii within the intersection shall ensure that vehicles regularly using the road do not encroach into opposing lanes whilst traversing the intersection.



- Consideration should be given to ongoing maintenance requirements and drainage requirements when designing intersections. The more complex an intersection is, the more difficult it will be to maintain.
- A documented process shall be established to ensure intersections are reviewed for compliance to design standards and approved prior to opening the intersection to regular traffic flow.

13.2 Intersection traffic control

Appropriate traffic control shall be provided at intersections to enable the safe and efficient movement of vehicles through an intersection.

Traffic volume, loaded haulage routes and MP over MV/LV right of way should be considered when determining traffic flow priority through an intersection.

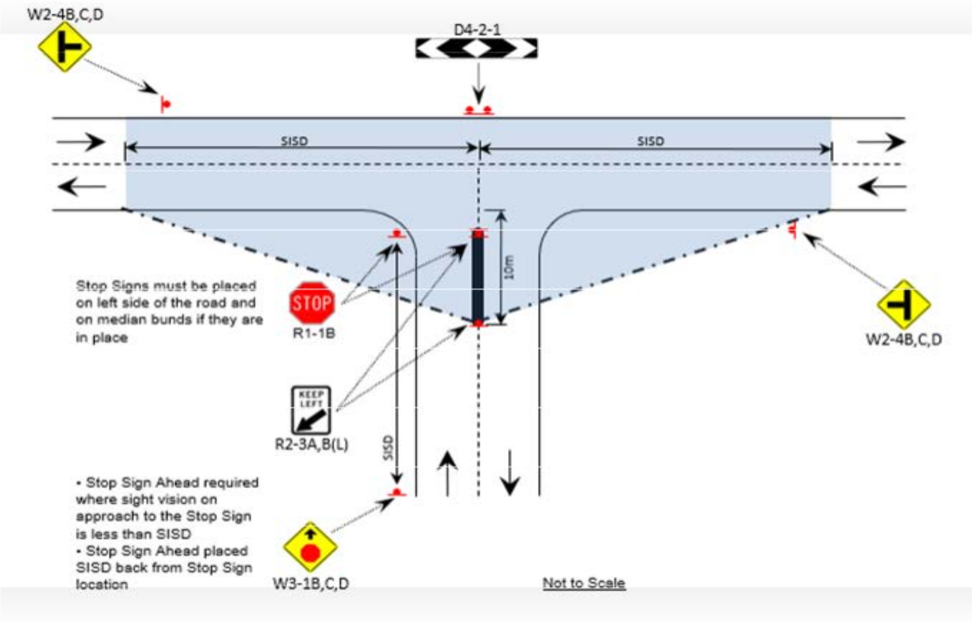
Median/centre safety berms should be used to provide traffic separation within an intersection and be positioned and sized (max. 1.2m high) so that they do not restrict sight distance on approach and throughout an intersection. Median/centre safety berms should be positioned to "channel" vehicles into the required orientation (square, 90°) during the approach to an intersection.

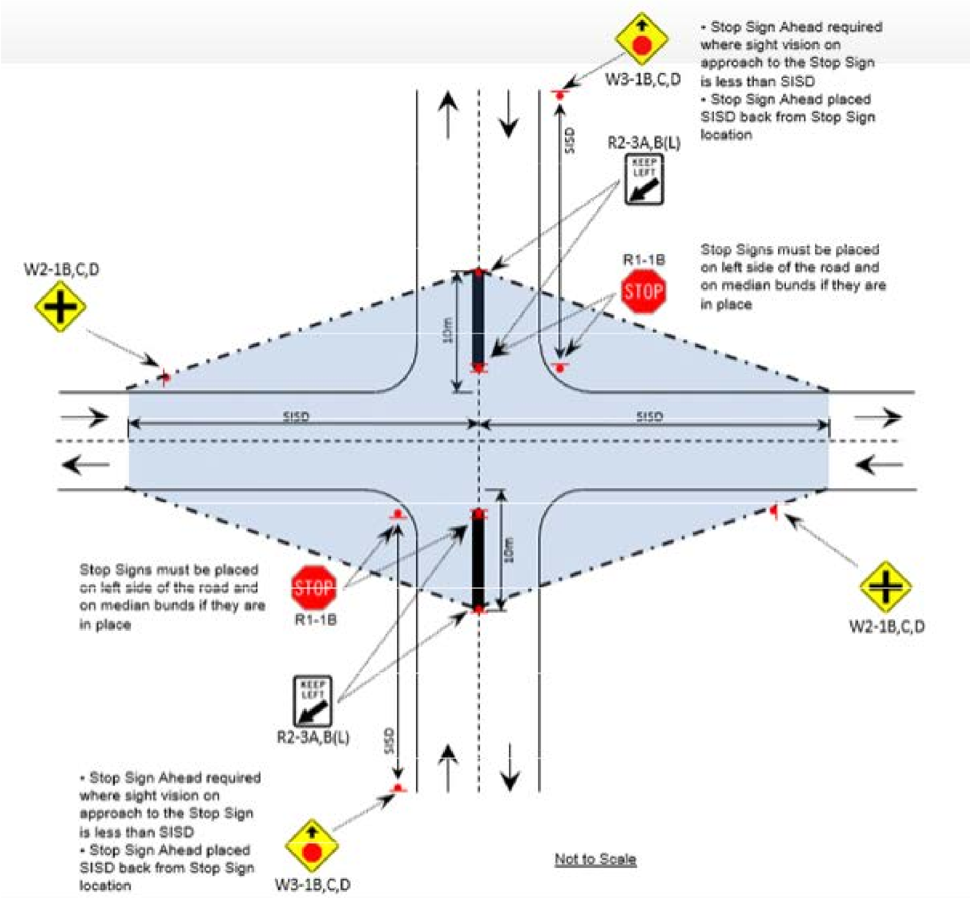
Adequate signage should be installed to provide warning on approach to an intersection and to provide clear direction within the intersection. The following should be utilised to control traffic at intersections:

- Where hierarchy/priority mine traffic rules are not applied, *stop* signs should be utilised to control right of way obligations at intersections
- For primary roadways, *Bi-directional hazard marker* signs placed where roads terminate
- *Keep left* signs placed on median/centre safety berms
- Where hierarchy/priority mine traffic rules are not applied, *Stop sign ahead* signs placed on the road approach where sight vision on approach to the stop sign is less than SISD requirements
- *Intersection/junction Warning* signs utilised to provide warning to road users of intersecting roads.

In conjunction with the requirements above and those of section 16.1 Signage, the following diagrams detail traffic control signage requirements for common intersections:

Intersection traffic control requirements for 'T' and '+' Intersections (Australian signs displayed):





14 Sight distances on curves and grades

Mine roads shall be designed and constructed to ensure that the sight distance to an existing or potential object or hazard on the roadway is greater than the required stopping distance. Utilise safe intersection sight distance (SISD) values from section 13.1 Intersection Design for minimum stopping distance values at various speeds.

Sight distance is the extent of peripheral area visible to the vehicle operator, and it is dictated by:

- the driver eye height of the lowest vehicle using the road (utilise 1.5m for mine LV's)
- road geometry and/or physical objects that restrict or impair vision.
- vehicle design.

As an example:

- On hill crests, the sight distance may be restricted by the vertical curve or crest of the hill. In this instance the crest may need to be flattened.
- At horizontal curves or intersections the sight distance may be restricted by batters, vegetation, signs or other obstructions.

Where possible, sight restrictions should be removed or speed reduced to achieve sight distance requirements.

15 Safety berms and barricades

Appropriate controls shall be provided to prevent vehicles from falling over road edges with a vertical drop-off of more than 0.5m.

Safety berms formed with earthen material shall be designed and constructed to the following specifications:

- Good quality material used that will resist weathering and compact suitably.
- Consideration given to addressing potential material settlement over time, such as adding additional height.
- Provision of drainage breakthroughs where required. They should be no greater than 1m wide and angled away from the direction of travel (refer to **Figure 5** below).

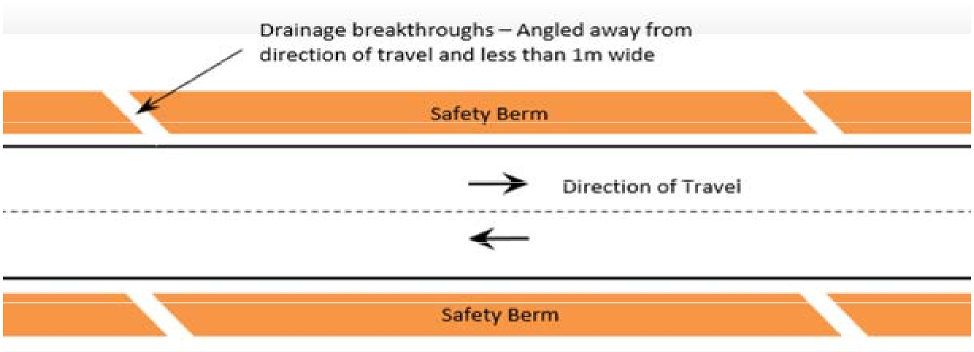


Figure 5. Drainage breakthroughs in roadside safety berms

- Standard trapezoidal safety berms shall have a minimum height equal to or greater than 50% of the tyre diameter of the largest vehicle regularly using the road (Refer to **Figure 6** below).
- Standard triangular safety berms shall have a minimum height equal to or greater than 66% of the tyre diameter of the largest vehicle regularly using the road (Refer to **Figure 6** below).
- The roadside facing batter angle of safety berms should be 45 degrees (1Vert. to 1Horiz.).

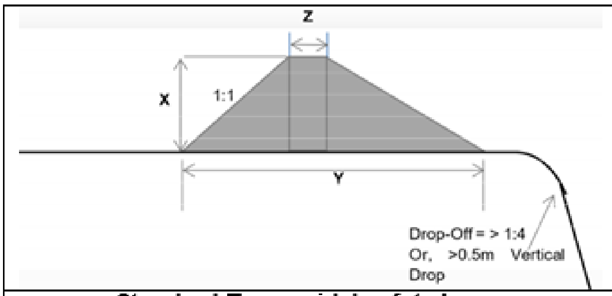
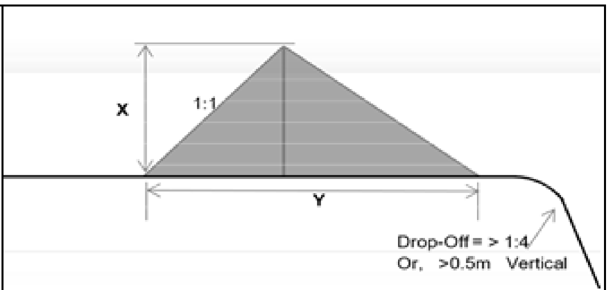
 Z X 1:1 Y Drop-Off = > 1:4 Or, >0.5m Vertical Drop	 X 1:1 Y Drop-Off = > 1:4 Or, >0.5m Vertical
Standard Trapezoidal safety berm (minimum height shall be 50% of the diameter of the largest vehicle tyre using the road)	**Standard Triangular safety berm (minimum height shall be 66% of the diameter of the largest vehicle tyre using the road)**
X = Safety Berm height; Y = Safety Berm footprint width; Z = Safety Berm crest width	

Figure 6. Design requirements for standard Trapezoidal and Triangular safety berms

The following table details typical safety berm dimensions for vehicles:

Vehicle	Standard tyre size	Inflated tyre diameter	Standard trapezoidal safety berm			Standard triangular safety berm	
			X	Y	Z	X	Y
MV / LV	Various	1.4m	0.7m	2.6m	1m	1m	2.3m
Cat 777	27.00R49	2.7m	1.4m	4.1m	1m	1.8m	4.2m
Cat 785	33.00R51	3.2m	1.6m	5.1m	1.4m	2.2m	5.1m
Cat 789	37.00R57	3.5m	1.8m	5.5m	1.4m	2.4m	5.6m
Cat 793	46.90R57	3.6m	1.8m	5.6m	1.4m	2.4m	5.6m
Kom 930E	53.80R63	3.8m	1.9m	6.0m	1.6m	2.6m	6.0m
Cat 797	59/80R63	4.0m	2.0m	6.3m	1.6m	2.7m	6.3m
<Insert/delete truck types as required>							
Note: Safety berm footprint width is based on a roadside facing batter angle of 45° and an outer side batter angle of 37°. Some dimensions have been adjusted for standardization.							

- Safety berm dimensions shall be increased to a height of greater than or equal to 3m with a minimal footprint width of 7m in areas that represent a higher level of risk such as:
  - Drop-off heights are greater than 5m directly along the road edge; and/or
  - High travel speeds or higher approach speeds;
  - Only poorer quality material is available to construct the safety berm from;
  - The safety berm control changes from a deflection mechanism to more of an impact absorption mechanism, for example when approach angles are less acute.
- As the size and shape of safety berms may be altered by erosion, material settling, or by contact from mining equipment; safety berms shall be regularly inspected and maintained to the required dimensions.

Where barricades (Armco guard rails, cable rails, bollards, etc.) are utilised as a control to prevent vehicles falling over road edges with a vertical drop-off of more than 0.5m, they shall be supported with an engineering certification that demonstrates the adequacy of that control measure for the application.

15.1 Road centre dividers

Consideration should be given to separate roadways (opposing lanes of traffic flow) where possible particularly in areas such as known fog zones, on left hand curves and particularly left hand curved downhill ramps. In such circumstances the roadway should be separated by a median/centre safety berm that is at least ½ the tyre height of the largest vehicle using the road or other physical barrier.

Where roadways are separated for extended lengths by a median/centre safety berm or other physical barriers then those segments of roadway shall be considered single lane segments, and single lane roadway width applied accordingly.

16 Delineation and signage

16.1 Signage

Signs shall be installed throughout the road network to provide warning and instructional information to road users. Signs should not be ambiguous and they shall provide clear and concise information to road users.

Signs specifications shall conform to national road authority standards (e.g. Australia AS1742 & AS1743). Signs should be appropriately sized to match the application and vehicles being utilised at the area of placement. Typically the following signs sizes should be utilised:

- Size A (generally 600mm size) – for applications where vehicles < or equal to 150t haul truck size.
- Size B (generally 750mm size) – for applications where vehicles >150t haul truck size.
- Size C, D or larger custom size (generally +900mm size) – for applications determined through a risk assessment.

Signs shall be made of reflective material so they are visible during times of low light or at night.

Signs shall be regularly maintained e.g. washed regularly, damaged or ineffective signs replaced, out of date signs removed, etc. such that their purpose of providing clear and concise information to road users is not compromised.

Signs shall be placed so that road users have time to interpret and react to their message. Consider the following when placing signs:

- Signs shall be located and placed at a height that is within the driver's line of sight. Regulatory signs (e.g. stop signs) shall be placed such that the base of the sign is a minimum of 1.5m above the road surface.
- Signs shall be placed on the left-hand side of the roadway, and when in place, on median/centre safety berms at intersections.
- Warning signs should be placed 1.5x the local speed limit prior to an oncoming hazard (e.g. 50km/hr speed limit – sign placed 75m before hazard).
- Regulatory signs (e.g. stop signs) shall be placed at the point at which a specific regulation commences.
- Signs should stand out and be placed so that the background does not make them unnoticeable.
- Signs should be appropriately placed so they do not create 'sign pollution' (i.e. too many, or inappropriately positioned signs so that drivers are confused or miss the required information).

The following list details minimum specific sign use and placement requirements:

- Signs for controlling traffic at intersections shall comply with the requirements detailed in section 13.2 Intersection Traffic Control.
- *Chevron Alignment Marker* signs should be utilised to augment the delineation of tight radius curves on primary roads. Where used, a minimum of three markers shall be used at any one curve, with a minimum of two markers shall be visible on approach to the curve, and they shall be aligned for the direction of approaching traffic.
- *Pedestrian Crossing* signs shall be utilised at designated pedestrian road crossing locations.
- Where median/centre safety berms are utilised on roadways, *Keep Left* signs shall be utilised on each end of the safety berm.
- Signs indicating the *Maximum Permissible Vehicle Height* and where applicable, *Powerline Crossing Number* shall be utilised where roadways pass under overhead power lines or structures.
- *Railway Level Crossing* signs shall be utilised where roadways cross railway lines.
- *Floodway Crossing* signs and *Water Depth Indicators* shall be utilised where designated floodways cross roadways.
- Speed signs.

16.2 Delineation

Delineators should be provided to adequately define the edge of the running surface of a road. Consider the following when selecting and placing delineators:

- Delineator height should be adequate to match the equipment used on the roadway.
- The spacing of delineators on straight sections of road should be a maximum of 100m apart with the posts in pairs, one each side of the road.
- Around tight curves and over crests the spacing of delineators should be reduced to a maximum of 50m or closer such that the reflectors from at least 3 delineators on the same side of the road can be seen at any one time whilst traversing the curve or crest:
    - For primary and secondary haulroads guideposts shall be between 1.5 and 2.4 metres high
    - For primary and secondary access roads guideposts shall be a minimum of 900mm high.
- Delineator spacing should be reduced in areas subject to frequent visibility restrictions such as fog.
- Delineator density should be increased to identify such things as culverts, median/centre safety berms, traffic islands, road intersections etc.
- The red reflector shall be placed on the left hand side of the road and the white reflector on the right hand side of the road.

16.3 Bollards

High visibility bollards, berms or segregation barriers should be installed where vehicles interface with surface infrastructure e.g. buildings, structures, service corridors, etc. and/or ground level or underground hazards such as covered sumps, soak wells, and drains not designed to support the weight of vehicular traffic.

17 Separation/segregation of vehicles

Where practicable the road network shall be designed to provide separate roadways for MP and MV/LV. When creating LV/MV only roads, ensure they are created for a purpose of reducing risk and that they do not increase risk with the establishment of additional MV/LV and MP intersections.

18 Roadside collision hazards

The risk associated with the roadside collision hazards shall be controlled by firstly eliminating the hazard where it's practical to do so, or secondly by putting protection (e.g. safety berms) between the road running surface and the collision hazard.

Some examples of roadside collision hazards are trees, large rocks, mounds, drains, creeks, water, erosion gutters and power poles. A roadside collision hazard can either be a crash hazard (e.g. trees, large rocks and power poles), or a hazard that has the potential to cause rollovers (e.g. mounds, drains and erosion gutters).

19 Overhead structures

All locations where overhead power lines or structures cross mine roads shall:

- be passively measured by survey.

For overhead structures (not power lines) have the maximum permissible vehicle height determined by applying a 1m minimum clearance distance.

For overhead conveyors have controls established to protect vehicles and pedestrians from potential falling material

When designing mine road routes the hierarchy of controls should be considered when interacting with high voltage power lines

- elimination – mine roads are kept well clear of power lines
- substitution – power lines are run under mine roads instead of above
- administration – signage warning of overhead power lines and clearance heights.

For power lines have the maximum permissible vehicle height determined by the Electrical Engineering Manager using the following minimum clearance requirements:

Power Line Nominal Voltage (phase to phase) (KvA)	Minimum Clearance
≤ 1.1	1.0 m
> 1.1 ≤ 33	2.3 m
> 33 ≤ 66	2.5 m
> 66 ≤ 110	3.0 m
> 110 ≤ 220	4.0 m

- Power lines shall be recorded in a site register indicating:
  - Crossing location coordinates
  - Power line crossing number
  - Survey height, date and time
  - Power line voltage
  - Maximum permissible vehicle height
- Have signs installed to indicate the maximum permissible vehicle height and where applicable power crossing number
- At power line crossing locations where the height of any vehicle capable of operating on that road exceeds the maximum permissible vehicle height of the crossing, have pre- warning clearance indicators installed.

20 Lighting pollution

Along roads and at intersections consideration shall be given to the following:

- the location and impact of background lighting and its potential to disorientate or confuse operators while driving on haul roads and at intersections
- dedicated haul road and intersection lighting to ensure lighting is adequate
- additional lighting in areas where interaction with pedestrians occurs
- the visibility of heavy vehicles and, in particular, haul trucks during night operations
- light absorption - Any dark coloured material will absorb light and reduce visibility e.g. high fines content of rejects leads to dusty matte surface rather than shinier flat surfaced fresh gravels, due to high fines; more dust problems

21 Audits and inspections of mine roads

- All surface mines shall conduct a documented audit of their mine roads checking for compliance to this recognised standard. These audits shall be carried out at least once every twelve months, and consider both day and night time operations.
- Periodic inspections shall include height clearance checks to check for road surface build up in particular.

- Checks of the conditions of structures such as culverts for condition / deterioration
- Ensure daily inspections of active haul roads including intersections are carried out by competent person/s (Open Cut Examiners, Supervisors etc.). With these inspections reference must be made to Sections 106 and 141 of the Queensland Coal Mining Safety& Health Regulation 2017.

22 References

1. Queensland *Coal Mining Safety and Health Act 1999*
2. Queensland Coal Mining Safety and Health Regulation 2017
3. AS 1742 Manual of uniform traffic control devices & AS 1743 Road signs - Specifications
4. AS/NZS 3007: 2013 Electrical equipment in mines and quarries - Surface installations and associated processing plant