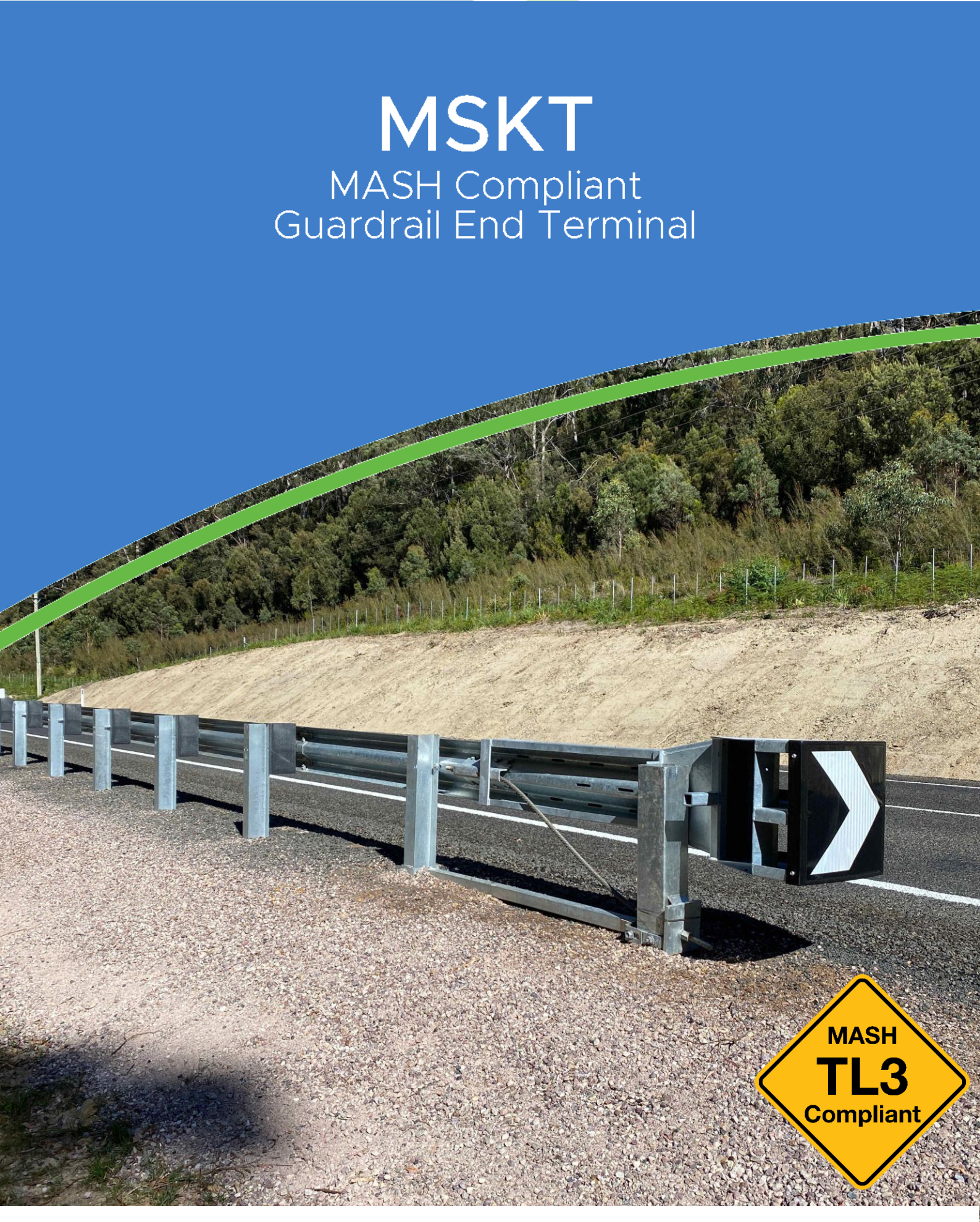
MSKT

MASH Compliant
Guardrail End Terminal



SafeDirection
CRASH BARRIER SOLUTIONS

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Version	Date	Revisions
04	February 2026	Updated format

Leading Safety

Successfully crash tested to MASH Test Level 3

Complies with AS/NZS 3845.1:2015 Road safety barrier systems and devices

All seven (7) mandatory crash tests performed

Assessed for shallow angle impacts (5degrees)

Higher redirection capacity when compared to NCHRP Report 350 Terminals
(the MASH impact represents a 73% energy increase when compared to NCHRP 350 testing)

Impact Performance

Impact energy is dissipated by the sequential kinking process

Slotted anchor rail lowers the impact forces

Longer feeder chute allows the impact head to travel in a mor predictable manner

Stable vehicle impact behaviour

Compatibility

Connects directly to RamShield® w-beam barriers

The MSKT impact head can be used as a replacement item for legacy SKT systems

Fast Assembly

Same installation sequence to earlier SKT versions

No concrete required

Stiff driving post sections

1.0 Introduction

The MASH Compliant Sequential Kinking Guardrail End Terminal (MSKT) is an energy-absorbing, tangential end terminal, designed to minimise the severity of impacts occurring at the end of the safety barrier system.

Designed for attachment directly to w-beam guardrail, the MSKT is latest advancement in guardrail end terminal technology providing compliance with MASH Test Level (TL) 3 and TL2.

The MSKT represents the latest configuration for the SKT terminal that was first introduced in 1997. Since that time the SKT has become one of the world's leading end treatment solutions.

The tangential design feature allows the MSKT to be installed parallel to the roadway reducing the requirement for earthworks and site grading associated with traditional parabolic-flared terminal designs.

The MSKT is available in two configurations. The compact MASH TL2 Terminal is an economical solution where the posted speed is less than or equal to 70 km/h. The standard MASH TL3 Terminal is acceptable for all posted speeds greater than 70 km/h.

2.0 Specifications

Crash Test Compliance	MASH Test Level 2 and Test Level 3
System Length, MASH TL2	9.5 m
System Length, MASH TL3	14.3 m
System Height	800 mm
System Finish	Hot dip galvanised in accordance with AS/NZS 4680

3.0 How the MSKT Works

During head-on impacts, the MSKT impact head slides over the w-beam guardrail. The w-beam is sequentially kinked as it moves through the head and exits away from the traffic face. The kinking action of the rail absorbs the kinetic energy of the impacting vehicle bringing the vehicle to a controlled stop.

As the impact head slides over the w-beam guardrail, the bolted hinged posts at post locations 1 and 2 yield at ground level. The yielding action of the hinged posts contributes to a soft impact for vehicle occupants.

The use of steel line posts at post locations 3 and beyond provides the MSKT with the necessary lateral support required for safe vehicle containment and re-direction through the length-of-need section.

4.0 Crash Test Performance

The MSKT has been fully crash tested and evaluated according to the specifications for Test Level 3 (TL3) of the AASHTO Manual for Assessing Safety Hardware (MASH). The MASH specification is an update to and supersedes NCHRP Report 350 for the purposes of evaluating new safety hardware devices.

MASH is also the basis of testing procedures for road safety systems as stated in *AS/NZS 3845.1: 2015 Road Safety Barrier System and Devices.*

The introduction of MASH follows changes to the vehicle fleet, researching of real-life impact conditions and updated criteria for evaluating barrier performance.

The MSKT is classified as a gating, re-directive end terminal. The MASH test matrix nominates seven (7) impacts performed with a 2270 kg pick-up truck and an 1100 kg passenger car as shown in Figure 1. MASH TL3 impacts are performed at 100 km/h and MASH TL2 impacts are performed at 70 km/h.

Table 1: MASH Evaluation of Guardrail End Terminals.

Test Description	Test Purpose
30	Examines the risk of vehicle instability.
31	Evaluates the capacity of the terminal to absorb sufficient energy to stop the heavy vehicle in a safe and controlled manner.
32 & 33	Examines the behaviour of the terminal during oblique impacts at the end of the system, assessing occupant risk and vehicle trajectory.
34	Evaluates the impact performance where the behaviour of the terminal changes from gating to redirection, assessing occupant risk and vehicle trajectory.
35	Determines the point-of-need where the terminal redirects the heavy vehicle.
37	Examines the behaviour of the terminal during reverse direction impacts.

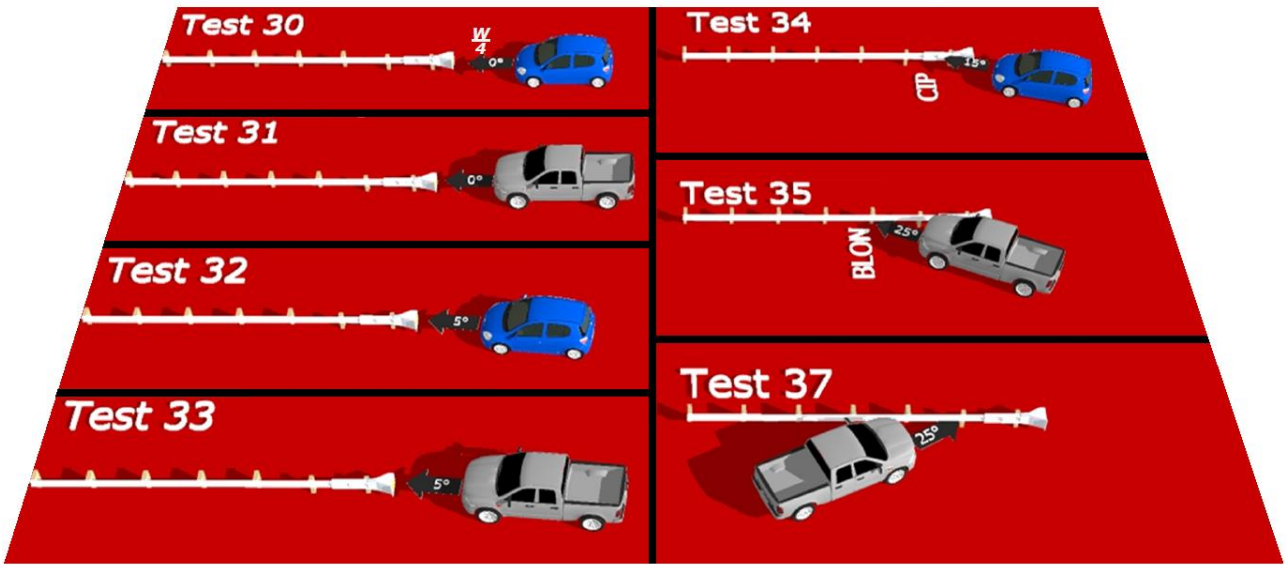


Figure 1: MASH Test Matrix for the MSKT.

5.0 Material Traceability

Safe Direction operates a quality management system, independently certified to the requirements of ISO 9001:2015. A multi-stepped procedure is used by Safe Direction to verify the compliance of the material used in the production of MSKT guardrails to AS/NZS 1594.

Mill certificates and independent third-party laboratory test results are verified against Australian Standard guidelines recording the steel heat numbers, mechanical results and chemical composition. Safe Direction product is then stamped during manufacture with a 4-digit number providing industry-leading traceability to the steel heat number. The format for stamping w-beam guardrails is:

Example: SD 9419 350 27

Where: SD = product from Safe Direction
9419 = the last 4 digits of the heat no.
350 = steel grade (i.e. HA 350)
27 = base metal thickness (i.e 2.7 mm

TEST CERTIFICATE BLUESCOPE STEEL

CHEMICAL ANALYSIS

Percentage of element by mass (L=Cast, P=Product, -S=Soluble, -T=Total, CF=Chemical Formula, n=Min, x=Max)

Item No	Heat / Unit No	NATA Lab	L/P	C	P	Mn	Si	S	Ni	Cr	Mo	Cu	Al-T
0010	6709419	0632	L	.157	.019	.74	<.005	.015	.016	.035	.004	.042	.034

Item No	Heat / Unit No	NATA Lab	L/P	Ti	B-T	N	Nb	Sn	V	CF1	CF2	CF3
0010	6709419	0632	L	<.002	<.0003	.0045	.001	.002	<.003	.29	.10	.00

CF1=C+ (MN/6) + ((CR+MO+V)/5) + ((CU+NI)/15) CF2=NI + CR + CU + MO CF3=NB + TI + V

MECHANICAL TESTING

Tensile AS 1391

Item No	Heat No	Tested Unit	NATA Lab	Cat	Loc	THICK mm	ReH MPa	Rm MPa	Lo mm	ELONGN %
0010	6709419	1H1F9690	0631	B	LQF	2.70	420	520	80	25
0010	6709419	1H1F9845	0631	B	LQF	2.70	390	500	80	22

ITEMS COVERED BY THIS CERTIFICATE

Item No	Heat No	Ordered Dimensions (mm)	No of Units	Mass (Tonnes)	Unit Identities
0010	6709419	740.0X2.70XCOIL	6	24.030	1H1H9291AA 1H1H9291BA 1H1H9291CA 1H1H9291DA 1H1H9292AA 1H1H9292CA

6.0 Design Considerations

6.1 Offset from the Traffic Lane

Road safety barriers should be located (e.g. offset, lateral position) as far as possible from the edge of the traffic lane as site conditions permit but within the limits described below. This enables errant drivers to recover and regain control of the vehicle, minimising the frequency of barrier impacts. Wider offsets can reduce nuisance impacts on the barrier and enable disabled vehicles to be free of the traffic lanes on a high-speed road, therefore reducing the risk of secondary crashes.

Providing a consistent barrier offset is especially important for long lengths of continuous barrier. Consistent barrier design creates a uniform view, while frequent changes in barrier offset can mislead drivers and negatively impact decisions while driving, especially in adverse visibility conditions.

The offset is measured from the edge of the traffic lane to the face of the w-beam guardrail.

The offset needs to ensure that the available stopping sight distance and intersection sight distance are not impeded. Increased offsets allow vehicles to stand clear of the adjacent traffic lane after an impact if the vehicle is disabled and for maintenance activities. The practicality and costs of maintenance of a barrier and the areas on both sides of the barrier should be considered along with Occupational Health & Safety implications.

The recommended offsets to barriers are detailed in Table 2. It is recommended that barriers must not be closer than 0.5 m from traffic lanes on rural roads to minimise nuisance hits. Similarly, the minimum offset on urban roads is 0.3 m.

Table 2: Recommended Offset Distances. Source: Table 6.5 Austroads Guide to Road Design Part 6.

	Rural High Speed [1, 3]	Rural Low Speed	Urban Freeways [3]	Urban Roads [2]
Desirable	4.0 – 6.0 m	3.0 – 6.0 m	4.0 – 6.0 m	2.5 – 3.0 m
Minimum	3.0 m	2.5 m	3.0 m	1.0 m

Notes:

1. *Operating speed greater than or equal to 80 km/h.*
2. *The offset may be governed by the required offset to kerbs.*
3. *Adoption of widths less than 3 m shall include assessment of desired operating practices, including emergency response, maintenance and police enforcement.*

6.2 Flaring

Generally, there should be uniform clearance between traffic and roadside features, particularly in urban areas where there are many roadside features. Uniform alignment enhances road safety by providing the driver with a certain level of expectation, thus reducing driver concern for and reaction to the roadside features and barriers.

The MSKT may be installed on a 25:1 straight flare away from the roadway. This will achieve a 600 mm offset measured from the face of rail over the length of the TL3 configuration.

Whilst providing a flare is not mandatory, the use of a straight flare positions the impact head further away from the edge of the travelled way and reduces the potential for nuisance impacts.

6.3 Advance Grading

It is recommended that the area in advance of the MSKT be limited to a grading of 10H:1V to ensure that the vehicle's suspension is neither extended nor compressed at the moment of impact with the barrier.

6.4 Adjacent Grading

Adjacent grading refers to the surface on which the terminal is installed and the area immediately behind. It is recommended that this area be relatively flat (10H:1V) so that the terrain does not contribute to vehicle behaviour. Where re-direction is expected (beyond the point-of-need), the terminal posts should have 600 mm of fill material behind them, providing sufficient lateral support.

For near head-on impacts with the front-right of a vehicle, grading of 10H:1V should extend 1500 mm behind the nose of the terminal, minimising the potential for vehicle roll as the terminal is engaged.

6.5 Run-Out Grading

Since all w-beam guardrail end terminals are gating, consideration should be given to the area parallel to and behind the safety barrier system. When struck at or near the nose at an angle, w-beam guardrail end terminals will typically yield, allowing a vehicle to continue into the area immediately behind and beyond the terminal.

The *Austroads Safety Barrier Assessment Panel – Technical Advice 21-003* recommends a run-out area be provided for all guardrail end terminals. The run-out area should:

- Contain no fixed hazards (e.g. poles and trees);
- Be traversable, with a lateral slope of 4:1 or flatter: and
- Measure 18.5 m x 6 m, measured from the point-of-need.

Generally, a risk evaluation would conclude that an end terminal installed without the required run-out area could be considered a lower risk than leaving a roadside hazard completely unshielded.

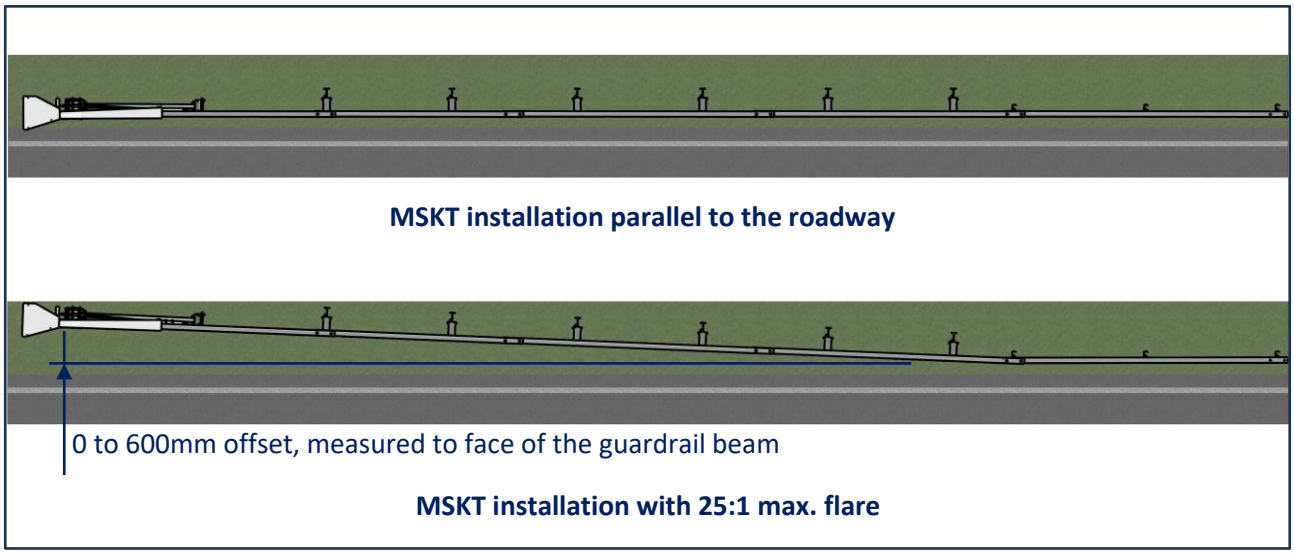


Figure 2: TL3 MSKT Set-out Options.

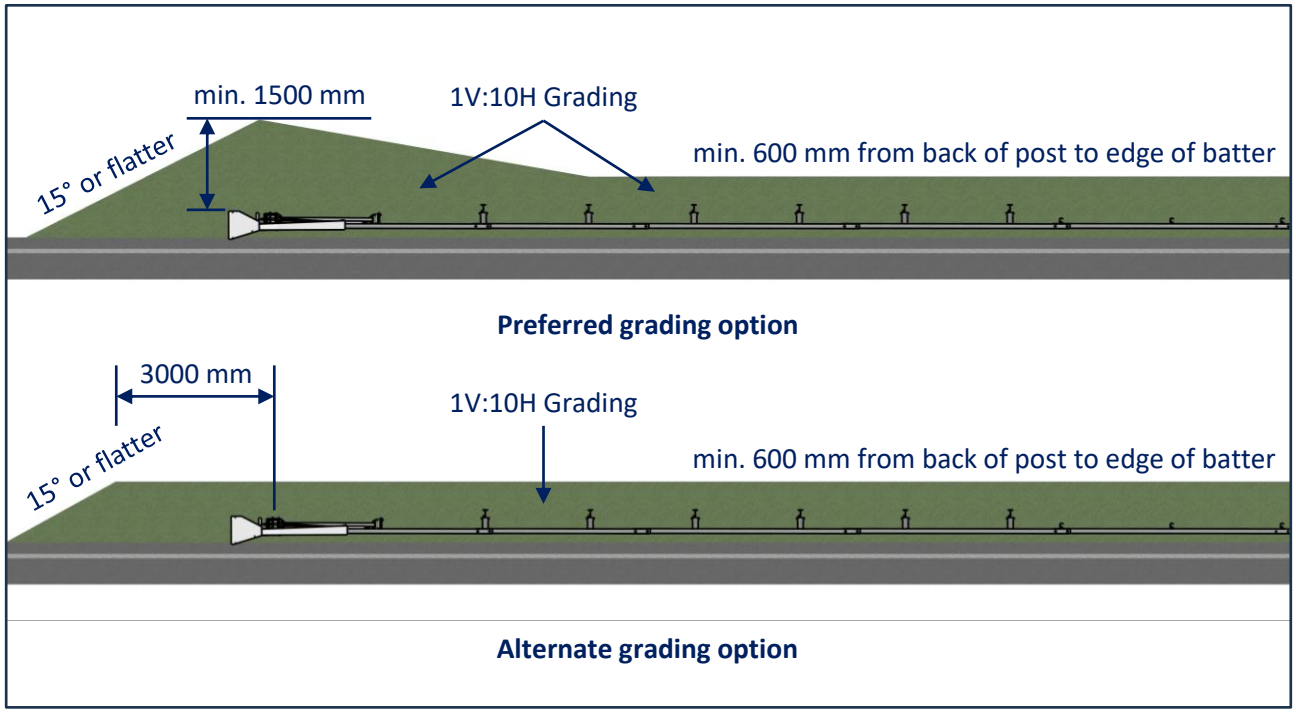


Figure 3: MSKT Grading Options.

6.6 Placement in Concrete

The line posts of the MSKT provide lateral resistance during side-on impacts and are designed to absorb some crash energy through post rotation in the surrounding material prior to fully yielding.

There may be instances when designers prefer the area beneath the safety barrier system to be paved. Whilst a paved surface has aesthetic appeal, it is important that it does not have an adverse effect on the functionality of the terminal.

When installed in a paved area, it is recommended that a 'leave-out' area in the pavement be provided that will allow at least 180 mm of post deflection at ground line. This 'leave-out' area can be filled with a low-strength concrete mix. Refer to Figure 4.

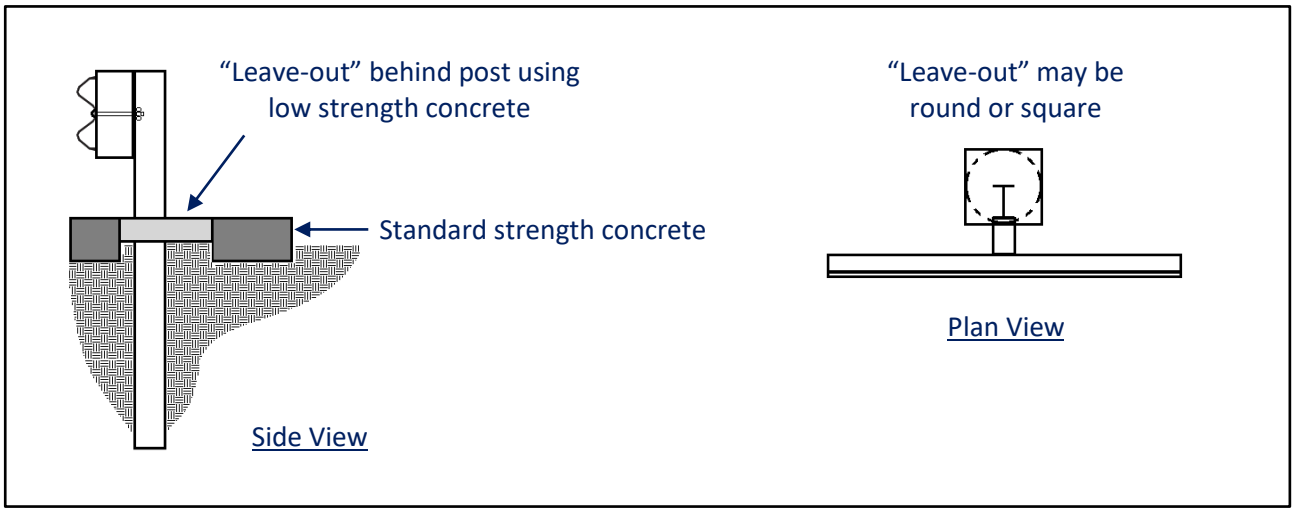


Figure 4: MSKT Post Installed in a Concrete Pavement.

6.7 Placement on Curves

When the MSKT is installed at the end of a guardrail system following a curved alignment, the MSKT must be installed along a straight alignment (using straight rails) over the length of the terminal. To prevent encroachment onto the travelled way, the terminal may be installed on a straight flare as previously described.

6.8 Other Obstructions & Hazards

During head-on impacts, the MSKT impact head slides over the w-beam guardrail. It is important that there are no obstructions located or positioned below the impact head, such as vegetation, that may hinder the travel of the impact head.

Since the MSKT functions by sequentially kinking the rail away from the traffic face, a risk assessment is recommended if pedestrians and/or cyclists will be accessing the area behind the terminal.

6.9 The Point-of-Need

This is the location along the terminal that has demonstrated heavy vehicle containment and re-direction. When assessed for MASH TL3 conditions, this impact (Test 35) is performed with a 2,270 kg pick-up truck travelling at 100 km/h and impacting at 25 degrees.

The MSKT point-of-need is post location 3, a distance of 3.81 m downstream from the start of the terminal.

In order to adequately shield a roadside hazard, the beginning length-of-need is required to be calculated for that site. At a minimum, the MSKT should be installed so that the terminal point-of-need (post 3) aligns with the site beginning-length-of-need. Figure 5 provides an example.

The point-of-need location may vary between terminal types. However, provided the terminal point-of-need and the site beginning-length-of-need are aligned, the road safety barrier system will provide the same re-directive capabilities, regardless of the terminal selected.

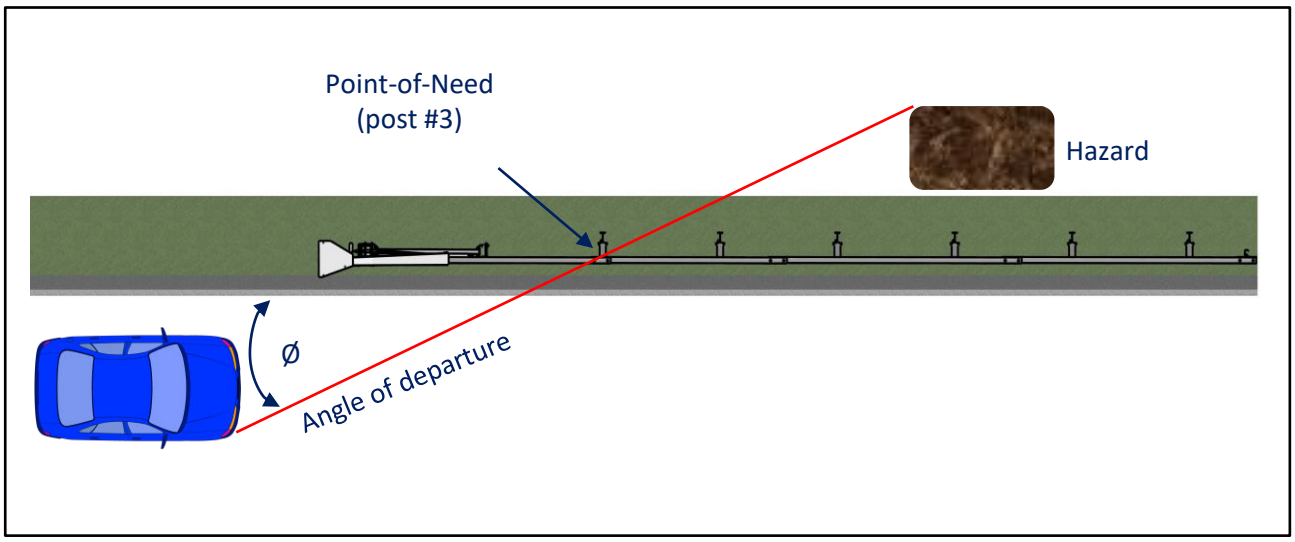


Figure 5: MSKT Point-of-Need.

6.10 Kerbs

Placing kerbs in front of terminals on high-speed roads is not recommended. As an alternative, a shallow gutter in front of the terminal or subsurface grated drainage should be considered.

On lower speed roads, it is recommended that the location of the kerb be as close as practicable to the face of rail minimising the potential for vehicle launching. If the posted speed is ≥ 80 km/h the kerb height should be limited to 100 mm.

6.11 Minimum Installation Length

It is recommended, where space permits, to install continuous safety barrier rather than designing a barrier to shield a specific hazard. A continuous safety barrier aims to protect the entire roadside and prevent head-on collisions.

At constrained sites where continuous barrier is not achievable, a shorter length barrier may be installed. In these circumstances it is recommended that the guidelines of *Austroads Safety Barrier Assessment Panel – Technical Advice SBTA 21-002* be referenced.

6.12 Terminal Rail Lap

The MSKT impact head is designed so that double thickness rail along with the splice bolts that can pass through regardless of rail lap orientation.

The *Austroads Safety Barrier Assessment Panel – Technical Advice 17-001* recommends that terminal rails be lapped in the direction of impacting traffic.

For leading terminals on two-lane, two-way roads, impacting traffic is considered to be from the adjacent traffic lane. For departure terminals on two-lane, two-way roads, impacting traffic is considered to be from the opposing traffic lane (i.e. not the adjacent traffic lane).

This treatment applies to the whole of the length of the terminal and its splice joints.

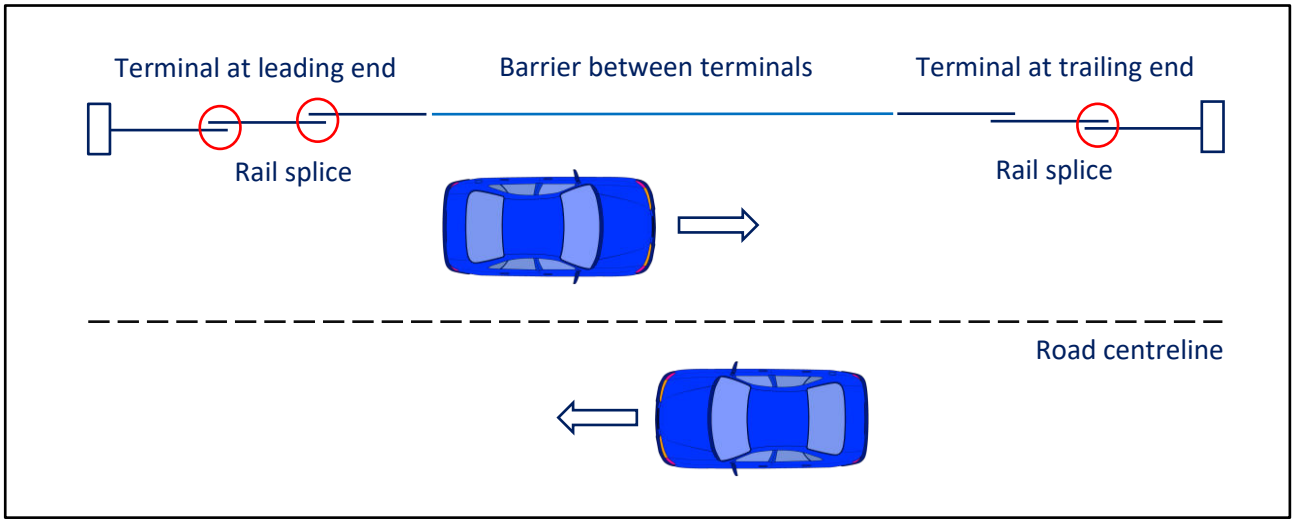


Figure 6: Technical Advice 17-001 Rail Lap Guidelines.

6.13 Design Life

The durability of the finished hot dip galvanized coating is a function of the environment to which the article is exposed. According to industry standards, hot-dip galvanized coatings can last up to 50 years in rural environments and up to 25 years in more corrosive environments, such as coastal regions. These estimates are based on average environmental conditions, and the actual lifespan of a galvanized coating will depend on the specific conditions it is exposed to.

Example: The web thickeness of a MSKT post has a thickness of 4.3 mm. Hot dip galvanising will provide a minimum average coating thickness of 70 µm. When installed in a C3 environment, the coating will provide approximately 33 years until first maintenance.

Table 3: Coating Thicknesses, AS/NZS 4680

Article Thickness, mm	Average Coating Thickness, µm	Average Coating Mass, g/m²
≤ 1.5	45	320
> 1.5 ≤ 3	55	390
> 3 ≤ 6	70	500
> 6	80	600

Table 4: Corrosivity Classifications, AS 4312

Corrosivity Category	
CX	Severe Surf Shoreline
C5	Surf Seashore
C4	Calm Seashore
C3	Coastal
C2	Arid/Urban Inland
C1	Dry Indoors

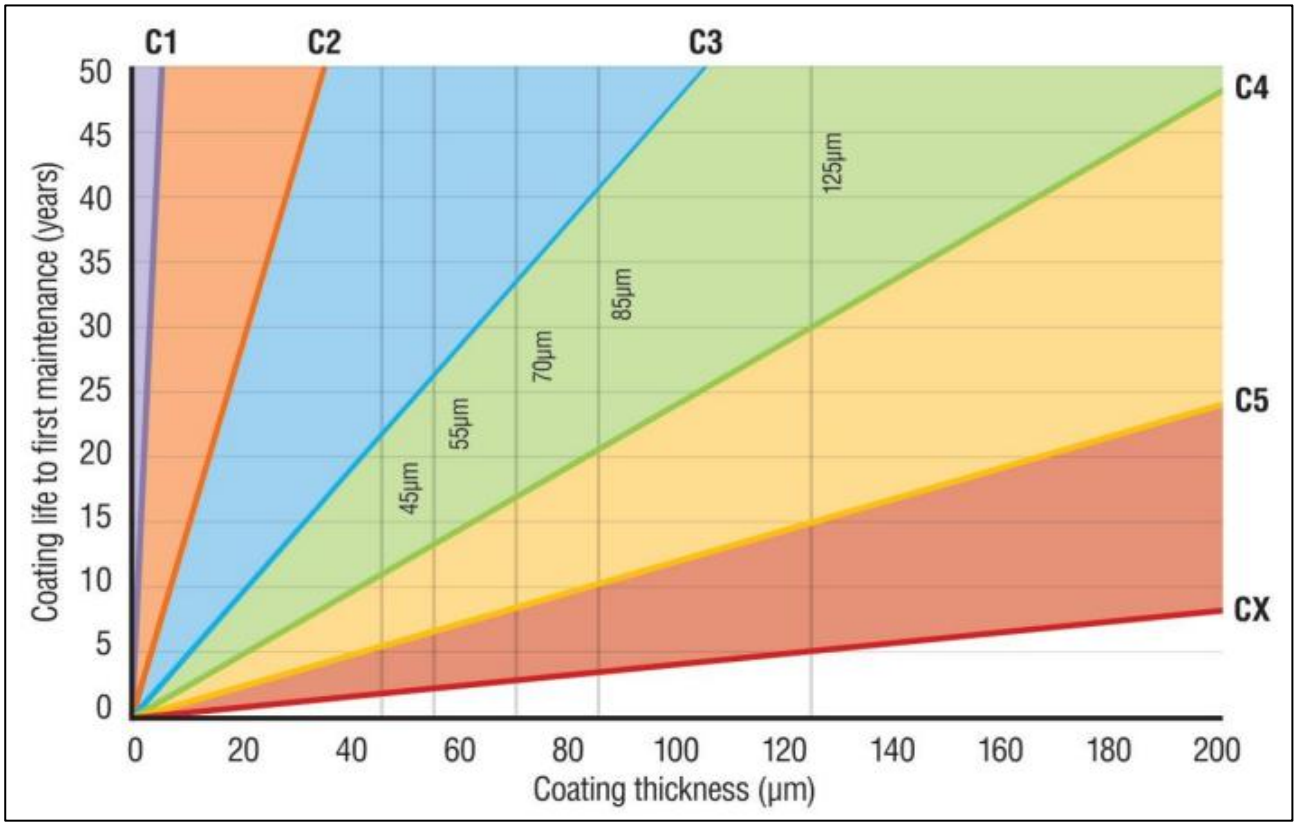
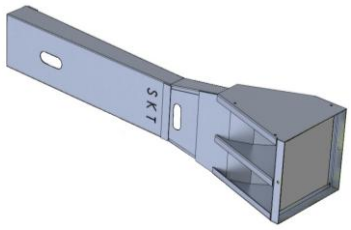


Figure 7: Calculated Corrosivity Rates for Hot Dip Galvanised Coatings, AS/NZS 2312.2.

7.0 Bill of Materials

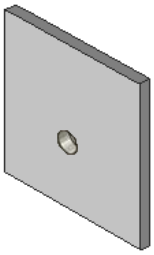
Item Description	Item Quantity		Unit Weight (kg)
	TL2 Configuration	TL3 Configuration	
MSKT Impact Head	1	1	80
3810 mm Slotted Anchor Rail	1	1	43
2860 mm Mid-Span W-Beam Rail	2	1	32
3810 mm Mid-Span W-Beam Rail		2	43
150 x 150 mm RHS Hinged Post Top – Post 1	1	1	11
Hinged Post Bottom w/ Soil Plate – Post 1	1	1	55
Hinged Post Top – Post 2	1	1	11
Hinged Post Bottom – Post 2	1	1	18
1830 mm Steel Line Post	3	6	24
200 mm Wide Blocking Piece	3	6	4
2 m Anchor Cable with 2 x 1” Nut/Washer	1	1	7
Anchor Bracket	1	1	6
Bearing Plate	1	1	5
Bearing Plate Retainer Tie	1	1	
M16 x 220 mm Hex. Bolt/Nut/2 Washers	2	2	
M20 x 220 mm Hex. Bolt/Nut/2 Washers	1	1	
1/2” x 1 ¼” Anchor Bracket Shoulder Bolt/Nut/2 Washers	8	8	
M8 x 35 mm Hex. Bolt/Nut/2 Washers	2	2	
5/8” x 10” Mushroom Post Bolt/Nut	3	6	
M16 x 32 mm Mushroom Splice Bolt/Nut	25	33	
Total Weight	**390 kg**	**550 kg**	

8.0 Component Identification (not to scale)



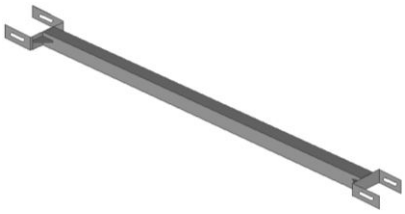
Impact Head

3810 mm Slotted Anchor Rail



Bearing Plate

2860 mm & 3810 mm Mid Span Rails

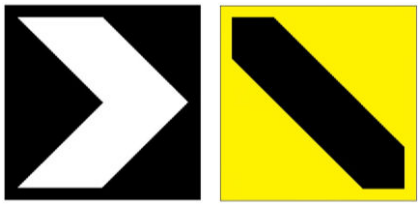


Ground Strut

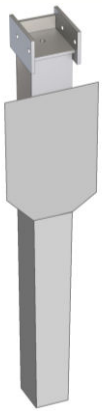
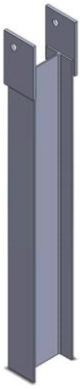
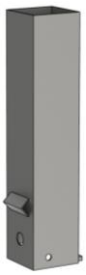
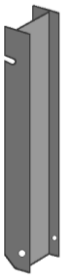
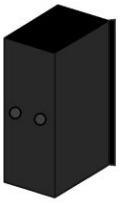
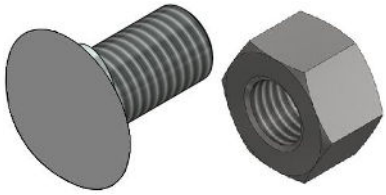
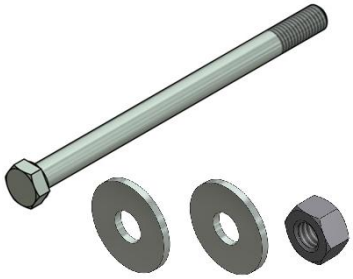
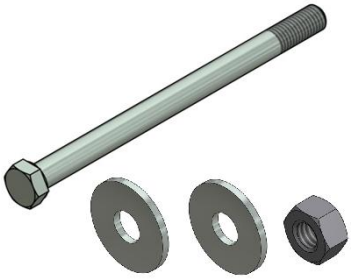
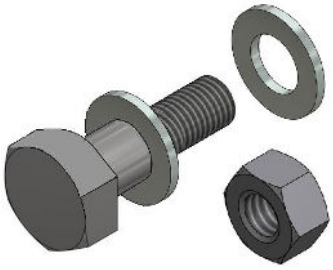
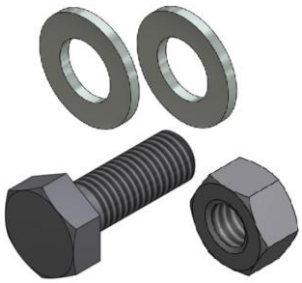
2m Anchor Cable with Nuts/Washers

Cable Anchor Bracket

Impact Head Cover (optional)



Impact Head Delineator Options

		
Bottom Post 1	Bottom Post 2	Steel Line Post
		
Top Post 1	Top Post 2	200 mm Blocking Piece
		
M16 x 32 mm Splice Bolt & Nut	5/8” x 10” Post Bolt/Nut	M20 x 220 mm Bolt/Nut/Washers
		
M16 x 220mm Bolt/Nut/Washers	½” Anchor Bracket Shoulder Bolts	M8 x 35 mm Bolt/Nut/Washers

9.0 Tools Required

Tools required for the installation of the MSKT are the same as those used for the installation of all guardrail barriers. This includes:

- Post driving equipment or auger.
- Battery drill driver with 32 mm attachment.
- Hand socket with 24 mm attachment.
- Metal snips.
- String line.
- Tape measure.
- Hammer.
- 12 mm diameter pinch bar.
- Slings or chains.

9.1 Recommended PPE

It is recommended that the following personal protective equipment (PPE) be provided for the safe installation of the MSKT:

- Safety footwear.
- Gloves.
- Hearing protection.
- High visibility clothing.
- PPE as required for the use of post driving equipment or auger.

10.0 Site Establishment

10.1 Traffic Control

Prior to the commencement of any work, the site should be evaluated for risks to workers, pedestrians and other road users. The establishment of traffic control should provide safe travel for passing vehicles and/or pedestrians and appropriately protect workers near the roadside.

10.2 Underground Services

The installation of the MSKT requires the supporting posts to be embedded into the ground. Prior to the installation of posts an investigation for potential underground hazards is recommended.

10.3 Overhead Obstructions

The site should be evaluated for potential overhead instructions that may present a risk during the installation process. These obstructions typically include power lines, signage or trees.

10.4 Unloading Exclusion Zone

Only appropriate load-rated slings and chains should be used for the safe unloading of product. It is recommended that an exclusion zone be maintained around the unloading process. This provides distance between moving machinery and workers in the event that goods or the machinery move unexpectedly.

Unloading and the storing of the product on a level surface is recommended. Storing product adjacent to the installation area eliminates the requirement for workers to carry items over long distances.

11.0 Installation Sequence

- Set-out.
- Installing the bolted hinged posts at post locations 1 and 2.
- Installing the ground strut.
- Installing the steel line posts at post locations 3 and beyond.
- Attachment of the cable anchor bracket using the special shoulder bolts.
- Attachment of the guardrail.
- Attachment of the impact head.
- Attachment of the cable assembly.

11.1 Set-Out

It is recommended that a string line be used to establish the alignment of the terminal and the post locations. The offsets nominated in this document are measured to the face of rail. When establishing the post locations of the terminal, take care to note the following:

- The first two posts from the end of each terminal have no offset blocking piece.
- The blocking pieces used within the terminals are 200 mm wide.
- The 1.905 m spacing for the posts throughout the terminal is different from the standard w-beam barrier spacing of 2.0 m.
- With the exception of the 1st anchor rail, the intermediate rail panels are spliced mid-span between posts.
- The installed rail height is 790 mm.

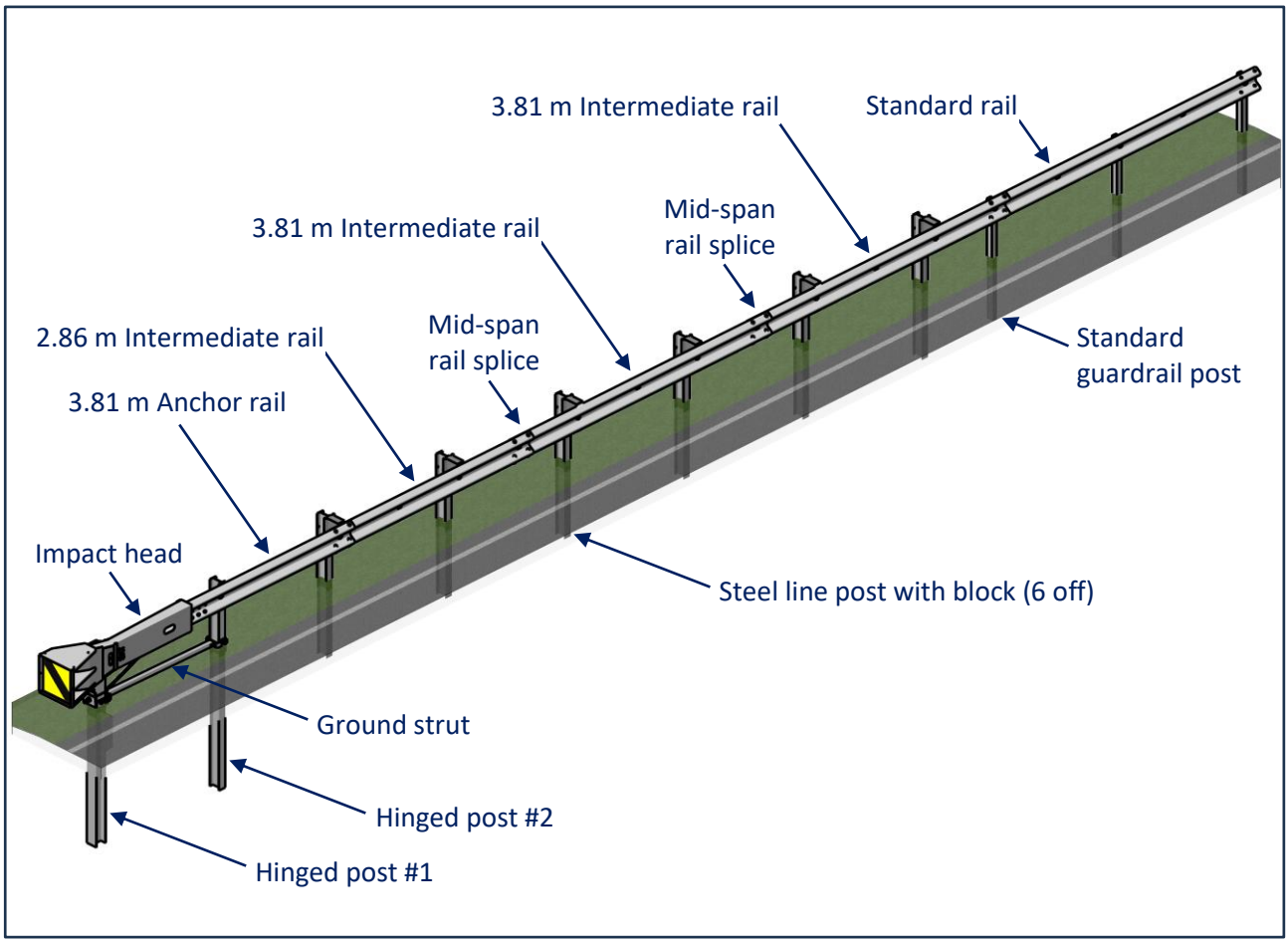


Figure 8: MSKT Layout.

11.2 Installation of Hinged Posts 1 & 2

Potential Hazards: *Use of post driving equipment or auger, contact with underground hazards, excessive noise, hand injury from pinch points and injury from movements and posture.*

Recommended Control Measures: *Observe the safe work instructions as per machinery requirements, ensure the area has been inspected for underground hazards, wear appropriate hearing protection, wear gloves, observe correct techniques when lifting (bend at the knees), and use a team lift when installing bottom post 1.*

Hinged posts are installed at post locations 1 and 2. The hinged post assembly comprises a bottom section and top section that is bolted together. The lower section of the post must be installed prior to the attachment of the upper section.

The bottom of post 1 is aligned so that the soil plate is located on the downstream side of the post i.e. away from the impact head. The bottom of post 1 may be installed by:

- Driving with an appropriate driving head to the required depth, approximately 1800 mm, or
- Auguring a pilot hole approximately 1800 mm deep, and driving the post to the required depth with an appropriate driving head, or
- Auguring a hole approximately 1800 mm deep, placing the post in the hole and backfilling. The post hole should be large enough (e.g. 300 mm diameter) to allow the backfill material to be placed in 150 mm lifts and compacted with tamping equipment.

The bottom of post 2 is aligned so that the hinge bolt hole is located on the downstream side of the post i.e. away from the impact head. Post 2 is positioned 1.905 m from post 1.

The bottom of post 2 may be installed by:

- Driving with an appropriate driving head to the required depth, approximately 1800 mm, or
- Auguring a pilot hole approximately 1800 mm deep, and driving the post to the required depth with an appropriate driving head, or
- Auguring a hole approximately 1800 mm deep, placing the post in the hole and backfilling. The post hole should be large enough (e.g. 300 mm diameter) to allow the backfill material to be placed in 150 mm lifts and compacted with tampering equipment.

Once installed, bottom posts 1 & 2 should not protrude more than 100 mm above ground level.

Note: *If installing bottom posts 1 & 2 with a driving head, do not pound on the side plates as this may cause damage to the welds.*

The top for post 1 is a 150 mm x 150 mm rectangular hollow section (RHS). Top post 1 is orientated with the angle spacer facing oncoming traffic. The bearing place will ultimately rest on the angle spacer of top post 1.

The side plates of bottom post 1 are fabricated with two (2) holes. A M16 x 220 mm hex. bolt, nut with two (2) washers is used to secure the top and bottom post sections through the upstream hole of bottom post 1 (nearest the impact head).

The downstream hole of bottom post 1 is used to secure the ground strut. Position the ground strut between posts 1 and 2 and secure to post 1 through the downstream hole with a M16 x 220 mm hex. bolt, nut and two (2) washers.

The top for post 2 is an I-beam cross section. The upper portion of post 2 features an open slot used to attach the guardrail to the post. The open slot is orientated towards post 1 (nearest the impact head).

A M20 x 220 mm hex. bolt, nut with two (2) washers is used to secure bottom post 2, top post 2 and the ground strut. Once secured the bolt should be on the downstream end of the post (towards post 3).

There is no torque requirement for these bolts. They should be tightened to a snug position.

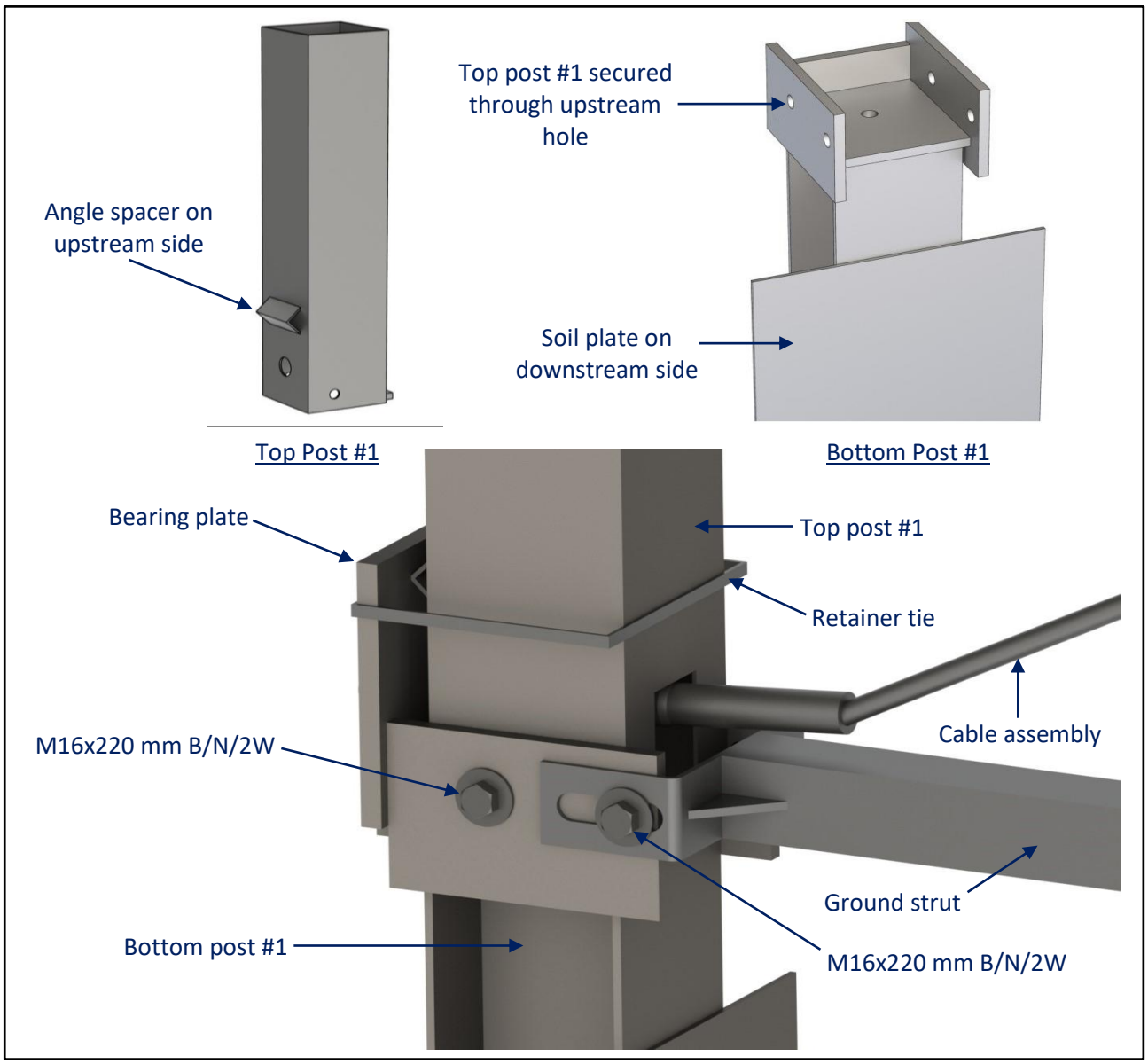


Figure 9: MSKT Post #1 Connection Detail.

11.3 Installation of Steel Line Posts

Potential Hazards: *Use of post driving equipment or auger, contact with underground hazards, excessive noise and hand injury from pinch points.*

Recommended Control Measures: *Observe the safe work instructions as per machinery requirements, ensure the area has been inspected for underground hazards, wear appropriate hearing protection and wear gloves.*

The steel line posts are approximately 1830 mm in length and are manufactured from an I-beam cross section. They are installed at post locations as follows:

- **TL2 MSKT**: Post locations 3 to 5.
- **TL3 MSKT**: Post locations 3 to 8.

The steel line posts may be installed by:

- Driving with an appropriate driving head to the required depth, approximately 1100 mm, or
- Auguring a pilot hole approximately 1100 mm deep, and driving the post to the required depth with an appropriate driving head, or
- Auguring a hole approximately 1100 mm deep, placing the post in the hole and backfilling. The post hole should be large enough (e.g. 300 mm diameter) to allow the backfill material to be placed in 150 mm lifts and compacted with tampering equipment.

The steel line posts are spaced at 1.905 m centres.

11.4 Attaching the Cable Anchor Bracket

Potential Hazards: *Hand injury from pinch points.*

Recommended Control Measures: *Wear gloves.*

For ease of installation, it is recommended that the cable anchor bracket be secured to the slotted anchor rail prior to securing the rail to the posts. This ensures that the top of post 2 does not interfere with the attachment of the cable anchor bracket.

The anchor rail is identified by the horizontal slots punched into the end of the rail. The anchor rail also has eight 19 mm diameter holes to accommodate attachment of the cable anchor bracket.

The cable anchor bracket is secured with eight (8) 1/2” x 1 ¼” hex. shoulder bolt, nut and (2) washers. A single washer is positioned on either side of the rail.

Note*: The cable anchor bracket bolts and nuts are specially engineered. No other bolts are to be used at this location. The bolts are manufactured with a unique shoulder.*

The cable anchor bracket is positioned with the welded plate of the bracket towards post location 2. Align the bracket with the holes in the anchor rail and insert the bolts and hand-tighten.

Once all bolts are inserted, ensure the shoulders align with the cable bracket slots. When positioned, slightly tap with a hammer until the shoulders and slots are fully engaged. The bolts can now be fully tightened. There is no torque requirement for these bolts. They should be tightened to a snug position.

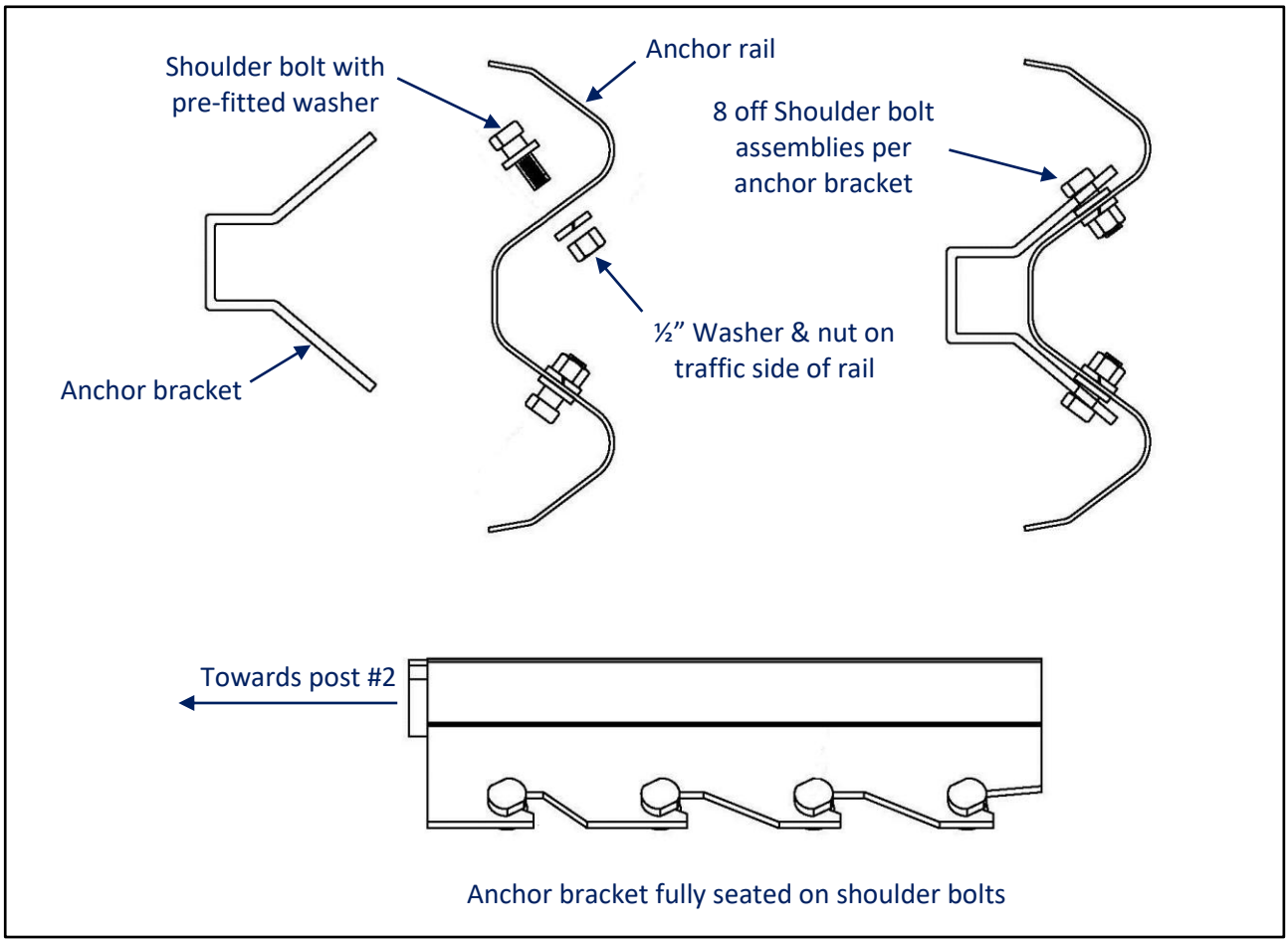


Figure 10: MSKT Anchor Bracket Attachment.

11.5 Attaching the Guardrails & Blocking Pieces

Potential Hazards: *Injury from movements and posture, hand injury from pinch points, strain to wrists from tightening bolts and excessive noise from use of impact driver.*

Recommended Control Measures: *Observe correct techniques when lifting rails (bend at the knees), wear gloves, use a pinch bar to align holes, use an impact drill to tighten bolts and wear appropriate hearing protection.*

The anchor rail is positioned at the start of the terminal with the slots towards post 1. The anchor rail is secured to post 2, using a standard M16 x 32 mm mushroom head splice bolt and nut through the post slot.

Note*: The anchor rail is not bolted at post 1.*

Subsequent rails position the splice connection mid-span between posts.

Note*: The TL3 MSKT requires one (1) 2860 mm and two (2) 3810 mm rails following the anchor rail. The TL2 MSKT requires two (2) 2860 mm rails following the anchor rail.*

All rails are spliced together using eight (8) standard M16 x 32 mm mushroom head bolts and nuts. The lapping of the terminal rails are orientated as described in Section 6.12.

The use of a pinch bar will assist in aligning the splice holes as the bolts are inserted. The use of a driving pin to elongate the splice holes is NOT permitted.

At the steel line post locations, a 200 mm wide blocking piece is positioned between the posts and the rail. The rails are then secured with a 5/8” x 10” mushroom head bolt and nut with the bolt passing through the rail, blocking piece and post.

There is no torque requirement for these bolts. They should be tightened to a snug position. The finishing height of the rail is 790 mm ± 20 mm above ground level.

Note*: All rails used within the MSKT are straight. No curved rails are permitted within the terminal section.*

11.6 Attaching the Impact Head

Potential Hazards: *Injury from movements and posture and hand injury from pinch points.*

Recommended Control Measures: *Observe correct techniques when lifting the impact head (bend at the knees), use a team lift, wear gloves and use a pinch bar to align impact head.*

Ensure the cable anchor bracket is secured to the anchor rail prior to the attachment of the impact head. Align the impact head over the end of the anchor rail with the protruding tube positioned on the non-traffic side of the system. Slide the impact head forward until the post angle attachments on the impact head are aligned with the holes in post 1.

When correctly installed, the exit slot of the MSKT impact head is towards the non-traffic side of the system.

Secure the impact head to post 1 with two (2) M8 x 35 mm hex. bolt, nut and (2) washers.

11.7 Installing the Cable Assembly

Potential Hazards: *Hand injury from pinch points.*

Recommended Control Measures: *Wear gloves.*

The cable assembly is integral to the anchorage of the terminal, contributing to the tensile and flexural strength of the system.

Place the cable assembly through the cable anchor bracket and through the opening at the base of post 1. Secure the cable assembly to the anchor bracket with the 1" hex. nut and washer that is supplied pre-attached to the cable.

Place the bearing plate at the base of post 1 with the 125 mm dimension up and the 75 mm down. The bearing plate will rest on the angle spacer welded to post 1. Secure the cable assembly to the bearing plate with the 1" hex. nut and washer that is supplied pre-attached to the cable.

To prevent rotation of the bearing plate, secure with a cable tie positioned around the post.

While tightening the cable, use a hammer to tap the cable anchor bracket from the downstream end to ensure that it is securely interlocked with the shoulder bolts. Restrain the cable at the end being tightened with vice grips to avoid twisting the cable.

Upon completion of installation, the cable should be taut.

11.8 Installing the Impact Head Cover

The installation of impact head covers is a requirement on the Victorian classified road network. The attachment of an impact head cover is optional outside of Victoria. This will be at the discretion of the project manager.

The cover slides over the impact head and is secured at the sides using galvanised self-drilling metal screws.

11.9 Attachment of Delineation.

The style of delineation is dependent upon state road authority requirements. The delineator is an adhesive marker that attaches directly to the impact head. If a cover is to be installed, the delineation will attach to the impact head cover.

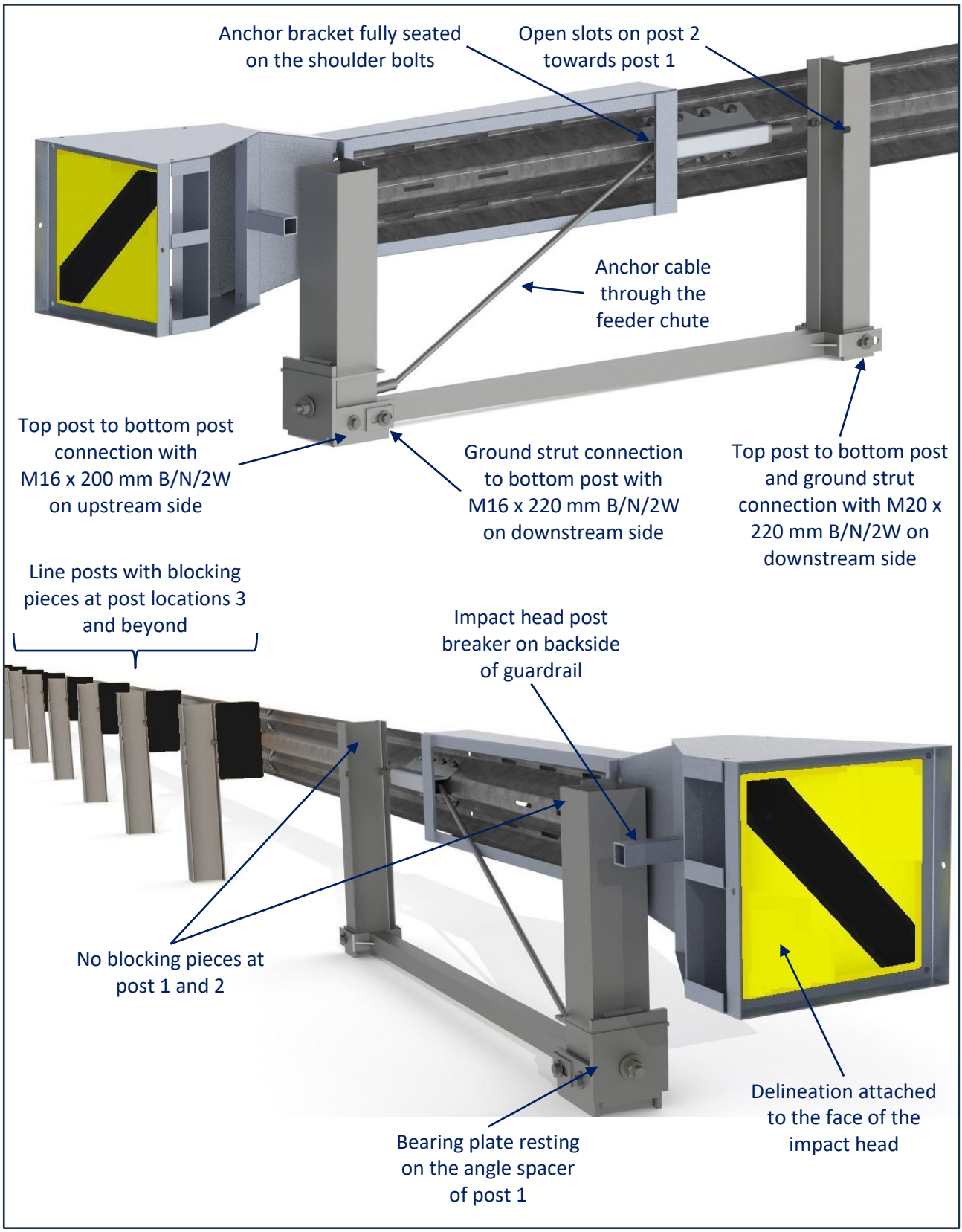


Figure 11: MSKT Installation - Isometric View.

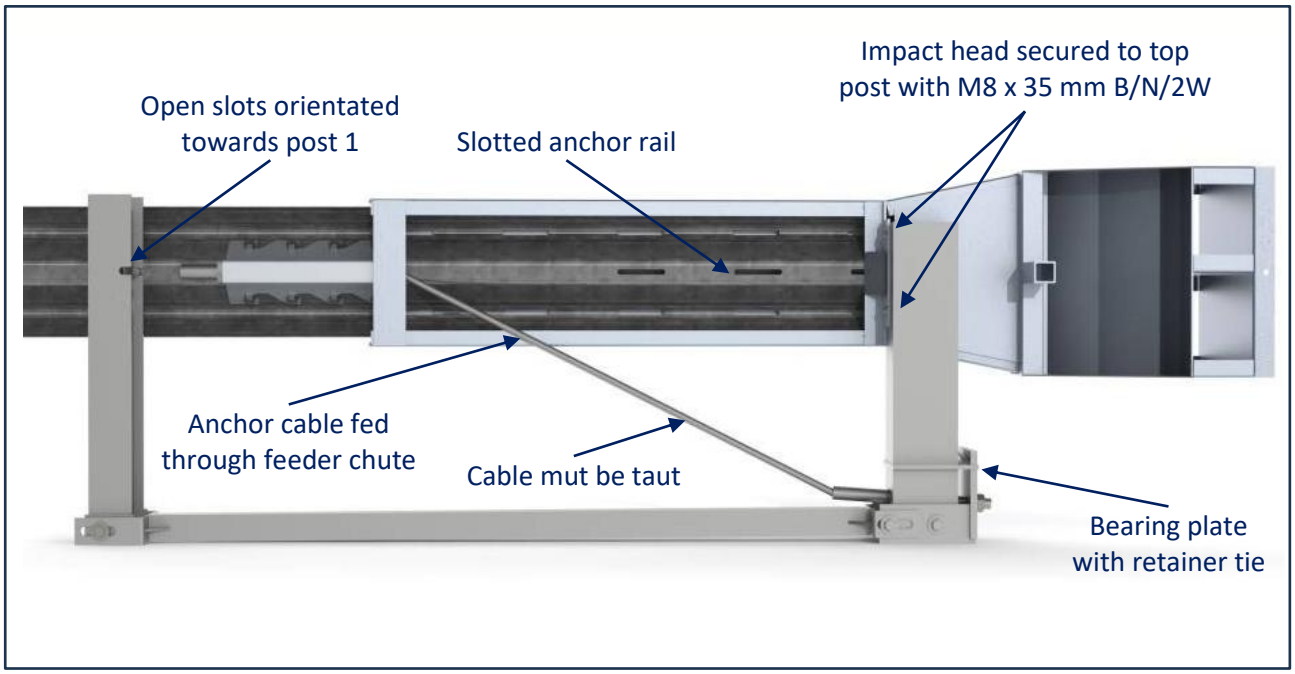


Figure 12: MSKT Assembly - Rear View.

MSKT Inspection Form (page 1 of 2)

Inspection Date	
Client	
Project Reference	
Name of Inspector	
Company	

❑ Yes ❑ No	The height measured to the top of the terminal rails is 790 mm ± 20 mm.
❑ Yes ❑ No	The rails throughout the terminal are straight and not curved.
❑ Yes ❑ No	The 1st rail is the 3810 mm anchor rail containing horizontal slots.
❑ Yes ❑ No	The anchor rail is not secured to post 1.
❑ Yes ❑ No	The anchor rail is secured to post 2 with a M16 x 32 mm mushroom head bolt & nut.
❑ Yes ❑ No	The anchor rail is spliced at post 3 with subsequent terminal rails spliced mid-span between posts.
❑ Yes ❑ No	All rails are spliced with eight (8) M16 x 32 mm mushroom head bolt & nuts.
❑ Yes ❑ No	Hinged post 1 is bolted on the upstream side of the post with a M16 x 220 mm bolt/nut & 2 washers.
❑ Yes ❑ No	Hinged post 2 is bolted on the downstream side of the post with a M20 x 220 mm bolt/nut & 2 washers.
❑ Yes ❑ No	Bottom posts 1 and 2 do not protrude more than 100 mm above the ground line.
❑ Yes ❑ No	Top post 2 is orientated with the open slot to receive the post bolt on the upstream side of the post.
❑ Yes ❑ No	The posts throughout the terminal section are spaced at 1905 mm centres.
❑ Yes ❑ No	200 mm blocking pieces are attached to the steel line posts at post locations 3 and beyond.
❑ Yes ❑ No	The rail is secured to the steel line posts with a 5/8” x 10” mushroom head bolt & nut.
❑ Yes ❑ No	The protruding tube on the impact head is positioned on the non-traffic side of the system.
❑ Yes ❑ No	The impact head is secured to post 1 with two (2) M8 x 35 mm bolt/nut & 2 washers.
❑ Yes ❑ No	The bearing plate at post 1 is correctly aligned with the 125 mm dimension up and the 75 mm down.

MSKT Inspection Form (page 2 of 2)

Inspection Date	
Client	
Project Reference	
Name of Inspector	
Company	

❑ Yes ❑ No	The cable anchor bracket is properly secured to the anchor rail using the special shoulder bolts.
❑ Yes ❑ No	The cable assembly is taut and a retainer is fitted to the bearing plate.
❑ Yes ❑ No	A ground strut is secured between post 1 and 2 using the M16 x 220 mm bolt/nut & 2 washers at post 1 and a M20 x 220 mm bolt/nut & 2 washers at post 2.
❑ Yes ❑ No	The fill material around the posts is suitably compacted.
❑ Yes ❑ No	Any minor damage to the galvanised finish is repaired using two coats of an organic zinc rich pain.
❑ Yes ❑ No	A cover is attached to the impact head (if required).
❑ Yes ❑ No	Delineation is attached to the impact head.
❑ Yes ❑ No	The fill material around the posts is suitably compacted.

Comments

12.0 Maintenance

Except for repairs due to impacts, it is recommended that an annual inspection be undertaken to assess the following:

- The impact head is appropriately delineated.
- Debris has not accumulated around the terminal which may impede the function of the terminal.
- Vegetation around the terminal is appropriately maintained.
- Nuisance impacts have not gone undetected.
- The anchor assembly is taut and the bearing plate is correctly aligned.

12.1 Bushfire Damage

The MSKT is constructed from hot dip galvanised steel components. The performance of hot dip galvanised components when subjected to a fire depends upon numerous factors such as flame duration, flame intensity and the characteristics of the galvanised finish.

Bushfires can produce high temperatures, however exposure of roadside structures to maximum flame intensity is generally for a short duration as the fire front moves forward. The combination of the reflectivity of the galvanised surface and the heat sink provided by the mass of the steel to which the hot dip galvanising is applied has shown galvanised steel to provide excellent performance during bushfires.

If it is observed that a bushfire has caused damage to the galvanised coating it is recommended that these item(s) be replaced.

13.0 Repair

In the event of a vehicle impact, damage to the terminal is to be assessed in accordance with Table 5. Typically, impacts with a MSKT will require replacement of damaged sections of rail and posts. The bearing plate, cable assembly and the anchor bracket are often reusable.

Additional tools required for repair include:

- Acetylene torch to cut away damaged rail.
- Heavy duty chain to remove the impact head.
- Sledge hammer.
- Post extractor.

Similar to the installation sequence, it is recommended that the guidelines contained in Section 10.0 be observed in the establishment of traffic control and an unloading exclusion zone in addition to investigation for underground services and overhead obstructions.

Table 5: MSKT Damage Assessment Guidelines.

Type of Damage	Description of the Damage	Remedial Action
Damage to the galvanised coating on the posts.	The sum total of the damaged area does not exceed 45 cm^2 (0.5 % of the total surface area) and no individual damaged area exceeds 40 cm^2.	An organic zinc rich paint is to be applied to the repair area in two coats.
	The sum total of the damaged area exceeds 45 cm^2 (0.5 % of the total surface area) or an individual damaged area exceeds 40 cm^2.	The post is to be replaced.
Damage to the galvanised coating on the rails.	The sum total of the damaged area does not exceed 200 cm^2 (0.5 % of the total surface area) and no individual damaged area exceeds 40 cm^2.	An organic zinc rich paint is to be applied to the repair area in two coats.
	The sum total of the damaged area exceeds 200 cm^2 (0.5 % of the total surface area) or an individual damaged area exceeds 40 cm^2.	The rail is to be replaced.
Damage to the blocking pieces.	The blocking piece is cracked or chipped.	The blocking piece is to be replaced.
Damage to the posts.	The posts are bent or the welds have cracked.	The posts are to be replaced.
Damage to the impact head.	The impact head has superficial damage. Its ability to function is not compromised.	The impact head may be reused. If uncertain, replace the impact head.
	The impact head is distorted and its ability to function is compromised.	The impact head is to be replaced.
Damage to the rails.	The rail is dented, twisted or flattened.	The rail is to be replaced.
	There are nicks in any part of the rail.	
	The slots in the rail are distorted.	
Damage to bolts.	The body of the bolt is distorted.	The bolt is to be replaced.
	The thread of the bolt is damaged.	
Disturbance of material around the posts.	The material around a post is loose.	The material is to be suitably compacted.

13.1 Removal of the Impact Head

Potential Hazards: *Injury from movements and posture, hand injury from pinch points, hand injury from damaged edges and injury from sudden movement as the impact head is released.*

Recommended Control Measures: *Observe correct techniques when lifting the impact head (bend at the knees), wear gloves and maintain an appropriate exclusion zone around the impact head until removed from the rail.*

A head-on impact with the MSKT will cause the impact head to travel over the rails. The rails are sequentially kinked as they move through the impact head.

Using an acetylene torch, cut away the damaged rail near the exit chute of the impact head. In most instances, the impact head can now be removed by hand.

If the impact head is unable to be removed, attach a heavy-duty chain through the opening behind the impact plate. Secure the other end of the chain to equipment capable of pulling the impact head from the rails. Ensure the downstream rail is still bolted to the supporting posts prior to applying the load.

13.2 Removal of Damaged Posts

Potential Hazards: *Hand injury from pinch points, hand injury from damaged edges and injury from sudden movement as the posts are released.*

Recommended Control Measures: *Wear gloves and maintain an appropriate exclusion zone around the post until removed.*

Posts 1 and 2 are hinged and will typically yield at ground level. Bottom sections of posts 1 and 2 are often reusable and therefore will not be required to be removed.

Damaged steel line posts should be removed using an appropriate post extractor. Once a damaged post is removed, the ground material should be suitably compacted before a replacement post is installed.

13.3 Removal of Damaged Rails

Potential Hazards: *hand injury from pinch points, hand injury from damaged edges, injury from sudden movement as rails are released and excessive noise from use of impact drill.*

Recommended Control Measures: *Wear gloves and wear appropriate hearing protection.*

Using an impact drill, remove the splice bolts at the rail connection. Rails that have twisted or bent during impact may need to be cut into manageable sections using an acetylene torch.

13.4 Retrofit using MSKT Impact Head

The MSKT represents the latest configuration for the SKT terminal that was first introduced in 1997. Earlier versions of the SKT were crash tested in accordance with NCHRP Report 350.

Changes have been made to the impact head design with the introduction of MASH which represents a significant increase in impact energy when compared to NCHRP Report 350.

The MSKT impact head has been successfully crash tested to NCHRP Report 350 and may be used as a replacement item for pre-MASH versions of the SKT, including the SKT-350 and SKT-SP.

13.5 Emergency Procedure After Impact

In some circumstances, an assessment of the damaged terminal is undertaken to evaluate the extent of damage and determine replacement parts required. There is often a time lag before the terminal is appropriately repaired.

In these circumstances, consideration for a temporary repair is recommended. This is achieved as follows:

- Remove any damaged rail and the impact head from the roadway.
- Using an acetylene torch, cut away the damaged rail near the exit chute of the impact head.
- Remove the damaged impact head by hand. If this is not possible, attach a heavy-duty chain through the opening behind the impact plate. Secure the other end of the chain to equipment capable of pulling the impact head from the rails. Ensure the downstream rail is still bolted to the supporting posts prior to applying the load.
- Locate the first upright post downstream of any damaged rail and cut off the rail approximately 225 mm in front of the post. If the post is at a splice location, the rail can be removed by unbolting the splice connection.
- Re-install the impact head over the rail and secure to the post through the top and bottom angle attachments.
- If the impact head is damaged and unable to be reinstated over the rail, turn down and bury the end rail as far away from the traffic as possible.
- Erect appropriate warning signs adjacent to and in advance of the damaged terminal.

The procedures are temporary only and should only be implemented until a full repair is undertaken. It is always recommended that damage to guardrail end terminals be prioritised and undertaken as soon as possible.

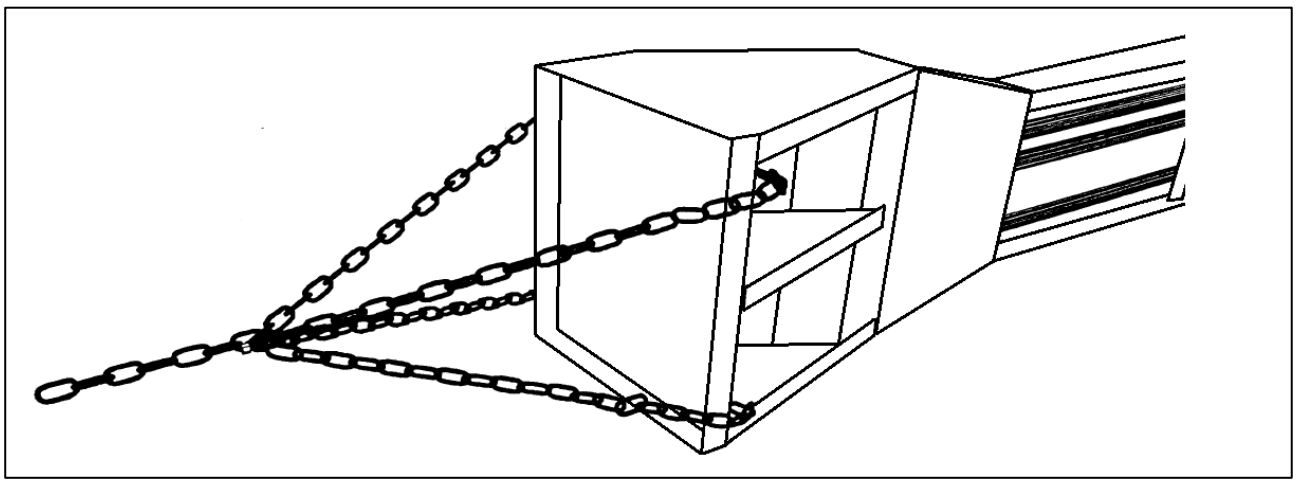


Figure 13: Attachment of Chains to Remove Damaged Impact Head.

SafeDirection

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