Risk Assessment
Using the TRAM safety system to prevent falls from road tankers

Prepared by

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About the author

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STANDFAST CORPORATION

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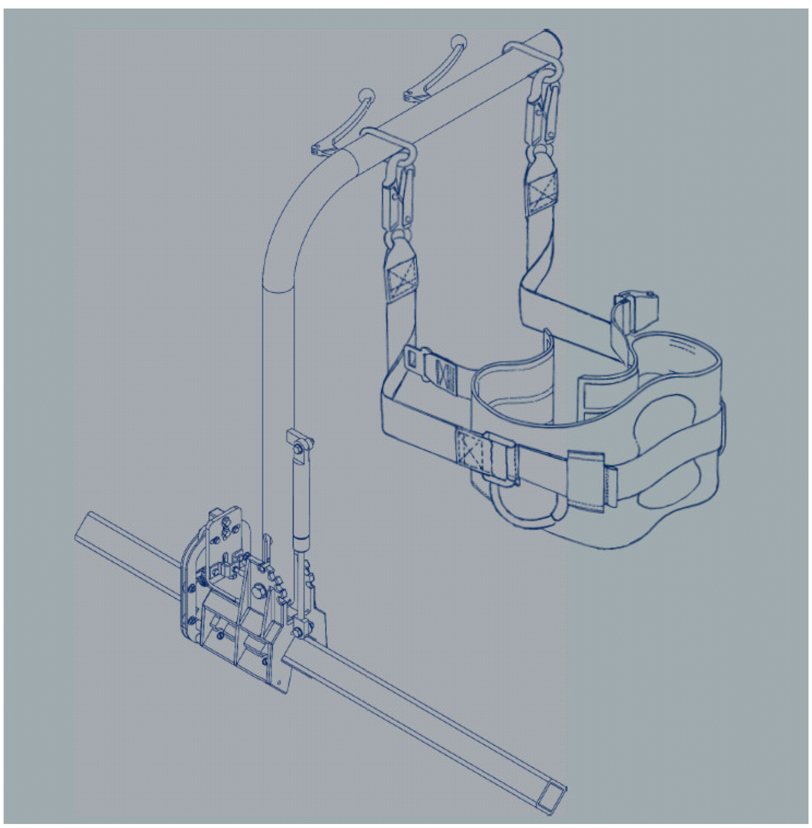
1. Introduction

Standfast Corporation (Standfast) conducted a Risk Assessment to assess the use of the TRAM (Total Restraint Access Module) to prevent falls from road tankers.

The TRAM is designed to provide a safe means of accessing the top of tankers from the ladder and working on top of road tankers. The TRAM safety system is designed so that the user is firmly attached to the unit at all times and cannot fall. The safety system includes a mechanical component that slides along a rail fixed to the tanker and a specially designed restraint belt attached by two lanyards. The TRAM provides a handhold that moves with the operator (vertically and horizontally) and is also a moveable anchor point for the restraint belt.

The TRAM has been developed in response to the continuing problem of workers being killed or seriously injured as a result of falls from road tankers. Product development of the TRAM sought input from the road tanker transport industry, including manufacturers, owners and drivers, as well from occupational health and safety (OHS) professionals and engineers. Hazardous Operability Studies were used to analyse the risk of falling from road tankers and devise a safe working system. The innovative engineering of the TRAM is the result of this effort and represents both new technology and a change in paradigm for road tanker safety. This report will assess the effectiveness of the TRAM in controlling the risk of falling from road tankers.



Drawing 1: The TRAM (Total Restraint Access Module)

Grant Tracy, Director of Safety for Standfast conducted the Risk Assessment and prepared this report. The level of information collected about road tanker height safety in the preparation of this report is uniquely comprehensive. The report will present the most recent review, including new findings and greater detail than previous discussions on this topic.

The Risk Assessment was undertaken to meet the employer's obligation to identify foreseeable hazards, assess the risks of those hazards and eliminate the risks, or if not reasonably practicable to do so, then control the risks.

2. Method

A hazard identification exercise was conducted as follows:

- a review of literature relating to falls and road tanker height safety was conducted,
- safety statistics, as collated and published by regulatory authorities were analysed,
- a search for fall event histories of falls from road tankers was performed. Web searching provided a number of fall from road tanker accident reports and investigations. The fall event histories have been collated and reported in the document Falls From Road Tankers Fall Event Histories and is attached in Appendix I,
- an extensive series of meetings through out Australia, Europe, Great Britain, the USA, Canada, Japan and New Zealand with regulatory authorities, industry groups, tanker manufacturers, fleet owners, drivers and OHS representatives, thereby ensuring a comprehensive understanding of road tanker height safety was developed,
- various fall protection systems for use on top of tankers were reviewed. This included the existing systems on tankers in operation. Meetings were held with designers and manufacturers of handrail systems and promotional and other material was reviewed,
- all aspects of TRAM design, manufacture and testing were reviewed, and
- the TRAM was tested in operation.

Key Issues:

- a "What might go wrong?" approach was used,
- hazards were identified,
- risks were assessed using the Fine Method, that is consequence, exposure and likelihood factors were determined and a level of risk calculated,
- the TRAM was applied as a control,
- the effectiveness of the control was assessed,
- OHS principles such as the hierarchy of controls are used to assess the risk control. Published research, statistics and case studies were used as evidence to support assessment of controls, and
- residual risk was calculated.

The results of the Risk Assessment, detailing the assessment of risk, discussion of controls and residual risk is provided in Section 3.

3. Results

Hazard

Working at height

Risk (Fine Method)

Fall from height

Consequence (most likely)

- Very serious / permanent disability / 25
- Fall event histories collected for this Risk Assessment included some cases where drivers have lived after falling from tankers with serious injuries, such as paraplegia, whilst other drivers have died.

Exposure

- Frequently / approximately once daily / 6
- The requirement for access to the tanker top varies across industry. There is an effort to reduce the need to access the tanker top or access at a fixed location with full gantry. However, it was discovered through extensive industry meetings that access to the tanker top (where a fixed gantry is not available) cannot be eliminated altogether. (Access to the tanker at a fixed location where a full gantry is used has not been included as an exposure for this Risk Assessment.)

Likelihood

- Almost certain / Is the most likely outcome / 10
- The likelihood of very serious injury / permanent disability (or worse) occurring as a result of a fall from a tanker is almost certain. As some falls have resulted in fatality, it is unlikely that the victim will escape with non-permanent injury. The biomechanics of the fall could be modelled to show that the resultant forces would be far greater than the failure load of soft tissue and bone.

Risk = Consequence x Exposure x Likelihood

- 25 x 6 x 10 = 1,500
- >300 / Very high risk

Controls

Elimination / Substitution / Minimisation

- The TRAM should not preclude current efforts to eliminate or reduce the need for tanker top access. However, to eliminate the need for tanker top access does not seem possible and certainly has not been achieved to date. Therefore, the working at height hazard and fall from height risk must be treated with additional controls.

Engineering

- The use of bottom loading should reduce the need to access the tanker top, and therefore reduce frequency of exposure and the overall risk.
- ‘Diptronics’ allow the level of fuel in petroleum road tankers to be measured without needing to access the top of the tanker. This very costly engineering control may improve height safety and control the risk of fall in petroleum road tankers, but is not applicable to dry bulk powder tankers.
- Powered man lids have been proposed as a possible engineering control for tanker top height safety. There was no evidence found for the success of this approach through the current Risk Assessment project. There were some concerns expressed about the workability of such an approach, particularly with regard to maintenance.
- Loading and unloading road tankers at fixed locations with full gantry would provide a control to the risk of fall. However, the road tanker industry has not found it reasonably practicable to limit access to tanker tops to fixed locations with full gantry. For example, some loading and unloading locations do not provide a gantry. Drivers also occasionally need to check the lid seals en route as a defect could cause spillage or spoil the load.
- The TRAM utilises innovative engineering to provide a fall protection system that is specifically designed for road tankers.

  An ideal system of mobility and restraint is achieved through the vertical movement of the hand-hold, which is also where the two 75cm lanyards are attached. For example, whilst standing and walking the anchor points are approximately at waist level. If the driver was kneeling, squatting or sitting to work, then the hand-hold and anchor points can be lowered to accommodate this change in posture.

  The horizontal movement of the TRAM along the fixed rail ensures that the operator can move safely along the top of the tanker. Whilst walking along the top of the tanker the handhold provides support to the operator who must hold the unit and release a ‘dead mans brake’ to allow movement. The user, wearing the purpose-designed restraint belt attached by two lanyards, is firmly attached to the unit at all times and cannot fall. The system provides the operator with mobility and restraint.

  Unfortunately the poor height safety record for road tanker safety is paired with an approach that has not included the use of personal fall protection. The obvious need for a shift in paradigm was the genesis for the revolutionary approach taken in the TRAM design.

  A review of work-related fatalities involving falls in Australia found that more than 96% of victims were not using personal fall protection (NOHSC, 2000). It was found that all, or nearly all, of the deaths were preventable and the use of personal fall protection devices was recommended.

- **The TRAM controls the risk encountered when moving on to the tanker from the ladder, and off the tanker back on to the ladder.**

  The movement of the hand-hold from its horizontal position (when the driver is on the ladder) to its vertical position (when the driver is standing on top of the tanker), has been termed a ‘moving rung’. The ‘moving rung’ also ensures that the operator is facing inwards to the ladder as they move from the top of the tanker back on to the ladder. The TRAM provides a solid handhold that moves with the operator through the transition and is also a moveable anchor point for the restraint belt that is attached by two lanyards. The TRAM safety system is designed so that the user is firmly attached to the unit at all times and cannot fall. This is a revolutionary and unique engineering control to the risk of moving on to the tanker from the ladder, and off the tanker back on to the ladder.

  Handrails and static line systems do not adequately control the risk of falling from road tankers, as the risk of moving on to the tanker from the ladder, and off the top of the tanker back on to the ladder is not controlled. Many of the falls from road tanker fall event histories show that there is a risk of falling at this transition.

  The TRAM is the only safety system that controls the risk of falling when moving on to the top of the tanker from the ladder, and off the top of the tanker back on to the ladder.

Health & Safety Laboratory (2005) *Safety of workers when accessing the top of tank containers*

A recent report, *Safety of workers when accessing the top of tank containers*, by The Health and Safety Laboratory, in the UK included a biomechanical assessment of the transition at the top of the ladder. The Health and Safety Laboratory found that:

“The transfer between the ladder and the walkway, particularly in the descent, is considered to be the most hazardous element of the whole access operation”

The descent– the most hazardous element of the access operation

The TRAM was acknowledged by the Health and Safety Laboratory as the only practicable control for the risk of fall whilst accessing or working on top of tank containers:

“At present only one tank-based system [the TRAM] has been identified which could effectively prevent or protect a worker from the consequences of a fall on the ladder or from the top of the tank”

The transfer between the top of the ladder and the walkway using the TRAM

Health & Safety Laboratory (2005) ***Safety of workers when accessing the top of tank containers***

The transfer between the ladder and the walkway, particularly in descent, is considered to be the most hazardous element of the whole access operation because of the following factors:

- *Proximity to the tank edge spanning approximately 270 degrees during the transfer manoeuvre*
- *Awkward postures and movements required*
- *Likely high demands on strength to maintain stability*
- ***Less than 3 contact points is normal***
- *A lack of purpose provided handholds*
- *Difficulty in seeing footholds during descent*
- *Lack of opportunity for recovery / Lack of protective measures - e.g. no handrail protection*
- *Typically small area on tank top for manoeuvring into position*

- The TRAM controls the risk of fall by restraining the user. Although the user can move along the top of the tanker, they are prevented from reaching a fall-risk position.

  The provision of physical barriers must form a complete perimeter and surround any worker at height on all edges where there is a risk of fall. Unfortunately most handrail systems only provide a barrier on one side of the work area. It has already been discussed how there is a risk of fall at the point of access and egress but importantly more than half of the remaining edges of the work area usually remain unprotected. Work tasks on top of the tanker usually require the driver to move from one end of the tanker to the other, stopping to carry out specific tasks in the (top) middle where tank openings are located. The driver is therefore exposed to risk of fall at the end of the tanker and along the unprotected side edge.

Health & Safety Laboratory (2005) ***Safety of workers when accessing the top of tank containers***

"Assuming the handrail does provide some fall protection… ***there is an equal likelihood of a fall from the unprotected side of the tank.*** *At best the handrail therefore only … protects against a fall for the extent of its length. The opposite side of the tank and both ends remain unprotected."*

- There are widely held concerns about the effectiveness of the handrails from the tanker industry and even from the designers and manufacturers of handrails.

Health & Safety Laboratory (2005) ***Safety of workers when accessing the top of tank containers***

"The function of what is referred to as a handrail may need to be clarified…There are currently no standards against which the performance of a handrail is tested or approved"

"there is some uncertainty whether these devices will be effective in restraining a person if they were to fall against them."

- The TRAM The TRAM and horizontal rail has been tested to the specifications of, and is compliant with:
    - *BS EN 795:1997 Protection against falls from a height — Anchor devices — Requirements and testing*
- The TRAM restraint body belt has been tested to:
    - *BS EN358:2000 Personal protective equipment for work positioning and prevention of falls from a height - Belts for work positioning and restraint and work positioning lanyards*
- Standards do not require guardrails or handrails to be designed to withstand loads of the same magnitude as personal fall protection systems.

EN 795:1997 Protection against falls from a height — Anchor devices — Requirements and testing *Type tests for devices employing horizontal rigid anchor lines* *A static test shall be carried out …with a force of* ***10 kN*** *applied in the direction in which the force can be applied in service. The force shall be maintained for 3 min. The anchor device shall hold the force.* *A dynamic strength test shall be carried out [100kg mass / 2 500mm] The drop mass shall be arrested.*	**BS 5395-3: 1985 Stairs, ladders and walkways** *Lateral loading* *General duty –* ***0.36kN***

- The TRAM is suitably robust, sturdy and durable to meet the harsh mechanical forces that are encountered in Australian road transport. Road tankers may travel long distances over secondary roads en route to deliveries.

  Feedback from fleet operators has been critical of the ongoing and costly maintenance and repairs needed by the handrail systems. The vibration and buffeting of handrails causes the movable parts of the system to loosen, which affects the stability of the system when erected.

  The TRAM is comparatively compact and strong in its construction, whilst the TRAM rail is rigid and fixed to the tanker.
- The TRAM is made of high grade stainless steel which will not corrode and is resistant to many chemicals that are found throughout industry and transported by road tankers. For example, the stainless steel TRAM is ideal for use on vehicles working at aluminium smelters where there is atmospheric sodium hydroxide, which would prohibit safety systems that used aluminium parts in construction.

- The TRAM has been ergonomically designed so that it can be raised and lowered so that it is at a suitable height for all users.

  In comparison, handrail systems may not be safe for workers who are taller than average who are at risk of fall by pivoting over handrails. Anthropometric principals dictate that a single fixed height will not provide a safe barrier to all people from the range of shortest to tallest.

- The TRAM provides fall protection even when other hazards and risks exacerbate the risk of fall from height. For example, in a number of the case studies the driver was overcome by hydrogen sulphide, precipitating a fall from the tanker. There were also case studies of falls that were precipitated by physical hazards such as pressurised water and compressed air hoses or hatches on pressurised tanks.

  The TRAM may be the only control robust enough to keep a driver who has been injured or rendered unconscious from falling.

- The top of the tanker presents numerous trip hazards that can send a driver over or off the top of the tanker in any direction. The case study and testimonial below demonstrates how the TRAM ‘saved’ a driver.

Case Study and Testimonial

An independent road tanker operator in Australia had installed a TRAM safety system on his vehicle. This experienced driver had been sceptical about the need to control the risk of falls from road tankers and had only installed the TRAM to comply with the new law, the Victorian Occupational Health and Safety (Prevention of Falls) Regulations 2003.

Recently, he was moving back along the top of his tanker when he tripped on an open hatch near the end of the vehicle. The TRAM prevented him from falling over the end of the tanker. The driver reported that the TRAM had saved him from serious injury or even death. He also noted that only the TRAM would have saved him as handrails would not have stopped him falling off the end of the tanker.

Behavioural

- Safety principles predict that it is better to eliminate, minimise or engineer out risks, than to rely on human behaviours. In fact, human behaviour and risk could be seen as cause and effect.

  Humans can be expected to take risks, have accidents and underestimate the catastrophic. For example:

  - a driver climbs onto his road tanker without fall protection even though he is parked outside of a load-out facility with fall protection (takes a risk),
  - the driver slips and falls to his death (has an accident), and
  - the driver could not have thought that his actions would result in falling to his death (underestimate the catastrophic).

- Some road tanker companies instruct their drivers to only access the top of tanker at fixed locations with full gantry. However most road tankers have ladders providing the opportunity to access the tanker top away from fixed locations with full gantry. Human behaviour principles would predict, and meetings with road tanker industry stakeholders confirm, that drivers will disobey instructions and continue to access their road tankers away from fixed locations with full gantry. The fall event histories show that drivers have been killed in falls when, in violation of instructions, they have accessed the top of their road tanker away from fixed locations with full gantry.
- A subtler problem can be found in an analysis of handrails and human behaviour. The problem occurs because it is perceived that the handrails eliminate the risk of falling, but falls can occur on the ladder at access and egress. Also, handrail systems may not be effective in restraining a person if they were to fall against them. Handrails reduce the perception of risk but do not adequately control the risk. The risk of fall is increased, as the behaviour is reflective of the perceived risk while the real risk is greater.
- It is a benefit of the TRAM that its design and operation facilitates favourable behavioural responses to height safety. For example;
    - the operator must grasp the hand-hold to operate the brake to move along the top of the tanker. Reaching and holding for support is a ‘natural’ response to a perceived risk of a trip, slip or fall, so the action required to operate the TRAM has facilitated a safe behaviour,
    - because the TRAM is attached to a fixed rail, the driver will always be guided to walk along the walk platform, which is to the side of the hatches, and devoid of trip hazards. So again, the design and operation of the TRAM has facilitated a safe behaviour, and
    - a worker may assess that the risk of fall is proportionate to the control measure. For example, if there was no control, then it might be assessed that there was no risk, but using a fall protection system with specially designed restraint belt suggests that there is a risk of falling. The TRAM design and operation will alert the driver to the height safety hazard and facilitate appropriate behavioural responses.

  As we expect workers to take risks, have accidents and underestimate the chance of catastrophe, the work system should be designed to mitigate the influence of these behaviours.
- The TRAM requires competency based training to ensure that the system is operated correctly.

  Training and instruction can help to change human behaviours through providing information to workers about risks and to showing them how to perform their work safely. Training drivers to use the TRAM will increase their awareness of the risk of falls from road tankers and provide the requisite skills to perform their work safely.

  The advantage of requiring competency-based training in a safety system is that the training is then the starting point. That is, the worker is trained and tested before they are allowed to start their work. The increased risk of death and injury on the first day of work or before experience is gained is well recognised. In a study into worker death by falls in the USA, 40% of the fall fatalities had been employed for six months or less (US Department of Health and Human Services, 2000). A requirement for competency-based training has the potential to prevent nearly half of all falls, as these falls occur because of a lack of skills and experience.

It is appropriate that all workers who work at height are trained in the associated hazards and risk of fall. This is particularly so for safety systems that requires user interaction. We note that even though all handrail systems require operation to erect the barrier, there have not been any height safety training programmes provided by manufacturers of handrail systems found during the preparation of this report.

- The operator who has passed the TRAM competency-based training may provide instruction to a third party for limited and supervised access to the tanker top. For example, a service station worker who has not been trained to operate the TRAM may request access to the tanker top to measure the fuel in a tanker. The driver who will be qualified to use the TRAM will also be qualified to instruct and supervise the service station worker. The inclusion of this competency raises the skills and knowledge of the operator and the opportunity to instruct and supervise will reinforce those skills and knowledge. In this way, the competency based training helps to develop a safe approach to height safety.
- Because the TRAM requires the worker to follow instructions to use the system safely, it can be argued that either a lack of competency or deliberate misuse can render the system unsafe. However, very little instruction or training is required to use the TRAM properly and once attached to the system it is nearly impossible to fall, even if, with reckless disregard to their safety, a worker tried to jump off the vehicle.

  Although the main principle of workplace safety law is that those who create risk from work activity are responsible for the protection of workers, there is also a general duty for employees to co-operate with their employers and take care. The TRAM requires workers to understand and comply with very simple instructions and actions. Failure to do so would demonstrate disregard to their own welfare.

Residual Risk / Effectiveness of Control

- The discussion of controls shows that the TRAM is a suitable and effective measure to prevent falls from road tankers.
- The fall from height is controlled and so the consequence of fall from height is eliminated.
- The exposure or rate of access to the top of road tankers may not change but the risk of fall has been controlled which mitigates the effect of exposure on the total risk.
- Total residual risk is acceptable.

4. Discussion

The assessment of risk has shown that the risk of falling from road tankers is very high and must be controlled with suitable and effective measures.

The risk of falling from road tankers cannot be eliminated; therefore other controls must be used to mitigate the risk.

The TRAM utilises innovative engineering to provide a fall protection system that is specifically designed for road tankers.

The TRAM controls the risk of fall from road tankers.

The TRAM was assessed to be a more effective measure than handrails and static line systems in preventing falls from road tankers. Handrails and static line systems do not adequately control the risk of falling from road tankers, as the risk of moving on to the tanker from the ladder, and off the top of the tanker back on to the ladder is not controlled. Many of case studies in the *Falls from Road Tanker Fall Event Histories* (see Appendix I) show that there is a risk of falling at this transition. The TRAM is the only safety system that controls the risk of falling when moving on to the top of the tanker from the ladder, and off the top of the tanker back on to the ladder, as well as movement along the top of the tanker.

5. Conclusion

The TRAM was found to comply with the requirements of the NSW Occupational Health and Safety Regulation 2001.

The Risk Assessment found that the TRAM is a suitable and effective measure to prevent falls from road tankers.

References

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Appendix I: Falls From Road Tankers Fall Event Histories