Quarries National Joint Advisory Committee (QNJAC)

Guidance Note

The Safe Operation of Articulated Dump Trucks (ADTs) in Quarries and Surface Mining Operations

(With reference to ADT use in civil engineering and construction projects)

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1.0 Introduction and scope

Articulated Dump Trucks (ADTs) are a commonly used piece of equipment in the quarry, opencast mining and construction sectors. When used safely and efficiently they are a valued piece of equipment that plays an essential role in many operations from highways construction and earthworks, to load and haul and stockpile movement.

However, with increasing use of this equipment there has been an increasing trend of these vehicles being involved in overturn incidents. Overturns have become so common in fact that there may now be an industry wide perception that these incidents are somehow a 'routine' hazard associated with their use – in the view of some plant operators the vehicles are *designed* to be able to roll over.

The Myth:

"ADT's are designed to overturn"

Wrong – This is simply a dangerous myth and should be challenged. The purpose of the centre articulation on an ADT is to allow the two sections of the vehicle to articulate separately (twist and steer) and allow all of the wheels to maintain maximum contact with the ground all of the time, thus maximising traction and brake efficiency. It is this feature which makes ADT's so versatile over poor terrain. It has nothing whatsoever to do with being 'designed to overturn'.

The Truth:

"If an ADT has overturned, then something has gone wrong."

When operated and maintained by competent drivers, in a properly designed and maintained environment, ADT overturns are a wholly preventable occurrence.

Scope of this guidance document

This guidance is intended for sites where ADTs are in use, including quarries and opencast mines with the aim of reducing or eliminating the risk of body and cab overturns. It uses examples of good practice provided by UK quarry and coal mine operators together with input from specialist earthmoving contractors and manufacturers of ADT vehicles. This guidance will also be relevant to construction/civil engineering projects where ADTs are used in earth moving operations.

The guidance document has been drawn up with the focus on three key principles:

Safe Driver – guidance on training and competence of machine drivers

Safe Machine – guidance on choice of machine, inspection & maintenance

Safe Environment – guidance on planning and design of the environment where the ADT is to be used

Additional training materials are provided as a supporting appendix to this guide to enable operators to embed good practise within their organisations.

2.0 Types and causal factors of ADT overturns

2.1 Types of overturn

Analysis of ADT incidents has shown that there are 3 main modes of overturn.

1. **Skip body overturn**

This is the most common type of overturn incident where the skip body turns on its side leaving the drivers cab upright. Usually these incidents do not result in significant damage to the machine or injury to the driver. However, they have the potential to result in a serious or perhaps even fatal outcome should the falling skip body come into contact with other plant or persons in the close vicinity of the vehicle.

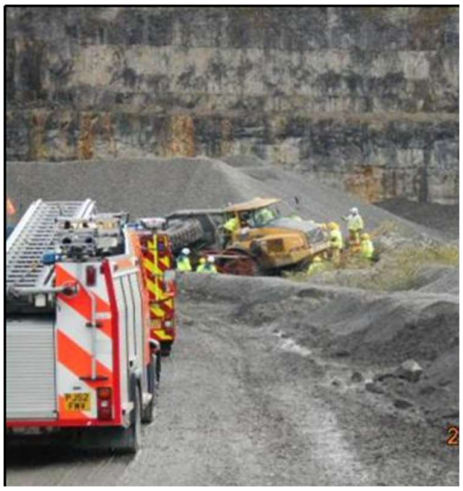
2. **Cab overturn**

This is a less common event where the skip body remains upright but the cab overturns. This is often a result of the rear articulated half of the vehicle lifting the cab and front wheels off the ground, allowing the cab to topple on the articulation. It

is very common for drivers to suffer injury in a cab turnover incident – in extreme cases (eg. where seatbelts are not being worn) these incidents have the potential for serious injury or fatal outcomes. A cab overturn will also have the potential to cause significant damage to the vehicle.

3. Whole machine overturn

This is the least common type of overturn incident where both the skip body and cab turn over. These incidents will often result in serious injury to the driver and significant damage to the vehicle. Often these events occur at speed or involve falls from height, thus increasing the likelihood of a tragic outcome.



Example Incident

In October 2015 a serious incident with an ADT resulted in a body overturn. The driver sustained 9 cracked ribs, a damaged spleen and cuts to his head. He was hospitalized for 9 days and off work for 6 months. The driver was wearing his seatbelt, if not, his injuries would have been much worse.

Any ADT overturn incident, even if does not directly lead to personal injury, will cause unnecessary business disruption, create machinery repair cost and can put others at risk during the recovery operations.

2.2 Key causal factors in ADT overturns

Investigation of ADT overturn events has identified the following causal factors as being common, either individually or in combination.

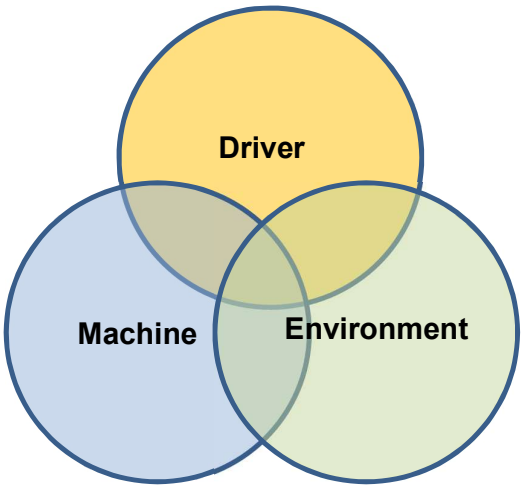
- Soft or sticky or un-compacted ground
- Tipping too close to an edge
- Tipping on an excessive gradient or on a cross-fall
- Moving/Reversing up a slope, stockpile or bund edge
- Carrying unstable loads such as silts and slurries
- Carrying sticky or cohesive loads such as clays and soils
- Excess speed or sharp braking, especially on corners and bends
- Poor haul road conditions
- Mechanical failure of key components such as the lifting rams, suspension
- Incorrect use of the differential lock
- Poor visibility/weather conditions
- Use of tailgates on cohesive materials
- Vehicle runaways
- Travelling on excessive camber and gradients
- Incorrectly inflated tyres or tyre blowout
- Failure of drivers or site supervisors to adequately identify and assess risk

Example photographs illustrating some of these are contained as Appendix 9.1

The importance and influence of these factors is usually relatively easy to identify in investigations carried out ***after*** an ADT overturn incident. The challenge is then for operators to identify them as risk factors ***before*** an incident takes place.

It is often the case that the root cause of an incident is simply attributed to 'driver error'. While competence of the driver is always a key consideration, often this ignores the failure of site management to adequately assess the hazards associated with ADT operation on a site.

All of these factors can be incorporated in the overlapping concepts of **Safe Driver**, **Safe Machine** and **Safe Environment**. A failure to take into account one or more of these will mean that an operator of ADTs is exposing themselves and their workforce to unnecessary and preventable risk.



3.0 The Legal Framework

The *Quarries Regulations 1999* provide the legal framework for the safe operation of ADTs in UK quarries and opencast mining operations.

There is a general requirement under *Regulation 6 "General Duties of the operator"* for the quarry operator to take the necessary measures to ensure, so far as is reasonably practicable, that the quarry and its plant are designed, constructed, equipped, commissioned, operated and maintained in such a way that persons at work can perform the work assigned to them without endangering their own health and safety or the health and safety of others.

This is supported by specific requirements under *Regulation 14 "Rules controlling risk from vehicles"*. The *Approved Code of Practice* for this regulation sets out what the rules should include. All of them are relevant to the safe use of ADTs - safe driver, safe machine and safe environment.

These two regulations underpin the approach taken in this guidance of safe driver, safe machine, safe environment, irrespective of whether or not you are a quarry operator, employee or a contractor.

There are then specific regulations relevant to each of the three elements of the guidance

Safe Driver

Regulation 9 sets out the requirement for all those working in a quarry to be competent to perform the tasks assigned to them and this includes the drivers of ADT's. It is the duty of the operator to ensure that this is the case rather than the duty of the driver.

Regulation 10 sets out the requirement for operators to have in place instructions, rules and schemes and this includes ensuring that these are followed (i.e. by way of adequate supervision).

Regulation 42 sets out the duty of persons at work at a quarry to carry out their duties with reasonable care for their own health and safety and that of others.

Safe Machine

In addition to *Regulation 12* and *Regulation 14* of the *Quarries Regulations 1999*, the *Provision and Use of Work Equipment Regulations 1998* are relevant to the safe provision and use of vehicles on site including, suitability, inspection, maintenance, controls, roll over protection and restraining systems.

Safe Environment

Regulation 12 sets out the requirement for the haul roads and working areas to be inspected and maintained for safe operation.

Regulation 13 sets out the requirement for benches and haul roads to be designed, constructed and maintained to allow vehicles to be used and moved upon them.

Regulation 31 sets out the requirement for specific rules to define how tips are to be constructed and operated – in relation to ADT use these would particularly be relevant to control of tipping points.

Application to civil engineering and construction projects

For civil engineering and construction projects the legal framework is set out in *The Construction (Design and Management) Regulations 2015*. In relation to the use of ADTs, these regulations focus particularly on the 'safe environment' element.

Regulation 13, places a duty on the *Principal Contractor* to plan, manage and monitor, health and safety matters during the construction phase, taking account of the general principles of prevention. Additionally, under *Regulation 12*, a construction phase health and safety plan must be drawn up setting out the arrangements for health and safety.

Regulation 16, by virtue of *Regulation 27*, requires traffic routes (haul roads, ramps etc.) to be suitable, so far as reasonably practicable, for the vehicles using them, arranged to ensure safe separation of pedestrians and vehicles and be maintained to ensure safety.

Regulation 16, by virtue of *Regulation 28*, requires vehicles to be operated, loaded or towed in a manner ensuring safety. This includes a requirement to take suitable and sufficient measures to prevent vehicles falling in to excavations or overrunning the edge of any embankment or earthworks."

4.0 Safe Driver

Under *Regulation 9* of the *Quarries Regulations 1999* Quarry Operators are required to ensure that all persons operating machinery are competent to undertake the tasks that they have been assigned.

An ADT is often seen as the 'entry level' machine for an inexperienced mobile plant operator on a quarry or opencast site. This is because these machines are seen as requiring basic skill levels for operation and are well suited for operators who have limited heavy mobile plant experience. Central cab position, automatic gear selection and retarder controls may make the modern ADT seem a simple step forward for a new operator whose previous driving experience may have been a domestic car or van.

So what factors define and influence ADT driver competence?

- **Competency and Training** - All ADT drivers should hold or be working towards a recognised competency qualification from a scheme which has an independent check of competency, such as MPQC, CPCS and NPORS (after October 2016). Competency is a measure of skills, knowledge, attitude, training and experience and drivers should know their limits of operation. Mobile Plant drivers should be authorised by the Site / Quarry Manager *only after* they are satisfied of their competence.

- **Induction** - All ADT drivers should have a comprehensive induction to site which should include details on the specific site hazards including layout, traffic routes, loading and tipping zones. It must include local mobile plant excavation and tips rules as well as site emergency procedures. A good induction should also include a site tour prior to commencement of work.

- **Compliance** - ADT drivers have a duty to comply with any site rules and procedures to ensure their safety. Such rules such as wearing seatbelts, following speed controls / limits and any vehicle priority order are essential.

- **Change Management** – Mines, quarries and construction sites are constantly changing environments. ADT drivers should be aware of how changing conditions such as changes in topography, lighting, visibility, weather and other activity can increase the risk of an overturn. Any change should be recognised and the risk reassessed by the persons supervising the operation and any outcomes communicated to drivers.

- **Familiarisation** - Drivers should be familiar with the make and model of ADT they are using. If the machine is changed for any reason, drivers should take time to re-familiarise themselves with the machine including its access/egress, driving controls and safety features. An example familiarisation checklist has been developed to assist this.

- **Fatigue** – is a proven factor in relation to mistakes and misjudgements by drivers of mobile plant. To avoid routine and monotony drivers should be able to take clear rest breaks ideally out of the cab so that arms and legs can be stretched. Suitable rest/welfare units should be provided including an area where safety discussions/briefings can take place. Where possible job roles and tasks should be changed and rotated so monotony does not set in. Consideration should be given to the timing of toolbox talks and other training so as to break up the daily routine.

- **Communication** - drivers should ideally have access to an effective in-cab communication method between mobile plant and other site personnel e.g. two-way radio. Sites should have clear protocols in place to define how messages are relayed and the language that is to be used in these. Hand held mobile phones, whilst useful as a backup, should not be used whilst operating mobile plant as the main communication method.

- **Distractions** - In cab distractions such as personal electronic equipment including mobile phones, tablets, gaming devices, music players etc should not be used when driving ADTs. In cab control systems and programming should not be altered or amended when the vehicle is moving.

It is also recognised that ADT activities (as with any mobile plant activity) should be routinely and effectively supervised to ensure safe rules and practices remain in place and are effective.

Competence assessment - examples

Possession of the requisite Machine Operator Competence card should never be assumed to be a *guarantee* of driver competence. The competence card should be used as a reason to allow the plant operator on site prior to further on-site assessment and subsequent sign off of capabilities for the activity that the ADT is to be utilised for.

Example 1: A card holding driver whose experience is limited to use of an ADT for stocking out processed materials from a plant bin to a product stockpile should not automatically be deemed 'competent' to operate the same machine on a steeply inclined haul road hauling blasted rock from the quarry face. In this example, further close supervision and assessment of the driver would be required to ensure that the driver was aware of the additional considerations that should be taken into account when operating the machine in this mode, e.g. correct use of the retarder for downhill loaded sections of the haul.

Example 2: A card holding machine operative at a quarry is used as an occasional relief driver on ADTs and may sometimes go several months between spells on the ADT. In this example the quarry operator should consider if additional refresher training or additional supervision is required before the driver is deemed competent to carry out the task.

Example 3: An ADT is hired for use on site that is of a different model to those already in use at the site. It should not be assumed that all current drivers are deemed competent to operate this machine until some additional familiarisation training has been carried out – typically, different manufacturer's models may have subtle differences in operation of park brakes, retarders and other safety devices that are critical to the safe operation of the ADT.

Driver training – good practice example

Recent developments in technology mean that some manufacturers of ADTs are able to provide driving simulator rigs that allow new drivers to gain valuable initial experience in a 100% risk free environment.

5.0 Safe Machine

There are several factors and considerations to be taken into account to ensure the correct combination of machinery and optional accessories are fitted when selecting an Articulated Dump Truck (ADT) for a materials handling operation. Many will be important when seeking to reduce the risks of an overturn to an absolute minimum.

- Correct choice of equipment.
- OEM features and accessories fitted to help reduce overturn risks.
- Daily Inspection, Defect Reporting and Maintenance procedures to ensure risk items for overturn have been checked.

5.1 Correct Choice of Equipment

ADT - advantages

- “Swiss Army Knife” adaptability to work on mixed ground conditions all year round, easier to establish a site and temporary haul roads and run in poor weather.
- High ratio of loaded weight to unloaded weight
- Flexible in a range of work environments: mining, quarrying, landfill operations, road construction, restoration, civil engineering.
- Good visibility all round because of central cabin – the ADT is a traditional starting point for new mobile plant operators.
- Safer – design of chassis means drivers cab is mainly isolated from the effects of the trailer/body overturn by an oscillation bearing.
- Less dependent on weather related site conditions – will run in most weather.
- Lower Purchase Price vs rigid models and resale market accessible.
- Easy relocation site to site via traditional low loader with little or no dismantling.
- Lower ground bearing pressure with less disturbance of sub-soils when on restoration activities.

- Six-wheel drive giving better traction, six-wheel braking giving better retardation in poor weather.
- Auto-retarder and traction control available

ADT – disadvantages.

- Limited body capacities 20-60 tonnes rear tip and 30-40 tonne rear ejectors
- Overturn of trailer more likely vs rigid machine turnover on rear tip ADTs.
- Ease of operation means the ADT is often seen as an entrance point for plant operators - new and inexperienced operators can be involved in incidents/accidents.
- More complexity in the driveline components compared to rigid frame dump trucks.
- Lower top speed and productivity on good ground conditions, compared to rigid frame dump trucks.

5.2 OEM features and accessories fitted to reduce overturn risks

Automatic traction control & differential (diff) locks The ability to apply a differential lock under load is essential for safe operation, and the ability to disengage a diff-lock under load is advantageous to aid turning at the ends of straight haul roads, around tight corners and at tipping areas. It is a requirement that the operator appreciates the effect a diff lock can have on turning, as Automatic Diff Locks cannot yet read the road ahead. Traction aids can ensure braking in a straight line which supports machine stability, thus allowing the operator to negotiate inclines, declines and poor underfoot conditions without additional manual inputs.

Tipping Inclinometers are useful where the tipping area is not well managed, or the tip is very soft. They can help the driver make decisions on whether to tip at a particular place or reposition their machine to level up. Some systems provide an interlock preventing the tipping function when safe tipping angles are exceeded. *It is essential however that reliance on the use of inclinometers is not used a substitute for effective assessment of safe tipping areas. The 'safe' angle may vary from site to site or within the site itself depending on ground conditions and the material being carried.*

Body Up alarms and warning lights are used to remind the operator that the body is raised. The machine forward speed should be limited when the body is raised. Having the body raised when travelling can increase the risk of overturn even at slow speed.

Speed limiters can be adjusted by the supervisor to limit the maximum forward speed of a machine under power on. This can reduce the potential for excessive speed, and risk of overturn on flowing bends.

Dumper body heating options - Carry back is the material that remains in the body after tipping and will impact machine stability and efficiency. The risk of carry back is significantly more with some materials than others; clay, chalk, unstable silts and clay-

loams are often the worst to handle, especially in cold wet conditions.
Heated body options provide a more efficient means to reduce carry back and reduce the risk of a stuck load in colder conditions. The body heater reduces the amount of material hanging in an elevated body as the truck draws forward to clear its load during the tipping process.

Rear tailgate is an ideal aid for load retention with free-flowing materials such as ballast, stone and sand on rough terrain and slopes.

ADT's typically have a mechanical tailgate hinged at the top; this does limit the size of material being tipped (i.e. very large stones or frozen material) and sticky materials, such as clay can hang up on this design of tailgate. Therefore drivers of loaders that are filling ADTs, need to be trained and such material should not be placed directly against the tailgate or where large rocks can strike or obstruct the tailgate during tipping. In worst cases the front cab chassis can lift and rotate about the oscillation bearing when the tailgate fails to release the material.

Body side extensions provide a means to increase the volume of a dumper body for carrying lower density materials such as dry sand, coal and blasted rock where there are lots of voids. The extra volume should only be used to raise the payload closer to the manufacturers rated capacity. Particular care should be taken on sites where material densities are variable (e.g. on many opencast coal sites) so that dumpers are not overloaded when working with higher density material.

Management and worksite care is required when handling soils and clays where the material density is greater, as the centre of gravity of the load moves upwards proportionally to the height of the side extension fitted. This can have an effect on stability when travelling and tipping. The OEM can advise on optimum sizing of side extensions for a given material.
Where side extensions are fitted consideration must be given to including a headboard to better protect the front chassis/cab from shifting material during loading or under braking, and material falling from the front corners during turning.

Machine options offered by some OEM's:

Ejector bodies are a skip design offered by some OEMs that use a ram or plough to eject material from the body without the need to raise the skip. Clearly these have a significant potential to reduce the risk of skip overturns as they eliminate the instability caused when the skip is raised. Ejector equipped ADTs have the advantage over conventional units in applications where overhead obstructions exist, where tipping has to take place on a slope, or where sticky materials would otherwise risk being carried back in the dumper body. They may also have advantages in relation to cycle times versus conventional ADT body designs as tipping can be carried out whilst in motion. Against this the disadvantage of additional cost and complexity should be considered. However, recent developments in capacity and design mean that the ejector body should now be considered a viable alternative to the conventional design for units up to 40t capacity.

Remote GPS machine monitoring gathers machine specific information and is linked to GPS. It can be used to record and transmit a variety of date relating to payload, engine/transmission status, fuel usage and other efficiency data.
Machine systems can be typically monitored to record events and operator warning alarms such as overheating or advanced notice of an engine oil change. They may also record significant events such as inclinometer tipping warnings, heavy braking and inappropriate gear selection. It is good practice that data downloaded from machine systems is regularly reviewed with the driver to identify improvements in driving habits and efficiency.

Payload Meter or load indication light is an externally mounted indicator to inform the excavator or loader operator when the machine has the correct payload - reduces the risk of an ADT overturn due to overload.

Seat belt monitoring lamps and high visibility seat belts are useful for the supervisors to ensure drivers are wearing this essential safety equipment. Poor practice such as plugging belts in behind the driver should be rigorously eliminated.

Tyre choice: Low profile wide tyres are routinely specified on the most common size of ADT. These aid traction and stability in poor ground and offer reduced ground bearing pressure when compared to narrower tyres. The wider tyre provides greater stability when tipping in un-compacted material and therefore reduces the risk of turn over.

On Board Tyre monitoring may be an option on some models and can also be retrofitted as a non-OEM item. It is used to inform the driver of tyre pressures and temperatures. Tyre pressure is important as rear tyre deflection has a significant influence on stability on rear tip ADTs as the weight is transferred from the front to the rear during tipping. Low tyre pressure can also impact stability during cornering.

Additional reversing cameras and working lamps - These support all year round operation of ADTs. Some manufacturers offer additional reversing lamps and cameras at the sides and rear of the machine to aid reversing up, or when spotting or tipping. By being able to pick up edge protection, previously tipped loads, and ruts in the surface the driver is less likely to reverse the ADT into a position where the rear chassis is at an angle where it becomes unstable.

Lubrication of Tailgates – Grease Point extensions hoses for ground level greasing is essential for promoting greasing and inspection of the tailgate pivots and hoist ram top bearings.

In cab warnings and tipping reminder stickers can help with introducing new safety messages, and also keeping best practise for tipping fresh in drivers' minds.

Auto-lube Greasing Systems – eliminate the need for daily greasing by drivers or maintenance personnel.

5.3 Daily Inspection, Defect Reporting and Maintenance

It is very important to follow a daily pre-start inspection & defect reporting routine. This should be based around the specific OEM manual for the machine. Copies of relevant sections should be readily available to drivers for reference and training purposes.

Some key areas for closer inspection in the quest to reduce ADT overturns are:

Tyre inflation – do all the tyres look correctly inflated, and are there any noticeably under inflated? Loader or excavator drivers also have part to play, and so must be encouraged to report any soft tyres during the loading process.

It is not uncommon for ADT tyre pressures to be varied by drivers depending on the ground conditions in order to maximise traction. However, from the point of view of the drivers daily checklist the key focus should be on ensuring that tyres appear equally inflated on both sides of the vehicle – uneven tyre pressures can lead to instability, particularly during the tipping cycle.

Drivers should also be trained to recognise damage to tyres that could lead to a rapid pressure loss – this could potentially trigger a body overturn if a blowout occurred during the tipping cycle with the body upraised.

Daily brake checks and testing – a clear procedure for drivers to carry out a daily check of brake efficiency should be written into the site rules. The format of this can vary but might entail a series of checks from simple system observations and drivers checking normal braking response *ahead* of being in full operation to a stopping test against marker boards on a designated brake testing area. Also, on some machines braking efficiency may be tested at regular intervals using an on-board device or via a device that is swapped between site machines. It is good practice to record the output of these tests and track and trend results to identify deterioration in braking performance ahead of any potential failure.

Suspension - Inspection of the rear suspension helps identify any deterioration of the rubber suspension blocks (elephant's feet), or reduction in ride height due to gas over oil suspension going down – this can lead to instability. Check around the suspension blocks looking for major rubber de-lamination or rubber separation. If you can see shiny metal or the security chain inside contact the maintenance department. When driving if the suspension feels like it's wandering on the back end stop and re-inspect. The truck will be noticeably unstable when solely relying on the security chain for suspension when tipping or when travelling on flowing bends. A detailed inspection of the suspension system by a suitably competent person is essential after a body overturn event.

Inclinometer if fitted – management keys should be removed and not overridden. Before setting off check the display screen is indicating approximately the correct angle whilst stationary and angle displayed is changing with the road conditions once truck starts to travel.

Tailgate – greasing of the bearings involved in the operation and condition of operating ropes or chains is critical as a fraying rope or failing bearing could lead the tailgate failing to open. Is the tension across the two ropes equal so the load during tipping/opening is distributed evenly?

Clean cab - Keeping the cab floor and controls clean and tidy is a basic driver discipline. Storing heavy loose objects such as grease guns, tools and spares in the correct compartments can reduce the risk of driver injury should the vehicle have a cab overturn. It will also prevent them from jamming hand and foot controls.

5.4 Periodic inspection and servicing

All ADTs should always be inspected and serviced according to the recommended intervals of the OEM. With respect to the prevention of overturns, particular attention should be paid to monitoring the wear and condition of braking systems, suspension components, tipping rams and tailgate components.

When an site is operating ADTs that have been supplied via a third party (eg in a subcontracted earthmoving project) the operator needs to satisfy themselves that any machine coming to site has been suitably inspected, maintained and serviced prior to commencement of work. A good earthmoving contractor will usually offer the client open access to inspection records for this purpose.

External tyre inspection programme

Routine inspection of correct tyre pressures and condition as part of the maintenance programme will reduce cost of operation and also reduce the risk from instability from lower pressures across axles, which is typically highlighted when the skip is elevated and the load is transferred over the rear most axles.

Inspection can also identify early side wall or tread impact damage which not only can be repaired proactively and save a tyre becoming beyond economical repair, but also prevent a sudden failure and loss of pressure.

Most UK earthmoving tyre service providers are able to offer a scheduled tyre inspection programmes. Your earthmover tyre provider can suggest further recommendations.

6.0 Safe Environment

The safe operation of Articulated Dump Trucks (ADTs) is directly impacted by the environment they operate in. A competent driver operating a correctly specified and well maintained machine will be at an increased risk of overturn if the physical environment he or she is being asked to operate in has not been suitably designed, assessed and maintained with overturn risk in mind.

Whilst ADTs are adaptable all-terrain vehicles with expanded capabilities over rigid dump trucks, it does not mean they can *go anywhere*.

They have a defined operational envelope that will require reference to all of the following factors:

Geotechnical Design & Excavation and Tips Rules – The use of ADTs within the quarry for loading, hauling and tipping activities should form part of the Site or Quarry Design Plan. Detailed information on site standards and controls should be included in the Excavation and Tips rules for the site. These rules form a core 'safe working practice' for the ADTs and should be communicated and trained out to all staff.

Material being carried - The material being carried can vary dramatically from single sized granular materials to mixtures of overburden, clays, silt and soils etc. This material can therefore range from being free-flowing in nature, to a sticky material that sticks to the top and sides of the ADT skip hopper. Different materials have different weights. Semi-liquid loads such as slurry, and liquid loads can create instability as the load is sloshed from one side to another. The result of any imbalance can result in an overturn incident. Drivers of ADTs should be aware of the nature and type of material they are carrying and load capacities and cornering speeds varied accordingly.

Ground Conditions - Ground conditions can vary around the site depending on geology, topography and activities at site. The ground conditions can affect stability, especially when on soft materials such as silts and clays and on poorly compacted materials, including material tipped for stockpiles. Other high risk areas include those that were once lagoons or wetland areas. In those cases, the presence of excess water may make the ground especially soft. The site operator should assess, review and maintain these areas to ensure they are fit to be used by ADT's as and when required.

Loading Areas - Loading areas should be optimised to provide a good working system for loading the ADT. Site operators should consider machine type/capacity, access and egress for the machine, maintenance of the working surface to avoid undue adverse cambers, gradients and soft ground. Vehicles should not be overloaded, and material should be placed evenly on the vehicles to avoid creating an imbalance.

Haul Roads

Haul roads should be designed in accordance with geotechnical principles.

Width - Ideally the haul road width should be a minimum of twice the vehicle width for one way traffic, or three and a half times the vehicle width for two-way traffic. Consideration should be given for segregated lanes for light vehicles and pedestrians.

Gradients - Slope gradients should ideally be 1 in 10 or less. Where excessive slopes are present, the provision of runoff areas should be considered.

Surface – The surface of a haul road should be constructed and maintained to avoid potholes and other surface irregularities. These increase stress and fatigue on both machine and driver.

Bunding - Haul roads should be bunded to a *minimum* height of 1.5 metres or half of largest vehicle tyre diameter. Increasing bund height well above the minimum should be considered in the vicinity of bends, corners and ramps.

Surface water control - Surface water should be directed off the roadway into well maintained ditches and traps so as to avoid waterlogging the surface. Standing water has been proven to be a major factor in earthmover tyre damage and this may indirectly impact on the likelihood of ADT overturns.

Other design factors - Cross falls and adverse cambers over 3 degrees should be avoided. Tight turns and blind corners and blind summits should always be avoided where possible. Consider visual improvement aids such as indicator poles/mirrors etc where view is restricted. It may also be possible to consider direction of sun rise and sun set in the road layout as the effect of driving directly into low sunlight has been shown to be a significant risk factor in mobile plant operation.

Speed limits - Speeds limits should be appropriate to conditions and enforced.

Inspection - Haul roads must be inspected and maintained to a suitable design standard which may involve graders, dozers etc.

Tipping Area

Vehicle movements - Establish a safe zone of work, considering access, egress and movement of vehicles. Routes in the tipping area for ADTs should avoid the need for sharp turns whilst loaded - ideally long sweeping turns should be planned, with tighter turns if required on the unloaded run of the tipping cycle. ADTs should never tip adjacent to each other or other items of plant or equipment. A minimum exclusion zone should be maintained at all times around the tipping ADT to ensure that no one is at risk in the event that the skip was to overturn.

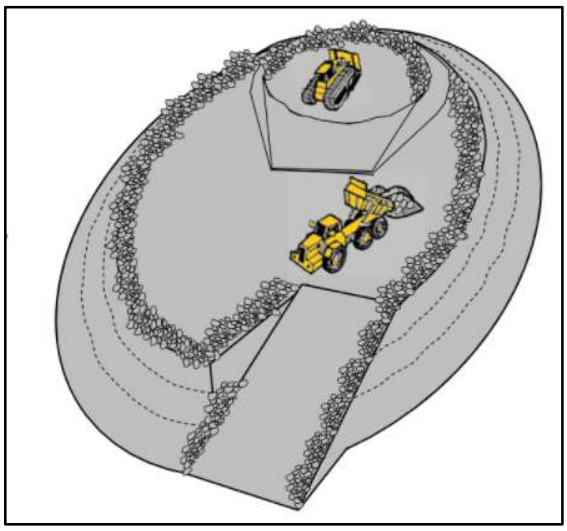
Tipping point - Tipping areas should be designed and maintained with minimal cross-fall and camber, ideally less than 3 degrees. Fixed tipping points should have permanent tipping blocks that are free from spillage. Moving tipping points such as waste tips must have edge protection. Never end tip over an unprotected edge. Avoid tipping down slopes – ideally a tipping point should be level in all directions.

Surface condition - Tipping material often creates an un-compacted and unstable surface zone. Typically this is compacted and levelled with a dozer. Try to prepare, use and maintain a suitable working and running surface, consider rutting, surface roughness, sliding, sinking on soft and hard spots on the performance of the ADT. Do not tip on an area where the cab is elevated upwards.

Inspection - The tipping area is often a rapidly changing environment. It is essential that frequent inspection of the tip area is carried out and that tipping operations are stopped as required allowing the area to be maintained to the planned specification.

Worker involvement – drivers should be actively encouraged to report any concerns relating to the tipping operation to their supervisor. Drivers should be empowered to halt the operations in the event that they consider remedial action necessary to maintain safety in the tipping area.

Stockpiling

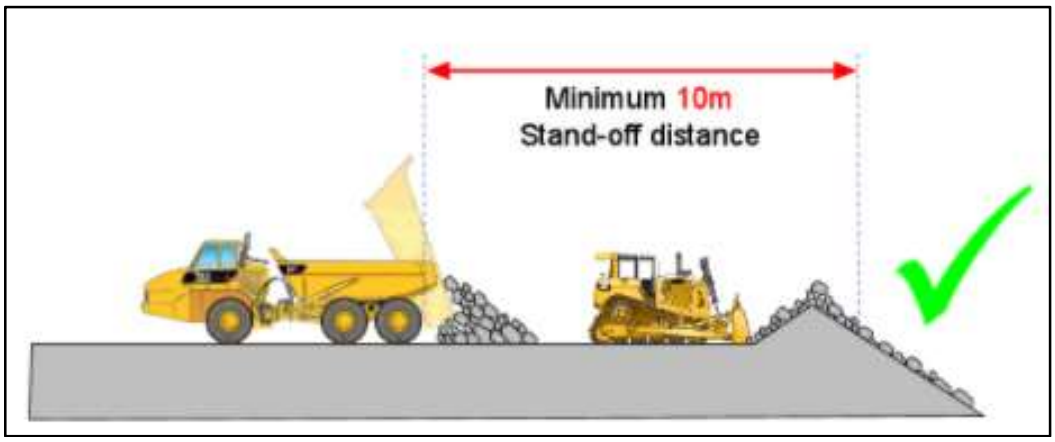


Stockpiling is a particular tipping activity, usually with free flowing materials. Where large stockpiles are generated, access ramps and tipping areas are provided on the top of these structures. Where installed, an access ramp should be a minimum of one and a half times the vehicle width with a gradient of 1 in 8.

In quarry applications in particular it is common for a single stockpile to be used for loading at its base at the same time that materials are being added to the stockpile from the top. In these circumstances the site operator should ensure that appropriate controls (ie bunding, stand offs etc) are in place to prevent undercutting and destabilisation of the tipping area.

The bunded edges of stockpile ramps are a particular high risk area for overturns, particularly if the ADT has to reverse up the slope. In the event that tipping is carried out on a sloping ramp, the driver should always drop the tipper body in a stationary position after discharge of the load.

Consideration to stand off (typically minimum 10 meters) between working ADT and dozer, direction of working and avoid zones of instability.



Weather - Changes in weather can dramatically affect the characteristics of road surface conditions and thus impact on ADT stability. Rainwater can soak into surfaces causing a softening of ground conditions. Equally, thawing of frozen ground can lead to softening conditions. Dry weather can create dust. Drivers and those supervising operations should be alert to changing weather conditions and change work practises and locations if, and when, the need arises.

7.0 Safe recovery of ADTs following overturn incidents

The focus of this guidance is on the prevention of ADT overturn events by adoption of good working practices. However, if a site operator is faced with an ADT overturn it is equally important to give guidance of the safe recovery of a machine post incident.

It is likely that the prevailing mind-set of a site operator who deems that ADT overturns are somehow 'routine' is also likely to be that recovery of the machine is also a routine event. ***In reality this is far from the case as the risk associated with vehicle recovery could in many cases be greater that the risk associated with the overturn itself***.

At many sites the approach in the past has been to right an overturned vehicle as quickly as possible using whatever equipment was available, usually with a hydraulic excavator and thus allow normal operations to proceed without delay. This is a poor and unacceptable practice for the following reasons:

- Persons may be put at unnecessary risk during the recovery operations if these are not adequately planned and supervised
- Further vehicle damage (and cost) may be incurred in the recovery operation if not properly planned
- An important chance to learn from the incident may be lost if the vehicle is recovered quickly – and with it a lost opportunity to prevent a future incident
- The machine may be put back into service without adequate safety checks
- The incident may be reportable to the HSE either as an injury incident or dangerous occurrence (if the incident was called by a fall of ground) and this may mean the scene needs to be left undisturbed until directed otherwise.

Safe steps in the recovery of an overturned vehicle

It is not possible to give comprehensive guidance on the recovery of an overturned ADT. Although common modes of failure can be identified each event is unique and should be treated as such. However, the following steps should be considered before any attempt is made to right the vehicle:

Immediate actions:

- Make the area around the vehicle safe - this will almost certainly mean suspending all other mobile plant activity in the area around the vehicle. In the event of cab overturns consideration should be taken to prevent or contain possible leaks of fuel or hydraulic oils.
- In the event of serious injury or dangerous occurrence and likely RIDDOR reporting of the incident consideration should be given to making the area an exclusion zone pending investigation / advice from HSE.
- Even if the ADT driver appears to be unhurt they should be prevented from operating other machines until they have been assessed for the effects of shock etc. Particular care should be taken in the event of cab overturns to ensure the driver has no effect of concussion or other hidden injury.
- It is now common for many UK operators to carry out Drugs and Alcohol testing of employees involved in significant incidents such as an ADT

overturns. This is to be recommended as it can be used to rule out this as a possible causal factor.
- A comprehensive statement of events should be taken from the driver and any other witnesses as soon as is practically possible after the event.
- A comprehensive photographic record of the event should be made including the approach areas to the incident site itself.

Planning the recovery operation:

- The recovery operation will *always* require the completion of a formal and recorded assessment of risk, together with a Safe System of Work (SSOW). The operation should be closely supervised by a suitably competent and experienced person.
- The SSOW should detail exactly how the machine is to be righted, who is to carry this out, and what controls are to be put in place to control the hazards identified in the risk assessment
- Consideration should be given to the experience of the site team in relation to previous similar events. Any risk assessment or SSOW documents from previous events should be reviewed and learnings applied to the current recovery operation. In the event that the site team have not got the required competencies to effect the recovery themselves, guidance should be sought from off site.
- Subject to suitable risk assessment a correctly sized hydraulic excavator *may* be appropriate to right the overturn – particularly if this is a body only event.
- In some cases it may be deemed necessary to utilise the services of a specialist heavy plant recovery company.

The recovery operation:

- In the case of a skip overturn it is usually good practice to remove as much of the remaining material from the dumper body as possible – this will minimise the load for the recovery machine(s).
- The parking break should be applied *before* the machine is righted.
- A rigorous exclusion zone should be enforced around the machine for the duration of the recovery operation.

After righting the vehicle:

- A comprehensive examination of the machine by a suitably competent person should be undertaken prior to any attempt to move it under its own power.
- The machine should be taken to an appropriate workshop or similar safe area to be thoroughly checked over before consideration is given to put it back into service. This is particularly the case in cab and whole machine overturns.
- Brake efficiency, tyre pressure and condition etc should also be noted at this point as these may be factors to consider when determining the cause of the incident. It may also be appropriate to download any vehicle telemetry data if the vehicle has this facility as this can be used to determine speed etc at the time of the incident.

Post incident investigation:

- It is vital that every overturn incident is investigated as a *high potential* incident and that the root causes of the incident are determined.
- It is often far too easy to attribute root cause as ‘driver error’. This will often overlook other causational factors that were in the direct control of the site management.
- Learnings from the investigation should be incorporated in future working at the site and shared with other sites and wider industry bodies as appropriate.

Subject to a comprehensive risk assessment a suitably sized hydraulic excavator may be appropriate for the recovery of an overturned dumper body – however, each incident should be assessed separately before deciding on the recovery method to be used

8.0 Summary

The ADT is a versatile and common workhorse of the quarry, surface mining and construction sectors and is likely to remain so for the foreseeable future.

However, from a safety perspective its versatility and ease of use means that site operators may become complacent in terms of adequately assessing the risks associated with their use. In particular the potential for damage and injury resulting from body and cab overturns is often overlooked and learnings from previous incidents are not adopted.

This guidance maintains that ADT overturn incidents are a wholly predictable and preventable occurrence when the operator takes into consideration the principles of Safe Driver, Safe Machine and Safe Environment.

By adoption of these principles the responsible operator will be able to manage the risk appropriately and minimise the potential for losses as a result of lost production, damage to equipment and injury to members of the workforce.

The responsible operator should also be aware of the changes in technology and how they have the potential to make ADT operations even safer. The increasing use of driving simulators, inclinometers and ejector bodies may likely become the standard practice of the future as opposed to the 'good practice' of today.

Technology in action – ADT driver simulator

9.0 Appendices

9.1 Examples of some key causal factors in ADT rollover incidents

1. **Material Stuck in the tailgate**

Impact – material hangs in tailgate moving centre of gravity to extreme rear of ADT. Causes cab wheels to lift off ground and cab rolls over

2. **Block tipping (rear wheels up tipping pile)**

Impact – Rear wheel rides up tip on one side only moving centre of gravity to one side. Causes rear of vehicle to overturn as skip is raised.

3. Poor haul road design & maintenance

Impact – cross-fall on road plus poor and uneven running surface results in rear or complete machine overturn.

4. Careless driving on an otherwise well maintained road

Impact – wheels on one side drop into drainage ditch causing overturn of vehicle.

Driver distraction leading to error may be root cause but consider impact of haul road widths and fatigue as possible contributory factors?

5. Excessive speed

Impact – excessive speed increases chance of driver error and increases likelihood of overturn if truck impacts banking on edge of road.

Potential for injury is much increased with speed.

6. Soft-spots in tipping area

Impact – soft surface material moves under action of drive wheels creating instability and dynamic loading. Results in cab or skip overturn

7. Runaway vehicle

Impact – vehicle ‘runs away’ whilst descending a slope due to mechanical failure or incorrect use of retarder or brakes.

High potential for serious or fatal outcome.

8. Incorrect use of Diff-lock

Impact – incorrect use of diff-lock mechanism causes machine to lose traction and skid on slope.

9. Sticky material in raised body

Impact – material hangs in body of machine as skip is raised causing centre of gravity to shift to one side. Overturn more likely if combined with uneven or sloping tip point

10. Tipping down a slope

Impact – Centre of gravity moves to extreme rear of the ADT as skip is raised causing cab wheels to lift of ground. Cab turns over.

11. Skip unbalanced due to movement of wet slurry load

Impact – centre of gravity moves as material ‘slops’ in skip body in response to movement of the machine. Combined with uneven ground, excess speed, or sharp cornering this may send skip body over in lowered position.

9.2 Useful references

The following references may be of use to increase understanding of issues related to ADT safety in quarries, mines and construction sites:

Health and safety at quarries - Quarries Regulations 1999
Approved Code of Practice and guidance
HSE Books – L118
www.hse.gov.uk/pubns/books/L118.htm

Ground Conditions for Construction Plant
Construction Plant Association
www.cpa.uk.net/sfpsgpublications/

Traffic Management in Quarries
QNJAC Guidance
www.qnjac.co.uk/qnjac-guidance/plant-fixed-and-mobile/traffic-management-in-quarries/