Code of Practice: Transportation, off-loading and storage of bitumen, bituminous products and asphalt in transit

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sabita

excellence in bituminous products

MANUAL 25

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PREFACE

The general properties and characteristics of bituminous products that could give rise to Health, Safety and Environmental hazards and effects are well documented in other Sabita publications and are not repeated in this document. This document should therefore be used in conjunction with Sabita Manual 8 - *Guidelines for the safe and responsible handling of bituminous products.*

This document deals specifically with the operational procedures necessary to maintain control over the Health, Safety and Environment, as well as the general quality control aspects arising during transport, offloading and storage of bitumen and bituminous products, and asphalt in transit.

The loading of bitumen is addressed in a separate Sabita publication. This document should therefore also be used in conjunction with Sabita Manual 23, Code of Practice: *Loading bitumen at refineries.* Reference should, also be made to the Occupational Health and Safety Act and Regulations, The Road Traffic Act (Including AARTO Regulations, 2008) and other relevant legislation to assure that users remain current with legal developments.

Note:

The application of coal tar products is no longer considered acceptable practice since their use in road construction introduces undue health and environmental hazards. Sabita therefore does not endorse their application and reference to this material is excluded from this document.

GLOSSARY OF TERMS

Term/abbreviation	Description
ALARP	As Low as is Reasonably Practicable
“asphalt”	A mixture of predetermined proportions of aggregates, reclaimed asphalt, filler, bitumen and other agents which are heated and mixed together in a specialised mixing plant ready for road construction.
“bitumen”	A viscous or semi-solid black or brown substance derived from the distillation of crude petroleum oil. Bitumen softens when heated and is pumpable at 120 °C or more;
“bituminous binder”	Includes paving grade bitumen, cutback bitumen, bitumen emulsion and modified binders used in road construction and maintenance;
“boil over”	The rapid increase in volume caused by the presence of water in hot bitumen and the subsequent overflow of bitumen from a tank;
“bulk road tanker”	A vehicle designed, manufactured and equipped in accordance with recognised and acceptable standards and specifications, and in this context specifically for the transport of Bitumen;
“consequence”	A consequence is a potential event resulting from the release of the Hazard which results in adverse effects i.e. directly in loss or damage;
“control”	A Control is any measure (barrier) put in place to act against some undesirable force or intention, in order to maintain a desired state. Controls can be pro-active (preventive) or re-active (recovery or mitigating) measures;
“cutter”	An additive which is blended with bitumen to temporarily reduce the viscosity of the bitumen to assist spraying e.g. paraffin;
“driver”	In the context of this CoP, the person who is solely responsible and accountable for the safe operation of a Bulk Road Tanker transporting and offloading bituminous binders;
"driving time"	Means any period of time that the *driver* of a motor vehicle contemplated in the regulations, occupies the drivers' seat of such motor vehicle, whilst such motor vehicle is being operated on a public road or occupies the drivers' seat of such motor vehicle, whilst the engine is running.;
“earthing” and “earth cable”	The connecting of an insulated object to earth, so that external electric charges are conducted away and do not accumulate on the object;
“hazard”	The potential cause of harm to people, assets, the environment or company reputation;
“heating flues”	An oil or gas fired burner with a wide bore pipe which is fitted to a binder tank for heating purposes;
HSE	*Health, Safety and Environment* as used in the context of managing the aspects of: Occupational Hygiene and Safety of persons at work; The health and safety of persons in connection with the use of plant and machinery; The protection of persons other than persons at work against hazards to health and safety arising out of or in connection with the activities of persons at work; The protection of the environment against adverse effects arising out of or in connection with the activities of persons at work;
“incident”	An event or chain of events which has caused or could have caused injury, illness and/or damage (loss) to assets, the environment or reputation of the organisation;
MSDS	Material Safety Data Sheet
“naked flame”	All uncontained flames, fires, exposed incandescent materials and welding arcs;

Term/abbreviation	Description
“practice”	Accepted methods or means of accomplishing stated tasks;
“procedure”	A documented series of steps to be carried out in a logical order for a defined operation or in a given situation;
"resting period"	Means the period of time that the driver of a motor vehicle contemplated in the regulations is required to rest or taking time of driving, after exceeding the prescribed driving time, within the prescribed maximum driving time in a period of 24 hours;
“risk”	The product of the likelihood that a specified undesired event (consequence) will occur and the severity of the consequences of the event;
“source of ignition”	Naked light, fires, exposed incandescent materials, electric welding arcs, lamps not of the approved pattern, sparks and flames produced by other means. They all provide temperatures in excess of the ignition temperature of a flammable substance;
“threat”	The causal factor (act/emission/condition) that could cause the “top event” or “initiating event”;
“trem card”	Transport emergency card. Used for vehicles carrying dangerous goods;
“ullage”	The amount by which the tank falls short of being full (i.e. “free space” available in a tank/compartment/container);

INTRODUCTION

SABITA and its members strive towards operating in accordance with accepted industry standards to assure that best available techniques and technology are applied during the entire process of production, handling and application of bitumen and bituminous binders.

Bitumen is delivered hot (up to 230˚C) and frequently under pressure. Therefore, exercising extreme caution and correct handling of bitumen helps minimise risk of burns or other injury to those associated with deliveries as well as damage to the environment or equipment.

In South Africa the transportation of dangerous goods by road is governed by a number of statutory requirements. Not all bituminous products are by definition "dangerous goods" however, the activity of transporting bituminous products in a potentially "hostile public road environment" requires sound management practices to assure the safety of employees and society in general.

This code of practice is intended as a guide to ensure that the potential risks associated with the activities of road transportation and offloading of bitumen, bituminous binders and asphalt are managed to as low as is reasonably practicable, including the risks of poor product quality associated with transport activities.

Incorrect practices during the handling of bituminous binders and asphalt can be detrimental to the quality of the paving mix. Contamination by small amounts of solvents or different grades of bituminous binders can have serious adverse effects on the quality of the binder. Likewise, contamination of, and excessive heat loss in the asphalt mix delivered to the paving site, can be detrimental to the quality of the paving mix.

Such adverse effects often only manifest themselves once the final product has been applied. It is therefore of the utmost importance that product quality is maintained by ensuring that bituminous products and asphalt are handled in a standardised way, and that possible sources of contamination or practices that could affect quality are identified and eliminated from the outset.

The code of practice therefore includes, where necessary, testing and sampling practices as relevant to the activities of transport and offloading bitumen and bituminous binders.

SCOPE OF ACTIVITIES COVERED IN THIS CODE OF PRACTICE

The general regulatory requirements in connection with Operators, Bulk Road Tankers, and Tanker Drivers, including the industry operational standards are well documented in the SABITA *Manual 23: Code of Practice – Loading of Bitumen at Refineries* and will not be repeated in this document. This code of practice will focus on the activities as outlined below:

Transport (road haulage) of bitumen and bituminous binders from the point of exit at a loading facility to the point of delivery (discharge) at an asphalt production facility.

Offloading bitumen and bituminous binders into storage tanks at an asphalt production facility.

Transport (road haulage) of asphalt from the asphalt production facility to the paving site.

Notes:

For purposes of this code of practice it is assumed that all the necessary requirements for load authorisation, load quantity and quality certification, and vehicle and driver fitness, have been complied with during the loading process;

The spraying operation of bitumen at a road site, is explicitly excluded from this code of practice.

1. TRANSPORT AND OFF-LOADING OF BITUMEN

Note: Delivering contaminated product to a customer can have serious adverse consequences. Almost without exception substandard quality bitumen and bituminous binders will result in severe financial loss to the bitumen supplier or haulier.

1.1 GENERAL QUALITY CONSIDERATIONS FOR TRANSPORT AND OFF-LOADING OF BITUMEN

Quality assurance of bitumen and bituminous binders requires attention to some specific quality control measures throughout the entire supply chain. Incorrect handling during transport and delivery operations can quickly undo the strict quality assurance provided at the manufacturing source. However, awareness and the application of some basic control measures during transport, storage and handling will ensure that the risk of substandard quality is managed to as low as is reasonably practicable. Quality issues typically arise during the following activities:

- Loading (at manufacturing or intermediate storage facility)
- Heating
- Switch loading (contamination)
- Cleaning (flushing tanks and transfer hoses)
- Transport/haulage
- Off-loading (product discharge at destination)
- Sampling

1.2 PRODUCT COMPATIBILITY AND CONTAMINATION

Bitumen and bitumen emulsions are not compatible. A violent reaction will be created if these two are mixed. The paving grade bitumen or emulsion will also be contaminated and the customer will not be able to use it.

As far as is reasonably possible dedicated Road Tankers should be used for transporting specific bituminous binders in order to minimise the likelihood of contamination between different products and grades of products.

However, the need to change from one product to another will arise from time to time. In such cases specified precautions must be taken and flushing procedures adhered to if any possibility of contamination between incompatible products and the resulting effect on product quality, as well as possible boil-over, is to be avoided.

With this revision it became clear (from comments by reviewers) that there is difference of opinion on the switch loading and flushing methods/procedures applied by the Industry in Southern Africa. It was therefore deemed necessary to revisit this aspect to ensure that this publication provides information which is up to date and in-line with internationally accepted best practice.

The main differences seem to be:

- Using water as a flushing medium (potential for violent boil-over); and
- Switching between Emulsions and Bitumen or any other bituminous product.
- After thorough research of current international practice, it was concluded that only minor adjustments are required and the flushing procedure and Table 1 was revised accordingly.

1.2.1 Switch loading and Flushing

Paving and hard grade bitumen may be switch loaded. However, if bitumen emulsion is to be loaded into a tank that has contained bitumen, it is necessary to drain as much bitumen as possible from the tank, after which the

tank and pipeline should be flushed out with MC30, paraffin or diesel to remove any remaining residue. Surplus MC30, paraffin or diesel fuel should be flushed out with water.

Care must be taken when switching between paving or hard grade bitumen and cutback bitumen, as product properties could be adversely affected if the previous load has not been drained properly. Flushing is however not required, providing the tanker was totally empty after discharging.

If it is intended to load cationic emulsion after anionic emulsions have been carried (or vice versa) then the tank must first be flushed out with water, followed by MC30 or diesel. Anionic and cationic emulsions must not be allowed to come into contact with each other, as immediate chemical breaking will take place.

Note: Flushing is always necessary when changing from anionic to cationic emulsion or vice versa.

Change of product may be carried out only when approved and supervised in accordance with the following procedure and flushing table:

- Park the tanker at the flushing point at the depot.
- Make sure that the valves and pipelines are clear before coupling up to the flushing plant. If the valves and pipes have to be heated, do this gently with the burner.
- Drain the tanker into the flushing plant tanks. It is recommended that the rear wheels of the truck tractor be parked on elevated ground to ensure more effective drainage.
- Pump about 6000 litres of flushing product into the tanker.
- Agitate the tanker contents by driving around for at least 15 minutes.
- Drain the mixture into the flushing plant.
- If further flushing is required, proceed with the process as indicated in the table.
- Check that the tanker is clean and free of previous product, water and residue. ***Note: See boil-out procedure in 1.2.2 if presence of water is still suspected.***
- Check that the valves and pipes are clean.
- The tanker is now deemed clean and fit to proceed to the loading point.
- To prevent contamination of product, ensure that all flushing material is drained out of the tanker.

1.2.2 Boil-out procedure for suspected presence of water in products (excluding emulsions)

If it is suspected that water may be present (not visible when tank/s are inspected) the following procedure is recommended to prevent boil-over:

- Personnel involved in the loading MUST BE POSITIONED AT GROUND LEVEL and must be fully clothed with the required PPE.
- SLOWLY transfer a quantity of product up to a maximum of approximately 25% of the tank capacity into the tank.
- Whilst filling is in process, carefully listen for any unusual sound (a “crackling” noise similar to that heard when frying potato chips in hot oil) coming from within the tank. STOP LOADING IMMEDIATELY if this noise is heard.
- If practicable, leave the tank lid open and drive around in the depot yard to agitate the mixture in the tank and assist with rapid water dispersion and boiling-off.
- If driving around the depot is not practicable, park the vehicle in a safe place and wait for at least one hour and check if the “crackling noise” has ended.
- If no more noise is heard, continue with loading of product as usual or otherwise allow more time for boil-out to complete.

Table 1: Flushing table

Product last loaded	Product next loaded				
	Paving and modified bitumen	Cutback bitumen	Anionic bitumen emulsion	Cationic bitumen emulsion	Fuel oil
Paving and modified bitumen	-	A*	A	A	A*
Cutback bitumen	C	-	A	A	C
Anionic bitumen emulsion	A	A	-	B	A
Cationic bitumen emulsion	A	A	B	-	A
Fuel oil	A	A	A	A	-
Suspected presence of water	D	D	-	-	D

Procedures corresponding to symbols in table:

A: Drain vehicle of product and flush with MC30, paraffin or diesel.

**** This operation is not required if tank/s and lines have been thoroughly drained.***

B: Flush out surplus product from the tank/s with water until it is not discoloured, and drain tank/s and lines; flush with MC30, paraffin or diesel; flush out surplus MC30, paraffin or diesel with water (about 450 litres per tank/compartment) and drain tank/s and lines.

C: Ensure tank/s and valves are thoroughly drained and inspect tank/s for visible signs of water.

D: Follow the boil-out procedure described in paragraph 1.2.2 above.

1.3 THE EFFECTS OF HEATING

Bitumen is a poor conductor of heat. With LP gas heating, the temperature on the surface of the flues can easily reach 500 ˚C, and it is therefore important to circulate the binder while heating, especially in the case of modified binders. Localised over-heating can cause carbon to form around the flues and/or degradation of the polymer in the binder. This can lead to blocked nozzles when spraying and/or premature hardening of the binder.

If binders are stored for long periods above their application temperatures, a loss in quality may occur. Maximum storage and spraying temperatures should not be exceeded. (See Sabita Manual 8, Table 3 on page 24 for recommended Time and Temperature limits for binders).

1.4 EMULSIONS AND MODIFIED BITUMEN

- Must be loaded through a sieve to remove any lumps which may have formed.
- When filling a tank, the emulsion must not be allowed to fall from a height as this will damage the emulsion. Ensure loading arm extends to bottom of top load tanker compartments.
- Positive displacement pumps cause shearing of the bitumen droplets, and thus damage the emulsion if not hot - i.e. Above 50 ˚C. Impeller, centrifugal or low-shear pumps are best for pumping emulsions.
- Only heat the emulsion just prior to pumping.
- Emulsion must be circulated for a short period (30 minutes) daily to prevent settlement.
- Continued heating and/or circulation of polymer modified bitumen (especially with a gear pump) will cause the bitumen droplets to agglomerate and the polymer to separate.

1.5 SAMPLING

Sampling and testing of bitumen and bituminous binders is a vital function to verify that the desired product quality is maintained throughout the supply chain cycle. Care should be taken to prevent contamination of product during sampling. Ensure that suitable clean and dry sampling equipment is used.

1.5.1 General sampling method and precautions

Samples are drawn at various stages of the cycle and should be done from a dedicated purpose designed sampling cock in the tank side or delivery line. Where there is no suitable sampling cock available, a sample shall be taken from the top of the tank or road tanker compartment by lowering a weighted sampling can or thief sampling can, as appropriate, into the material.

Sampling must be carried out by a competent, trained person in accordance with the sampling process based on the requirements of ASTM D140 and any additional aspects specified in TMH 5.

The following general safety precautions shall apply:

- Always use the correct PPE, i.e.:
  - Head and neck protection: Hard hat (preferably fitted with chin strap), a neck apron or suitable heat resistant Balaclava.
  - Face protection: Goggles and a full-face visor.
  - Overall: 100% cotton fire retardant, preferably with high visibility markings and legs to be worn over boots;
  - Hand protection: Heat-resistant gloves with long sleeves.
  - Foot protection: Safety boots that can be removed easily.
- There shall be no smoking while sampling.
- Containers shall not be held in the hand while sampling and sealing. Tongs, or some other device, shall be used to hold the containers while the sample is being taken.
- The sampler shall, as far as practical, stand above and away from the sampling valve or outlet and on the windward side.
- The sample shall be taken slowly and carefully to prevent splashing of the material.
- The container shall be placed on a firm, level surface to prevent splashing, dropping or spilling.

General sampling procedure and precautions:

- Sampling valves should be locked to prevent accidental or unauthorised tampering.
- The contents of the tank, tanker or trailer must be thoroughly circulated before sampling.
- Samples must be taken in clean two litre or five litre tins, free from solvent or other bituminous binders. Glass or plastic containers may be used for emulsions.
- Sample size must be at least 1,5 litres unless specified otherwise.
- Care shall be taken to prevent contamination of the samples with solvents, cleaning fluids, or different types of bituminous materials.
- Between sampling and testing, the sample shall not be transferred from one container to another if this involves reheating of the sample after cooling.
- Where a tin is used, the sample container shall be tightly and positively sealed immediately after the sample is taken.
- The sample container shall not be submerged in solvent, nor shall it be wiped with a solvent-saturated cloth. Any spilled materials on the outside of the container shall be wiped with a clean dry cloth immediately after the container is sealed.

- Samples must be allowed to cool before sealing. Ensure that lids are airtight and cannot become dislodged during transit. All samples must be labelled as indicated below. Labelling must be on the container, not on the lid.
- Heat must not be applied to samples, except when required for testing. Samples should be stored at moderate ambient temperatures. This is particularly important in respect of emulsions and cutbacks, as extreme temperatures could change the properties of these products.

Sample labelling:

Samples, marked with an indelible marker, must contain the following information:

- Grade of bituminous binder.
- Date and time when sample was taken.
- Refinery or supplier.
- Batch number of the product.
- Transporter.
- Registration numbers of tanker and/or pup trailer.
- Delivery note number.
- Temperature of product.
- Name of person taking the sample.

Sample volumes must be large enough to ensure that at least one litre can be retained, after testing, in case additional testing is required to resolve a dispute. Retained samples should be kept for a minimum of six months, unless a longer period is specified. It is the responsibility of the customer to ensure that samples are clearly marked and stored for the agreed period of time in a manner that would enable easy and rapid retrieval.

Sampling at a secondary manufacturer:

When paving grade bitumen is emulsified or modified at a binder factory, samples of the base bitumen and the processed binder product must be taken to check for compliance. The sampling of the base bitumen must be done during offloading of the tanker in accordance with the procedures described above.

The secondary manufacturer must keep retained samples of the processed product, after testing, in case additional testing is required to resolve a dispute. Retained samples should be kept for a minimum of six months, unless otherwise specified. These samples must be clearly marked and readily available if required for testing.

Labelling of the retained samples must contain the following information:

- Sample number;
- Type and grade of product;
- Date and time when sample was taken;
- Batch number of the product;
- Tank number;
- Base bitumen details;
- Temperature of product; and
- Name of person taking the sample.

1.5.2 Quality testing and certification

A laboratory certificate must be provided with each load of bitumen supplied by a refinery. The laboratory certificate should be attached to the weighbridge certificate and handed to the consignee by the driver.

The same applies to the supply of bitumen emulsions or modified binders from a secondary manufacturer, the latter shall also supply a copy of the laboratory certificate for the base bitumen together with the modified binder

laboratory certificate. It is the consignee's responsibility to ensure that products delivered are sampled and tested to ascertain compliance with the relevant specification.

Minimum testing requirements for the different binders are:

Product	**Test**
Paving grade bitumen	Penetration and softening point
Cutback bitumen	Viscosity at 60˚C
Bitumen emulsion	Binder content
Polymer modified binder	Softening point
Bitumen rubber	Haake viscosity at 190˚C

The customer shall immediately (ideally within one day of delivery) notify the haulier in writing should results be found to be out of specification or differ significantly from the results supplied by the refinery or supplier. Instant action should include the immediate isolation and suspension of the use of the tank containing the suspect product, joint independent re-testing and correlation testing. The haulier shall, by all means possible, investigate the probable cause of contamination.

Table 2: Recommended sampling and testing regime

Source	**Sample taken from**		**Type of binder**	**Tests required**
	Supplier tanker	**Haulier**		
Refinery	Yes		Paving grade	Full batch
	Yes		Cutback	Full batch
Secondary manufacturer		Yes	Paving grade	Penetration; softening point
		Yes	Cutback	Viscosity @ 60˚C
	Yes		Emulsion	Full batch
	Yes		Modified	Full batch
Asphalt plant or site		Yes	Paving grade	Penetration; softening point
		Yes	Cutback	Viscosity @ 60˚C
		Yes	Emulsion	Binder content
		Yes	Polymer modified	Softening point
		Yes	Bitumen rubber	Haake viscosity @ 190˚C

Notes:

Full batch infers the full spectrum of tests required in terms of the manufacturer's quality management system, although in some cases some tests may only be required on a frequency basis. Compliance of these test results to the product specification and the reporting thereof constitutes the laboratory certificate which is a prerequisite for the release of the product.

In the case of the haulier these are the minimum tests required but do not prohibit the consignee from doing additional quality control testing on the product sample.

1.6 ROAD SAFETY PLANNING FOR TRANSPORT OF BITUMEN AND BITUMINOUS BINDERS

The transport of bitumen and bituminous binders invariably involves haulage over relatively long distances and routes may include congested traffic and "hostile" road conditions. The need for road safety is a challenge for which there are no easy solutions. The risks associated with driving are high and in particular, Southern African road conditions present major challenges to transport operators. Road Transport, however, can be proactively managed to ensure that the inherent risks are as low as reasonably practicable ("ALARP" level).

Dealing with the challenges of Road Transport demands a risk-based approach. It is therefore essential that local hazards and risks are identified and appropriate risk reduction measures taken. Journey management for Bitumen Road Tankers is one such risk reduction measure and to this end, managers and supervisors responsible for Road Transport must have a good knowledge of the geography of and road conditions in their operational areas.

Note: It is highly recommended that bitumen transport operators include journey management policies and procedures as an integral part of business planning to ensure that associated risks are managed to an acceptable level.

1.6.1 Driving and Duty Hours

Driver fatigue is a major contributing factor in vehicle accidents and should be a key component of the journey management process. Maximum daily driving and on-duty hours should, as a minimum standard, always be within the country legal requirements.

Daily driving and on-duty hours for Heavy Goods Vehicle operators in SA are currently regulated only by various Industry Sectoral Determination agreements and may therefore vary. Requirements are under consideration for inclusion in National Road Traffic legislation but have as yet not been promulgated. In the absence of clear legal prescriptions, the requirements specified below are recommended as the minimum standard to be adopted by Bitumen Transport Operators:

- Maximum hours on duty during any 24/hour period: 15 hours (less a minimum half-hour break).
- Maximum weekly on-duty hours – 90.
- Maximum period of continuous driving: 2,5 hours.
- Minimum break after working a maximum of 5,5 hours: 30 minutes.
- Minimum daily rest period between working shifts: 9 consecutive hours. The rest must be taken in a continuous block and either away from the vehicle or, if taken in a sleeper cab, while the vehicle is stationary.

Notes:
Should a bulk truck driver's working hours be regulated, this will supersede what is contained in this manual.
Irrespective of any legal limits, or the limits specified above, drivers must not drive or be requested to drive when feeling tired. If they become tired while driving they must stop and take a sufficient break in accordance with good fatigue management practice before continuing.

1.6.2 Journey Management

Why Journey Management?

Journey Management is used to prevent undesired HSE consequences of land transport journeys. Supervisors responsible for individuals driving on company business are accountable for preparing or approving a Journey Management Plan (JMP). Vehicle operators driving a Bitumen Road Tanker are responsible for meeting the requirements of a JMP when required.

Note: As a minimum requirement all trips which contain continuous driving in excess of 3 hours should be subject to a risk assessment and, if necessary, case specific journey management plans instituted to ensure that risks are at the ALARP level.

What is Journey Management?

Journey Management is a process for planning and executing necessary land transport journeys in compliance with all HSE requirements. Journey Management can be broken into three phases:

Plan the Journey

A key deliverable of the journey management process is the JMP. Typically, a Dispatcher or a Journey Manager compiles the JMP. Prior to executing the journey, the Driver needs to be fully briefed on the journey and the associated risks and mitigating measures as documented in the JMP.

The aspects that are addressed in the planning of the journey include (amongst others):

- Assuming that the trip is necessary, decide when to drive and determine driving and duty hours, including rest breaks;
- What vehicle to use and is it suitable and in proper condition;
- Required driver skills and competence; and
- What route to take and where to make rest stops.

Execute the Journey

Drivers are responsible for executing journeys in line with the agreed JMP, but others may need to play a role as well. For example, the JMP may include preparations for a 'Man Lost' procedure that may need to be started by the Journey Managers. This is relevant when driving through deserted or hostile areas, including areas without mobile phone coverage.

Close-out of the Journey

Closing-out the journey simply means that a process of review takes place at the end of the journey. The aim of this process is to confirm that the objectives of the journey were met, or otherwise, and it enables the capture of lessons that can help to improve the journey management process and/or plan for future journeys. It is therefore recommended that a debriefing session is conducted as soon as practicable after the end of a journey.

1.6.3 Journey plans

Journey management plans and controls should include at least the following elements:

- Competent person to supervise journey management plans and procedures.
- Routes between supply points and major destinations must be drawn up using an effective journey management system in order to avoid unsuitable roads and congested areas as far as practicable.
- Night driving restrictions when risks of night driving are demonstrably higher.
- Known hazards, such as steep gradients, narrow bridges and poor road surfaces *en route* to be identified.
- Route hazard maps to be produced and made available to drivers.

Note: The SA National Road Traffic Regulations 281 (2) (b) requires the driver of a vehicle carrying 'dangerous goods' to produce on demand "a document containing a clear indication of the route to be followed by the vehicle, planned in accordance with code of practice SABS 0231 "Transportation of dangerous goods – Operational requirements for road vehicles"

- Journey times must be established for such routes and rest and reporting points designated on long routes which will exceed normal driver shift time (shift start times designed to avoid excessive exposure to peak hour traffic).
- Resting points where suitable accommodation is available to be designated by management.
- Trip time and any other special route hazard information to be given to driver with customer invoice paperwork.
- Temporary route hazards such as road-works displayed on notice boards in driver rest rooms.
- Weekly tool-box meetings with drivers to discuss route hazards and other safety issues established as a normal practice.
- Procedure for activation of emergency reaction plans.

1.6.4 Journey execution – Best practice "arrive intact" guidance

Getting behind the wheel and driving a Bitumen Bulk Road Tanker loaded with hot bitumen assumes enormous responsibility and a duty of care towards other road users, the general public and the environment en-route during a bitumen delivery. Applying the following "on the road" best practice guidance should reduce the risks associated with bitumen road transport incidents to as low as is reasonably practicable:

Pre-departure

- The vehicle and driver are compliant in accordance with the "fitness to operate" requirements of the SABITA Code of Practice, Loading of bitumen at Refineries.
- The driver has been fully briefed with regards to the journey plan and updated road hazard information for the planned route.
- All required trip/load documentation is on board and securely stowed in the cab of the vehicle (all documents pertaining to the load, should be stored in a fixed orange box clearly marked "DOCUMENTS").
- Where the vehicle is equipped with a burner to heat the load, ensure that the burner is SHUT DOWN before departure.

En route to destination

- Burners MUST NOT be operated when the vehicle is moving. If heating of the load is required en-route the vehicle must be stopped in a safe location and the correct procedure for heating operations followed. NEVER leave the vehicle unattended whilst heating of the load is in progress and keep a close watch on the burner during the process.
- Adhere to defensive driving techniques whilst on-the-road and in particular observe speed limits and appropriate following distances as dictated by weather and road conditions.
- Strictly follow the planned route as per the agreed journey plan however, also exercise sound judgement and do not hesitate to contact the despatch control centre/supervisor to report adverse conditions and request permission to deviate from the planned route if required in the interest of safety.
- In the case of imminent adverse weather conditions (heavy rain, thunder activity, high winds, sleet/snow, mist/fog/veld fires causing poor visibility, etc) find a safe location to park, secure the vehicle, and report to the despatch control centre/supervisor to discuss/agree on action until conditions change for the better.

Actions in the event of an accident or emergency

In the event of an accident or emergency en route, take the following actions where safe and practicable to do so:

- Apply the braking system, stop the engine and isolate the battery by activating the master switch where available.
- Avoid sources of ignition, in particular, do not smoke or switch on any electrical equipment.
- Inform the appropriate emergency services, giving as much information about the incident or accident and substances involved as possible.

- Put on the warning vest and place the self-standing warning signs as appropriate.
- Keep the transport documents readily available for responders on arrival.
- Do not walk into or touch spilled substances and avoid inhalation of fumes, smoke, dusts and vapours by staying up wind.
- Where appropriate and safe to do so, use the fire extinguishers to put out small/initial fires in tyres, brakes and engine compartments.
- Fires in load compartments shall not be tackled by members of the vehicle crew.
- Where appropriate and safe to do so, use on-board equipment to prevent leakages into the aquatic environment or the sewage system and to contain spillages.
- Move away from the immediate vicinity of the accident or emergency, advise other persons to move away and follow the advice of the emergency services.
- Notify the despatch control centre/supervisor of the incident as soon as all emergency actions have been completed.
- Remove any contaminated clothing and used contaminated protective equipment and dispose of it safely.

Note: Refer to the SABITA Bitumen spill protocol – Version 1, August 2013 for the response plan established for bitumen spills resulting from incidents where bitumen is in transit on any public road or port within the jurisdiction of a municipal, provincial or national government authority.

Arrival at destination

- Stop the Road Tanker in a safe position and obtain permission to enter the site.
- Present the consignor's and haulier's documentation to the customer's representative to confirm/agree that the correct product is on board.
- Where available, determine the gross mass of the tanker on a weigh bridge and record the mass and temperature of the bitumen on the weighbridge certificate.
- Establish/confirm the correct receiving tank/s and proceed to the discharge point where the customer's representative should be in attendance.

Preparing for discharge of load

- Identify the correct storage tank to discharge to.
- Confirm that sufficient empty space (ullage) is available to discharge the full load into the receiving tank. Where automatic tank gauging is not available a dipstick shall be used to determine empty space.
- Ensure that at least two fire extinguishers of the correct type are strategically placed.
- Put on correct PPE, i.e.:
  - *Head and neck protection*: Hard hat (preferably fitted with chin strap), a neck apron or suitable heat resistant Balaclava.
  - *Face protection:* Goggles and a full-face visor.
  - *Overall:* 100% cotton fire retardant, preferably with high visibility markings and legs to be worn over boots.
  - *Hand protection:* Heat-resistant gloves with long sleeves.
  - *Foot protection:* Safety boots that can be removed easily.
- Place drip trays in position to contain spillages.
- Connect earth cable between the road tanker and site discharge pump set/manifold.
- Before connecting the discharge hose-coupling to the tanker, check that the discharge valve is not plugged with solidified bitumen If the product requires heating, check the fuel lines for damage before lighting the hand held burner. Carefully heat the valve to clear it if required.
- Switch on the Road Tanker's bitumen pump to ensure that the impeller is running freely. Switch pump off and apply further heat if the impeller does not run smoothly when switched on.

Discharging the load

- Discharge the load under constant control and observation. Two persons must always be present during the offloading process and the required safety regulations must be adhered to.
- Connect the discharge hose from the Road Tanker to the site discharge pump. Ensure that the seals are fixed in position in the pipe's female coupling; keep discharge valve in closed position.
- Open the manhole covers on the Road Tanker and the receiving tank. Keep in mind that if the tanker is on a severe incline overflow through the manhole could cause a spillage.

Note: Do not proceed with discharge if it is raining. Water ingress into the hot bitumen could cause frothing due to steam, and this could result in boil over.

- Open the storage tank inlet valve.
- Ensure burners on the road tanker and receiving tank are switched off before commencing with transfer of product. Secure the hand held burner in its correct stowage position.
- Open the tanker discharge valve slowly, activate the discharge pump and, when the bitumen begins to flow freely through the pump, open the tanker discharge valve to its maximum open position.
- If the load is a heated one, allow fifteen to thirty minutes after initial discharge to allow material to drain from sides of tanker.
- Visually inspect the Road Tanker compartment/s to ensure that the whole load is completely discharged into the customer's tanks.
- When the load is completely discharged, switch the pump off, remove the hoses and close valves and man hole hatches.
- Drain flexible hoses and store them on an incline to facilitate slow drainage into a quarter drum. This ensures empty serviceable hoses ready for the next operation.
- Replace and secure fire extinguishers and remove drip trays.
- Proceed to the weighbridge if applicable, and obtain a tare mass. Obtain the customer's signature on the delivery notes. Check all documents and visually inspect the vehicle and trailers for leaks.
- Return to the depot or to the nearest wash-bay, as instructed.

2. STORAGE OF BITUMEN AND BITUMINOUS PRODUCTS

INTRODUCTION

A variety of bituminous products is stored at a typical bituminous binder or asphalt production plant. The properties and characteristics of these products pose a risk to the health and safety of people handling the products, and in some cases the product could also pose a threat to the environment. Incorrect storage practices may also severely impact on the quality of bituminous products. This section provides guidance for safe operation and environmental protection in the operation, inspection and maintenance of storage facilities for bituminous products and heating oils.

Note:
For more detailed technical guidance on the subject, readers are encouraged to read this section in conjunction with:

- ***SANS 10089-1:2008 Edition 4.3, Part 1: Storage and distribution of petroleum products in above-ground bulk installations;***
- ***The Energy Institute Bitumen Safety Code, September 2005 4th edition;***
- ***Safe Handling of Bitumen: A Practical Guide, Nynas Bitumen Communications Dept, Belgium, October 2005; and***
- ***Guidance for Safe Bitumen Tank Management, Refined Bitumen Association Ltd, London UK.***

2.1 PLANNING OF BITUMEN BULK STORAGE FACILITIES

2.1.1 Types of storage tanks

*(*Tank design specifications are not discussed in this document except to emphasise that tanks should be designed in accordance with a recognised standard e.g. API 650).

Typically, storage tanks will comprise a vertical cylindrical shell with a conical roof. Vertical tanks yield the highest bitumen-to-tank volume ratio of all tank configurations. Vertical tanks with cone-shaped roofs are preferred, although temporary storage in horizontal tanks is acceptable.

At mobile/temporary asphalt plants, hot bitumen may also be stored in insulated horizontal cylindrical or rectangular tanks (Isotainers and Bitutainers). The use of Iso/Bitutainers is currently not widespread in South Africa, but this trend could change in future due to increased bitumen imports.

Typical bitumen storage tanks are pictured above

2.1.2 Siting and layout of a tank farm

When planning the siting and layout of tank farms (tank storage areas) it is important to consider the following aspects in the context of operational efficiency and emergency response:

- The fall of the ground in relation to other risk areas that could be exposed in the event of accidental large-scale spillages. This factor will determine the design and extent of secondary containment (bunding) to prevent spillage from migrating to other risk areas;
- Grouping and spacing of tanks in accordance with the hazard classification of stored products. (This will determine safety distances for fire prevention and fire-fighting purposes);
- Access for emergency responders and equipment (Fire-fighting); and
- Safe access for bulk road tankers that will off-load product to storage tanks.

2.1.3 Tank siting and secondary containment

As a basic engineering principle, it is accepted that tank farms will be sited on purposely prepared ground and that tanks will be erected on a solid base and level ground. Ideally, the entire site should be as level as possible with minimum slope for drain age in any direction. If these ideal design conditions prevail the calculation of secondary containment capacity may be done by applying the standard calculation formula i.e. the recommended volumetric capacity of the containment area is equal to the volume of the LARGEST TANK + 10%.

However, if the ground around the area on which the tanks are standing slopes downward from the tanks, the minimum height of the bund wall, or the surface area, must be adjusted to accommodate the desired volume within the containment area. (See SANS 10089 para graph 4.5.2.1 for more details of application of bunding).

Note: For cutback bitumen the provision of secondary containment is mandatory. However, it is good practice and highly recommended that sufficient bunding is provided for all classes of bituminous products and heating fuels.

2.1.4 Tank grouping and spacing

The first step for grouping and spacing of storage tanks is the determination of the hazard class of bituminous products. In accordance with SANS 10089-1:2008 Edition 4.3 the bituminous products and heating fuels stored at an asphalt plant may be classified as follows:

- Cutback bitumen in general use in South Africa fall into the following class:
  - Class II: liquids that have a closed-cup flash point of 38 °C or above, but below 60,5°C.

- Road grade bitumen:
  - Class IIIB: liquids that have a closed-cup flash point of 93 °C or above.

- Bitumen emulsions:
  - Unclassified.

Note: For cutback bitumen the provision of secondary containment is mandatory. However, it is good practice and highly recommended that sufficient bunding is provided for all classes of bituminous products and heating fuels.

2.1.5 Grouping and spacing of storage tanks for cutback bitumen (Class II)

Group together in the same bund and space as follows:

- Minimum shell-to-shell spacing of tanks with a diameter not exceeding 10 m should be not less than 2 metres. For tanks exceeding 10 m but less than 20 m diameter the shell-to-shell spacing should be increased to 3 metres;

- Minimum distance of tanks from the near side of a public road, or nearest building on the same property should be not less than 8 metres; and
- The minimum distance between any tank and the toe of the inside of a bund wall shall be at least 1.5 m.

2.1.6 Recommendation for road grade bitumen (Class IIIB) and bitumen emulsions (unclassified)

Road grade bitumen and emulsions do not pose a significant fire or environmental risk. For practical purposes road grades may therefore also be grouped with cutback bitumen. However, it is recommended that bitumen emulsion storage tanks are segregated from those containing cutback bitumen for the following reasons:

- Radiated heat from a major fire in adjacent cutback bitumen tanks could result in escalation of temperature above the recommended maximum of 85°C. This could lead to the unnecessary loss of product that could otherwise have ensured at least partial continuation of supply to customers.
- Due to the water content and lower boiling point (100°C) the bitumen emulsion could reach boiling point and boil over as a result of the radiated heat from the adjacent tanks on fire.

There is no prescribed distance for spacing emulsion tanks but it is recommended that the spacing as for other classified products is applied if available land space permits.

3. MANAGING THE CONTENTS OF TANKS

3.1 PREVENTION OF SPILLAGE DUE TO OVERFILLING

Numerous spills have occurred from storage tanks due to overfilling. Spillages from bitumen storage tanks have the potential to cause serious injury and, in the case of cutback bitumen, environmental damage. Most bitumen is stored at high temperatures which could result in serious burns if contact is made with the human skin or eyes. Spillage of cutback bitumen could lead to fires if an ignition source is present.

The main direct cause of overfilling is the incorrect determination or ignorance of the available ullage - i.e. empty - space in tanks. The probable underlying causes of this situation are listed below and, in each case, the recommended control measures are described:

Probable underlying cause	**Control measurers**
Lack of knowledge of tank capacity	• Tank capacities are clearly marked in a conspicuous place on the tank skin. • Tank farm operators are fully literate.
Use of incorrect tank dip tables and conversion factors	• Tanks have been properly calibrated and correct tank-specific dip tables are available. • Appropriate (IP approved) conversion factor tables are used. • Regular checks that correct tables are used.
Unsuitable or incorrectly applied tank measurement equipment	• Suitable dip tapes/sticks and paste for manual dipping of tanks are provided and used. • Operators have been properly trained and declared competent to use the equipment. • Regular checks (by observation) that operator skills are maintained. • The installation of automated tank measurement instrumentation should be considered.
Incorrect interpretation of tank contents measurement information	• Operators have been properly trained and declared competent to correctly record observed temperature, density, content measurements and interpret information. • Regular checks (by observation) that operator skills are maintained.
Poor communication between the delivery tanker driver and asphalt plant operating personnel	• A written communication system (register) is in place to ensure effective communication of tank content measurement and ullage information. • Delivery tanker drivers must witness and verify tank content measurements.
Lack of active supervision and monitoring during product transfer operation	• Plant operator monitors progress of transfer by regular tank dipping or (if installed) by observation of automated tank gauge.

3.2 CONTROL OF PRODUCT TEMPERATURE DURING STORAGE

3.2.1 Importance of correct storage temperature

Bitumen is practically solid at ambient temperature and to be transferred and applied it must be heated to and maintained at a temperature that will transform it to a liquid state. Keeping the binder at the right temperature is perhaps the most important goal of any bitumen storage facility.

If bitumen is thermally abused in storage, handling or application, it may harden and quality will be compromised. Bitumen emulsions pose particular challenges to ensure that the temperature is maintained at recommended levels. From a quality perspective, it is therefore essential that the product temperature is controlled correctly. When handled properly, bitumen may be reheated or maintained at elevated temperatures without adverse effects.

For the selection of a product's storage temperature, refer to the bitumen handling temperature recommendations given in Appendix 1. In the case of specialty products, e.g. hard bitumen grades, users should refer to the manufacturer's recommendations.

3.2.2 Effects of overheating in storage

The characteristics of bitumen products can change when stored for prolonged periods at high temperatures. Bitumen will gradually harden. The penetration, a measure of the bitumen hardness, may decrease by three to five units monthly. The hardening process will increase when higher storage temperatures are used, and in partly filled tanks where more air is present.

If the bitumen is overheated locally, deposits may be produced. These deposits appear on heating coils and other inner parts of storage tanks. After a while such deposits may be dislodged and interfere with pumping or mixing actions.

Bitumen emulsions require careful temperature control and should never be allowed to be heated above 80˚C. If any part of the emulsion gets hotter than 80˚C localised boiling may occur and severely compromise the quality of the emulsion.

3.2.3 Effects of under-heating in storage

Care should be exercised to ensure that the temperature at the bottom of an empty tank does not become so low so that it allows water vapour to condense.

An empty, cold tank should initially be filled gradually. This will give any remaining moisture time to evaporate. For tanks containing cold bitumen, heating should be carried out at a low rate until the bitumen temperature has reached 120˚C. This enables moisture to evaporate before hot bitumen is added to the tank. It is important that bitumen covers the heating tubes when heated.

It is recommended that tanks should be filled in three stages, allowing the temperature in the tank to reach equilibrium each time one-third portion has been loaded.

3.2.4 Tank insulation

Bitumen should be stored in well insulated tanks, which reduces the need for extra heating and will reduce heating costs. The temperature of the heating source can also be reduced, so that the bitumen will not be unnecessarily exposed to excessive contact temperatures.

4. GENERAL SAFETY CONSIDERATIONS FOR TANK FARM OPERATIONS

4.1 TANK MARKING

For identification purposes tanks should be marked individually with a unique number and the product grade. Additionally, cutback bitumen tanks should be marked 'danger flammable' on their shells and in visible proximity to vents and other tank openings.

4.2 AVOIDANCE OF BOIL OVER

To avoid the risks of boil over in bitumen tanks, particular care should be taken to:

- Remove water from pipework and other facilities before passing product through them to a tank already containing bitumen;
- Avoid ingress of water through open hatches and inspection covers on the roof of a tank, particularly during fire-fighting activities or during emergency tank cooling; and
- Ensure tank is free of water when it is returned to service after cleaning/maintenance.

4.3 ACCESS TO BITUMEN TANK ROOFS

Access by personnel to hot bitumen tank roofs should be strictly regulated at all times. It should be avoided as far as is reasonably practicable during product movements into or out of the tank concerned. Where company operating procedures require an operator to observe product levels during tank filling strict safety measures shall be in place and diligently followed.

4.4 INSPECTION

- External inspection of the exposed parts of tank walls and fittings to detect leaks and other possible defects should be carried out routinely.
- Bitumen tank vents are particularly susceptible to fouling. A regular inspection schedule should be established to check for proper functioning. Inspection and cleaning of vents should normally be possible without emptying the product from the tank. However, a carefully defined PTW procedure is necessary in each case to avoid risks of ignition at the vent and to minimise exposure of personnel to vapours and fumes.
- Areas of thermal insulation likely to be contaminated by bitumen spills should be of a non-absorbent type, sealed, inspected frequently and, to avoid auto-ignition, replaced whenever there are signs of product impregnation or damage to the cladding.
- A regular schedule for integrity checks on steam and hot oil heating coils should be established. This should include coil draining checks with the tank in service and pressure testing of the coil when the tank is out of service.

4.5 MAINTENANCE AND TANK CLEANING

Bitumen tanks may have to be taken out of service from time to time for purposes such as product change, inspection and maintenance.

Decommissioning procedures and their precautions will differ accordingly. In cases where personnel need to enter the tank for inspection and/or cleaning purposes, extensive precautions for decommissioning and gas-freeing apply.

Best practice in the petroleum industry is to hire the services of an approved specialist tank cleaning contractor rather than undertaking the task with inexperienced own personnel. Sabita encourages its members to adopt a similar policy to ensure the associated risk is managed to as low a level as is reasonably practicable.

5. QUALITY CONSIDERATIONS FOR TRANSPORT OF ASPHALT

INTRODUCTION

Asphalt transport practices can have a profound effect on the mix temperature at the paving site, aggregate and/or temperature segregation of the mix, drainage of the bituminous binder in the mix and paving quality. We tend to invest a lot of time and capital on some parts of the process like the asphalt manufacturing plant and paving equipment, but unfortunately the supply chain is only as good as the weakest link – in this instance the delivery of the asphalt to the paving site by the use of vehicles. *(Rupert Pöhl, 2003)*[1]

Managing transport practices effectively should therefore be a high priority in order to improve project performance, resulting in better quality roadways and, ultimately, decreasing the life-cycle costs of our roadways.

There are a few straightforward practices that can be utilised to effectively manage the challenges of transporting asphalt pavement mixes from plant to job site. This section is aimed at highlighting some of the main challenges of asphalt transport from plant to the paving site, and providing best practice recommendations for managing these challenges.

Asphalt transport activities and key objective

Asphalt transport involves all actions and equipment required to convey asphalt from a production facility to a paving site, including truck loading, weighing and ticketing, hauling to the paving site, dumping of the mix into the paver or material transfer vehicle hopper, and truck return to the production facility. *(Roberts et al., 1996)*[2]

In essence, the key objective of asphalt transport should be to *maintain mix characteristics and heat retention* between the production facility and the paving site. It therefore follows that good quality control is imperative during each step/activity in the 'transport cycle'.

Main challenges and considerations

The main challenges and considerations that are essential to maintaining the desired characteristics when transporting asphalt pavement mixes are discussed below under the following headings:

- Types and condition of trucks;
- Driver requirements for asphalt transport;
- Loading at the production facility;
- Transporting to the paving site;
- Unloading at the paving site; and
- Operation synchronization.

5.1 TYPES AND CONDITION OF TRUCKS

5.1.1 Truck types and configuration

Trucks to haul hot mix asphalt from the plant to the paving site can be rigid or articulated tipping vehicles. To assist with the quality and productivity of road construction, trucks transporting asphalt should be equipped with

[1] Rupert Pöhl, *Achieving Better Efficiency in The Transport of Hot Mix Asphalt to Site from a Fixed Plant in Gauteng* p. 7 (2003).

[2] Roberts, F.L., Kandhal, P.S., Brown, E.R., Lee, D.Y., and Kennedy, T.W. (1996). *Hot Mix Asphalt Materials, Mixture Design, and Construction*. National Asphalt Paving Association Education Foundation. Lanham, MD.

the appropriate thermal insulation to ensure the integrity of the mix during the journey. Where thermal covers are used, it should be laid directly onto a load and should be able to withstand temperatures of + 200^{0}C as well as be resistant to bitumen damage.

Research suggests that there are three basic truck types used for asphalt transport classified by their respective asphalt discharge methods:

- End dump
- Bottom dump (or belly dump)
- Live bottom (or flo-boy)

Each truck type is capable of adequately delivering asphalt from a production facility to a paving site. However, certain situations such as the ones listed in Table 1 below, may make one truck type advantageous over another. Note that the latter two truck types are not commonly found or used in southern Africa, probably because of quite substantial increased cost of operation. These truck types are therefore not described or discussed here.

Table 1. Truck type situations

Situation	Preferred Truck Type	Reason
Paving on congested city streets	End Dump	Better manoeuvrability because it has no trailer and is smaller than a bottom dump or live bottom truck.
Paving using a mix highly vulnerable to segregation	Live Bottom	Live bottom trucks deliver the asphalt by conveyor, which minimizes segregation.
Paving on rural highways	Bottom Dump	Usually has a larger capacity than end dump trucks (therefore fewer trucks are needed) but requires space and equipment for windrows*.

**** The use of windrows is not practiced in paving operations in South Africa.***

In southern Africa a small number of Live Bottom Trucks are found however these trucks are not a common site on local paving projects. End Dump Trucks is currently the most popular choice of truck.

End dump trucks unload their payload by raising the front end and letting the payload slide down the bottom of the bed and out the back through a tailgate.

To facilitate discharging asphalt into the paver hopper or MTV, dump trucks have an elongated tailpiece to prevent spillage around the paving unit. Ideally the configuration of the truck body should conform to the following:

- The overhang of the body should be at least 750 mm, preferably 800 mm.
- An absolutely minimum clearance of the chassis and/or springs of 650 mm should be maintained when fully loaded.

- Brake boosters must not extend past the wheels (tyres) if they have less than 650 mm clearance from the ground when fully loaded.
- The chute height above the ground in the tipped position should not be less than 850 mm, preferably 900 mm.

5.1.2 Truck condition

Truck break-down during transport of asphalt to the paving site will have severe knock-on effects for paving operations and it is therefore imperative that the transport operator ensures that vehicles are maintained to a high standard.

Paving contractors should ensure that truck operators, whether own fleet or contractor operated, have planned maintenance programs and a daily and pre-trip inspection regime in place to minimise the risk of truck break-down during delivery to a paving site.

Specific items to be checked regularly and before a trip are *inter alia*:

- General roadworthy condition (We don't want to give traffic inspectors any reasons for side-lining or delaying a delivery).
- Complete absence of oil leaks.
- Fully functional brakes.
- Good idling and tipping capability, with no hydraulic leaks.
- Tail-gate in good condition for tipping into paver hopper.
- Suitable tarps, in good condition, available to cover the asphalt during transport to the paving site.

5.2 DRIVER REQUIREMENTS FOR ASPHALT TRANSPORT

The Dump Truck Driver has an important role to ensure that asphalt arrives at the paving site on time and at the desired quality. Over and above the obvious regulatory requirements with regard to licensing (PrDP) and general competence, Dump Truck Drivers responsible for delivering asphalt must have certain other important attributes and skills. A summary of the awareness, knowledge and essential skills and attributes include:

- Awareness of the "perishable nature" of the cargo and the driver's important role in the quality assurance loop.
- Drivers should be experienced and, along with thorough operational knowledge and skills of trucks and related equipment to be operated, they should be able and willing to carry out instructions correctly;
- Ability to manoeuvre in confined areas.
- Straight and rapid reverse over long distances.
- Avoidance of damage to works, e.g. kerbs and edges of fresh mats.
- Ability to connect smoothly with the paver and correct release of breaks.
- Controlled tipping without spillage.

5.3 LOADING AT THE PRODUCTION FACILITY

Before leaving the plant, there are several best practices that can ensure your mix arrives on site in proper condition:

- **Prepare truck bed for mix**

  Prior to loading, truck beds should be cleaned and lubricated with "release agents" to keep foreign substances out of the mix and to prevent it from sticking to the truck bed. Approved non-petroleum-based

release agents should be used for lubrication. Silicone emulsions or biodegradable vegetable oil emulsions are suitable release agents. Petroleum based products, such as paraffin or diesel fuel, should not be used not only because of environmental impacts of such substances, but because they will degrade the quality of the asphalt binder, resulting in a non-uniform asphalt mat.

- **Prevent aggregate segregation during load**

  The way that the material is dropped in the transportation vehicle has a significant impact on the extent of aggregate segregation. Therefore, dropping the material onto the vehicle in one batch is less preferred than in smaller masses. Asphalt mixes should be placed into the truck bed in a way that minimizes aggregate segregation. Dropping asphalt from the storage silo or batcher in one large batch creates a single pile of asphalt mix in the truck bed. Larger sized aggregate tends to roll off this pile and collect around the base. Therefore, it is recommended that the asphalt mix is loaded in several smaller masses (three is typical) at different points in the truck bed to prevent the collection of large aggregate in one area.

- **Minimise heat loss**

  Both hot mix asphalt and warm mix asphalt cools during truck transport, which affects its characteristics when laid by the paver and during compaction. Asphalt mixes are usually loaded into a truck at a fairly uniform temperature, but during transport, some of that heat can be lost at the surface which causes a cool thin crust to form that surrounds a much hotter core.

  A study by the Quality Improvement Committee of the National Asphalt Pavement Association (NAPA) showed that the surface temperature of covered loads dropped more slowly than un-covered loads but temperatures 100 mm below the surface between covered and un-covered loads were not significantly different *(Minor, 1980)*[3].

  However, notwithstanding the research indications, it remains best practice (to prevent conditions such as air temperature, rain, wind and length of haul from creating heat loss) to use insulated truck beds and thermal blankets to cover the load.

  Hessian is not acceptable. The sheets (blankets) should cover the entire exposed surface of the asphalt load and should be well tied down to keep it in place until tipping.

  Although the drop in temperature over short haul distances may not adversely affect the paving and compaction operations, covering of the load will minimise both heat loss and hardening of the binder film as a result of exposure to air flow.

5.4 TRANSPORTING TO THE PAVING SITE - OPERATION SYNCHRONIZATION

Truck transport should be planned such that the mix transport rate (expressed in tons/hr) closely matches plant production rate and laydown rate. Some factors to consider are:

- Number of trucks to be used;
- Truck type;
- Average truck hauling capacity;
- Production facility output rate;
- Availability and condition of storage silos at the production facility;
- Time to lubricate the truck bed before transport;
- Waiting time at the production facility;

[3] Minor, C.E. (1980). Are Hot-Mix Tarps Effective? Information Series 77. National Asphalt Pavement Association. Landham, MD

- Loading, weighing and ticketing time at the production facility;
- Time to cover the load (when thermal covers are used);
- Distance between the production facility and the paving site; and
- Average truck speed.

Traffic affects delivery rates because it affects truck speed, especially in congested urban areas, where heavy and/or unpredictable traffic may substantially increase, or at least vary, truck travel time. As truck travel time increases, more trucks are needed to provide a given delivery rate. As traffic gets worse, trucking costs increase. Additionally, the unpredictability of traffic may result in either long paver idle times while waiting for the next truckload of mix or large truck backups as several trucks all reach the paving site or production facility at the same time *(NAPA, 1996)*[4].

5.5 UNLOADING AT THE PAVING SITE

Asphalt mixes should be unloaded as soon as possible after arriving at the paving site in order to minimise mix cooling. Also, on jobs with more than one mix type the quality inspector and/or paving supervisor should be certain the correct mix is loaded into the paver.

In most cases, truck transport appears to cool only the surface of the transported asphalt mass, however this cool surface crust can have detrimental effects on overall mat asphalt quality if not properly dealt with. Actions such as reducing transport time, insulating truck beds or using appropriate thermal cover, can decrease asphalt surface cooling rate. However, in addition, since the majority of the asphalt mass is still at or near its original temperature at loading, mixing of the crust and interior mass together at the paving site ("remixing") will produce a uniform mix near the original temperature at loading.

5.5.1 Use of Material Transfer Vehicles (MTVs)

MTVs are not new to the paving industry and have been around for the approximately the last 29 years although, in the Southern African context, the use of MTVs have only gained popularity in the last decade or so. It is probably fair to say that the technology offered by MTVs has dramatically improved pavement life and quality to the extent that MTV's is considered an essential tool for today's road builders.

The major advantages that MTVs offer are:

- Can store asphalt mix, allowing haul vehicles to unload as soon as they arrive; and
- Has built-in technology which remixes materials for control of aggregate and temperature segregation.

A downside to MTV use is that it will increase the per ton cost of asphalt paving. The technology may also not be suitable or practicable on certain projects. However, some clients may specify (in tender documents) the use of MTVs on certain projects and this should at least level the "playing field" as far as that component of a tender is concerned.

5.6 LONG HAUL DISTANCE

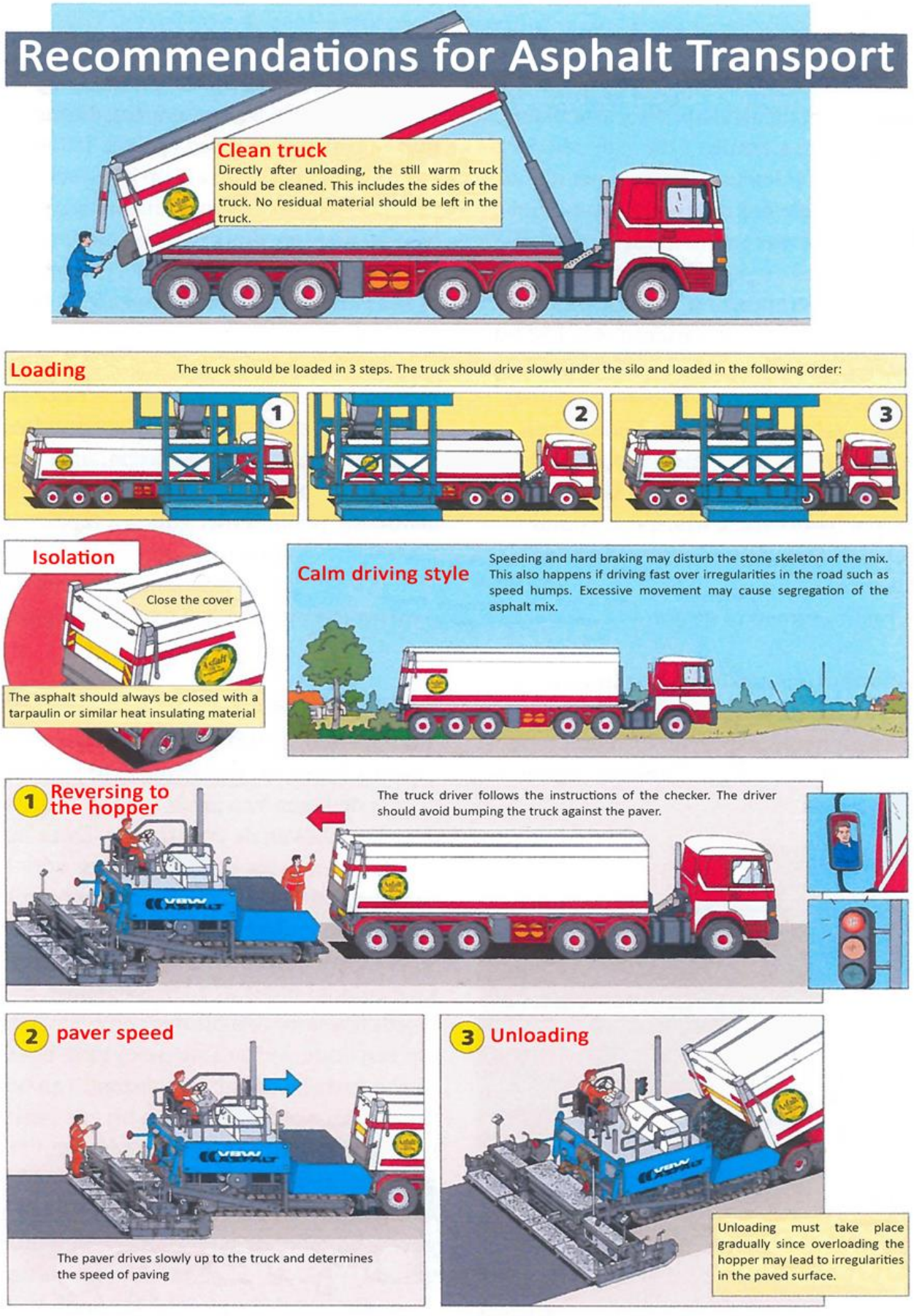
Long haul distances e.g. more than 80 km could bring with them issues that will require special consideration. These special considerations include elevated plant loading temperatures to counter mix cooling during transit as well as drainage of the bituminous binder in the load arising from both elevated temperatures and duration of the trip from plant to paving site.

[4] National Asphalt Pavement Association (NAPA). (1996). *Balancing Production Rates in Hot Mix Asphalt Operations*, IS 120. National Asphalt Pavement Association. Landham, MD.

To counter the adverse effects of long-haul distances it is highly recommended that WMA mixes are considered for these conditions. It also goes without saying that on long haul distances properly installed thermal blankets should be used to prevent both heat loss and aeration and, consequently, hardening of the binder.

Drainage of the binder within the load mass can be prevented by the use of modifiers or additives (especially in the case of porous asphalt mixes). Drainage in the truck usually manifests itself with regular patterns of fattiness of the mat associated with paver loads in the case of end-dump trucks. Clearly the use of MTVs may limit this. When such patterns of fattiness are noted, steps should be taken to prevent it.

The graphic image below summarises a very basic asphalt transport cycle from plant to paver



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2. SABITA Manual 32, Best practice guideline for warm mix asphalt, September 2011.

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5. Roberts, F.L., Kandhal, P.S., Brown, E.R., Lee, D.Y., and Kennedy, T.W. (1996). *Hot Mix Asphalt Materials, Mixture Design, and Construction*. National Asphalt Paving Association Education Foundation. Lanham, MD

6. Australian Asphalt Pavement Association, PowerPoint presentation, "Safety Around Bituminous Materials"

APPENDIX

Recommended bitumen handling & storage temperatures (Source: The Energy Institute Bitumen Safety Code, September 2005 4th edition)

Grade	Minimum pumping temperature (°C) Note [1]	Typical bitumen temperature at time of application (°C)		Maximum handling and storage temperature (°C) Note [5]	Typical Long term storage temperature (°C) Note [6]
		Mixing and short-term storage Note [2] Note [3] Note [5] Note [7]	Spraying Note [4] Note [7]		
Road grades (BS EN 12591:2000)					
150/200	105		155 - 165	190	65
70/100	115	140 - 150	170 - 180	190	75
50/70	120	150 - 160		190	80
35/50	125	155 - 165		200	85
Cutback grades (SANS 4001-BT2) - Note [8]					
MC 10	10		10 -30	30	
MC 30	15		45 - 65	60	
MC 3000	80		125 - 145	100	

Notes:

i. ***Maximum pumping viscosity - approximately 2 Pa.s (all grades).***
ii. ***Mixing/coating viscosity - approximately 0,17 - 0,20 Pa.s (all grades).***
iii. ***When used in warm mix asphalt, these mixing temperatures can be reduced by 25 - 30°C.***
iv. ***Spraying viscosity - approximately 0,04 - 0,1 Pa.s.***
v. ***Based on generally satisfactory experience of the storage and handling of road grade bitumen in contact with air. Subject to the avoidance of flammable atmospheres in the vapour spaces of storage tanks. Storage periods should not exceed 24 hours. (For cutback bitumen see Note 8).***
vi. ***Based on a protracted storage period without the addition of fresh binder. For bulk bitumen the temperature should not fluctuate above or below 100°C as this increases the risk of condensation leading to boil over. Storage periods should not exceed 10 days.***
vii. ***For polymer-modified bitumen, emulsions and proprietary products, advice on handling, spraying and storage should be contained in a MSDS obtainable from the supplier.***
viii. ***Based on generally satisfactory experience of storage and handling cutback bitumen in contact with air. Subject to the avoidance of sources of ignition in the vicinity of tank vents and open air operations. Storage time at elevated (spraying) temperatures should not exceed 8 hours for cutback bitumen.***