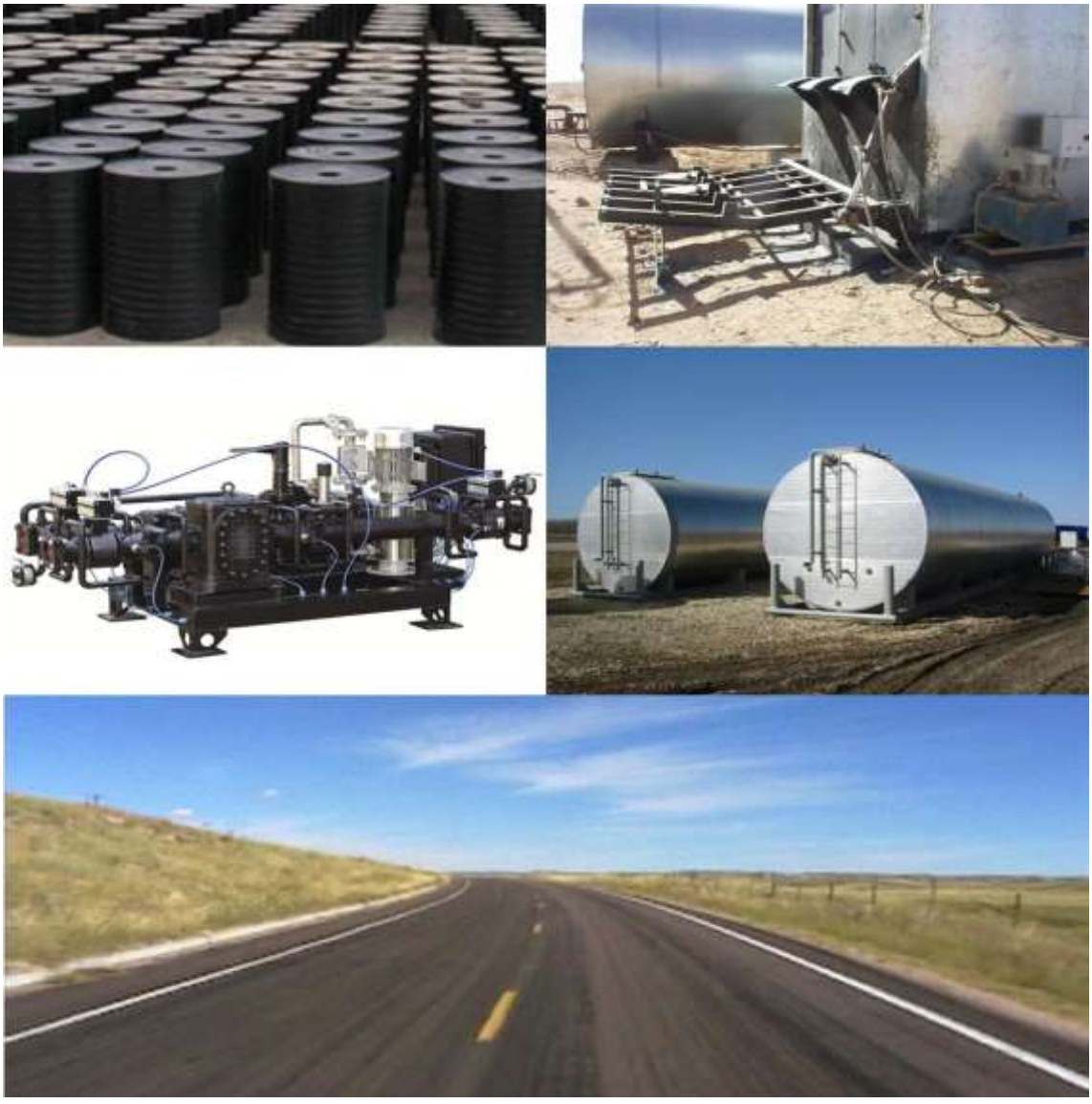
Guide for the control of HSE hazards associated with the field production of medium curing cutback bitumen



Scope and objectives

Scope

This guide deals specifically with the activity of blending cutback bitumen in a "***field production"*** *facility*. The cutback grade within scope is Medium Curing (MC). Slow Curing (SC) and Rapid Curing (RC) cutback bitumen is not within scope as these are unlikely choices for road paving projects in South Africa.

Objectives

The objectives of this guide are as follows:

i. To create awareness and understanding of the potential HSE hazards and threats associated with blending MC cutback bitumen;
ii. To provide guidance on minimum acceptable operating conditions; and
iii. To make recommendations for control of hazards associated with MC cutback bitumen blending.

Abbreviations, definitions and terms used in this guide

Acceptable	Acceptable to the authority administering this standard, or to the parties concluding the purchase contract, as relevant
Approved	Approved by the approving authority
Approving authority	The appropriate of the following: a) in terms of the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993), the Chief Inspector; b) in terms of the Mine Health and Safety Act, 1996 (Act No. 29 of 1996), the Mining Engineer; c) in terms of the Trade Metrology Act, 1973 (Act No. 77 of 1973), the Director of Metrology; d) in terms of the National Water Act, 1998 (Act No. 36 of 1998), the Director-General of Water Affairs and Forestry; e) the local authority concerned
ALARP As Low as "Reasonably Practicable" *(As defined in the Occupational Health and Safety Act)*	Means practicable having regard to: (a) the severity and scope of the hazard or risk concerned; (b) the state of knowledge reasonably available concerning that hazard or risk and of any means of removing or mitigating that hazard or risk; (c) the availability and suitability of means to remove or mitigate that hazard or risk; and (d) the cost of removing or mitigating that hazard or risk in relation to the benefits deriving there from.
AIT (Auto Ignition Temperature)	Hydrocarbons that are heated can ignite if they are exposed to air. A fuel vapour/air mixture can ignite without the introduction of an ignition source. The minimum auto-ignition temperature is the lowest temperature at which the fuel vapours spontaneously ignite.
Bonding	The provision of a low resistance electrical connection between conductive objects without necessarily providing a connection to earth

BTA tank (Bulk to agriculture tank)	Above-ground, horizontal storage tank, 9000ℓ in volume, installed on low concrete or steel supports.
BTF tank (Bulk to farmer tank)	Above-ground tank, 2200ℓ in volume, installed on high or low prefabricated stands
Bulk mixing plant	Means machinery, appliances or other similar devices that are assembled in such a manner so as to be able to mix materials in bulk for the purposes of using the mixed product for construction work
Bund wall	Wall designed to confine product spillage to the bunded area
Bunded area	Area bounded by ground contours that confine spillage, or an area surrounded by bund walls
Construction work	Means any work in connection with- (a) the construction, erection, alteration, renovation, repair, demolition or dismantling of or addition to a building or any similar structure; (b) the construction, erection, maintenance, demolition or dismantling of any bridge, dam, canal, road, railway, runway, sewer or water reticulation; or the moving of earth, clearing of land, the making of excavation, piling system or any similar civil engineering structure or any similar type of work;
Competent person	Means a person who: a) is having the knowledge, training, experience, and b) where applicable, has qualifications specific to the work or task being performed: Provided that where appropriate qualifications and training are registered in terms of the provisions of the National Qualification Framework Act No.67 of 2000 these qualifications and training must be regarded as the required qualifications and training; and c) is familiar with the Occupational Health and Safety Act and with the provisions of the regulations that apply thereto;
Cutback bitumen	Paving grade bitumen blended with a small quantity of volatile solvents to reduce viscosity for ease of handling and application, which, after the volatile solvents have evaporated, essentially reverts to the paving-grade bitumen base
Cutters	Means any one or a combination of the following products used in cutback blending: - Kerosene's (Illuminating Paraffin or Jet A1 fuel) used for Medium Curing grades; - Automotive Gas Oil (Diesel) used for Slow Curing grades.
Earthing	The provision of a low resistance electrical connection between conductive objects and earth
FR (Flammable Range)	The range between the LFL and UFL. The upper (rich) and lower (lean) flammability limits define the range of concentrations of a vapour in air that can be ignited and sustain combustion. Any composition outside of these limits cannot be ignited.

FP (Flash Point)	The minimum temperature at which a flammable liquid gives off enough vapour to form an ignitable mixture with air.
Field production	Means the production of cutbacks at a temporary installation on a road paving/sealing project.
LFL (Lower Flammable Limit)	The minimum concentration of a vapour (usually expressed as the % of vapour in air) required to sustain a fire.
NEMA	The National Environmental Management Act, 1998 (Act No. 107 of 1998) and Regulations as amended.
OHSA	Occupational Health and Safety Act, (Act No. 85 of 1993) and Regulations as amended.
Responsible engineer	Engineer who is registered with the Engineering Council of South Africa and who is competent to pronounce on the acceptability and operability of the plant in scope of this guide.
Skid tank	Above-ground tank on skids, 9000ℓ, 14000ℓ or 23000ℓ in volume, which can be dragged over short distances, normally used on construction sites
Temporary installation	Installation that is erected for short term purposes to supply cutback bitumen for the duration of a road paving/sealing project.
UFL (Upper Flammable Limit)	The maximum concentration of a vapour (usually expressed as the % of vapour in air) beyond which a fire cannot be sustained, as the amount of oxygen would be insufficient to support combustion.
Volatile/Volatility	The ability of a liquid to vaporise, (i.e. change from liquid to gaseous state) at normal atmospheric pressure and temperature. E.g. LPG is extremely volatile (Propane boils at -42 °C); Petrol is highly volatile and readily vaporises at 20°C; Kerosene's are less volatile than petrol but volatility increases exponentially with increased pressure and temperature.

1. Introduction

Medium Curing (MC) grade is the cutback of choice used on road paving projects in Southern Africa. Kerosene's (Illuminating Paraffin and Jet A-1 fuel) are the solvents (cutters) usually used for blending MC cutbacks. There is also a growing tendency to use MC 30 cutback bitumen as a cutter to produce cutback grades with a lower cutter content. (MC 30 could have a cutter content of up to 45%)

Cutback bitumen is normally supplied from refineries and a limited number of other manufacturing plants. At these facilities cutback blending takes place under tightly controlled conditions that ensure due regard for quality and safety during the production process. For quality and safety reasons field production of cutback bitumen is not recommended however SABITA acknowledges that field production may sometimes be required and also that the activity can be successfully executed if appropriate quality and HSE standards are applied.

SABITA was approached by industry to provide guidance in this regard and has produced this publication in the hope that it will be used as a good practice reference for the design and operation of field production facilities in future.

2. Understanding the hazards and associated risk of cutback blending

General Health and Safety hazards and Environmental aspects

The primary and most common hazards and potential consequences associated with handling of hot bitumen, exposure to bitumen fumes, environmental concerns, etc. are well documented in various SABITA publications and readers should refer to the relevant SABITA manuals for further information.

In this publication the primary focus is on creating awareness and understanding of the hazards and potential consequences (fire and explosion) associated with the mixing of volatile and flammable hydrocarbons (cutters) with less hazardous straight-run bitumen.

Flammable properties of cutbacks that influence safety considerations

Paving grade bitumen

The base material of cutbacks is paving grade bitumen (Usually 70/100). At normal ambient temperatures (in a solid state) bitumen is considered *not combustible or flammable*. However, if heated to a high enough temperature, bitumen *will* vaporise and the vapour *could ignite* in the presence of a spark or open flame. ***The temperature at which this occurs is well above the temperatures normally used in bitumen production and paving operations.***

Cutback bitumen

By adding volatile and flammable cutters to paving grade bitumen the characteristics, and specifically the flammable limits, of the blend is significantly altered as can be seen from the table below:

Table 1 - Typical relevant properties of the components of MC cutback bitumen:

			Flammable Range[1]	
Product	**AIT[1]**	**FP[1]**	**LFL**	**UFL**
Paving Grade Bitumen 70/100	> 300°C	> 230°C	(NA)	(NA)
Cutters:				
Kerosene (Illuminating Paraffin)	> 220˚C	> 43˚C	1%	6%
Kerosene (Jet A-1)	> 220˚C	> 38˚C	1%	6%
MC 30 cutback bitumen	> 220˚C	≥ 36 - 40˚C	1%	6%

(1) Sources: MSDS of various international proprietary suppliers

(NA) Data not available/insignificant

Table 2 - Typical relevant properties of a range of MC cutback bitumen blends:

			Flammable Range[1] [2]	
Product	**AIT[1]**	**FP[1]**	**LFL**	**UFL**
Cutback blends:				
Cutback Bitumen MC30	> 220˚C	≥ 36 - 40°C	1%	6%
Cutback Bitumen MC70/250/800	> 220˚C	≥49 - 60°C	1%	6%
Cutback Bitumen MC3000	> 220˚C	> 61°C	1%	6%

(1) Sources: MSDS of various international proprietary suppliers. SANS 4001 – BT2:2012 Edition 1 specifies a minimum flashpoint of 38°C (ASTM D93) for all MC grades

(2) Based on the flammable range of the cutter and the likely scenario that at blending temperatures the more volatile (and lighter) fractions will vaporise above the liquid surface

Significance of the relevant flammable properties of cutbacks

Auto ignition temperature (AIT)

Research indicates that the optimum operating temperature for cutback blending (excluding refinery operations) range from 115 °C to 170 °C depending on the grade.

This is well below the AIT of bitumen and cutbacks and provided heating is controlled within the prescribed limits auto ignition is not a likely threat.

Flash point and volatility

The flash points of **all** the cutters and the cutback blends are ***well below*** the cutback blending temperatures. The blending temperature range is also well above ambient temperature and this means that the volatile cutters will definitely vaporise and flammable mixtures could evolve just above the surface of the blended liquid.

Blending/mixing also involves agitation (stirring) of the mix which will increase the rate of evaporation/vaporisation and may lead to the formation of fine mists in the vapour space of blending tanks. ***Under these circumstances and in the presence of air the cutback vapour could certainly flash if a flame or spark of sufficient energy is induced.***

Finally, an important cautionary observation in connection with the use of flash point as an indicator is a statement in the Energy Institute, Model code of safe practice, Part 11, Bitumen Safety Code:-
"Due to the slow and variable after reactions which can occur during storage in heated tankage (giving rise to the evolution of very light flammable vapours), the flash point is not a reliable indicator of the temperature at which the product in a confined space is likely to produce a flammable atmosphere."

Flammable range

The figures in Table 1 show that the flammable ranges of cutters used for blending medium curing cutbacks are very similar. The range of 1% to 6% vapour by volume in air is a very narrow range and it requires very little variation in vapour concentration to "adjust" the mixture below or beyond the LFL and UFL limits. ***However it is significant to understand that a very low concentration of vapour is required to form a flammable mixture.***

In the presence/prevalence of air in the vapour space (empty space above liquid) of the blending tanks, the atmosphere could fluctuate from below the LFL (too lean), through the flammable range, to above the UFL (too rich), and *vice versa*. ***If an ignition source of sufficient energy is present in the vapour phase of the liquid (cutback) the vapour could ignite at any given time if the mixture is within the flammable range.***

Static electricity

Static electricity presents fire and explosion hazards during the handling of petroleum products. Certain operations can give rise to accumulations of electric charge that may be released suddenly in electrostatic discharges with sufficient energy to ignite flammable hydrocarbon gas/air mixtures.
Kerosene is considered to be low-conductivity liquid and is "classified" as a ***static accumulator.***

When a flammable atmosphere could potentially be present in the cutback blending process measures must be taken to prevent or control electrostatic hazards.

Examples of bitumen and cutback related incidents

Historical information and data relating to bitumen incidents in South Africa are difficult to obtain however there have been numerous incidents reported in the international media that illustrate the potentially hazardous nature of storage and handling of bituminous products. Below is a list with links to some of the events reported in the media:

i. http://www.dol.govt.nz/news/media/2010/fulton-hogan-sentencing.asp

ii. http://www.aria.developpement-durable.gouv.fr/ressources/fd_5232__portet_sur_garonne_cc_gb_vfin_27102010.pdf
iii. http://ncsp.tamu.edu/reports/CCOHS/record1286.htm
iv. http://www.sunshinecoastdaily.com.au/news/explosion-boral-bitumen-site/1557945/
v. http://hotplantconsulting.com/articlefifteen.html

3. Defining the minimum acceptable operating conditions

Equipment and design considerations for safe field production of cutback bitumen

The use of "make shift" methods such as blending in bitumen distributors or blending in drums is not recommended because the efficacy of quality and HSE controls will be severely compromised. There is unfortunately also no blue print for an ideal "size" or setup for the field production of cutbacks.

Responsible engineers should assess the anticipated project supply demands and design blending facilities accordingly. The economic viability of establishing a fit for purpose facility will certainly influence decision making and the "urge" to compromise on quality and HSE standards for the sake of financial savings must be resisted.

This guide will not attempt to define or describe the ideal design criteria but rather provide some guidance on aspects that should be considered when planning a field production facility. The guidance is based on the following assumptions:

- Bitumen required for cutback production will be supplied and stored in drums or in bulk (in a skid tank) until required for blending;
- The rate of cutback production is a function of the speed that the bitumen stock can be transferred from the drums or from bulk storage. *(This requires heating the bitumen to suitable temperatures for pumping)*;
- Cutter stock (Kerosene or MC 30) will be supplied in bulk by road tanker and stored in BTF/BTA or skid tanks until required for blending *(Supply/storage and handling of cutters stock in drums should be avoided as far as possible)*;
- Cutback bitumen is blended in a mixing tank and transferred (pumped) directly to a bitumen sprayer for onward transport and application of the binder;
- Portable heating equipment with reliable temperature control devices is used to ensure that maximum operating temperatures are not exceeded;
- Portable pumping equipment suitable/certified for Class II petroleum products are used for transfer of cutter stock and blended product.

Design standard for storage and handling equipment

At a minimum the facility should comply with the relevant requirements of **SANS 10131:2004 Edition 1** - **Above-ground storage tanks for petroleum products.** This standard provides guidance for the above-ground storage and handling of petroleum products at consumer installations with a total storage capacity not exceeding 200 m^3.

When designing the field production facility consideration should also be given to incorporate the following in the design:

- If drums are used to store bitumen stock:
  - A skid-mounted de-drumming and bitumen melting unit with built in storage of suitable capacity;
  - Suitable means to safely open and transfer full bitumen drums to the de-drumming unit;
- If possible procure and store cutters (Kerosene and or MC30) in bulk to eliminate the hazards associated with decanting and handling of drums;
- Use skid tanks instead of BTF or BTA tanks for increased stability.

General health and safety legal compliance

It goes without saying that in general the requirements of the OHSA must be complied with and in particular due consideration must given to the relevant requirements of the Construction Regulations. Some important relevant provisions are:

- Clients for whom the construction work is performed must ensure that health and safety specifications for field production of cutbacks are included in the contract tender documents and subsequently adequately addressed in the Health and Safety Plan of the appointed contractor;
- The contractor responsible for erecting and managing the field production facility must submit a method statement for approval by the Client prior to commencement of the work. See *Annexure 1 of this guide for a generic Hazard Control Sheet that may be used as reference for compiling specifications;*
- Personnel responsible for designing, erecting, supervising and operating the facility shall be competent to perform the work and a process should be in place to assess competence and ensure that only personnel with the requisite knowledge, experience and skills are assigned to such work;

Environmental authorisation

In accordance with the provisions of NEMA the establishment and operation of a field production facility may (and probably will) require environmental authorisation before commencement of the activity. Potential operators (Clients/Principle Contractors) must check with the relevant local or provincial authorities to ensure compliance as necessary.

General operational HSE considerations

- A competent person shall be designated to supervise field production of cutbacks and shall always be on site when production is in progress;
- Operators shall wear appropriate PPE to protect them against burns (from heated equipment and hot bitumen spills) when working in close proximity of hot equipment;
- An adequate number of portable 9kg dry chemical powder fire extinguishers shall be readily available during production;
- Do not allow smoking or naked flames within 15 meters of any production equipment;
- Always inspect opened drums and storage tanks to ensure that cutter stock has not been contaminated with water or material that could cause foaming or fire;
- Ensure that temperature control equipment is functioning properly and maintain the temperature in the mixing tanks between 115° and 120°C. To minimise the potential for fire - DO NOT exceed 120°C;
- Keep tank manholes/covers closed during blending operations to prevent ingress of air into the tanks. This has the effect of maintaining a “too rich” atmosphere in the vapour phase and will minimise the potential of ignition;
- Always be alert and observant whilst blending is in progress. If dense, yellow vapour is rising from the bitumen melter, mixing tank, or storage tanks it is an indication of overheating to the extent that an ignition source such as a spark could cause an explosion. IMMEDIATELY shut down heating equipment if this condition is observed;
- NEVER allow the bitumen level to fall below the heating coils or tubes while the heating equipment is in operation;
- Maintain measures and equipment that are in place to control static electricity hazards. Some typical measures to prevent static accumulation during cutback blending include the following:
    - Avoid Splash Filling by employing bottom entry with a deflector plate or by using a fill pipe terminating close to the bottom of the tank;
    - Bond all metallic objects together to eliminate the risk of discharges between objects that might be charged and electrically insulated; and to avoid discharges from conductors to earth, it is normal practice to include bonding to earth (‘earthing’ or ‘grounding’). **Note: *Bonding/earthing should have a resistance of less than 10 Ω and the bonding and earth straps/cables should be routinely checked for conductivity and continuity;***
    - Restrict flow/filling velocities to below 1m/s or as close as possible to this limit;

Example Hazard Control Sheet

HAZARD Control SHEET No: Generic/HSE/ FPCB/112013	**Activity:** Field production of cutback bitumen	Page 1 of 1
Hazard Group/s: Hydrocarbon fuels/vapour and Hot fluids >100^{o}C	**Location**: Cutback field production facility on road sealing project	

Assessment of hazard

Top event/s: Loss of control/Loss of containment

Potential consequences: (1) Tank explosion/fire; (2) Loss of containment of hot bitumen; (3) Flying fragments/objects

Risk classification	**Medium/High**	Serious injury and fatalities have occurred in similar operations

Threats:

1. Inadequate design of plant**; 2.** Improper construction of plant**; 3.** Improper operation of plant**; 4**. Inadequate maintenance of critical plant components

Controls:	**HSE Critical Task/s**	**Responsible Position**
1.1 Control in design and construction		
❖ Facility is designed to SANS 10131:2004	Knowledge of standard	Project Manager
❖ Plant components are appropriate for bitumen service	Specify appropriate standards	The responsible engineer
❖ Design is approved by a competent design authority	Submit design for approval	Project Manager
❖ Individual plant components constructed to acceptable design standard	Quality control checks	Project Manager
❖ Facility construction supervised by competent person	Assign appropriately qualified person	Project Manager
❖ Facility commissioned by a competent person	Assign appropriately qualified person	Project Manager
1.2 Control in operation		
❖ Operating manual/ safe work procedures available	Compile manual/procedures	The responsible engineer
❖ Plant operated by competent operators	Train personnel/assess competence	Facility Manager
❖ Plant operated in accordance with operating manual and approved procedures	Operators follow procedures	Plant Operators
	Monitor compliance and correct any deviations immediately	Facility Manager
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1.3 Control in maintenance		
❖ Planned maintenance	Plan and implement schedule	Engineering Manager
❖ Regular inspection of critical plant components	Identify critical components;	Engineering Manager
	Train inspectors;	Facility Manager
Recovery:		
❖ Fire Emergency Plan	Include Plans in Operating Manual	Facility Manager
❖ Medical Emergency Response Plan		
❖ Facility Spill Response Plan		

References

Legislation:

Occupational Health and Safety Act and Construction Regulations; National Environmental Management Act;

Industry Standards:

SANS 10131:2004 Edition 1

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