Guidelines for the safe and responsible handling of bituminous products

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sabita

excellence in bituminous products

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* These manuals have been withdrawn and their contents have been incorporated in Technical Guideline 1 (see below).

** This manual has been withdrawn and its software programme incorporated in TRH12: *Flexible pavement rehabilitation investigation and design.*

*** These manuals have been withdrawn and their contents have been incorporated in Technical Guideline 2 (see below).

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DVD410 **The safe handling of bitumen**

DVD420 **Treatment of bitumen burns**

DVD430 **Working safely with bitumen**

DVD440 **Firefighting in the bituminous products industry**

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Some of the material incorporated in this document is based on guidelines developed by the Petroleum Institute (now incorporated into the Energy Institute), CONCAWE, the Refined Bitumen Association (RBA), Eurobitume, Austroads, the New Zealand Pavement and Bitumen Contractors Association (NZBCA) and the Australian Asphalt Paving Association (AAPA). Their permission to do so is gratefully acknowledged.

The comprehensive revision culminating in this third edition draws on the most up-to-date information, knowledge and experience available from various sources including specific techniques and methodology developed by the oil industry. In particular, the Hazards and Effects Management Process (HEMP) and BowTie methodology developed by Royal Dutch Shell plc is today regarded as best practice for risk assessment and the demonstration that risks are managed to As Low As Reasonably Practicable (ALARP). The use of information and material available from Shell and incorporated in the revision of this document is also gratefully acknowledged.

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Preface

The standards of worker health, safety and environmental conservation are constantly under review in the bituminous products industry as the state of knowledge expands. This guideline reflects the state of knowledge and HSE procedures at the time of publishing.

The scope of this manual has been revised to incorporate international best practice in respect of the methodology used for hazards and effects management. This document is however not intended to be a detailed or exhaustive demonstration of HSE management of all activities associated with the storage, handling and application of bituminous products. Rather, it should be viewed and utilised as a generic "high level" assessment of product specific hazards and should prompt further site-specific detailed risk assessment of activities and associated hazards.

Reference should be made to Sabita's publication *Health, Safety and Environment Manual* for Sabita members (August 2010) for more comprehensive information and guidance on health, safety and environmental management processes and procedures that describe the HSE control framework recommended for a typical Sabita member organisation.

In general, the structure of the document is based on the concept of HEMP associated with the handling of bituminous products and offers precautionary (control) measures to minimise the risk of exposure to such hazards. It should be read in conjunction with instructions issued by site supervisors, and with those of plant specific operating manuals, all of which should be observed by users of bituminous binders.

Note

In accordance with global nomenclature, the term "bituminous" refers exclusively to binders and mixtures of binders and aggregate containing bitumen. The term does not include tar products produced by the pyrolysis of coal.

As it is now globally accepted that the use of coal tar products as binders for road construction may introduce undue health and environmental hazards; their use is no longer considered best practice. Sabita therefore does not endorse the use of coal tar products as binders and reference to this application is excluded from this document.

Glossary of terms

Additive	Any substance which is added in small portions to bitumen to impart some particular property, e.g.: improved adhesion, lower viscosity.
Adhesion agent	An additive which forms a water resistance chemical bridge between binder and stone chip.
Anti-foaming liquid	A substance which, when applied to the surface of bitumen reduces the surface tension. This action breaks foam as it forms on the treated surface.
Auto ignition	When a material ignites on its own accord unaided by an external source of ignition such as a flame.
Auto ignition temperature	The temperature at which a material will ignite on its own accord. (Not to be confused with flash point which requires an external source of ignition such as a flame).
Barrier cream	A cream or ointment applied to the skin prior to contact with irritant substances. Some work by blocking the pores of the skin with soapy solids - dry work - and others by spreading a water resistant film - wet work. They may later be wiped or washed off taking the irritant with them.
Bituminous binder	A mixture of bitumen, additives, modifiers, emulsifiers and cutters applied to road surfaces as a spray in, e.g. chip seals or in an asphalt mixture.
Bitumen	A non-crystaline solid or viscous black or brown substance derived from the distillation of crude petroleum oil. Bitumen softens gradually when heated and can be pumped at 120°C or higher temperatures.
Bitumen emulsion	Very fine particles of bitumen dispersed in water with the aid of chemical emulsifiers. Acid emulsifiers make cationic emulsions and alkaline emulsifiers make anionic emulsions. Usually emulsions contain 60-70% bitumen.
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.
Bund wall	An enclosed area around a tank, capable of retaining a spillage from the tank or pipe-work.
Carcinogenic	Capable of causing cancer.

Combustible	Capable of burning with sufficient rapidity to produce heat and flame.
Cutback bitumen	A liquid bituminous product obtained by blending bitumen with a volatile petroleum solvent. Bitumen to which solvents such as illuminating paraffin or kerosene have been added to make it more fluid.
Cutter	An additive which is blended with bitumen to temporarily reduce the viscosity of the bitumen to assist handling e.g. illuminating paraffin or kerosene.
Extender oil	An aromatic oil extracted during the manufacture of petroleum lubricants, used in the manufacture of bitumen rubber.
Flammable	Synonymous with inflammable. Any substance, solid, liquid, gas or vapour, which is easily ignited. The term non-flammable refers to substances, which are not readily ignited, but does not necessarily indicate that they are not non-combustible.
Flammable limits/range	A flammable vapour mixed with air will only ignite/explode if the mixture is in the flammable range. The minimum and maximum percentage gas concentrations, which can be ignited, constitute the lower and upper limits respectively. The flammable limits and the flammable range are also known as the explosive limits and the explosive range respectively.
Flash off	The rapid evolution of vapour from volatile liquids.
Flash point	The lowest temperature at which a flammable liquid will give off vapour, which can be ignited.
Foam	A collection of small bubbles of air or gas forming in liquid, which rise and form a blanket on the surface. For firefighting a foam produced from water and chemicals is sprayed on the surface of the burning material to exclude oxygen.
Gas free	An enclosed space or area is considered to be gas free when the concentration of flammable or toxic gas in it is within prescribed safe limits, and the oxygen content is sufficient to sustain the respiration of workmen entering the enclosed space or area.
Hazard	The inherently dangerous properties of a substance.

HRA	Health Risk Assessment as contemplated in the Hazardous Chemical Substances regulations of the Occupational Health and Safety Act.
Heating flues	An oil or gas fired burner with a wide bore pipe which is fitted to a binder tank for heating purposes.
Hot work	Work involving flames or equipment, which can cause ignition of flammable vapours.
Initial Boiling Point (IBP)	The temperature at which solvents like paraffin begins to boil.
Ignition temperature	The temperature to which a solid, liquid or gas must be heated to start burning.
Modifiers	Substances added to bitumen to modify its rheological characteristics for improved performance over a range of operating conditions. Modifiers broadly fall within the categories of polymers, aliphatic synthetic waxes and natural hydrocarbons.
Naked flame	All uncontained flames, fires, exposed incandescent materials and welding arcs.
Risk	The probability of substances, operations or circumstances causing harm to people or the environment.
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.
Tremcard	Transport emergency card that will assist in the correct application of emergency measures in vehicles carrying dangerous goods.
Ullage	The amount by which the tank falls short of being full.
Viscosity	A measure of the ease at which a liquid can flow. A high viscosity liquid is one which does not flow easily. Binder viscosities are usually measured in pascal seconds or centistokes.
Volatile solvents	A low boiling point hydrocarbon (typically of the kerosene type) used in the manufacture of cutback bitumen to produce a binder with a temporarily low viscosity which will increase again as the solvent evaporates.

Sabita Health, Safety and Environment policy

Sabita encourages its members to carry out their business in such a way that the health and safety of their employees, and of other persons both on and near their sites, is not endangered, and that the quality of air, water and soil is protected for the continuing benefit of all ecosystems.

Accordingly, in adopting a responsible integration of environmental and economic considerations, members are urged to design, operate and maintain their facilities in such a manner as to:

- avoid harm or injury to the health of employees or other persons on their premises, or those living in the vicinity;
- avoid damage or loss to the environment;
- ensure the manufacture of quality products, and promote the safe and efficient delivery of those products; and
- implement the best available technology to limit emissions, noise and the production of waste.

Through visible management, commitment and the contributions of employees, Sabita members are encouraged to strive for continuous improvement in their performance under the health, safety, and environmental requirements of the State and the industry, and compliance with the relevant legislation. It is anticipated that every employee of Sabita's membership, and those on their premises and work sites, will comply willingly with this policy.

Sabita members not directly involved in the manufacture, storage and transportation of bituminous binders should also note the wide-ranging benefits resulting from the implementation of safe and healthy working practices.

Conservation of life and the environment is an obligation.

1. Introduction

In South Africa bitumen is used primarily for road construction, but finds uses in a variety of other applications where waterproofing and adhesion are important requirements. Approximately 90% of all bitumen consumed in South Africa is used to construct and maintain the extensive road network. Waterproofing, roofing, flooring, anti-rust paints and sealants for dams and reservoirs account for the other 10% consumption.

Successful management of the hazards associated with the storage, handling and transport of bituminous products requires a sound understanding of the types, properties and characteristics of bitumen and bituminous binders. This document summarises the health, safety and environmental data currently available on bitumen and bituminous binders, and the information covers the following:

- Product description, uses and typical properties;
- Hazards and effects of bituminous products; and
- General advice on handling, emergency treatment and disposal.

2. Product description

Composition

Bitumen is a complex combination of hydrocarbons with small amounts of oxygen, nitrogen, sulphur and trace amounts of metals. A typical analysis is 82-88% carbon, 8-11% hydrogen, 0-1,5% oxygen, 0-1% nitrogen, 0-6% sulphur, and trace amounts of vanadium, nickel, iron, magnesium and calcium.

Crude oils normally contain small quantities of polycyclic aromatic hydrocarbons (PAHs) which are retained in bitumen. Some of these PAHs are suspected of causing cancer in humans. However, the concentrations of these suspected carcinogens are extremely low, and no causal link between bitumen and cancer in humans has been established.

To avoid confusion and misunderstanding that may arise from the use of different terms such as bitumen, asphalt etc., it is essential to be clear about terminology. In this document the following nomenclature is used:

Bitumen: A black or dark brown solid or semi-solid thermo-plastic material derived from the distillation of crude petroleum oil and possessing waterproofing and adhesive properties. Bitumen is defined in this way in most parts of the world outside North America, where the term used is "asphalt cement" or simply "asphalt".

Natural Bitumen: The term bitumen is also used for “natural bitumen” which can occur as natural deposits or as a component of naturally occurring asphalt, in which it is associated with mineral matter. Although natural bitumen may be similar in physical properties to bitumen, it is different in composition and is rarely, if ever, used in South Africa.

Asphalt: Refers to a mixture of bitumen (as defined above), or a bituminous binder (as defined below) with mineral matter such as stone, sand and a filler e.g. cement, lime or rock flour.

Bituminous binders: A mixture of bitumen, additives, modifiers, emulsifiers and cutters used in applications for road surfaces or the manufacture of asphalt mixes.

Note

Refer to the Glossary of Terms in the Preface (page 9) for a detailed list of the terms used in this document.

3. Types and grades of bitumen and bituminous binders

There are four main types of bitumen in general use in road construction and maintenance in South Africa:

- Penetration grade bitumen;
- Cutback bitumen;
- Bitumen emulsion; and
- Modified bituminous binders.

3.1 Penetration grade bitumen

Penetration grade bitumen can be manufactured by straight-run distillation or by blending two or more base bitumen components. Penetration grade bitumen is used either as a primary binder or as base bitumen for the manufacture of cutback bitumen, modified binders or bitumen emulsions.

3.2 Cutback bitumen

These are mixtures of bitumen with volatile petroleum diluents such as white spirit, kerosene or gas oil to render them more fluid for ease of handling and application. Depending on the level and volatility of the diluents used, the original properties of the bitumen may be partly or completely recovered by evaporation after application of the cutback. Cutbacks are sometimes heated for handling and application to temperatures up to 175°C. Grades are designated by the solvent used and the lower limit of kinematic viscosity at 60°C. Cutback grades are mainly used in road prime coats and chip seals.

3.3 Bitumen emulsions

Two phased systems consisting of a dispersion of bitumen droplets in water which contains an emulsifier. The emulsifiers are added to enable the formation of the emulsion, to render it stable and to modify its properties. The emulsions are available in two classes: cationic and anionic, depending on the electrical charges on the bitumen globules. In a cationic emulsion the bitumen particles are positively charged; in an anionic emulsion they are negatively charged. Usually emulsions contain 60-70% bitumen.

3.4 Modified bituminous binders

The rheological properties of bituminous binders can be modified by the introduction of polymers (including rubber crumbs) or hydrocarbons or alopathic synthetic wax. Modification with rubber crumbs requires the addition of oils and fluxes in some cases. Bitumen emulsions may also contain modifiers, typically in latex form. Modified bituminous binders are mainly used in road construction and maintenance in conditions where enhanced performance is required.

Note

Oxidised and hard grades of bitumen used exclusively in industrial applications such as roofing, flooring and pipe coatings are not covered in this document.

4. Hazards and potential adverse effects associated with the handling and use of bitumen

4.1 General overview

The hazards associated with bituminous products are invariably inherent in the very nature of the product, and the handling and application processes. When handling and using bitumens the potential adverse effects (unwanted consequences) arise from:

- The elevated temperatures generally necessary for ease of handling and application;
- Vapour and fume emissions associated with the product when heated;
- The combustible and sometimes flammable nature of the product;
- Persistent skin contact, particularly when in solution;
- Contact of hot bitumen with water in piping, storage tanks or other vessels, resulting in violent expansion of water to steam of more than 1 600 times its volume. This can give rise to dangerous froth-over and may cause boil-over and rupture of the tank roof;
- Use of compressed air to clear pipeline blockage or suspected blockage in hot bitumen lines, or use of air in mixing in bitumen tanks. As a general rule the potential adverse effects associated with the manufacture, storage, distribution, product handling and use of bitumen arise from one, or a combination of three initiating (top) events:

    - Loss of containment;
    - Loss of control;
    - Exposure to health effects.

In the sections that follow, generic guidance is provided on methods to limit and control the hazards associated with the handling and use of bitumen and bituminous binders. In Annexure A a generic table of *Hazards, consequences and recommended controls* has been included as an example of the output of a typical risk assessment process.

It is highly recommended that the *Bitumen Safety Code*, 4th edition, September 2005, published by the Energy Institute, be read and used as reference for the HSE aspects of bitumen manufacture, blending, storage, distribution, product handling and use, and sampling associated with the design, construction, operation, inspection and maintenance of roads.

4.2 Managing the health aspects of bitumen storage and handling

4.2.1 Physical hazards and effects

The most significant hazard in the use of bituminous binders is exposure to elevated temperatures, with the associated personal effect being heat burns. Bitumen is often handled at temperatures above 130°C. Modified bituminous binders are handled at temperatures of up to 210°C. Skin contact with liquid bitumen at these high temperatures will cause severe burns and shock, and can be fatal. Contact with storage tanks and pipelines containing hot bitumen will also cause severe skin burns.

4.2.2 Chemical hazards and effects

Exposure to toxic vapours and fumes

In confined spaces, vapours from bitumen products can be a health hazard and may displace oxygen and cause suffocation. Potentially hazardous concentrations of polycyclic aromatic hydrocarbons (PAHs) and hydrogen sulphide (H_2S) may be present in the vapour space of bitumen storage tanks, or in bitumen fumes liberated when bitumen is heated.

H_2S is a chemical asphyxiant and inhalation can cause respiratory paralysis. Prolonged or repeated skin contact with bitumen fumes may lead to dermatitis and skin carcinomas.

Note

Because H_2S inhibits (deadens) the sense of smell, the familiar bad eggs odour cannot be relied on to warn of the presence of hazardous concentrations.

4.2.3 Exposure to solvents contained in cold bitumen

Repairs to equipment used in conjunction with cutback bitumen and emulsions may involve skin contact with solvents.

Prolonged or repeated skin contact with these solvents may lead to dermatitis.

4.3 Controlling the health hazards

Legal responsibilities

Over and above the general requirements to "provide and maintain, as far as is reasonably practicable, a working environment that is safe and without risk to the health of employees", the Hazardous Chemical Substances (HCS) Regulations, 1995, of the Occupational Health and Safety Act, prescribe specific actions that "apply to an employer or a self-employed person who carries out work at a workplace which may expose any person to the intake of a hazardous chemical substance at the workplace".

It is not practical to copy or discuss the detailed requirements of the HCS Regulations in this guide. South African users of this manual must however be aware that these regulations are the MINIMUM mandatory requirements for control of HCS at the workplace. Therefore, cognisance should be taken of the fact that the generic controls provided or discussed in this document will not necessarily mean that full legal compliance is achieved.

General control measures for health hazards of bitumen

The measures described below are also known as the "heirarchy of control" because they should be considered in the order presented.

Administrative controls

A Health Risk Assessment (HRA) as required by the HCS regulations should be performed. The HRA will also guide the implementation of adequate control programmes to minimise the potential exposure to hazards associated with bitumen, the identification of PPE that should be worn and the development of training programmes for bitumen workers.

Where indicated by the HRA, air monitoring and medical surveillance programmes should be implemented. This should only be done by an accredited occupational hygienist.

Engineering controls

Plant, equipment and processes should be planned and designed to minimise the likelihood of personal contact with hot bitumen or components of storage and distribution systems.

Storage tanks and pipelines containing hot bitumen and heated by steam, hot thermal oil or petroleum fired burners must be shielded or lagged with a suitable thermal insulation material.

Where hot bitumen is handled by persons working in places with restricted ventilation, e.g. indoors, effective Local Exhaust Ventilation (LEV) should be used to reduce exposure as far as possible.

Procedural controls

Always carry out bitumen operations at as low a temperature as possible to minimise potential exposure to bitumen vapours or fumes.

Confined space entry and work must be strictly controlled by a Permit To Work (PTW) system to eliminate exposure to oxygen-deficient atmospheres and hazardous concentrations of harmful substances.

Internal tank cleaning and repair operations should only be entrusted to competent specialist contractors with a proven track record.

Note

The development of vapours and fumes accelerates with increase in temperature.

Personal hygiene precautions

Good personal hygiene in respect of hands and inner clothing must be maintained in the course of work. Under no circumstances should a person who has been handling bituminous products eat, drink, smoke or go to the toilet before first washing their hands.

The application of suitable barrier creams to exposed parts of the skin, prior to working with bitumen, assists in subsequent cleansing should contact occur.

Petroleum products such as petrol, paraffin or diesel should never be used for skin cleansing purposes because they damage the skin.

Note

Barrier creams are not adequate substitutes for gloves or other impermeable clothing and should not be relied upon as the sole form of protection.

Personal Protective Equipment (PPE)

Note

Legally, and in terms of heirarchical hazard control standards, the prescription of PPE should not be the sole measure for controlling hazards. In order to assure the effectiveness of PPE, personnel should be trained in the correct use of PPE and arrangements must be in place for routine inspection and maintenance. Adequate facilities for storage should also be provided.

The objective of PPE is to prevent exposure and is also a recovery or mitigating measure. If controlled adequately the correct use of PPE can be an effective "*last barrier*" to prevent or minimise the potential consequences (effects) of a hazard.

While the task-specific risk assessment will determine PPE requirements, the typical PPE for a bitumen worker should be as follows:

Protective clothing for torso, arms and legs

Overalls appropriate to the hazard e.g. acid resistant or heat resistant should be the standard choice. These should have close-fitting cuffs and trouser legs capable of overlapping footwear. Added protection is offered by wearing a leather apron when there is a high likelihood of coming into contact with hot bitumen.

Face, neck and eye protection

As the minimum an approved face shield and suitable eye protection (goggles) should be worn. A heat resistant (racing type) balaclava will provide added protection for the exposed neck area and should be considered for certain tasks as identified in the HRA.

Hand protection

Heat-resistant/chemical-resistant gloves with close-fitting cuffs.

Foot protection

Heat-resistant heavy duty safety boots, close fitting at the top, such that trouser legs are capable of overlapping them. Under no circumstances should light shoes or sandals be worn.

Respiratory protection

Besides the obvious respiratory protection needed for confined space entry/work, there may be other tasks (as identified in the HRA) that require the use of respirators to protect workers from toxic vapours or fumes. These would typically be situations where it is not practicable to eliminate the existence of vapours or fumes entirely, i.e.when loading or offloading cutback bitumen and emulsions containing cutters. A half face-piece respirator with an approved P100/OV/AG filter is suitable for such applications.

4.4 Recovery measures for the consequences of bitumen health hazards

Emergency response planning - bitumen burns

Bitumen burns require unique treatment. Each location where hot bitumen is handled must have a bitumen specific medical emergency response plan that should as a minimum cover the following:

- Emergency water showers should be provided. It is recommended that a minimum flow of 75 litres a minute at 2,1 bar should be delivered for a minimum of 15 minutes. Eye bath facilities should be available in close proximity to operational areas where the likelihood of bitumen burns has been identified;
- First-aid workers that are likely to administer emergency treatment MUST be specifically trained for this purpose and available on each shift;
- An adequate number of approved bitumen burns first aid kits should be provided, including a supply of the green **BitSafe** bitumen burns tags;
- Arrangements should be in place to evacuate burn victims to an approved burn/trauma unit as not all emergency medical treatment centres are familiar with the correct methods for treating bitumen burns.

Guidance for first aid and medical personnel

No attempt should be made to remove firmly adherent bitumen from the skin of any victim at the work site!

Once the bitumen has cooled it is not harmful, and in fact provides a sterile cover over the burned area. As healing takes place the bitumen will detach itself, usually after a few days. If, because of the location of contact, it becomes necessary to remove the bitumen, liberal amounts of warm medicinal paraffin may be used. Alternatively, a blend of medicinal paraffin and kerosene may be used. However, care should be exercised as kerosene may cause skin irritation.

After any solvent treatment the skin should be washed carefully with soap and water, followed by the application of a proprietary defatting agent or skin cleansing cream. Only medically approved solvents should be used to remove bitumen from burns as other solvents could cause further skin damage.

Emergency treatment of bitumen burns

- Burns to the skin or eyes should be cooled immediately by drenching the burned area of the body under clean cold, preferably running, water. This treatment should continue until the bitumen has cooled. (This should take no less than 15 minutes);
- DO NOT break blisters or remove solid bitumen from the skin or area of the eye as it forms a sterile barrier to the affected part and will protect against infection. A bitumen plaque will normally detach itself within a few days;

- DO NOT, under any circumstances, apply ointments, oils, butter, solvents or other substances to a burn;

Note

When hot bitumen completely encircles a limb or other body part, a tourniquet effect may result as the bitumen cools. In such cases the bitumen should be softened as described above, and the patient referred urgently for specialised medical attention.

- Apply a BURNSHIELD dressing over the affected area and secure the dressing lightly with a sterile bandage;
- DO NOT remove or cut away clothing over burnt areas;
- DO NOT pull away clothing which has stuck, this may cause further injury;
- Keep the victim warm and provide plenty of fresh air;
- Attach a bitumen burns tag to the patient's clothing in a prominent position before transport to doctor or hospital.

4.5 Managing the safety aspects of bitumen storage and handling

Hazards arising from the combustible and flammable nature of bituminous products

It is important to understand the various components that, potentially, could combine to cause explosions and/or fires in the bitumen storage and handling processes.

Combustion of liquids occurs when flammable vapours released from the surface of the liquid ignite. Hydrocarbon vapour becomes flammable when its percentage in air is generally at about 1% by volume. This is known as the Lower Flammable Limit (LFL) and below this the mixture is said to be "too lean to burn" or "below the lower flammable limit". The flammable range extends to a higher level of about 8% by volume, when it is said to be above the Upper Flammable Limit (UFL) or "too rich to burn".

The amount of flammable vapour given off from a liquid, and therefore the extent of the fire or explosion hazard, depends largely on the temperature of the liquid, its volatility, the extent of the exposed surface area, duration of exposure, and air movement over the surface.

Other physical properties of the liquid, such as flashpoint, auto-ignition temperature and viscosity, give further information on the way in which vapour/air mixtures may develop, and also on the potential hazards.

Some examples of the typical properties of the hydrocarbon substances that may be present in bituminous products or used in bitumen operations are illustrated in the following table:

Table 1. Typical physical properties of hydrocarbon substances

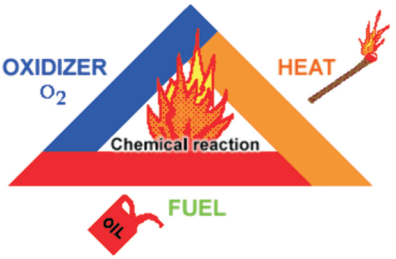
Product	LFL/UFL (%/Vol)	Flashpoint	Auto ignition temperature
Bitumen		300°C	500°C
Petrol	1,4% - 7,6%	< -40°C	370°C
Diesel (AGO)	1,3% - 6%	> 55°C	225°C
Kerosenes	0,6% - 6,5%	> 43°C	205°C
LPG (n-Butane)	1,9% - 8,5%	-60°C	287°C
LPG (Propane)	2,3% - 9,5%	-104°C	460 - 580°C
Hydrogen Sulphide	4% - 45%	-82°C	260°C
Toluene	1,3% - 7%	4°C	536°C

Mechanism of the ignition of bitumen

For effective blending and application in road construction and maintenance operations, bituminous binders need to be in a liquid state. To achieve this the viscosity of the product is lowered either by heating to produce a molten liquid of very high temperature, or diluting with volatile solvents that release flammable vapours, i.e. cutback bitumen and some bitumen emulsions, with the following results:

- Product is at a high temperature - above its flashpoint - and contact with an ignition source (flame) can ignite the flammable vapour released from the surface of the bitumen;
- The elevated temperature also increases volatility, i.e. the ability of the bitumen to release flammable vapours. Bitumen and its derivatives contain hydrocarbons in various concentrations, depending on the blend/mixture. Small quantities of the vapours of hydrocarbons in air can form a flammable mixture that can be ignited by a flame, hot surface, heating element, spark or other source of ignition, particularly in the vapour space of storage tanks, road tankers and other confined spaces where bitumen may be stored or handled;

- Bitumen foams in the presence of water as the temperature of bitumen is usually above the boiling point of water. Bitumen heated in the presence of small quantities of water forms foam that can quickly expand and cause the tank to overflow. The expanding foam can quickly reach hot objects or burners, and cause the bitumen and/or flammable vapours to ignite.



Control of flammable atmospheres in bitumen operations

An understanding of the anatomy of a fire is essential for establishing a decision-making framework for the development of controls for fire hazards. The fire triangle illustrates the necessary elements that must be combined in order for a fire to start and be sustained.

Controlling flammable atmospheres in bitumen operations will therefore be a function of effectively excluding and/or removing one or more of the three essential elements of fire. Fuel (bitumen) is obviously an essential ingredient of the bituminous product and asphalt industry, and cannot be removed or excluded.

Oxygen is ever present in the air that we breathe and in the atmospheres of the containment systems of our bitumen storage and handling processes. Oxygen can therefore also not be excluded or removed.

Note

A combination of the three elements fuel, oxygen and heat will, under ideal conditions, result in ignition causing a fire or explosion. It therefore follows that, by excluding any one of the three elements, a fire cannot start and, by removing any one of the three elements from a fire, the fire cannot be sustained and will be extinguished.

Heat (the source of ignition) is the only element that could possibly be excluded or removed in order to control fire and explosion threats. Heating of most bituminous products to temperatures of between 100ºC - 230ºC is also an essential requirement for ease of handling and application and can therefore also not be excluded or entirely removed. However we can control the heating of bitumen and also effectively control other ignition (heat) sources in our operations.

The relationship between the flashpoint/ignition temperature/flammable range and the ultimate formation or existence of flammable atmospheres in bitumen operations is very complex and is grade dependent. As can be seen from Table 1, bitumen is invariably stored and handled at temperatures above the flashpoints but, in most cases, below the auto-ignition temperatures of the hydrocarbon components of bitumen blends. In some cases the auto-ignition temperatures can actually be lower than the flashpoint of a bitumen blend/mixture.

Furthermore, because of operational requirements to pump and apply the bituminous binder, not much can be done about lowering heating temperatures. However, in practice there are some fundamental rules that can be applied to minimise the risk of ignition of potentially flammable atmospheres in bitumen operations.

Maximum storage and handling temperatures

The first rule of temperature control should be to control the maximum temperature at which bitumen is stored and handled. Bitumen should be stored and handled at the lowest temperature commensurate with efficient use, as recommended in Table 2.

Table 2. Recommended storage and handling temperatures for bituminous binders in general use

Bitumen type and grade	Minimum pumping temperature (°C)	Typical application temperatures (°C)		Maximum storage temperature (°C)	
		Mixing	Spraying		
Penetration grades				<24hrs	>24hrs
150/200 pen	105	-	155 - 165	160	115
80/100 pen	115	140 - 155	170 - 180	160	125
60/70 pen	120	150 - 160	-	160	125
40/50 pen	125	155 - 165	-	165	140
Cutback bitumen					
MC30	15	-	55	60	Amb.
MC3000	85	-	130 - 145	130	90
Emulsions[1]					
Cationic spray 60%	5	-	60	80	50
Cationic spray 65%	15	-	65	80	50
Cationic spray 70%	15	-	70	80	50-
Invert emulsion	5	-	60	80	50-
Modified binders					
SBR modified	150	175 - 190	200 - 210	180	150
SBS modified	140	170 - 180	175 - 185	180	150
EVA modified	140	160 - 170	-	170	150
FT-Wax modified	120	135 - 145	-	150	120
Natural hydrocarbon modified	130	165 - 175	-	175	150
Bitumen rubber	160	190 - 210	200 - 210	165	140[2]
SBR modified emulsion 65%	15	-	65	70	Amb.
SBR modified emulsion 70%	15	-	70	70	Amb.

[1] Storage periods for emulsions may exceed 240 hours at the temperatures given in the 24 - 240 hour period.
[2] Bitumen rubber should not be stored for more than 72 hours.

Temperature control measures in bitumen operations will include the following:

- Engineering controls incorporated in the design of bitumen storage tanks:
    - heating element temperature controls;
    - tank maximum working temperature controls;
    - warning (alarms) for high temperatures in tanks.

Note

A planned inspection/maintenance programme should be in place to assure the integrity of control instrumentation.

- Procedural controls:
    - safe work practices to avoid excessive local heating (i.e. spraying operations, clearing of pipeline blockages, bitumen decanting, laboratory testing);
    - Control of sources of ignition.

Control of ignition sources in the presence of potential flammable atmospheres

- In terms of the Hazard Control Hierarchy, ignition sources in the presence of potential flammable atmospheres can generally be controlled in two ways:
    - by complete elimination; or
    - isolating the source (e.g. electrical sparks) by installing approved electrical protection equipment in hazardous areas.

Although very important for total and effective control purposes, the selection and installation of electrical protection equipment in hazardous areas is not discussed in this document. Design personnel can obtain detailed information on the subject by referring to various appropriate national (SANS) and international codes of practice. T*he Bitumen Safety Code,* 4th edition, September 2005, published by the Energy Institute, London UK, is an excellent general reference for this purpose.

Eliminating potential ignition source.

As the first step in this process a detailed risk assessment should be done to identify the hazardous areas in which flammable atmospheres could occur. A handy guideline to assist with identification of hazardous areas is the IP publication *Area classification code for installations*

handling flammable fluids. The code subdivides hazardous areas into the following zones:

- **Zone 0:** That part of a hazardous area in which a flammable atmosphere is continuously present or present for long periods (e.g. the vapour space of a cutback bitumen storage tank);
- **Zone 1:** That part of a hazardous area in which a flammable atmosphere is likely to occur in normal operation (e.g. immediately above/around/below the compartment hatch during bitumen road tanker loading);
- **Zone 2:** That part of a hazardous area in which a flammable atmosphere is not likely to occur in normal operation, and if it occurs, will exist for a short period only (e.g. around the pump seals and flanges of a bitumen pump manifold).

Note

Any area not classified under Zones 0,1 or 2 may, for ignition control purposes, be classified as a non-hazardous area. However, caution should be exercised in applying zone classification because operational activities in close proximity to designated zones could, under abnormal operating conditions, change the state of a safe zone to hazardous.

Having identified the hazardous zones in which flammable atmospheres in bitumen operations could occur, the following control measures should be in place:

Engineering controls

- Design and construction of storage and handling facilities and equipment in accordance with appropriate and approved specifications.

Administrative controls

- The continued operational integrity of electrical protection equipment in hazardous areas is assured by a planned inspection and maintenance program;
- A Permit To Work (PTW) system to control all hot work in confined spaces and other hazardous areas;
- A training programme to assure the competence of personnel required to perform work in hazardous areas (including emergency response training).

Procedural/process controls

Safe work practices, based on site-specific Job Hazard Analysis (JHA), include the following:

- Clear definition of what is "routine" and "non-routine" hot work;
- All non-routine hot work is subject to a clearance certificate/procedure and subsequent PTW control if the work will be performed in a hazardous zone;
- Designated safe areas for performance of all *routine* hot work (i.e. welding, cutting, etc.);
- General site safety instructions with regard to:
  - Smoking and the carrying of matches, lighters, etc.;
  - The use of spark or flame producing equipment on site;
- Clear procedures and instructions for loading and offloading of bitumen to prevent loss of containment and contact with potential ignition sources;
- To prevent frothing and/or boil over instructions must include inspection to ensure all tanks are free of water before loading bitumen. Additives and extender oils must also be checked for the presence of water before adding to bitumen;
- The application of excess heat (e.g. welding torch) on bitumen can cause thermal cracking and the development of flammable vapour. Open flame heating should only be used to free plugged bitumen valves as a last resort, and the vehicle must be in a safe zone area. Spray bars should be heated with caution and under supervision;
- The vapours in the closed space above a hot cutback are invariably flammable, but almost always in too high a concentration, above the Upper Explosive Limit (UEL) to be explosive. However, where escaping vapour starts to mix with air, extreme care must be exercised, since this is where the mixture may become explosive. Consequently, whenever practical during transfer operations, tank hatch covers should be kept closed, or at least lowered, to preserve the vapour-rich atmosphere above the binder;
- No surface of the heating flues should be exposed in the vapour space as this could cause a dangerous explosion. Tanks should always be dipped before lighting burners to ensure that the bitumen level is at least 200mm above the burner flues or heating coils.

4.6 Recovery measures for fires involving bituminous products

Introduction

This section provides general guidance for bitumen fires in normal day-to-day storage and handling activities, and does not cover the protection of large fixed storage installations or bitumen loading facilities at refineries. The scope is therefore limited to cover immediate response to small fires and management must ensure that a comprehensive fire risk assessment is performed to cover all potential fire scenarios on a particular plant or site.

Note

Large bitumen fires can be difficult to extinguish and this task is best left to competent professional fire fighting services.

Types of fires

For fire fighting purposes, fires are grouped in various classes as an aid to identification of the most appropriate extinguishing medium. The fire types most commonly encountered in the bituminous products industry are class A, B and C.

Class A fires: The combustible materials involved in this class of fire are usually organic materials such as grass, wood, paper, textiles etc. This class of fire is usually extinguished by either quenching or cooling with water.

Class B fires: Flammable liquids such as petroleum products, (e.g. petrol, diesel oil, paraffin, lubricants and bitumen) and flammable and combustible chemicals, are involved in this class of fire. When fighting Class B fires the exclusion of oxygen by smothering is usually employed.

Class C fires: This class of fire is essentially either a Class A or B fire that involves live electrical equipment. The reason for the separate classification is that no extinguishing agent containing water can be used to fight a fire involving electricity. Generally CO_2 (carbon dioxide) extinguishers are recommended as first choice to fight these fires. However dry chemical extinguishers can also be applied effectively but may damage sensitive electronic components.

Class D fires involve metals such as magnesium, aluminium, titanium and potassium, and require special knowledge, skills and extinguishing equipment. As it is not commonly encountered there will be no further discussion of class D fires in this guide.

General principles to consider when fighting bitumen fires

- When bitumen burns it becomes a mobile liquid that can readily flow, spreading the fire;
- Large bitumen fires are difficult to extinguish because of the high heat content of the liquid;
- Direct application of water to the surface of a bitumen pool on fire produces a froth of bitumen due to expansion of the water to steam, which is likely to boil-over, spreading the fire and endangering personnel. Straight water jets should never be used; application of water should only be by fog or spray nozzle and only performed by competent fire fighters;
- Un-burned liquid bitumen can be heated by the fire to a temperature well above its ignition temperature, making it necessary not only to extinguish the flames and cool the surroundings but in order to prevent re-ignition, to cool the product bulk before leaving it in contact with air;
- Bitumen fires produce a dense brown or black smoke, severely reducing visibility downwind of the fire;
- As an initial measure to limit propagation of fire, (particularly for large fires) the heating circuits of appliances to tanks and kettles should be switched off as soon as is practicable.

Fighting small bitumen fires

Small bitumen fires from leaks or spills can be extinguished using dry chemical (powder), foam, water spray, carbon dioxide or (where available) steam lances. The use of foam, water spray and steam must be avoided where it is not practicable to isolate the electrical supply from equipment near the fire.

Provision and maintenance of first attack equipment

Note

It is a legal requirement that fire extinguishers should be serviced by an accredited service provider at intervals of not less than once per year. It is also good practice to have an inspection schedule in place to perform *in situ* visual inspections of all fire equipment at least once per month.

- Generally, portable (typically 9 kg) dry chemical extinguishers are preferred for first attack on small bitumen fires. Alternatively

semi-fixed portable (wheeled) installations (typically 50kg trolley units) may also be considered;
- When planning the placement of first attack equipment, fire risk assessments should assure that the correct extinguisher is placed in the location where the fire potential has been identified. This takes the guess work of selecting the appropriate extinguisher out of the equation when an emergency arises;
- There should be a minimum of two extinguishers at each location (including road tankers and spray vehicles) in case one fails;
- In addition road tankers and spray vehicles should carry at least one shovel, and at each static loading/discharge point a shovel and a supply of clean loose sand should be readily available for emergency spill containment.

First attack training for personnel

- All personnel involved in work where the likelihood of bitumen fires exist, must be trained in the correct use of fire extinguishers. It should not be taken for granted that merely following the instructions on the extinguisher body will ensure correct application. Local authority fire services usually have fire training programmes that can be customised to accommodate specific needs;
- Regular fire drills should be planned and carried out to simulate realistic fire scenarios. Although it is prudent to protect trainees against injury during training exercises it must also be borne in mind that in a real life fire emergency the fireman's PPE will not be available and therefore training should be as realistic as is practicable;
- A training programme for first attack fire fighting should include the visual inspection requirements to ensure that fire extinguishers are checked before the start of a shift or activity where the potential for a fire exists (i.e. road tanker drivers, plant operators, laboratory staff, etc.).

Fire Emergency Plans

A fire emergency plan should be in place at every site/workstation where the potential of a bitumen fire has been identified. The plan should include procedures for:

- Raising the alarm in case of fire;
- Evacuation of affected personnel and vehicles;
- Calling local authority emergency response teams (i.e. fire brigade and if necessary an ambulance and the police);

- First attack on the fire (i.e. availability and strategic placement of suitable fire extinguishers, training of personnel in use of extinguishers, maintenance of fire extinguishers, etc.);
- Handing over fire-fighting command to the local authority fire chief;
- Mitigating damage and in particular managing fire-fighting water in order to prevent pollution;
- Signalling the end of the emergency.

Note

The best way to fight fires is to prevent them! Management must insist on, and enforce, good housekeeping practices and adherence to safe working procedures. Fire and explosions have devastating destructive power, and the time and effort spent on fire prevention is ALWAYS a good investment.

4.7 Managing the environmental aspects of bitumen storage and handling

Introduction

The main environmental hazards related to bitumen are associated with atmospheric discharges and the impact on the water environment resulting from loss of containment during the manufacturing, storage, transport, handling and use of bitumen, particularly cutback bitumen and emulsions.

Air pollution

The key emissions from bitumen processes that warrant control are bitumen fumes, odours, PAHs, H_2S, volatile organic compounds, and particulate matter.

Emissions could arise as result of the following activities or processes:

Activity/Process	May give rise to
Delivering, storing, heating, mixing and cooling of bitumen	Bitumen fumes, odours and PAHs
Storage and delivery of solvents and blending them with hot materials	Volatile organic compounds and odours
The oxidising of bitumen	H_2S, bitumen fumes, odours and PAHs
Burning of coal tar fuel in boilers	Coal tar fumes containing PAHs

Water pollution

Because of the viscous nature of penetration grade bitumen it is extremely unlikely that these binders could cause water pollution as a result of failure of storage systems. Cutback bitumen and bitumen emulsions, however, have the potential to cause serious environmental harm if they reach water courses or ground water.

In most cases hydrocarbons will form a layer at the surface of any water body. However emulsions, by their nature, incorporate a range of additional emulsification agents, acids and bases that are harmful in the aquatic environment and will emulsify the bitumen, distributing it throughout the water body and increasing the potential hazard.

Preventing air pollution and monitoring emissions

Environmental protection in South Africa is regulated under a myriad of laws, regulations, codes of practice and standards. Full legal compliance is not within the scope of this guideline and only a general discussion of generic prevention measures is included. However, it is strongly recommended that all parties involved in the planning, provision and application of bituminous products ensure that the requirements of the National Environmental Management: Air Quality Act, 2004 (Act no. 39 of 2004 effective from 1 April 2010) are taken into account when assessing environmental risk and impact of their operations. In particular, the schedule of listed activities and minimum emission standards identified in terms of section 21 of the Act is of importance to establish monitoring programmes and plans to manage emissions.

General pollution prevention measures in bitumen storage and handling processes

Plant operations

- As processes which involve the use of bituminous binders at elevated temperatures release fumes, a key method of reducing emissions is to keep the bitumen temperature as low as possible;
- To prevent or limit the emission of vapours during storage, manholes must be kept closed. Breather pipes must be open and functional at all times;
- All site static tanks should be inspected on a daily basis for possible subsidence or leaks. When not in use the valves should preferably be locked;
- Regular tank gauging and stock reconciliation should be standard practice as a measure to detect possible tank floor leaks;
- Contaminated materials should be removed from site and disposed of in an environmentally acceptable manner;

- Cleaning of contaminated equipment must be done under controlled conditions to prevent seepage of washing and flushing materials into water sources. Where possible make use of a certified wash bay.

Transport, and spray operations (Refer to Sabita Manual 23: *Code of Practice: Loading bitumen at refineries*, for safe loading procedures.)

- To minimise the risk of pollution of natural resources, i.e. rivers, dams, groundwater or wildlife during transportation, a route with the lowest possible pollution impact should be selected. This can be done by researching information on the area, or consulting with local authorities and emergency services. These bodies should be informed of the operation and its nature;
- During long trips the driver should stop periodically to do necessary in-transit vehicle inspections (at least every 2 hours if practicable);
- Spray bars on spraying vehicles must be covered when lifted, and the covers must have designated storage positions when the bars are down and the vehicle is spraying;
- Transfer lines (flexible hoses) contribute toward leakages and spillage. Where practicable, reverse the sprayer pump, leaving all lines empty, prior to storage;
- Pressure and nozzle checks are usually conducted next to the road to be sprayed. This must always be done using drip pans or paper, which can be picked up for safe disposal;
- All flexible discharge hoses must be stowed in designated positions. Hoses should be emptied before uncoupling. A procedure should be in place for collection and disposal of all hose drainings;
- All flanges, nozzles and pumps must be maintained in good condition to prevent spillage. Where necessary drip trays must be used to contain leakage;
- At the end of each day's spraying the spray bar system must be flushed with cleaning solvent. All flushing fluids must be collected in secure containers and returned to the base plant for recycling or safe disposal.

Temporary storage of bituminous products on construction sites

To prevent pollution, the establishment of static tanks on sites must be planned properly. Consideration must be given to:

- The hardness or firmness of the surface;
- The gradient;
- The drainage;

- Position of adjacent water sources and sensitive environmental areas;
- Accessibility;
- A bund wall around the tanks.

Disposal of bituminous waste

Although penetration grade bitumen has been declassified as a hazardous substance for packaging and transport purposes, other bituminous binders (i.e. cutbacks, emulsions, etc.) and waste contain hazardous substances. Care should therefore be exercised when bituminous waste is classified for disposal purposes.

Waste derived from bituminous binder applications may only be disposed of at approved waste disposal sites. Under no circumstances may waste be disposed of in any other manner or without the necessary written authority. Bituminous binder waste includes spills, scrapings, flushing residue, contaminated product and bituminous mixtures. Ensure that a certificate of safe disposal is obtained from the disposal site.

Note

The National Environmental Management Act No. 107 of 1998 holds the polluter accountable for any incident where environmental degradation has occurred.

5. General guidance for specific bitumen storage, handling and distribution activities

5.1 Vehicles, transport and transfer of bituminous products

General transportation requirements

Transportation of bituminous products must be conducted in accordance with legislation on the transportation of dangerous goods. Some bituminous products are classified as *Dangerous Goods* and all vehicles carrying such products must display hazard warning placards, which are used to provide the emergency services with information on how to handle the cargo being carried in the event of an accident or other emergency. These placards indicate the nature of the product, its UN number and telephone numbers of the transporter and a specialist response advisor, who should ideally be able to provide prompt physical assistance in cleansing and rehabilitation of the area. Regulations based on various codes of practice set out by the SABS govern the use of these warning panels.

All relevant documents must be carried in the vehicle, including:

- MSDS, route plan, tremcards, licences and permits;
- Dangerous goods transportation documents, supplier's commercial documentation;
- PrDP licence and any relevant medical documentation.

To assist emergency services, Tremcards must be available and stored in the designated space i.e. orange coloured box.

The driver must ensure that emergency breakdown triangles, fire extinguishers, flashing lights, first aid kit etc. are available. It is recommended that a first aid kit containing the minimum items listed in Annexure D is carried on each vehicle. Refer to Annexure F for a *pro forma aide mémoire* that can be used by drivers to check on availability of essential equipment before departure on a delivery trip. Legally, drivers must undergo the prescribed annual medical examination.

Care of vehicles and equipment

All bitumen equipment must be kept in good condition at all times. Hoses, fittings and threads in particular should be thoroughly cleaned after each delivery or transfer. Product lines, hand sprays, pumps, valves and hoses should be flushed after use to avoid bitumen slugs. Bitumen slugs blocking partially closed valves or leaking hoses may remain undetected until the bitumen is too hot to approach with safety.

Flexible hoses should be used under suction rather than under pressure. Hose assemblies should be inspected regularly for defects or holes. Defective hoses and fittings must be withdrawn and destroyed. Hose assemblies should be stored flat in such a way as to ensure that no residual binder is left in the line. When carried on items of plant or stored at the depot, both hose ends should be fitted with dust caps to prevent entry of foreign material (e.g. stones) that may jam or damage the bitumen pump.

Operators should inspect all equipment required for the transport and delivery of bitumen products before leaving the filling point. Faults should be reported and rectified before any further deliveries are permitted.

All ladders, catwalks, safety rails and grab points must be maintained in a good and clean condition. Accumulation of bitumen must not be allowed.

All vehicles, tanks and equipment should be maintained in accordance with acceptable practices, maintenance schedules and procedures.

Equipment checks

Vehicle checks must be carried out on a scheduled basis. In addition operational inspections should be done on a daily basis. Checklists must be completed and maintained by the responsible personnel i.e. the driver.

Regular checks on internal overflow and breather valves must be carried out to ensure they are in proper working order.

All delivery hoses must be inspected regularly, be in good condition and free of bitumen residue. All connections and hoses must be cleaned thoroughly after each delivery. Residual bitumen in hoses must be allowed to drain into suitable trays after use.

Spray nozzles must be inspected daily to ensure that they are undamaged and correctly fitted. The bitumen pump must be turned off before any attempt to inspect, replace or maintain spray nozzles, or any part of the spray bar or its fittings.

Product sampling

Binder samples should preferably be taken from purpose-designed sample cocks. Most tankers and sprayers are fitted with a sampling

device and this should be used at all times. If a sampling device is not fitted, the sample may be taken, with great care and under supervision, from a valve or single jet in the spray-bar.

During sampling or while handling the hot sample personnel should stand clear and wear the recommended PPE to avoid being burned. The binder pump should always be operated at the lowest speed when taking a sample to minimise pressure in the system.

The recommended method is to have sample cocks fitted to sprayers, tankers or storage tanks. In the event that the sample is drawn from the manhole, a thief sampler should be used. Care should be taken to allow the sample to cool in a safe place where it does not present a danger to other people in the area. The sample should be allowed to cool before the lid is put in place.

Heating

Note

Heating flues should be designed such that:

- the flues do not pass through the vapour space above the product;
- the surface temperature will not exceed 350°C on any part of the heating flue;
- the flame tube insert can be easily removed for service or replacement;
- the inlet or exhaust flues will not be closer than 1,5m horizontally from any manhole or vent pipe;
- the flues are not in direct contact with the tank.

The following requirements should be complied with during heating operations:

- Bituminous material must be at least 200mm above heating flues. Parking of vehicles on sloping ground may cause heating flues to become uncovered and therefore pose a danger during heating;
- When discharging a tank, burners must be turned off. Fire extinguishers must be removed and placed in a position ready for use before heating commences. Manhole covers must be open;
- Appropriate PPE must be worn during heating operations;
- Under no circumstances should burners be used while travelling. This is prescribed by legislation;

- No source of ignition should be permitted within 3m of the vehicle when loading or discharging. The operations must be supervised constantly;
- Sufficient ullage must be left in a loaded vehicle or tank to allow for expansion of the bitumen when heated;
- Gas cylinders must be stored and secured in an upright position. When turning off gas supply after use, the valve on the cylinder must be closed first, and thereafter the valve at the nozzle;
- Ensure that only required personnel are in the vicinity during the heating operation;
- A product should never be heated above the recommended temperature required for transporting, pumping and spraying. Thermometers should be checked regularly and any malfunctioning thermometer reported immediately;
- Cutback bitumen must only be heated in tankers with circulation facilities.

Precautions during heating

- Do not leave the tanker unattended when burners are on;
- Position tankers so that the wind will carry vapours away from the burners;
- Do not stand on top of the tank during heating;
- Discharge product from the tanker only when the burners have been turned off;
- Only heat product if heating tubes are covered by at least 150mm;
- Do not use burners if any heating equipment has fuel leaks;
- Do not stand directly behind burners when lighting or adjusting;
- Do not store open solvent or fuel containers near heating operation;
- Do not smoke or use cell phones during the heating operation.

Transfer (loading and offloading) of bitumen

The reader's attention is drawn to Sabita Manual 23: *Code of Practice: Loading bitumen at refineries*, which offers guidelines for procedures and safety requirements for hauliers collecting bitumen from refineries.

General considerations for transfer of hot bitumen are as follows:

- Tankers must not be offloaded during heating;
- It is recommended that two persons be in attendance during loading and offloading of bulk bitumen carriers. When loading, one person should be so positioned that he can clearly observe the product level to prevent the likelihood of spill over;

- Fire extinguishers must be removed from storage and placed in a suitable area ready for use;
- Flexible hoses and couplings must be inspected before use, and unsafe hoses must not be used;
- The type and level of material in both the supply and receiving tanks should always be checked. If the receiving tank contains some material ensure that it is the same as, or compatible with, the material being delivered and that there is sufficient space for the quantity being delivered;
- Ensure that there is no water in the tank prior to loading as this could cause a violent explosion, frothing or boiling over;
- Operators should be aware at all times of the potential dangers when transferring hot bitumen, and remain at a safe distance from the hose during transfer. All personnel not required for the operation should keep well away and not stand near or over the hose while it is in use. The equipment should never be left unattended during the transfer operation;
- When loading is carried out using a discharge extension through the manhole, the free end of the extension must be below the opening of the manhole;
- Before loading commences a check must be carried out to ensure that all discharge valves on the receiving tank are closed. Care must be taken to ensure that no valves are plugged with solidified bitumen, giving the impression of being in the closed position;
- The safest method of clearing plugged valves, on an empty tank, is to heat a steel bar to a temperature sufficient to melt the bitumen and no more, and to insert the heated bar into the plug;
- The use of gas burners or other open flame methods to free plugged valves must only be considered as a last resort. If this method is to be used the vehicle must be moved to a clear safe area with fire extinguishers on hand;
- During loading no source of ignition should be allowed in the vicinity of the receiving tank;
- Earthing the vehicle to eliminate the accumulation of electrostatic charge is necessary during the loading or offloading of cutback bitumen. This is done by making sure that the metal of the loading pipe is in electrical contact with the metal at the manhole by means of an earth cable. The simple act of a material flowing through a pipe or hose may generate sufficient static electricity to cause a spark when connecting/disconnecting hoses unless there is a continuous connection;
- Ullage of at least 10% should be left after loading to allow for expansion resulting from any subsequent heating;

- After completing the transfer of materials, a check should be carried out to ensure that the valves on both the supply and receiving units are closed and the bitumen pump is turned off;
- Carefully undo the hose. The bottom must first be loosened slightly. A small amount of material may flow out of the hose coupling into a drip tray, indicating that it is empty, that there is no pressure, and that it is safe to remove. If there is a large amount of material, or residual pressure in the hose, possibly due to a valve not having been closed properly, this procedure will ensure that the product squirts onto the ground rather than into the operator's face or over his body;
- The free end of the hose must be kept clear of the ground to avoid dirt, stones etc. lodging in the hose. There are special hose chairs available to plug and hold the end clear off the ground. Common practice is to turn the end of the hose up and over so that it will remain in that position. This procedure will also prevent entry of rainwater into the hose. Failure to do this could cause a dangerous boil over of hot material loaded next into the tank;
- After loading, the pump lines must be emptied by sucking back into the tank. On completion of discharge, pump, pipelines and hoses must be flushed out with paraffin or diesel and cleared of product. Hose couplings must also be thoroughly cleaned;
- Flushing fluids must be collected for re-use, and disposal must be in accordance with statutory requirements and best practice procedures;
- The manhole cover must be securely fastened before departure after loading;
- In the event of any spillage of bitumen during delivery or transfer (such as by hose failure or tank overflows), all valves should be closed, hoses disconnected, all caps screwed down and the customer or his representative informed of the spillage. The area should be cleaned and authorities must be informed so that they can certify that the site has been restored to its former condition.

Note

After the unloading of cutback bitumen that has been heated to spraying temperatures the tank will contain a gas/air mixture that may be in the explosive range. This is the time when the product is most hazardous. All sources of ignition and heat must be prevented from coming into contact with this explosive mixture.

Loading of different products

Change of product should be carried out only when approved and supervised. When loading the next product, due consideration must be given to the previous content of the vessel to avoid contamination or boil-over. Generally this requires draining the tank lines and flushing the system with appropriate fluid compatible with the new product being loaded. All flushing and other residue must be collected and disposed of in accordance with best practice procedures and the requirements of the relevant legislation.

When bitumen emulsion is to be loaded into a tank that has contained bitumen, it is necessary to drain out as much bitumen as possible. The tank and pipeline should be flushed out with MC30 or similar material to remove any remaining bitumen. All flushing solvents must be collected in a manner that complies with both best practice and statutory regulations.

Centrifugal or low shear gear pumps are preferred for pumping emulsions as some emulsions may be shear sensitive, especially latex modified emulsions. Positive displacement pumps suitable for penetration grade bitumen, cutbacks and modified binders have a tendency to shear emulsions after excessive circulation unless the emulsion is hot, i.e. above 50°C. When loading emulsion ensure that the emulsion is discharged into the bottom of the tank and not allowed to free fall from the top of the manhole.

There are two forms of emulsion - anionic (basic) and cationic (acid). If these are mixed, almost instantaneous *breaking* of the emulsion will take place in the tanker. The load will solidify and the tank will become difficult to clean. If it is necessary to change tank contents from one to the other product, the tank must be flushed out.

At the completion of discharge of emulsion, the pump, tank and lines must be thoroughly cleaned with MC30 or similar material to ensure that all emulsion is removed from the system. Any emulsion left in the unit could result in a boil-over when hot bitumen is next loaded into the vehicle.

5.2 Blending

Cutting back hot binders

On-site cutting back of hot binders with volatile solvents is undesirable and is strongly discouraged from both quality and safety perspectives. Best practice dictates that all blending operations using cutters be carried out at fixed facilities under controlled conditions with the recommended safety and quality measures in place.

Blending of modified binders

Blending of polymer modified binders and bitumen rubber must only be conducted in tanks and blending units designed for this purpose and must be carried out in accordance with the supplier's method statements. Due to the limited shelf life of some modified binders such as bitumen rubber, the blending of these materials must be done on site. The digestion of rubber in hot bitumen could cause an increase of 10 to 25% in volume. Sufficient ullage must be allowed for this increase to avoid boil over.

Polymers and rubber crumb must be stored in a dry place and away from any source of heat. The addition of rubber crumb to a blending tank should be done by mechanical means that is earthed to prevent the build-up of static electricity.

Adhesion agents should only be added to binders shortly before spraying unless they are temperature storage stable. The contents must be circulated for 15 minutes before spraying. Gloves and eye protection must be worn and care should be taken to avoid inhalation of fumes.

Compatibility with water should be established before dilution. When mixing water with emulsions, always add water to the emulsion and not emulsion to water.

5.3 Storage and storage temperatures

If binders are stored for long periods above their application temperatures, a loss in quality may occur. This is more likely in the case of cutback bitumen as considerable cutter can be lost. With modified bitumen, degradation of the modifier will occur, resulting in the subsequent loss of product quality. For safety reasons the maximum storage and spraying temperatures given in Table 2 (page 28) should not be exceeded.

Emulsions should only be heated prior to application. Heating should be gradual to reduce the possibility of deposits forming on the burner flues. Emulsions stored in bulk should be circulated for 30 minutes every second day. Drums containing emulsions should be rolled before use.

Table 3 Time and temperature limits for binders

Typical temperature / time limits for binders					
Binder class	**Short term handling**		**Storage**		**Maximum spraying temp. (°C)**
	Max.temp. (°C)	Max. holding time (hrs)	Max. temp. (°C)	Max. holding time (hrs)	
80/100	180	24	130	240	190
150/200	170	24	120	240	180
MC30	65	24	30	240	65
MC70	80	24	50	240	80
MC800	110	24	60	240	130
MC3000	130	24	90	240	155
Emulsions (not modified)	80	24	50	240+	80
S-E1; S-E2	180	24	150	240	200
C-E1	160	24	140	240	-
SC-E1; SC-E2	70	24	Ambient	240+	80
CC-E1	Ambient	240+	Ambient	240+	-
S-R1	165	24	140	72	210

6. Training

All personnel involved in the handling, storage, blending or spraying of bituminous binders must receive training in the safe handling of these products and the relevant legal requirements. HSE critical positions and tasks should be identified, documented and an appropriate training programme should be developed to assure the competence of personnel.

A typical training (competence assurance) programme could include the following:

- Task risk assessment training;
- Managing of task specific hazards as identified in the site risk assessments;
- Firefighting;
- Procedures to follow in case of emergencies;
- Treatment of bitumen burns;
- The use of protective clothing and safety equipment;
- Sampling procedures;
- Safe operation of bitumen handling equipment such as pumps, hoses, burners and compressors;
- Advanced driver training for bulk vehicle operators;
- Incident investigation.

Sabita has developed a basic bitumen safety training programme called **BitSafe**. The implementation of the **BitSafe** course is done through the recruitment and training of selected employees of Sabita member companies as trainers. After completing a "Train-the-trainer" course the trainers conduct the training at their respective places of work.

The course has been designed in a modular format which allows for short interventions of approximately two hours, thereby minimising the impact on operations. The course consist of 12 training modules which covers all the activities normally associated with the handling of bituminous binders. These are:

Module 1 (a): *Understanding the industry*
Module 1 (b): *The certification process*
Module 2 (a): *Hazards: General*
Module 2 (b): *Hazards: Fire prevention*
Module 3: *Health and safety awareness*
Module 4: *Reducing the risk*
Module 5: *Treatment of bitumen burns*
Module 6: *Our environment*

Module 7: *Loading of liquid bitumen*
Module 8: *Transport of bitumen*
Module 9: *Sampling and testing*
Module 10: *Storage*
Module 11: *Disposal of bitumen waste*
Module 12: *Application of bituminous binders*

For more details contact Sabita on 021 531 2718 or email info@sabita.co.za

Annexure A

Hazards and Effects Management Process (HEMP)

A.1 Brief introduction to the HEMP

The HEMP entails a detailed analysis and documentation procedure using four basic steps:

1. **Identify:**
   a. The hazards (what can cause harm):
   b. The threats (under what circumstances can the hazard be released); and
   c. The potential consequences (injury, damage, etc) if the hazard is released.
2. **Assess:**
   a. Consider the *likelihood* of the occurrence of the potential consequences and classify the risk using a risk assessment matrix; and
   b. Analyse the threats and determine the necessary controls (barriers) to prevent the release of the hazards.
3. **Control:**
   Document existing controls (barriers) and develop new/additional controls that are necessary to manage the risk to ALARP.
4. **Recover:**
   Develop comprehensive reaction plans to mitigate the adverse effects of potential consequences.

A.2 Suggested strategy for establishing a site HEMP programme

To assure full compliance with legal and HSE Management System requirements the HEMP must be organisation and site-specific.

- Select, train and appoint a HEMP facilitator (ideally an HSE practitioner);
- Establish a site HEMP team consisting of experienced personnel from each department or business function i.e. administration, engineering, production, laboratory, transport;
- Provide basic HEMP methodology training for team members;
- Prepare a project plan with scheduled HEMP workshops;
- Conduct HEMP workshops under guidance of the HEMP facilitator;

- Record/document the results of the HEMP in a hazard register similar to the format suggested in Annexure C of this manual;
- Compile a register of HSE critical activities (processes) and positions (jobs) for the site and assure competence of HSE critical positions;
- Conduct further detailed analysis of HIGH RISK hazards and demonstrate ALARP (using BowTie or similar methodology);
- Get management sign-off for hazard register;
- Communicate contents of hazard register as widely as necessary;
- Establish a procedure for maintenance of the hazard register including:
  - Management of change;
  - Regular review to check *barrier* efficiency;
  - Compliance auditing;
  - Follow up on remedial action, etc.

Note

Sabita members are encouraged to establish their own site-specific HEMP programmes to ensure that a detailed analysis of all HSE critical operational activities and associated hazards is completed.

A.3 Table of hazards, potential consequences and recommended controls

For purposes of this guideline a simple generic *high level* assessment has been prepared to illustrate how the HEMP is applied. Annexure C provides an example of a suggested structure and format for documenting the HEMP results in a hazard register.

As an example, the table below provides an overview of the most common hazards and effects associated with the types, properties and characteristics of bitumen and bituminous binders, and also a brief summary of the general precautionary measures that should be applied to control these hazards.

Note

Threats are not included here and only product-related hazards are discussed in this model.

Table A1. Hazards, potential consequences and recommended controls

Hazard	Consequence and effect	Recommended controls
Hazard group: Thermal Plant/Equipment/ Liquids at elevated temperatures Hazard source: Bituminous binders stored, transported and handled at temperatures between 100°C - 210°C Bitumen heating and application equipment/tools	People: Severe burns and shock, potentially fatal Assets: Damage to equipment, tools, structures not designed to resist high temperatures Environment: Destruction of sensitive flora	• Thermal insulation: shielding, cladding, lagging of plant and equipment • Avoid contact of hot bitumen with water to eliminate potential of boil over • Proper design and maintenance of plant and equipment to prevent leaks/spillage • Competent personnel follow correct operating procedures • Provide, maintain and use appropriate PPE as prescribed • Medical, fire and spill emergency response plans
Hazard group: Chemical Flammable and toxic vapours or fumes (kerosene, CO_2 hydrogen sulphide, bitumen fumes, nitrogen oxide, carbon monoxide, polycyclic aromatic hydrocarbons) Hazard source: Cutback bitumen and other bituminous binders that contain volatile organic compounds	People: Fires and explosions cause severe injury or death Acute health effect: (asphyxiation) could be fatal Chronic health effects: Long term regular and repeated exposure (skin contact) may cause skin cancer Assets: Fire or explosion results in severe damage or destruction Environment: Air pollution; ground water contamination; destruction of sensitive habitat	• Substitute cutback bitumen with less hazardous binders • Proper design and maintenance of plant and equipment to prevent leaks/spillage • All hot work and confined space work is strictly controlled by a Permit To Work (PTW) system • Where practicable provide adequate local exhaust ventilation at source of exposure • Provide, maintain and use appropriate PPE (respiratory protection) as prescribed • Personal health monitoring programmes • Medical, fire and spill emergency response plans • Air quality monitoring • Engineering controls to limit emission of noxious fumes

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Annexure B

Example of a risk assessment matrix

An example of a Risk Assessment Matrix (RAM), used to determine the risk potential in the hazard register example in Annexure C.

Severity	Consequences				Increasing likelihood				
	People	Assets	Environment	Reputation	A	B	C	D	E
					Never heard of in the industry	Heard of in the industry	Has happened in the organi-sation or more than once per year in the industry	Has happened at the location or more than once per year in the organi-sation	Has happened more than once per year at the location
0	No injury or health effect	No damage	No effect	No impact					
1	Slight injury or health effect	Slight damage	Slight effect	Slight impact					
2	Minor injury or health effect	Minor damage	Minor effect	Minor impact					
3	Major injury or health effect	Moderate damage	Moderate effect	Moderate impact					
4	PTD or up to 3 fatalities	Major damage	Major effect	Major impact					
5	More than 3 fatalities	Massive damage	Massive effect	Massive impact					

For practical application the four areas (colours) of the RAM describe the level of control required to manage risk:

- Manage for continuous improvement, although the organisation may set a higher priority for further risk reduction.
- Manage for continuous improvement through the effective implementation of the HSE Management System.
- Identify and implement controls and recovery measures to reduce risk to ALARP.
- Identify and implement controls and recovery measures to reduce the risk to ALARP and provide a documented demonstration of ALARP.

Note

The organisation defines the parameters and criteria in each of the consequences and likelihood categories, as well as the processes and methodology for determination of ALARP.

Annexure C

Suggested format for a hazard register

Hazard No.	Hazard	Activity	Location	Threats	Top event	Consequence or incident considered for RAM rating	Risk potential				ALARP documentation
							P	A	E	R	
H-01.12	Hydrocarbons: Cutback bitumen (flammable vapour).	Bulk loading and deliveries; Bulk storage and handling; Storage and handling of samples; Plant maintenance; Operation of bitumen heating system; Binder spraying operations.	Loading gantries, blending plants, laboratories.	• Equipment failure • The potential of ignition not recognised • Hot work in hazardous areas • Static electricity • Lack of work procedures • Procedures not followed.	Loss of containment.	Asset damage: Fire in loading gantry.	4B	4C	2C	1C	BowTie hazard Control Sheet; PTWS; EIA; Design standards; Ops standards and procedures; Site ERP.
							Comments: fire partially destroyed loading gantry at the XYZ refinery in April 2009.				
H-08.01	Moving transport on land.	Movement of vehicles/mobile plant.	Blending/storage and distribution sites: Road construction sites.	• Operator error • Lack of site planning • Lack of journey planning • Site work instructions not followed.	Loss of control.	Injury/fatality: Vehicle collision at road construction traffic control point.	4D	3D	1B	2B	Hazard Control Sheet; Site work instructions; Design standards; Site ERP.
							Comments: Several fatal incidents have occurred on SA roads during road construction projects				

Note

The development of hazard registers should be done by a carefully selected team with relevant engineering, operational and HSE experience under the guidance of a competent HEMP facilitator.

Annexure D

Contents of first aid kit

The items below can be ordered from most pharmacists or safety equipment suppliers. Sabita also provides complete bitumen first aid kits. Order from info@sabita.co.za.

The following items are in the bitumen burns first aid kit:

Antiseptic solution;
Antiseptic ointment;
Assorted packs of sterile burn dressing;
Cotton buds;
CPR mouthpiece;
Elastic bandages;
Eye pads;
Eye shields;
Gauze swabs;
Instant cold pack;
Latex gloves;
Micropore tape;
Non-adhesive burn dressing for open burns;
Rescue sheet;
Safety pins;
Scissors;
Sterile eye irrigation solution;
Triangular bandages;
Tweezers;
No. 3 wound dressing;
No. 5 wound dressing;
Burnshield dressings and burnshield liquid;
2 plastic interlocking straight splints

A 25ℓ container of water should be kept with the kit for cooling down the patient's burnt section.

Annexure E

Emergency telephone numbers

Doctor	
Ambulance	
Fire Brigade	
Police	
Bitumen Supplier	
Burns Unit/Medical Centre	

Annexure F

Pre-trip aide mémoire for bitumen road tanker driver

Company/operator: .....
Driver: .....
Vehicle No: .....
Trailer No: .....

Item	Quantity
Equipment	
Emergency triangle	2
Fire extinguisher (9kg dry chemical powder)	2
Shovel	1
Water in robust container	25 litre
The following PPE is worn or readily available: • Heat resistant overall and leather apron; • Face shield, goggles and heat resistant balaclava; • Heat and chemical resistant gloves; • Heavy duty safety boots; • Half face-piece respitator with appropriate filter.	 1 of each 1 of each 1 pair 1 pair 1
Hazchem decal	1
Elevated temperature warning decal	1
First aid kit (checklist for minimum contents inside)	1
Documentation	
Operator registration card displayed	
Orange document container mounted in the cab	
Public Driving Permit for Dangerous Goods (PrDP-G)	
Dangerous good declaration for product on board (either separate or part of a waybill, consignment or delivery note)	
Tremcard	
Material Safety Data Sheet relevant to product on board	
Roadworthy certificate	
Medical certificate	

Annexure G

Typical content of a Transport Emergency Card (Tremcard)

Cargo: MC30 Cutback bitumen **UN NO: 1999**

- **Black bituminous product**

Nature of hazard:

- Highly flammable;
- Product may adhere to the skin and cause burns;
- Fumes may cause eye and skin irritation, respiratory irritation, dizziness and nausea.

Basic personal protection:

- Face and eye protection;
- Protective overalls;
- Safety shoes;
- Heat resistant gloves.

Immediate action by driver:

- Stop the engine;
- No naked lights, no smoking;
- Mark roads with self standing warning signs and warn other road users or passers by. Keep public away;
- Keep upwind;
- Notify emergency services.

Spillage:

- Stop leaks if without risk;
- Prevent material from entering storm-water drains and rivers;
- Vapour may create explosive atmosphere;
- Use sand, earth or spill control material to contain spill.

Fire:

- Extinguish with dry chemical powder or fine water spray;
- Sand or earth may be used for small fires.

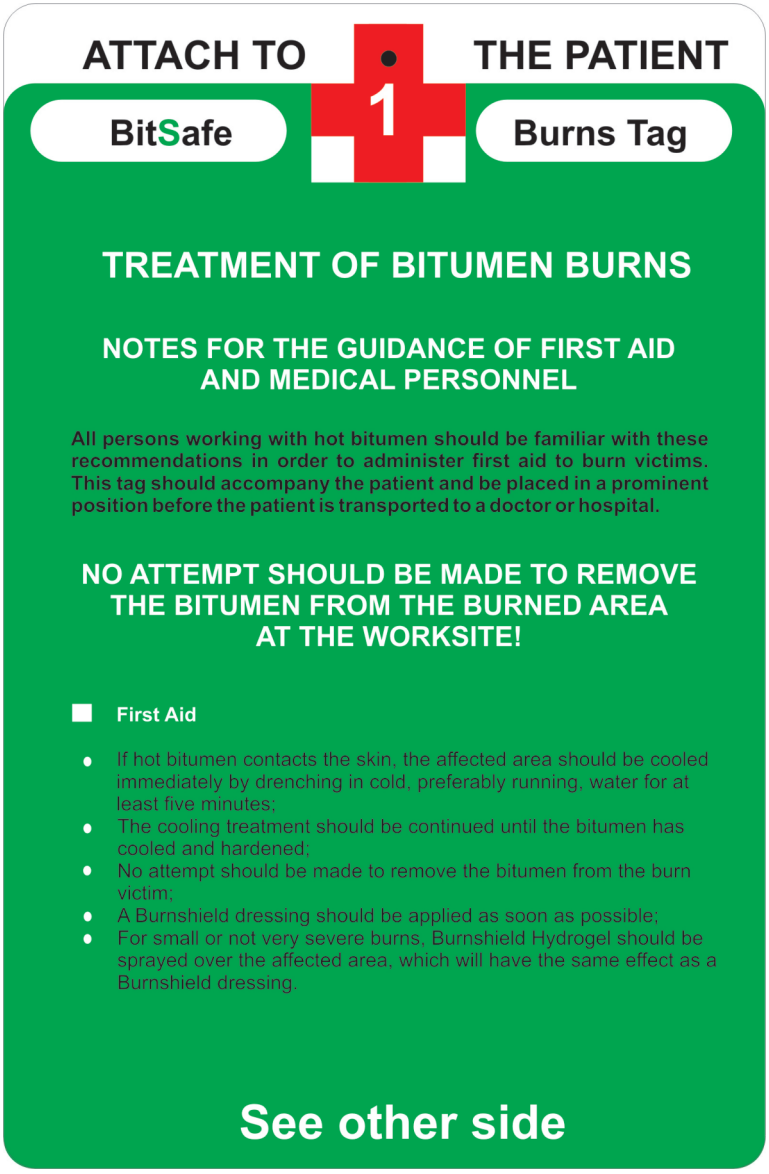
First aid:

- Remove to fresh air;
- In case of contact with hot bitumen immediately flush skin (or eyes) with large amounts of cold water. Do not remove bitumen from skin!

Annexure H

Bitumen burns card

H.1 Front page of the bitumen burns card



H.2 Back page of the bitumen burns card

ATTACH TO  **THE PATIENT**

Further treatment and medical care

- The bitumen layer will be firmly attached to the skin, and removal should NOT be attempted except at a medical facility under the supervision of a doctor. The cold bitumen will form a waterproof, sterile layer over the burn which will prevent the burn from drying out. If the bitumen is removed from the wound there is a possibility of complications;
- The bitumen should be left in place and covered with a dressing containing a paraffin-based ointment e.g. Flamazine. Such treatment will have the effect of softening the bitumen, enabling it to be removed over a period of days;
- The dressing should be changed daily or when soiled or dry, at which time any softened bitumen can be gently removed. Petrolatum-based antibiotic ointments or petroleum jelly may be used under medical supervision;
- The degree and extent of burns, and the general condition of the patient will dictate when transfer to a specialised burns unit is indicated.

Circumferential burns

Where hot bitumen completely encircles a limb or other body part, the cooled and hardened bitumen may have a tourniquet effect. The bitumen should be softened as described above and the patient referred urgently for specialised medical attention.

Eye burns

If hot bitumen enters an eye, it should be flushed with water until the bitumen has cooled. No attempt should be made by unqualified personnel to remove the bitumen. The patient should be referred urgently for specialised medical assessment and treatment.

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