BEST PRACTICE GUIDE FOR THE PROCUREMENT AND IMPORTING OF BITUMEN

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excellence in bituminous products

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FOREWORD

Bitumen is a vital component for cost effective construction and maintenance of the vast road networks in South Africa and neighbouring countries. Bitumen is produced and supplied in various grades at refineries in the RSA.

Following the announcement by some of the local refineries of their intention to either cease or pause with local production, the need to import bitumen has arisen.

Sourcing and importing bitumen of appropriate quality and consistency and at competitive prices is not as easy as it may sound or appear to the uninitiated. Imported bitumen comes with a substantial cost penalty and quality assurance from supply source to the asphalt producer and user is an aspect that demands procurement strategies and controls of the highest order.

Quality assurance of bitumen is of great concern for the major bitumen users (i.e., Asphalt producers, SANRAL and other government agencies responsible for building and maintaining paved road networks). The quality assurance process for locally produced bitumen is relatively straight forward but achieving the required level of control over the process could be a very challenging and costly exercise in the case of imported bitumen.

In addition to price and quality other important aspects associated with bitumen imports are compliance with enhanced Health, Safety and Environmental management practices (driven by strict International Safety Codes) and logistical challenges associated with off-loading (the bitumen Tanker) and storage and handling of the landed bitumen.

In response to these noted concerns, it was decided to produce this best practice guide to provide information to potential bitumen importers. It is hoped that this publication will ensure a greater degree of informed decision making before embarking on what could be a very risky commercial venture.

MANUALS PUBLISHED BY SABITA

Manual 1	Technical guidelines: Construction of bitumen rubber seals
Manual 2	Bituminous binders for road construction and maintenance (under review)
Manual 3	(Withdrawn)
Manual 4	(Withdrawn)
Manual 5	Guidelines for the manufacture and construction of hot mix asphalt
Manual 6	(Withdrawn)
Manual 7	SurperSurf – Economic warrants for surfacing roads
Manual 8	Guidelines for the safe and responsible handling of bituminous products
Manual 9	(Withdrawn)
Manual 10	Bituminous surfacing for low volume roads and temporary deviations
Manual 11	(Withdrawn)
Manual 12	Labour Absorptive methods in road construction using bituminous materials
Manual 13	LAMBs – The design and use of large aggregate mixes for bases
Manual 14	(Superseded by TG2)
Manual 15	(Withdrawn)
Manual 16	(Withdrawn)
Manual 17	Porous asphalt mixes: Design and use
Manual 18	Appropriate standards for the use of sand asphalt
Manual 19	Guidelines for the design, manufacture and construction of bitumen rubber asphalt wearing courses
Manual 20	Sealing of active cracks in road pavements
Manual 21	(Superseded by TG2)
Manual 22	Hot mix paving in adverse weather
Manual 23	Code of practice: Loading bitumen at refineries
Manual 24	User guide for the design of asphalt mixes (currently being developed)
Manual 25	Code of practice: Transportation, off-loading and storage of bitumen and bituminous products
Manual 26	Interim guidelines for primes and stone pre-coating fluids
Manual 27	Guidelines for thin hot mix asphalt wearing courses on residential streets
Manual 28	Best practice for the design and construction of slurry seals
Manual 29	Guide to the safe use of solvents in a bituminous products laboratory
Manual 30	A guide to the selection of bituminous binders for road construction
Manual 31	Guidelines for calibrating a binder distributor to ensure satisfactory performance
Manual 32	Best practice guideline and specification for warm mix asphalt
Manual 33	Design procedure for high modulus asphalt (EME)
Manual 34	(A) Guidelines to the transportation of bitumen and (B) Bitumen spill protocol (booklets)
Manual 35	Design and use of Asphalt in Road Pavements
Manual 36	Use of Reclaimed Asphalt in the Production of Asphalt
Manual 37	Sampling Methods for road construction materials (currently being developed)
Manual 38	A Health and Safety Guide for material testing laboratories in the road construction industry
Manual 39	Laboratory testing protocols for binders and asphalt
Manual 40	Design and construction of surfacing seals
Manual 41	Best practice guide for the Procurement and Importing of Bitumen

TECHNICAL GUIDELINES

TG 1 The use of modified binders in road construction
TG 2 Bitumen stabilised materials
TG 3 Asphalt reinforcement for road condition
TG 4 Water quality for use in Civil Engineering Testing Laboratories

SABITA DVD SERIES

DVD100	Test methods for bituminous products
DVD200	Training guide for the construction and repair of bituminous surfacing by hand
DVD300	Manufacture, paving and compaction of hot mix asphalt
DVD410	The safe handling of bitumen
DVD420	Treatment of bitumen burns
DVD430	Working safely with bitumen
DVD440	Firefighting in the bituminous products industry
DVD450	Safe loading and off-loading of bitumen

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Sabita acknowledges, with thanks, the time and effort given by Anton Ferreira (Lifeguard Safety Solutions) for compiling this important guideline document for the industry.

CONTENTS

1. OBJECTIVES

The primary objectives of this guide are:

- To list the most prominent Health, Safety, Environmental and Quality Assurance standards and other regulatory requirements associated with the import of bitumen;
- To provide a broad overview of the processes and associated activities necessary to assure a reasonable likelihood of success with managing the potential risks associated with the import of bitumen.

2. SCOPE

This guide is aimed at the activity of importing bitumen by sea in the following modes:

- As bulk liquid cargo in a bitumen Tanker;
- ISO tank-containers and Bitutainers ™;
- Drums; and
- Polyethylene bags and BituBale®

The bitumen in scope is paving grade bitumen (previously known as penetration grade) i.e., straight run bitumen produced at a refinery and does not include modified bitumen's such as cut-back bitumen, polymer modified bitumen's or bitumen emulsions.

3. REFERENCES

This publication is not intended to be a comprehensive guide on the requirements for importing bitumen and therefore it is recommended that the following referenced documents are read in conjunction with this guide:

3.1 STANDARDS AND SPECIFICATIONS

- SANS 4001-BT1:2012, Edition 1.1 - Penetration grade bitumen. Covers product specifications of four penetration grades of bitumen suitable for road construction and similar purposes;
- SANS 10089-1:2008 Edition 4.3 - Storage and distribution of petroleum products in above-ground bulk installations.

3.2 LEGISLATION

- Occupational Health and Safety Act (Act 85 of 1993 as amended) and applicable Regulations;
- International Trade Administration Act, (Act 71 of 2002): Import control regulations, Government Gazette No. 35007, 10 February 2012;
- National Ports Act (Act 12 of 2005);
- PORTS RULES, National Ports Act (Act 12 of 2005), 6 March 2009, Department of Transport;
- Guidelines for Agreements, Licences and Permits in terms of the National Ports Act (Act 12 of 2005), Transnet National Ports Authority 25 April 2008;
- Liquid Bulk Terminal Operator Licence, Transnet National Ports Authority, 1 December 2011;
- Harbour Master's Written Instructions, 2007 issued in terms of the National Ports Act (Act 12 of 2005).

3.3 INDUSTRY PUBLICATIONS AND RELEVANT OPERATING PROCEDURES

- SABITA Manual 2: Bituminous products for road construction and maintenance, Fifth edition, September 2012;
- Industry Protocol for Responding to Bitumen Spills on Land and/or Adjacent Water Environments, SABITA, December 2012;
- SABITA Manual 8: Guidelines for the safe and responsible handling of bituminous products, Fourth edition, October 2021;
- International Safety Guide for Oil Tankers and Terminals, International Maritime Organization, Fifth edition, 2006;
- Marine Terminal Management and Self-Assessment, OCIMF, September 2012;
- Guidelines for the Handling, Storage, Inspection and Testing of Hoses in the Field, 2nd Edition, OCIMF, January 1995;
- TPT/SOPCT 01/04/2013 – 31/03/2014, Standard Operating Procedures for Container Terminals;

4. DEFINITIONS AND ABBREVIATIONS

For the purposes of this guide, the following definitions and abbreviations apply.

Definitions

Agent	Refers to all representatives having commercial dealings with a vessel or its cargo, unless the context indicates that it refers to a particular kind of agent, and includes a vessels agent and a cargo agent
Bitumen	Bitumen in the context of this guide means paving grade bitumen ***(previously known as penetration grade);*** i.e., normal "straight-run bitumen" derived from crude oil and produced at a refinery
Bitumen container	Containers designed specifically for bitumen service including ISO Tank-containers, Bitutainers ™, Drums, Polyethylene bags and BituBale ®
Draught (Draft)	Depth of keel below waterline
Flammable (also referred to as 'Combustible')	Capable of being ignited and of burning. For the purposes of this Guide, the terms 'flammable' and 'combustible' are synonymous.
Flammable liquids Source: *(Harbour Master's Written Instructions in terms of the National Ports Act No 12 of 2005)* Corresponds to definition in the IMDG Code	Means a liquid, or mixture of liquids, or liquids containing solids in solution or suspension (except substances otherwise classified on account of their dangerous characteristics), which give off a flammable vapour at or below 61 degrees Celsius closed-cup test (corresponding to 65.6 degrees Celsius open-cup test), normally referred to as the "flashpoint". This includes liquids offered for transport at temperatures at or above their flashpoint, and, substances transported or offered for transport at elevated temperatures in a liquid state, which give off a flammable vapour at temperatures equal to or below the maximum transport temperature
Logistics	The planning, execution, and control of the movement / placement of goods and / or people, and the related, supporting activities, all within a system designed to achieve specific objectives
Payload	Amount of cargo that can be transported
Quality Assurance	Quality assurance is defined as planned and systematic actions necessary to provide adequate confidence that a product or service satisfies given requirements for quality. It is a proactive activity focused on providing confidence that quality requirements will be fulfilled.
Receiver	The consignee according to the contract for carriage. If the consignee designates a third party, this person shall be deemed to be the consignee. If the transport operation takes place without a contract for carriage, the enterprise which takes charge of the dangerous goods on arrival shall be deemed to be the consignee

Responsible Officer (ship)	A person appointed by the Master of the ship and empowered to take all decisions relating to a specific task, and having the necessary knowledge and experience for that purpose
Road tanker	A vehicle designed, manufactured and equipped in accordance with recognised and acceptable standards and specifications, and in this context specifically for the transport of Bitumen
Supplier	The enterprise which consigns dangerous goods either on its own behalf or for a third party. If the transport operation is carried out under a contract for carriage, consignor means the consignor according to the contract for carriage. In the case of a tank vessel, when the cargo tanks are empty or have just been unloaded, the master is considered to be the consignor for the purpose of the transport document
Tanker	A ship designed to carry liquid petroleum cargo in bulk, including a combination carrier when being used for this purpose
Terminal	A place where tankers are berthed or moored for the purpose of loading or discharging bitumen cargo
Terminal Representative	A person designated by the terminal to take responsibility for an operation or duty

Abbreviations

AASHTO	American Association of State Highway and Transportation Official Standards
EN	European Standards
HSE	Health, Safety and Environment
IMO	International Maritime Organisation
IMDG (Code)	International Maritime Dangerous Goods (IMDG) Code
ISGOTT	International Safety Guide for Oil Tankers and Terminals
ISO	International Standards Organization
ITAC	The International Trade Administration Commission of South Africa
MARPOL	International Convention for the Prevention of Pollution from Ships
OCIMF	Oil Companies International Marine Forum
SABITA	Southern African Bitumen Association
SANRAL	South African National Roads Agency Limited
SOLAS	International Convention for the Safety of Life at Sea
TNPA	Transnet National Ports Authority
TPT	Transnet Port Terminals

5. SOURCING OF BITUMEN FOR IMPORT

The first challenge facing potential bitumen importers is to find bitumen of appropriate quality and consistency, and a reliable supplier. A quick search on the internet will reveal that there are numerous potential suppliers across the globe offering just about any type and grade of bitumen for sale. In many cases suppliers also offer comprehensive procurement and supply chain management services on behalf of potential buyers.

It is not within the terms of reference or scope of this guide to recommend any specific supplier for consideration. Potential importers will have to conduct their own due diligence investigations to ensure that ultimately, they select a trustworthy supplier with a proven bitumen export track record. Some points to consider for selecting a supplier include but are not limited to the following:

- Is there any trade embargo in place that will prevent you from importing bitumen from a specific source;
- Is the supplier a manufacturer of bitumen (a refinery) and if not, where is the bitumen sourced from;
- If possible, ascertain the source of the crude oil from which the bitumen is produced. Not all grades of crude oil are suitable for production of bitumen of appropriate quality and consistency for road paving purposes. Insist on traceable verification and certification of the source;
- What is the supply capacity of the supplier and how is this verified or guaranteed;
- Is the supplier capable of managing supply chain processes such as quality control and quality assurance, packing, transport logistics, handling at port of loading, etc. or will you have to engage third party agents to handle this on your behalf;
- Make every effort to check supplier affiliations and processes to verify compliance with internationally accepted standards in connection with Health Safety and Environmental management of marine operations and quality assurance systems.

6. BITUMEN IMPORT LOGISTICS CHALLENGES

The bitumen importer is faced with a number of logistical challenges and some of these could be major and very expensive obstacles to overcome. Here follows a brief discussion of the main challenges, the minimum requirements for compliance with legal and industry standards, and some possible solutions as relevant.

6.1 IMPORT CONTROL REGULATIONS

Petroleum products are subject to import/export control and therefore a company or an individual that intends importing bitumen into South Africa requires an import permit.

The issuing of bitumen import permits is subject to requirements administered by the International Trade Administration Commission of South Africa (ITAC). To be considered for authorisation, you must contact the Economic Development Department regarding the required procedure.

6.2 BULK LIQUID CARGO SHIPPING

6.2.1 Availability of Bitumen Tankers

Due to specialised cargo handling requirements (heating, cargo pumps, tank and piping insulation, etc) bulk liquid bitumen is normally shipped in purpose-built product Tankers that are dedicated to bitumen service.

The cargo capacity (payload) of a bitumen Tanker would be somewhere between 2000MT to 10000MT and on average around 5000MT. In Oil Tanker terms these are "very small" Tankers and the economies of scale makes these ships quite expensive to operate and are therefore not very attractive options for ship owners. Hence, there are a limited number of vessels available for charter and the optimum quantity, timing and execution of bitumen orders is a critical factor for ensuring the financial viability of the venture.

6.2.2 Export Terminal and Tanker Voyage Operations

Operations in this particular context refer to the loading of bitumen at the port of export and the voyage to the in-bound port.

Whilst it is probably not possible to be directly involved in ensuring compliance with mandatory standards it is imperative that bitumen importers and terminal operators seek assurance that vessels chartered for transporting bitumen to our ports comply with applicable international, national and local marine regulations.

There is a myriad of certificates of fitness/compliance required in terms of MARPOL and SOLAS and many of these are specifically applicable to operation of Oil Tankers. Importers must ensure that their shipping agents or supplier representatives can provide written assurance of the vessel certification as applicable.

6.2.3 In-Bound Ports Cargo Handling and Storage Infrastructure

Ideally a purpose designed terminal is required for importing bitumen. A terminal will typically comprise of the following port cargo handling and storage facilities:

- A berth with sufficient *Water Depth Alongside* to accommodate the anticipated draught requirements of bitumen Tankers;
- A fixed or mobile shore unloading gantry/manifold installed alongside the Tanker to connect flexible discharge hoses between the Tanker manifold and a fixed delivery line;
- A fixed pipeline installation to deliver bitumen to a storage facility;
- An intermediate storage facility (tank farm) of sufficient capacity (ideally between 10,000mt and 20,000mt) and situated as close as possible to the Tanker berth;
- A vehicle loading gantry for distribution of bitumen to consumers.

Currently there are no "bitumen specific" terminals available in South African ports. To establish such infrastructure (ideally at Durban, Port Elizabeth and Cape Town) would require major capital investment. Such investment could probably only be justified with some guarantee of a sustainable demand for imported bitumen.

6.2.3.1 Temporary solutions for bulk liquid bitumen discharging

Currently local bitumen importers make use of discharging systems/methods that are less cost effective due to multiple handling that increases labour and transport costs. Bad weather (rain in particular) can also delay off-loading of vessels and ad substantially to the turn-around time of bitumen shipments which further adds to the cost due to high demurrage fees.

Figures 1A and 1B below illustrates two temporary systems for discharging bitumen as an alternative to a permanent bitumen terminal.

Mobile quayside Ship to Shore Bitumen Unloading Systems

Figure 1A – Ship to shore arrangement to discharge bitumen directly to road tankers

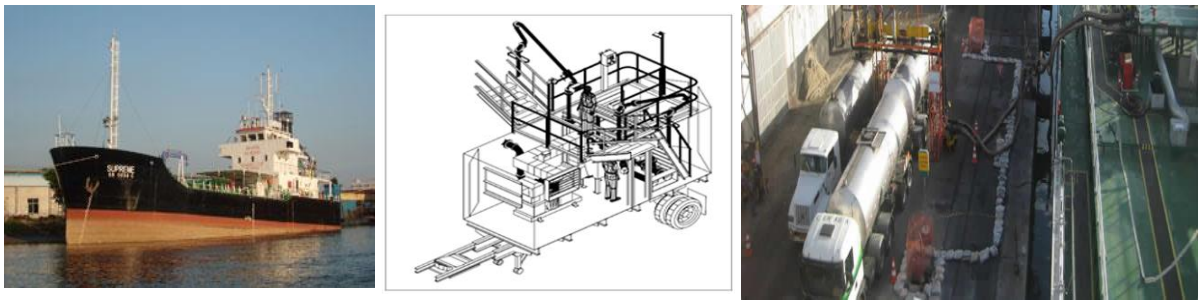

Figure 1B – Ship to shore discharge using a mobile discharge system positioned on the quay alongside the vessel.

The mobile unit may include a temporary holding tank and a manifold with loading arms that allows more than one road tanker to be loaded simultaneously.

6.2.4 Hazard classification of bitumen for port cargo handling purposes

The importance of correctly classifying imported liquid bitumen for cargo handling purposes is highlighted here to ensure that importers/terminal operators do not unnecessarily attract more onerous and stringent HSE management expectations from port authorities.

In accordance with the Harbour Master's Written Instructions issued in terms of the National Ports Act No. 12 of 2005, (Paragraph 3. Interpretation) paving grade bitumen IS NOT a flammable liquid. This implies that the more stringent requirements for port operations associated with flammable liquids do not apply. It is for this reason that importers must ensure that the bitumen is correctly classified and described in the ships transport documents. In accordance with the Dangerous Goods List of the IMDG Code the correct description for hot liquid paving grade bitumen should be as follows:

Class	UN Number	Proper Shipping Name
9	3257	ELEVATED TEMPERATURE LIQUID, N.O.S. at or above 100°C and below its flash point (Hot liquid paving grade bitumen)

6.2.5 HSE hazards associated with paving grade bitumen

Paving grade bitumen at ambient temperature is in a semi-solid state and generally regarded as a low-risk product which presents no significant hazards during handling. However, bitumen must be heated (to temperatures ranging from ± 160° C to 200 ° C) to allow the product to be pumped during transfer from a Tanker to a road tanker or storage tank. At these elevated temperatures the risk profile changes and some significant hazards are introduced.

Hazards and potential consequences associated with hot bitumen handling are briefly as follows:

- ***Bitumen burns:*** Worker contact with hot bitumen causing severe burns;
- ***Fire/explosion:*** Although hot paving grade bitumen is handled well below the flashpoint of the product flammable mixtures could evolve in the vapour space of cargo tanks, road tanker compartments and terminal storage tanks. These mixtures could ignite in the presence of ignition sources;
- ***Boil-over:*** If water comes into contact with hot Bitumen, the water undergoes a very rapid expansion. The foaming effect is highly dangerous to personnel in the vicinity. Water on top of hot bitumen creates steam. Bitumen on top of water creates a volcano of hot bitumen - 1 ℓ Water = 1100 ℓSteam
- ***Pollution:*** Hot liquid bitumen spilled into the harbour water may cause localised damage to the aquatic life in the immediate area of a spill;
- ***Disruption and financial loss:*** Although bitumen spillage *(in liquid or solid state)* into the harbour water may not have a major impact on the aquatic environment the spill will none the less have to be cleaned up. This could result in disruption of port services and substantial financial loss to the importer.

7. PACKING AND LOGISTICS FOR BITUMEN IMPORTED IN CONTAINERS

Bitumen exporters offer various options for transporting cold bitumen in containers. Given the current port cargo handling constraints of bulk liquid, importing bitumen in containers may be considered as an alternative option.

NOTE: ***In accordance with the definitions and classification criteria of UN Model regulations and the IMDG Code, cold bitumen IS NOT a dangerous substance.***

The aim of this section is to provide an overview of the packing and logistics options and to highlight some concerns relevant to storage and handling of bitumen in containers. *The commercial viability of* ***Containers versus Bulk Liquid*** *will not be explored here.*

7.1 ISO TANK-CONTAINERS AND BITUTAINERS ™ *(Collectively hereafter referred to as bitutainers)*

Bitutainers are essentially freight containers designed for shipment of cold bitumen *(ambient temperature)* in larger quantities. Bitutainers are manufactured to ISO 1496 Part 3 design standards under codes such as UN T2 or T3 and IMO 1 and certified by Lloyd's Register for carriage of dangerous goods by sea.

Bitutainers are equipped to heat bitumen through the application of various burner and heating systems. The bitumen can be heated in transit and maintained in liquid form if required however normal practice is to heat bitumen prior to use at the final destination but. Bitutainers are equipped with discharge valves that can be connected to an external bitumen transfer pumping system to discharge into storage tanks or road tankers.

7.2 SHIPPING LOGISTICS

Bitutainers are available in various sizes however in the international tank industry approximately 95 % of all tanks built are 6.058 meters (20ft) long ranging from 20mt to 29mt capacity and can be transported on various types of ships that can accommodate containers.

Availability of bitutainers and ships that can carry containers does not seem to be an issue in the international market. TPT operates container terminals at Durban, Ngqura, Port Elizabeth and Cape Town which means that adequate local port cargo handling infrastructure should also not be an issue.

As the *Terminal Operator* TPT will provide services in connection with discharging (off-loading) of bitutainers at Container Terminals. Importers must however make arrangements for collection and transport of the bitutainers to the final destination.

Importers should avail themselves of the requirements of TPT/SOPCT - Standard Operating Procedures for Container Terminals and TPT Conditions of Trade for Container Terminals.

7.3 BITUMEN IN DRUMS

Drummed bitumen is transported in a solid state at ambient temperature. The minimum design standard specified for imported bitumen drums should be DIN 1623 ST12. Material should be corrugated cold rolled steel with a plate thickness of 0.6 mm to 0.8 mm protected by an external anti-rust coating.

Drums are supplied in various dimensions and capacity ranging from 40kg up to 240kg. Drummed bitumen cargo can be transported in various ways on ships including conventional stacking on pallets. However, research shows that the most preferred packing mode seems to be to transport bitumen drums in conventional box type containers on container vessels. The most economical method proposed is to fit 110 of 180kg drums into a 6-meter (20ft) container with a payload of 20mt.

7.3.1 Drummed bitumen handling and quality concerns

Drummed bitumen poses real problems in terms of handling, storage and quality control. Some of the main issues that require due consideration is:

- Damage to drums (and bitumen) in transit;
- Adequate storage area at ultimate destination;
- Decanting of bitumen (overheating);
- Management of used drums (cleaning/reconditioning/storage);
- Disposing of old drums;
- Increasing cost of new steel drums; and
- Inland transport costs.

From a safety and quality control perspective the main concern is probably the process of decanting drummed bitumen. Lack of temperature control (using open flame burners) when heating drums could lead to overheating that could affect the quality of the bitumen. Handling hot bitumen incorrectly can be very hazardous. A purpose designed bitumen drum decanting and melting plant is highly recommended if drummed bitumen is imported in high volume.

7.3.2 Bitumen in bags

Bitumen bag systems are the most recent and innovative methods of containing and transporting solid bitumen. Many exporters offer bag systems of various configurations and storage capacity up to 1,000kg of bitumen. These systems facilitate the use and transport of bitumen, while reducing waste to an absolute minimum.

A bitumen bag is essentially a system comprising a polyethylene inner bag and a high strength polypropylene outer bag. The inner bag design allows bitumen to stabilise the package and the high strength outer bag facilitates safe and easy handling with conventional fork lift equipment. At the final destination the inner bag (with bitumen) is removed from the outer bag and the bitumen is melted with the inner bag for transfer to a storage tank. The outer bag can be recycled for further use. Some advantages of bitumen in bags are:

- Significant savings in handling time;
- 100% of Bitumen is used (As much as 3%-5% of bitumen remains in a drum due to “clinging”);
- No packaging disposal costs.

However, as with drummed bitumen, there is potential (in-transit) quality control issues and challenges in connection with decanting of bagged bitumen.

For transport purposes it is recommended that bitumen bags are packed in conventional box containers to minimize damage to bags/bitumen.

Transferring bitumen from bags to a liquid storage tank or production line will require a purpose designed bitumen bag decanting and melting plant.

8. TRANSNET NATIONAL PORTS AUTHORITY HSE MANAGEMENT EXPECTATIONS

Notwithstanding the relatively low risk associated with bitumen handling importers must understand that safety is critical to the shipping industry and that the associated activities are managed in accordance with a strict control framework within which shipping operates.

The framework embraces a number of regulatory requirements and industry safety management principles aimed at assuring enhanced HSE awareness and compliance with operational best practice. Consequently, port authorities may choose to prescribe higher HSE requirements than would normally be considered adequate for bitumen liquid cargo handling.

The port authority will require terminal operators to compile HSE procedures for approval (by the Harbour Master) and will also monitor cargo handling and terminal operations to ensure that they adhere to the procedures.

Besides procedures covering the Health and Safety aspects a major focus is on the prevention of spillages of cargo, especially cargo that would be a pollutant if it were to fall into the harbour. Procedures will also be required to prevent spilled cargo from entering the harbour water.

8.1 GENERAL REQUIREMENTS

In general, the requirements of the Port Rules issued in terms of the National Ports Act No. 12 of 2005, and in particular Chapter 3, 4 and 5 are applicable.

The TNPA HSE regulatory requirements and management expectations listed below may be applicable, partly or in whole, as directed by the port authorities.

8.2 TANKER AND TERMINAL OPERATIONS

The *International Safety Guide for Oil Tankers and Terminals* is, by reference, incorporated as a standard in the Port Rules in terms of the National Ports Act No. 12 of 2005. ISGOTT is the standard reference work on the safe operation of oil tankers and the terminals they serve. Bitumen importers must avail themselves of the contents of this publication.

The Guide is divided into four sections:

- Part 1: General Information;
- Part 2: Tanker Information;
- Part 3: Terminal Information; and
- Part 4: Management of the Tanker and Terminal Interface.

Parts 1 & 2 of ISGOTT deal mainly with petroleum properties and hazards and with Tanker shipboard operations whilst Parts 3 & 4 is more relevant for purposes of this guide.

The following chapters are of particular relevance for port cargo handling and terminal operations:

PART 3: TERMINAL INFORMATION

- Chapter 15, Terminal Management and Organisation
- Chapter 16, Terminal Operations
- Chapter 17, Terminal Systems and Equipment
- Chapter 18, Cargo Transfer Equipment
- Chapter 19, Safety and Fire Protection
- Chapter 20, Emergency Preparedness
- Chapter 21, Emergency Evacuation

PART 4: MANAGEMENT OF THE TANKER AND TERMINAL INTERFACE

- Chapter 22, Communications
- Chapter 26, Safety Management

9. QUALITY ASSURANCE STANDARDS AND SPECIFICATIONS

9.1 INTRODUCTORY OVERVIEW

The quality of bitumen for road pavement purposes must conform to the specifications of asphalt producers, SANRAL and other government agencies responsible for building and maintaining paved road networks.

In different regions and countries around the world, different standards and grading systems are used for determining the quality of bitumen. The most recognized standards for petroleum bitumen are published by:

- European Committee for Standardization (CEN)
- *Deutsche Industrie Norm (DIN EN)*
- *Association Française de Normalisation (AFNOR – NF EN)*
- *BSI Standards - the UK's National Standards Body (NSB - BS EN)*
- American Society for Testing and Materials (ASTM)
- American Association of State Highway and Transportation Officials (AASHTO)
- Standards Australia (AS)
- South African Standard Organization (SABS/SANS)

Quality assurance of locally produced bitumen is done in accordance with the requirements of SANS 4001-BT1:2012, Edition 1.1 - Penetration grade bitumen. The current standard covers product specifications of four penetration grades of bitumen most commonly used in the southern African region.

However, South Africa is transitioning from the current penetration grade bitumen specification framework to one which strives to define bitumen properties more closely related to the performance of bituminous layers. To facilitate the process of implementation of this new, performance related specification, SABS has published a technical standard – SATS 3208 (2019) Performance Grade (PG) specifications for bitumen in South Africa - which certain road authorities have adopted as a project specification.

Submission has now been made to The South African Bureau of Standards to adopt SATS 3208 as a full SANS specification.

This section of the document sets out the physical characteristics as well as the minimum guideline specification requirements for bitumen imported into South Africa to be used in road pavement construction.

9.1 RELATED QUALITY ASSURANCE DOCUMENTS

ASTM D92-02b, Standard test method for flash and fire points by Cleveland open cup tester.

ASTM D140/D140M, Standard practice for sampling asphalt materials

ASTM D4402, Viscosity Determination of Asphalt at Elevated Temperatures Using a Rotational Viscometer

ASTM D6521-13, Standard practice for accelerated aging of asphalt binder using a pressurized aging vessel (PAV)

ASTM D6648-08, Standard test method for determining the flexural creep stiffness of asphalt binder using the bending beam rheometer (BBR)

ASTM D7175, Standard test method for determining the rheological properties of asphalt binder using a dynamic shear rheometer

ASTM D7405, Standard test method for multiple stress creep and recovery (MSCR) of asphalt binder using a dynamic shear rheometer

ASTM D7643, Standard practice for determining the continuous grading temperatures and continuous grades for PG graded asphalt binders

SATS 3208 Performance Grade (PG) specifications for bitumen in South Africa

ISO 17025 Testing and calibration laboratories

ISO 9000 International standards on quality management

P 469: Determination of saturated, aromatic and polar compounds in petroleum products by thin layer chromatography and flame ionization detection

SABITA Manual 2 (PG) - Bitumen Binders for road construction and Maintenance

SABITA Manual 25: Code of Practice: Transportation, off-loading and storage of bitumen and bituminous products

SABITA Manual 39 - Laboratory Testing Protocols for Binders and Asphalt.

9.2 MATERIALS AND MANUFACTURE

The bitumen shall be derived from crude petroleum oil. The bitumen must be homogenous, storage stable and free of water and deleterious materials. It shall not foam when heated to 175°C. The formation of a thin layer of bubbles is not considered to be foaming. The presence of volatile organic components, i.e., cutters or other organic liquids may impact the rheological and physical properties. There is also a possibility of ash content (coke or coke residues) or inorganic chemical components which should not be present in the imported bitumen.

9.3 QUALITY SYSTEM

The bitumen supplier should have a recognised quality management system in place which is certified and regularly audited by an accredited quality assurance agency. The bitumen supplier should develop and maintain a quality plan that describes the specific processes for inspection and testing, acceptance/rejection criteria, details of proposed methods and other quality-related issues. It should describe how the requirements of this guideline will be met at all times and how evidence demonstrating this compliance is provided and maintained. The quality assurance plan shall at least describe:

(a) The Total Acid Number (TAN) of the bitumen;

(b) The bitumen sampling frequency and method;

(c) The sample testing scheme, including that to be adopted for blended grades;

(d) The penetration index.

All sampling and testing required by this guideline should be undertaken by a laboratory accredited to ISO 17025.

9.4 APPROVAL OF BITUMEN

All bitumen imported for use in road pavements should be subject to an approval process which would require the assessment of the information listed below:

(a) Provision of test results for the bitumen properties listed in Table 6.1 below and compliance with the property requirement where specified;
(b) Identification of the source refinery which should provide documentary evidence of registration and compliance with an internationally recognised quality management system;
(c) Tests of a sample of the bitumen ex the supply source during loading of the vessel.

9.5 BITUMEN QUALITY

All bitumen used for road pavements construction, in South Africa should meet the requirements as set out in Table 6.1.

On offloading of a vessel, the frequency of testing should be at least one test per 500t with the minimum test of G*/ Sin δ indicating acceptable results for the grade supplied.
All bitumen handling facilities should be operated under a registered ISO 9001 and / or SANS / SABS compliant quality assurance system. Guidelines on land transportation can be found in SABITA Manual 25: Code of Practice: Transportation, off-loading and storage of bitumen and bituminous products.

Table 1 - Performance Grade Requirements

Test Property	Performance grade											Test Method
	58S -22	58H -22	58V -22	58E -22	64S -16	64H -16	64V -16	64E -16	70S -10	70H -10	70V-10	70E -10	
Maximum Pavement design temperature Tmax (°C)			58				64			70			
Minimum grading temperature, Tmax (°C)			-22				-16			-10			
Original Binder													
Viscosity @165°C, ≥30 s^{-1} (Pa.s)	≤ 0.9												ASTM D4402
Storage Stability at 180°C (% diff, G^*_{HIGH} and G^*_{LOW}) at T_{max}	≤ 15												ASTM D7175
Flash Point ((°C)	≥ 230												ASTM D92b
After RTFO Ageing													
Mass Change (m/m). (%)	≤ 1.0												ASTM D2872
J_{NR} @ T_{max} , (kPa^{-1})	≤ 4.5	≤ 2.0	≤ 1.0	≤ 0.5	≤ 4.5	≤ 2.0	≤ 1.0	≤ 0.5	≤ 4.5	≤ 2.0	≤	≤ 0.5	ASTM D7405
Ageing Ratio, $G^*_{RTFOT}/G^*_{Original}$	≤ 3.0												ASTM D7175
After RTFO and PAV ageing													
Creep stiffness, S (60x_ at T_{min} +10°C , (MPa)	≤ 300												ASTM D6648
m (60s) at T_{min} + 10°C, minimum, (Mpa/s)	≥ 0.300												ASTM D6648
$\Delta T_c = T_cS - T_cm$. (°C)	≥ -5												ASTM D7643
Ageing Ratio, $G^*_{PAV}/G^*_{original}$	≤ 6.0												ASTM D7175

APPENDIX

UNAGED BINDER

- For traffic class S the G*/sin δ parameter is measured at high temperature, to link to the Superpave specifications;
- At intermediate temperature a frequency sweep is done to make it possible to follow the ageing behaviour of the binder (see ageing ratios after RTFOT and PAV);
- Related to application is the viscosity at 135°C. This value can be measured with the Brookfield viscometer, but alternatives are available;
- Flash point is added for safety reasons;
- Storage stability requirement is added for PMB. The DSR will be used to measure the G* from material of the top and bottom. Maximum difference in G* between top and bottom is defined.

RTFOT AGED BINDER

- A requirement on the mass change of the binder is added after RTFOT;
- The MSCR test has been adopted for permanent deformation sensitivity of the binder. The standard AASHTO procedure will be followed (JNR based on 10 loading cycles);
- A frequency sweep at intermediate temperature is done to calculate the ageing ratio. The ageing index is set on maximum 3, based on the change of G* at 10 Hz.

PAV AGED BINDER

- For low temperature cracking the Bending Beam Rheometer (BBR) test is used according to AASHTO specification. A criterion based on the BBR test results is ΔTc, being the difference in temperature at which S = 300 MPa and m = 0.300. ΔTc = -5 C will be the distinction value;
- For intermediate temperature, perform a frequency sweep at ([(Tmax +Tmin)/2]+ 4). The sweep has to be done in the frequency range between 0.05 to 20 rad/sec;
- The combination of the BBR results and the frequency sweep at intermediate temperature will make it possible to determine a Master-curve for the G* according to CA or CAM model and determine the R value at the cross over frequency;
- The frequency sweep at intermediate temperature after PAV will be used to calculate an ageing ratio, which is set at 6.0, based on SHRP data.

IMPORTED BITUMEN FOR MODIFICATION

For Bitumen that is imported with an intention to be modified *(to meet higher traffic class requirements as described in Sabita Technical Guideline 1: The Use of Modified Bituminous Binders in Road Construction)* further assessment of the bitumen would be beneficial to determine the compatibility of the binder with certain polymer modifiers. The SARA analyses of the binder can give an indication of compatibility and is described below.

SARA

Saturate, Aromatic, Resin and Asphaltene (SARA) is an analysis method that divides crude oil components according to their polarizability and polarity. The saturate fraction consists of nonpolar material including linear, branched, and cyclic saturated hydrocarbons (paraffins). Aromatics, which contain one or more aromatic rings, are slightly more polarizable. The remaining two fractions, resins and asphaltenes, have polar substituents. The distinction between the two is that asphaltenes are insoluble in an excess of heptane (or pentane) whereas resins are miscible with heptane (or pentane). (Wikipedia)

Note: How Bitumen Chemistry (SARA) Affects Compatibility and Stability of PMB's

Bitumen's are complex systems that can be subdivided into groups of molecules, saturates, aromatics, resins and asphaltenes. Saturates and aromatics can be viewed as carriers for the 'polar' aromatics (i.e., the resins and asphaltenes). The polar aromatics are responsible for the viscoelastic properties of the bitumen at ambient temperatures. This is due to the association of the polar molecules that leads to large structures, which in some cases may result in the generation of three-dimensional networks (i.e., 'gel'-type bitumen). The degree to which this association takes place depends on the temperature, the molecular weight distribution, the concentration of the polar aromatics, and on the solvency power of the saturates and aromatics in the maltenes phase. If the concentration and molecular weight of the asphaltenes is relatively low, the result will be a 'sol'-type bitumen. Using thin layer chromatographic method (IATROSCAN), bitumen can be separated into the four groups: saturates, aromatics, resins and asphaltenes (sometimes described by the acronym SARA).

Saturates, when isolated, are a clear (water white) liquid of medium viscosity and act as a diluting medium in bitumen. This fraction has lowest molecular weight and consists of straight and branched chain structures. Saturates usually amount number-average molecular weight is around 600 g/mol and they are mainly aliphatic. Very few polar atoms or aromatic rings are present. Their solubility parameter is between 15 and 17 MPa0.5 and their density at 20 °C is around 0.9 g/cm^3.

Aromatics (often called aromatics/naphthenics) are a black, highly viscous liquid. The fraction consists of ring structures and forms the bulk of bitumen. Aromatics are the most abundant constituents of a bitumen together with the resins, since they amount for 30–45 wt.% of the total bitumen. A number-average molecular weight of order 800 g/mol. Their solubility parameter is between 17 and 18.5 MPa0.5 and their density at 20 °C close but less than 1 g/cm^3.

Resins are chemically similar to the asphaltenes and they are a transition from oils to asphaltenes. They are semisolid or solid at room temperature, fluid when heated and brittle when cold. Resins, also called polar aromatics, can be numerous as aromatics (30–45 wt.%). Their molecular weight ranges from 300 to 2000, solubility parameter lies between 18.5 and 20MPa0.5 and their density at 20 °C is close to 1.07 g/cm^3.

Asphaltenes are high molecular weight (800–3500 g/mol), n-heptane insoluble black or brown amorphous solids containing, in addition to carbon and hydrogen, some nitrogen, sulphur and oxygen. Asphaltenes are the main component to bitumen fractional composition and constitute 5 to 25% of the bitumen. Their elemental analysis is stable from one bitumen to another with H/C ratio between 0.98 and 1.56. Their solubility parameter ranges between 17.6 and 21.7 MPa0.5 and their density at 20 °C is close to 1.15 g/cm^3.

Compatibility of a polymer can be defined as its ability to remain distributed in the bitumen without phase separation occurring. However, the degree of compatibility varies by bitumen, or more specifically the chemistry of the bitumen (SARA) and by type and grade of polymer used in the formulation of the polymer modified product. Compatibility also varies with concentration of the polymer and the higher the concentration of the polymer, the lower the degree of compatibility.

The addition of modifying agents (rubber crumbs, SBS, SBR, EVA or RET) with a molecular weight similar to or higher than asphaltenes disturbs the phase equilibrium: the polymer and the asphaltene will then 'compete' for the solvency power of the maltene phase, and, if insufficient maltenes are available, phase separation (also sometimes called de-mixing) between the polymer and the bitumen may occur, affecting the compatibility of the final product. Total incompatibility could cause segregation and even gelling.

There are other parameters that have an effect on the compatibility of polymers with bitumen. These parameters may contribute to the instability of the system, depending on the handling conditions (e.g.,

the storage conditions of the PMBs such as time, temperature, efficiency of mixing system). The quality of the polymer dispersion in the bitumen phase is influenced by a number of factors:

- the difference in solubility parameters of the polymers and the maltene phase of the bitumen;
- the amount and type of asphaltenes present in the bitumen;
- the type and concentration of the polymer;
- changes in the crude type;
- the manufacturing processes and handling conditions of the modified binder (Whiteoak, 1990).

The complexities of the inter-relationships between these factors are shown in Figure X. It can be seen that very high aromaticity levels of the bitumen constituents lead to a weakening of the polystyrene domains (of the thermoplastic rubber), causing low softening points and low flow resistance properties (Collins et al., 1991). At low aromaticity levels, however, insufficient polymer will be incorporated into the bitumen, which also leads to low flow resistance properties.

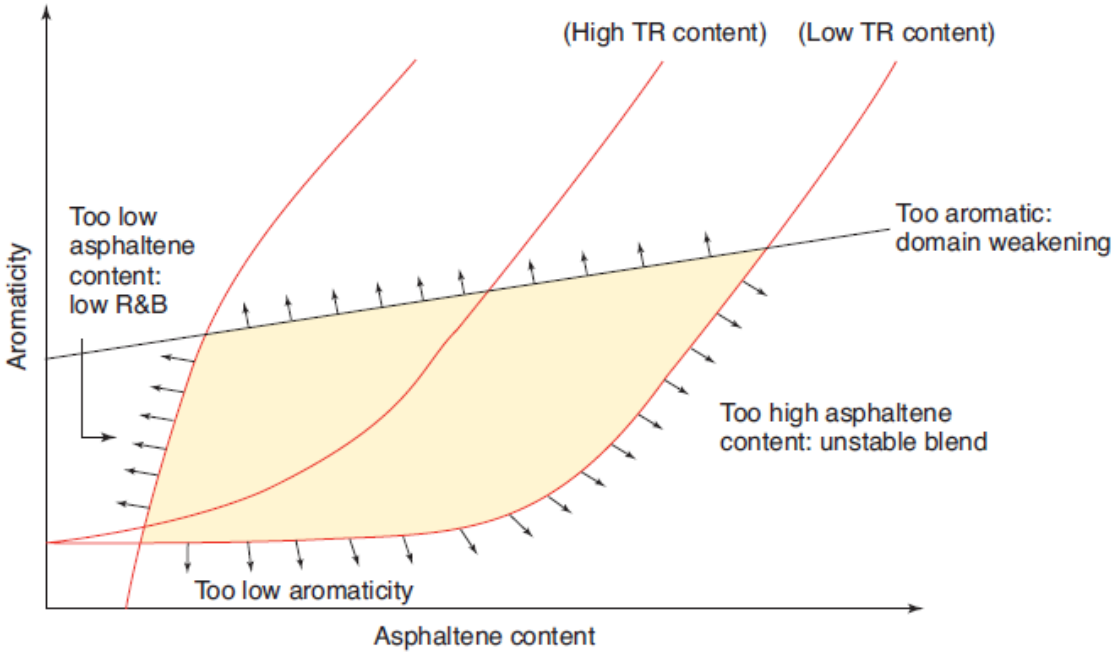

Figure 2 - Effect of aromaticity and asphaltene content on the stability of thermoplastic rubber (TR) bituminous blends (Whiteoak, 1990)

10. BIBLIOGRAPHY

The author acknowledges that in compiling this guide the following publications were extensively consulted as appropriate technical and regulatory information sources:

1. International Safety Guide for Oil Tankers and Terminals, Fifth Edition, 2006 ISBN-10 1856092917
2. Harbour Master's Written Instructions, 2007 issued in terms of the National Ports Act (Act 12 of 2005)
3. Marine Terminal Particulars Questionnaire (MTPQ) Guidelines, published by OCIMF May 2011
4. Port Rules, issued in terms of the National Ports Act, No. 12 of 2005, 6 March 2009.