BEST PRACTICE GUIDE FOR THE PROCUREMENT AND IMPORTING OF BITUMEN

MANUAL 41: 3rd EDITION – JUNE 2024

sabita

excellence in bituminous products

Published by

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ISBN 978-1-874968-77-1

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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. In the past bitumen was produced and supplied in various grades at four refineries in the RSA. However, at the time of publishing Edition 1 of this guide (August 2013), it was already evident that going forward, local refineries would not be able to ensure stable bitumen supplies to satisfy local demand. Supply of bitumen was erratic, particularly during peak road construction periods, resulted in delays to project completion.

In reaction to the anticipated supply shortages, major local bitumen suppliers and road construction companies were forced to revert to importing bitumen. The need for guidance on the procurement and importing of bitumen then arose and Edition 1 of this document was published to provide a broad overview of the processes and associated activities for bitumen import operations.

In the ensuing years, since the publishing of Edition 1, the local bitumen supply position has deteriorated to the extent that importing bitumen is now fait accompli. Following SABITA Member's feedback and representations this Guide was revised in 2021 when Edition 2 was published. The section on Quality Assurance Standards and Specifications was revised to include more specific detail on existing quality assurance protocols and specifications.

In 2022 concerns were raised regarding associated HSE activities needing to be considered by bitumen importers. These concerns related to offloading of bitumen during import operations and following deliberations with local stakeholders, the decision was taken to revise this Guide to provide more comprehensive guidance on critical HSE activities associated with the importing of bitumen. A Working Group was established to undertake the revision resulting in this 3rd Edition of the Guide.

Working Group

The following persons served on the working group tasked with this revision of the Guide:
Cobus Fourie - Shell SA (Chairperson)
Lorraine Wagner - Sabita (Scribe at working group meetings)
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ACKNOWLEDGEMENTS

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

SABITA also wishes to express sincere gratitude and appreciation to the following contributors:

- BRS Group, Durban for the valued input in connection with Ship to Shore discharge operations, and in particular Messrs Gary Templar (HSE and Operations Manager) and Heinrich Beeslaar (Technical Manager) who shared their "hands-on" practical experience;
- The staff of Rubis Asphalt and FFS Refiners in Cape Town harbour for their valuable input on the ship to pipeline operations in the Tanker Basin.

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

CONTENTS

1. OBJECTIVES

The primary objectives of this guide:

- To list the processes and associated activities necessary to assure a reasonable likelihood of success with managing the potential risks associated with the import of bitumen;
- To make specific recommendations for the management of the critical HSE and Quality Assurance aspects of a typical bitumen import operation.

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 Vessel;
- 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 Health and Safety requirements for importing bitumen. The author acknowledges that in compiling this guide various publications were extensively consulted as appropriate technical and regulatory information sources. It is recommended that the following referenced documents are read in conjunction with this guide

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;
5. Risk Assessment for The Importation of Bitumen for Road Construction into South Africa, Christiaan H. Hanekom, Stellenbosch University, March 2016.

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
Authorised representative	The person designated as "authorised representative" in the Terminal Operator Licence
Authority or TNPA	The Transnet subsidiary division Transnet National Ports Authority (TNPA) which is responsible for Regulatory control of the ports in the RSA
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 ®
COC	Certificate of Compliance with a referenced standard
Consignee	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
Dangerous goods	Includes dangerous cargo including but not limited to: (i) goods classified in the IMDG Code, published by the International Maritime Organisation, as amended from time to time;
Draught (Draft)	Depth of keel (of a vessel) 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	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

Good Industry Practice	In relation to the conditions of the Terminal Operators Licence means: The standards, practices, methods and procedures that would reasonably and ordinarily be expected from a skilled and experienced person engaged in the operation of a liquid bulk terminal.
Licensed Terminal Operator (LTO)	The business entity/person/s licensed to provide a port service or operate a port facility in terms of section 57 read with section 65 of the National Ports Act No. 12 of 2005 i.e., a Tanker Terminal.
IMDG Code	The International Maritime Dangerous Goods Code adopted by the Maritime Safety Committee of the International Maritime Organization by resolution MSC.122 (75).
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 (bitumen) that can be transported
Port Terminal/Tanker Terminal	Infrastructure, cargo-handling equipment, sheds and other land-based structures used for the loading, storage, transshipment and discharging of cargo or the embarkation and disembarkation of passengers. *In this document it refers to a place where tankers are berthed or moored for the purpose of loading or discharging bitumen cargo*
Quality Assurance	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	See 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
BRT (Bitumen 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
Shipper, Supplier and/or consignor	The enterprise which consigns bitumen 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
Shipping carrier	A person or company who carries goods (bitumen) to the final destination as per certain terms and conditions under maritime law. Is nominated/designated by either the shipper or consignee depending on the transport agreement i.e., CIF (Cost, Insurance, Freight) or FOB (Free On Board)

Tanker or Tanker Vessel	A ship designed to carry liquid oil, chemicals, petroleum, and gas cargo in bulk
Terminal Operations	Services provided at a port terminal, consisting of handling cargo, storing cargo, transshipment of cargo and delivering cargo to vessels and services related thereto.
Terminal Representative/s	A person/s appointed by the Terminal Operator to take responsibility for an operation or duty at a terminal. ***(Note that this is an ISGOTT requirement and most likely several appointments would be made to ensure proper supervision of critical cargo operations at a Terminal).***

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 - A BRIEF OVERVIEW

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 an import permit the importing Individual or Organisation must be registered as an Importer. Application forms IE230 and IE461 may be downloaded from the ITAC website at **www.itac.org.za.**

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 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 economy 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 - Available solutions

Currently, and probably at least in the foreseeable future, some 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 add substantially to the turn-around time of bitumen shipments which further adds to the cost due to high demurrage fees.

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 mobile shore unloading gantry/manifold installed alongside the Tanker to connect a flexible discharge hose to the Tanker manifold;
- 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.

Note: Currently there are three permanent "bitumen specific" terminals in South Africa, one in in the port of Cape Town and two in the port of Durban.

6.2.3.1 Temporary solutions for bulk liquid bitumen discharging

Figures 1 and 2 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 1 – Ship to shore arrangement to discharge bitumen directly to road tankers *(Images courtesy of Atlantis Bitumen and Energy S.A.)*

Figure 2 – Ship to shore discharge using a mobile gantry discharge system positioned on the quay alongside the vessel. The mobile unit usually includes a manifold with multiple loading arms that allows more than one road tanker to be loaded simultaneously. ***(Images courtesy of Colas South Africa)***

Fixed Ship to Shore Bitumen Unloading System

Figure 3 – Ship to shore discharge via a pipeline using a fixed quayside connection to an onshore storage facility. On the left the red arrow points to the shore pipeline connection flange and on the right the shore pipeline is connected, via a flexible discharge hose, to the vessel alongside at the Tanker Basin in the Port of Cape Town. ***(Images courtesy of Rubis Asphalt South Africa)***

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 ± 150° C to 180 ° 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 prevalent.

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 bitumen containers)

Bitumen containers are essentially freight containers designed/modified for shipment of cold bitumen *(i.e., at ambient temperature)* in larger quantities. Bitumen containers are manufactured to ISO design standards and certified by Lloyd's Register for carriage of dangerous goods by sea. Bitumen containers are available in single-skin or double-skin configuration.

Bitumen containers are equipped to heat bitumen through the application of various burner and heating systems. 20ft bitumen containers can be heated in transit and maintained in liquid form if required. (Note: bitumen transported in 40ft containers may not be heated in transit.) However,

normal practice is to heat bitumen prior to discharge at the final destination. Bitumen containers are also 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

Shipping containers are available in various sizes however, bitumen containers are usually 20ft tanks (stores up to 27,000 litres) and 40ft tanks (stores up to 65,000 litres)

Availability of bitumen containers and ships that can carry such 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 designated Terminal Operator TPT will provide services in connection with discharging (off-loading) of bitumen containers at Container Terminals. Importers must however make arrangements for collection and transport of the containers 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

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

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

8.2 TANKER AND TERMINAL OPERATIONS

The *International Safety Guide for Oil Tankers and Terminals (current version- **Sixth Edition,** June 2020)* 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 23, Mooring
- Chapter 24, Precautions on Ship and Terminal During Cargo Handling
- Chapter 26, Safety Management

Annexure 1 of this publication provides a step guide for a typical bitumen import process using bitumen tankers as transport method.

Annexure 1 - Step guide for a bitumen import process

A. Overview of functionaries, roles and responsibilities

Functionaries	Roles and Responsibilities
International Trade Administration Commission of South Africa (ITAC)	• Responsible for import and export control. • Applications for Bitumen import permits must be submitted to ITAC.
Shipper/Consignor (Exporting party)	• An internationally recognised manufacturer and/or distributor of bitumen; • Could be a 3rd party clearing and forwarding agent.
Consignee/Receiver (Importing party)	• The receiver (of the cargo) and, generally in practice, the owner of the imported bitumen; • Unless there are other instructions (written agreement with an Agent), the consignee is the entity or person legally required to be present to accept the shipment.
Vessel Agent	• Appointment is mandatory in accordance with Port Rules; • A vessel agent represents either the shipowner or the charterer – or both; • The shipowner appoints the agent however, if the ship is on charter, the charterer must appoint an agent. • Performs all the services as set out in the Agency Appointment Agreement (Inward and Outward Clearance of Vessel; Cargo Operations,etc.)
Licensed Terminal Operator (LTO) and Authorised Representatives	• A person (entity) authorised, in accordance with section 56. (1) of the National Ports Act, No. 12 of 2005, to operate a tanker terminal; • The LTO must nominate/designate an **Authorised Representative** who shall be accountable for overall management of the Terminal, including ship to shore cargo discharge operations; • The **Authorised Representative** may delegate responsibilities (appoint other persons in writing) to ensure compliance with applicable Regulations and Standards.
Cargo Discharge Crew (Shore Operations)	• Appointed by the LTO; Cargo discharge crews shall, as a minimum, consist of the following personnel: **For mobile gantry operations-** • A Shore Operations Supervisor should be in attendance on each shift, in the vicinity of the ship to shore connections, to monitor operations; • A sufficient number of competent gantry operators, per shift, must be available to ensure that safety is not compromised during loading of vehicles; **For discharge to a fixed port storage facility-** • A sufficient number of competent tank farm/pipeline operators, per shift, must be in attendance at the receiving facility.
Transport Operator	• Appointed by the owner of the imported bitumen; • Should have a good track record and operate a fleet of dedicated Bitumen Road Tankers; • Provides a sufficient number of suitably qualified and licenced drivers to ensure that Regulations with regard to duty hours are adhered to.

Bitumen imports process steps, activities and potential issues ***(Assuming that the importer has registered as a Bitumen Importer, is a Licensed Terminal Operator and has submitted a HSE Management system for Terminal Operations)***

Step #	Step description	Activity/s	Potential issues
b) i	Place order	Select trustworthy supplier, and request Full Corporate Offer	
b) ii	Apply for an import permit	Complete and Submit form **IE461**	
b) iii	Appoint a vessel agent	Vessel agent shall: Obtain/Prepare/Submit: • Commercial Invoice • Customs Invoice • Consular Invoice • Certificate of Origin • Bill of Lading • Insurance Certificate • Packing List • Letter of Credit • MARPOL and SOLAS COC's for vessel	Unnecessary delays in submitting or obtaining the necessary documents
b) iv	Appoint a reputable service provider to perform product quality assurance along the entire supply chain	Inspection/testing/ verification/certification in accordance with agreed quality standards	Incorrect quality standards specified
b) v	Prepare for terminal cargo handling operations	i. Appoint cargo discharge contractor; ii. Appoint Transport Operator	
b) vi	Discharge cargo	See Annexure 1 Section C for managing the HSE aspects of the cargo discharge operation.	

C. Health Safety and Environmental recommendations for ship-to shore bitumen transfer operations

i Regulatory framework

Generally, the Occupational Health and Safety Act (Act 85 of 1993 as amended) and the Regulations made thereunder, is the overriding applicable legislation. Of particular relevance is the definitions of "employer"; "employee"; Section 8 of the Act: General duties of employers to their employees and Section 9 of the Act:

In addition to, and in support of the OHS Act requirements, the provisions of the Port Rules issued in terms of the National Ports Act No. 12 of 2005, and in particular Chapter 3 Parts A and B, and Chapters 4 and 5 are relevant.

ii Industry guidelines and best practice

Chapter 5, Part B of the Port Rules incorporates two specific Industry Guidelines for consideration when designing HSE management systems for Tanker Terminal operations i.e.,

- International Safety Guide for Oil Tankers and Terminals, International Maritime Organization ISGOTT, (currently in its Sixth edition, 2020); and
- Guidelines for the Handling, Storage, Inspection and Testing of Hoses in the Field, 2nd Edition, OCIMF, January 1995.

These industry guidelines where extensively consulted, and in particular the ISGOTT 6 Ship/Shore checklist Parts 2; 4; 5A; 6; 9; where used as reference when Risk Assessments and Hazard Analysis was conducted to compile the Generic Hazard Register below.

Generic Hazard Register for ship to shore transfer of liquid bitumen at elevated temperature

a) Discharge via a mobile loading gantry

			Control Barriers	
#	**Hazard/Top Event/Potential Consequences**	**Threats**	**Prevention Controls**	**Recovery Controls**
1	**Hazard** Hot fluids - ≥ 150°C **Top Event** Loss of containment **Potential Consequences** • Failed transfer equipment, overfilling of BRT or Bitutainer results in major spill migrating to harbour water • Boilover resulting in serious burns to workers and major spill on land	• Improper operation of plant • Over pressure in transfer lines • Presence of water in BRT or Bitutainer • Inadequate ship/shore flange connection • Substandard cargo transfer hoses • Product temperature fluctuation leading to pump cavitation and/or foaming	• Personnel trained and certified to acceptable international standard • Safe loading procedures understood and properly executed • Active supervision by shore Operations Supervisor throughout cargo operations • Independent high-level alarms, (if fitted), are operational and have been tested • Cargo transfer rate and maximum allowable pump pressure is agreed and monitored during cargo transfer • Ship and shore personnel maintain a close watch for the escape of bitumen • Bitumen switch loading procedures • Inspect receiving tanks prior to start of cargo transfer • Loaders listen for “HISSING SOUND” from receiving tanks • Stop loading if rain is imminent • Emergency signals and shutdown procedures are agreed/executed • All flange connections are fully bolted • Portable drip trays placed under the manifold to retain any leakage • Hoses suitable for the service and properly tested, marked and certified • A documented inspection at least annually to confirm hose suitability for continued use • Visual examination of hose assembly BEFORE EACH unloading operation • Reduce pump RPM to stop cavitation	• The emergency signal and shutdown procedure to be used by the ship and shore have been agreed, explained and understood • Sufficient personnel on board and ashore to deal with an emergency • Execute emergency shutdown • Bitumen spill containment and clean-up material is readily available • Activate pollution emergency plan
2	**Hazard** 1) Adverse weather 2) Working adjacent to open water **Top Event** Exposure to high wind and/or lightning **Potential Consequences** 1) Serious injuries (potentially fatal) resulting from fall from height; lightning strike 2) Drowning	• High wind (≥ 30 kt/55kph) and/or lightning • Offshore wind gusts of 40kph to 55kph • Severe thunderstorm	• Check local weather forecast and be aware of sudden changes in weather • Install an anemometer to measure wind speeds • DO NOT commence or continue discharge operations in wind speeds in excess of 55 kph • If offshore wind is blowing at speeds between 40kph and 55kph personnel should wear lifejackets when working quayside • DO NOT commence or continue discharge operations if a thunderstorm is imminent (apply the 30/30 lightning safety rule) • Emergency signals and shutdown procedures are agreed/executed	• Sufficient personnel available ashore to deal with an emergency • Lifebuoys with line available quayside to throw to person/s in water • Activate medical emergency response plan • First aid responders are trained to administer CPR
3	**Hazards** Personnel at height; and personnel moving at same level **Top Events** Slips, Trips and Falls at same level; and fall from height **Potential Consequences** Serious injuries resulting from fall from height or impact against piping or other structures	• Unsuitable, uneven, obstructed or damaged gantry work platform • Inadequate fall prevention devices on gantry work platform	• Work platform designed and constructed with a sturdy non-slip surface • Work platform floor is kept free of waste, projecting fasteners or any other obstructions • Perform pre-startup inspections to check for damage to work platform • Guard rails installed on all sides of the platform and the sides of the access stairs • Toe-boards installed on the floor on all sides of the platform	• Personnel wear hard hats/bump caps with chin straps to protect skull against impact with structures

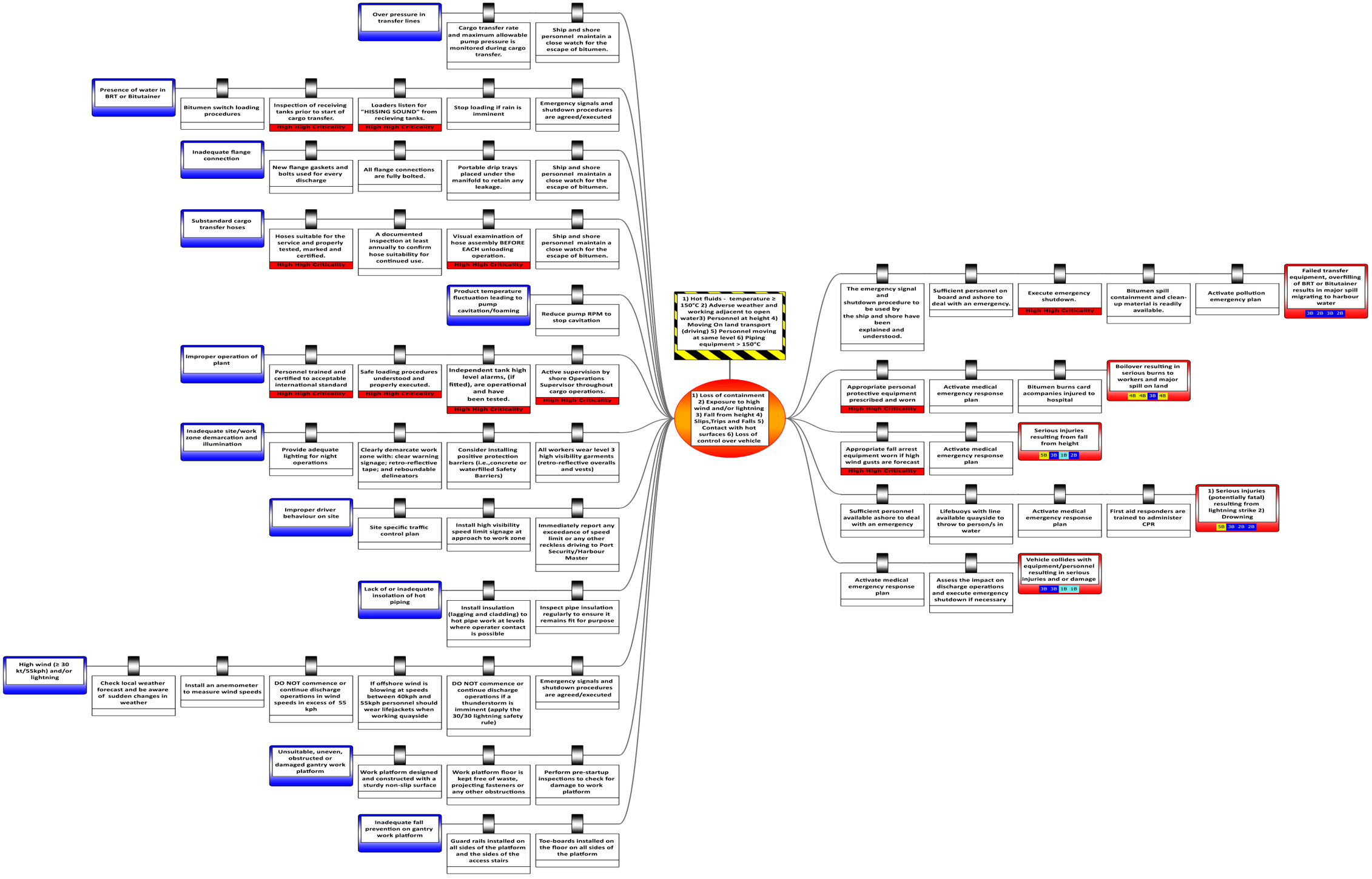
			Control Barriers	
#	Hazard/Top Event/Potential Consequences	Threats	Prevention Controls	Recovery Controls
4	**Hazard** Moving on land transport (driving) **Top Event** Loss of control over vehicle **Potential Consequences** Vehicle collides with equipment/personnel resulting in serious injuries and or damage	• Inadequate site/work zone demarcation and illumination • Improper driver behaviour on site	• Site specific traffic control plan • Clearly demarcate work zone with: clear warning signage; retro-reflective tape; and reboundable • Install high visibility speed limit signage at approach to work zone • Consider installing positive protection barriers (i.e., concrete or waterfilled Safety Barriers) • Provide adequate lighting for night operations • All workers wear level 3 high visibility garments (retro-reflective overalls and vests) • Immediately report any exceedance of speed limit or any other reckless driving to Port Security/Harbour Master	• Activate medical emergency response plan • Assess the impact on discharge operations and execute emergency shutdown if necessary
5	**Hazard** Piping equipment > 150°C **Top Event** Exposure to hot surfaces **Potential Consequences** Contact with hot surfaces resulting in burns	• Lack of or inadequate insolation of hot piping	• Install insulation (lagging and cladding) to hot pipe work at areas/levels where operator contact is possible • Inspect pipe insulation regularly to ensure it remains fit for purpose	• Personnel wear appropriate PPE to protect skin in case of contact with hot piping • Activate medical emergency response plan • First aid responders are trained to effectively deal with burn injuries

b) Discharge via a fixed pipeline to a tank farm

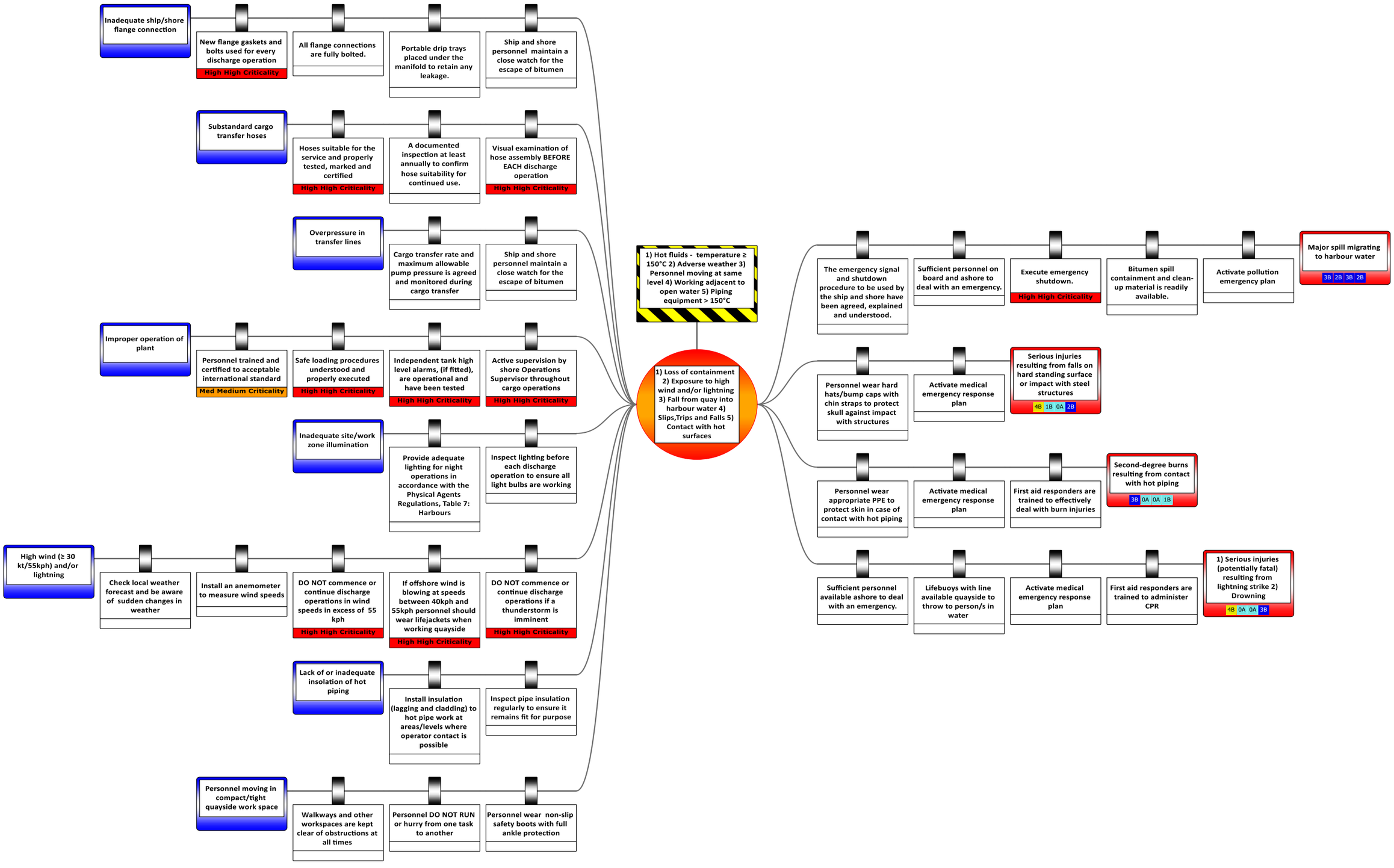
			Control Barriers	
#	Hazard/Top Event/Potential Consequences	Threats	Prevention Controls	Recovery Controls
1	**Hazard** Hot fluids - temperature ≥ 150°C **Top Event** Loss of containment **Potential Consequences** Failed transfer equipment results in major spill migrating to harbour water	• Inadequate ship/shore flange connection • Substandard cargo transfer hoses • Improper operation of plant • Over pressure in transfer lines	• New flange gaskets and bolts used for every discharge operation • All flange connections are fully bolted • Portable drip trays placed under the manifold to retain any leakage • Cargo transfer rate and maximum allowable pump pressure is agreed and monitored during cargo transfer • Ship and shore personnel maintain a close watch for the escape of bitumen • Hoses suitable for the service and properly tested, marked and certified • A documented inspection at least annually to confirm hose suitability for continued use • Visual examination of hose assembly BEFORE EACH discharge operation • Personnel trained and certified to acceptable international standard • Safe loading procedures understood and properly executed • Independent tank high level alarms, (if fitted), are operational and have been tested • Active supervision by shore Operations Supervisor throughout cargo operations	• The emergency signal and shutdown procedure to be used by the ship and shore have been agreed, explained and understood. • Sufficient personnel on board and ashore to deal with an emergency. • Execute emergency shutdown • Bitumen spill containment and clean-up material is readily available • Activate pollution emergency plan
2	**Hazard** 1) Adverse weather 2) Working adjacent to open water **Top Event** Exposure to high wind and/or lightning **Potential Consequences** 1) Serious injuries (potentially fatal) resulting from lightning strike 2) Drowning	• High wind (≥ 30 kt/55kph) and/or lightning • Offshore wind gusts of 40kph to 55kph • Severe thunderstorm	• Check local weather forecast and be aware of sudden changes in weather • Install an anemometer to measure wind speeds • DO NOT commence or continue discharge operations in wind speeds in excess of 55 kph • If offshore wind is blowing at speeds between 40kph and 55kph personnel should wear lifejackets when working quayside • DO NOT commence or continue discharge operations if a thunderstorm is imminent	• Sufficient personnel available ashore to deal with an emergency • Lifebuoys with line available quayside to throw to person/s in water • Activate medical emergency response plan • First aid responders are trained to administer CPR

			Control Barriers	
	Hazard/Top Event/Potential Consequences	**Threats**	**Prevention Controls**	**Recovery Controls**
3	**<u>Hazard</u>** Personnel moving at same level **<u>Top Event</u>** Slips, Trips and Falls **<u>Potential Consequences</u>** Serious injuries resulting from falls on hard standing surface or impact with steel structures	• Personnel moving in compact/tight quayside work space • Inadequate site/work zone illumination	• Walkways and other workspaces are kept clear of obstructions at all times • Personnel DO NOT RUN or hurry from one task to another • Personnel wear appropriate non-slip safety boots with full ankle protection • Provide adequate lighting for night operations in accordance with the Physical Agents Regulations, Table 7: Harbours • Inspect lighting before each discharge operation to ensure all light bulbs are working	• Personnel wear hard hats/bump caps with chin straps to protect skull against impact with structures • Activate medical emergency response plan
4	**<u>Hazard</u>** Piping equipment > 150°C **<u>Top Event</u>** Contact with hot surfaces **<u>Potential Consequences</u>** Second-degree burns resulting from contact with hot piping	• Lack of or inadequate insolation of hot piping	• Install insulation (lagging and cladding) to hot pipe work at areas/levels where operator contact is possible • Inspect pipe insulation regularly to ensure it remains fit for purpose	• Personnel wear appropriate PPE to protect skin in case of contact with hot piping • Activate medical emergency response plan • First aid responders are trained to effectively deal with burn injuries

Annexure 2 – BowTie diagram of ship to shore transfer using a mobile gantry



Annexure 3 – BowTie diagram of ship to shore transfer using a fixed pipeline to tank farm



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.

9.2 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.

9.3 MATERIALS AND MANUFACTURE

The bitumen shall be derived from crude petroleum oil. The bitumen must be homogeneous, 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.

9.4 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.

9.5 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.

9.6 BITUMEN QUALITY

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

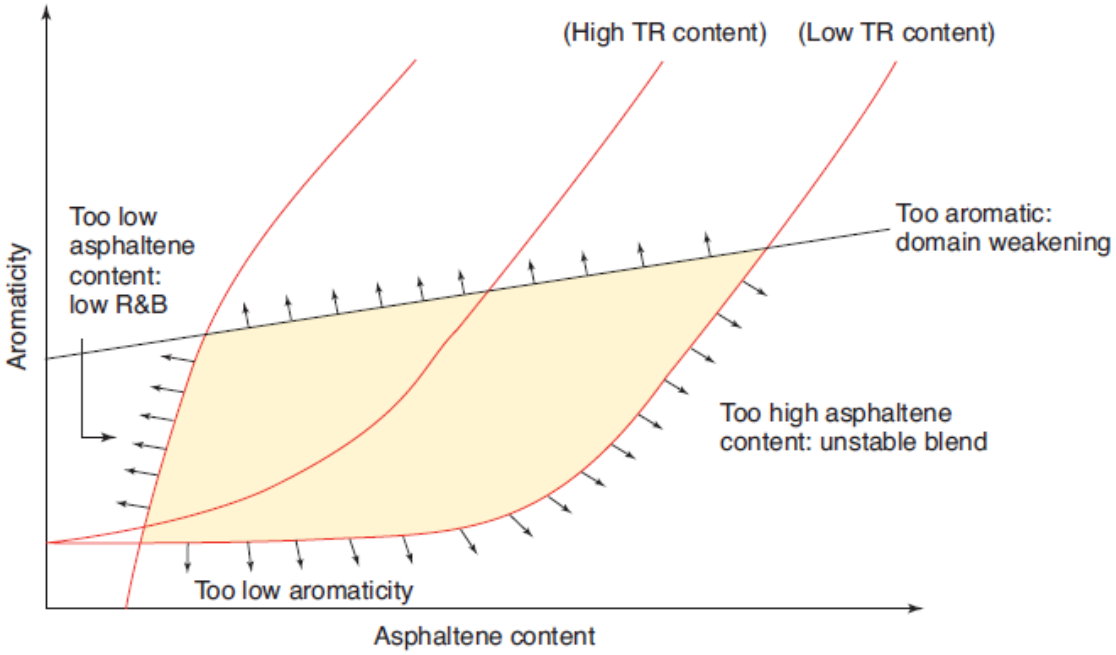


Figure 2 - Effect of aromaticity and asphaltene content on the stability of thermoplastic rubber (TR) bituminous blends (Whiteoak, 1990)