Guidance for Safe Bitumen Tank Management

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The Quarry Products Association is the trade association for the aggregates, asphalt and ready-mixed concrete industries. Its membership also includes companies manufacturing road construction and quarrying plant and equipment and UK producers of petroleum bitumen.

The Refined Bitumen Association is the consolidated voice of the UK bitumen supply industry. Its membership comprises the UK's five major bitumen producers who, between them, supply nearly all of the country's bitumen - approximately two million tonnes per annum.

The RBA promotes the most effective use of bituminous materials within the construction industry, provides technical support and funds research into bituminous products. It is also involved in the development of industry policy on quality assurance and best practices relating to safety, storage and handling of bitumen.

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Introduction

There are around 325 asphalt manufacturing plants throughout the UK involving approximately 1300 bitumen storage tanks. Spillages from these bitumen storage tanks as a result of overfilling, have a high potential for serious injury as bitumen is stored at high temperatures and has a large thermal capacity

Statistics compiled for the 6 years, from 1998 to 2003 for reported bitumen spillages at UK delivery sites, show that on average across the industry there were 60 spillages, with 78, 79 & 82 for the years 2001, 2002 & 2003 respectively. A study was commissioned by the RBA in the UK to address this industry wide problem. The findings of this study can be found in the report "Study of Asphalt Industry Bitumen Storage Tank Measuring Systems" which should be referred to for detail analysis and technical information.
(Please contact Tony Harrison at the Refined Bitumen Association for information on how to receive copies of this report).

This document explains the fundamental principles that need to be adopted at all asphalt plants, for the safe operation of bitumen storage tanks, to reduce the risk of occurrence of a potentially serious incident.

The Origin of Spills

Spills have occurred from the bitumen tanks on many sites due to overfilling as a result of the incorrect determination of the available ullage space due to a number of factors:

1. Lack of Knowledge of **Tank Dimensions & Capacity**
2. Use of Incorrect **Conversion Factors**
3. Unsuitable or Wrongly Applied **Tank Measurement Instrumentation**
4. Incorrect **Interpretation/Presentation of Tank Contents Measurement Information**
5. Poor **Communication between the Delivery Tanker Driver and Asphalt Plant Operating Personnel**

1 Tank Dimensions and Capacity

A Storage Tank Capacity and the Determination of Ullage

The correct determination of the ullage space in a given bitumen storage tank is crucial to preventing spills and to ensure this, it is important to establish what is the actual working storage capability of a given tank.

There is a lack of uniformity across the asphalt industry, with both tank manufacturers and site operating companies, when stating the storage capacity of site bitumen tanks, in terms of the terminology used and the units of measurement. Also, in some cases there is a lack of awareness by site operating personnel regarding the storage capability of their bitumen tanks and frequently there are no details or drawings readily available for reference regarding important tank sizing dimensions, including their height, diameter, positions of off take and overfill pipes etc.

It is vital that this information is available to enable the accurate calculation of tank capacities, obtained either from tank manufacturers drawings or by on site tank survey measurements and for the industry to adopt common terminology for defining tank capacity.

B Definition of Tank Capacity

Using the following terms and definitions we can calculate the tank storage capacity for any given tank (as long as the correct tank data is available):

Nominal Tank Capacity	Internal volume in m3 from the tank bottom to the tank top
Unavailable Tank Capacity	Internal volume in m3 from the normal tank draw off pipework to the bottom of the tank + Inside volume in m3 from the overfill/vent pipe to the tank top
Available Tank Capacity	Internal volume in m3 from the normal tank draw off pipework to the overfill/vent pipe
Safe Working Tank Capacity	90% of the available tank capacity in m3
Conversion from volume to mass	Multiply volumes in m3 by 0.92 tonnes/m3 to express the capacity in tonnes

By way of an example in the use of these terms and to show how confusion can arise, consider a new tank recently installed on a customer site to hold 100 tonnes of bitumen.

Nominal Tank Capacity	105.8 m3	97.3 tonnes
Unavailable Tank Capacity	5.3 m3 + 1.0 m3 = 6.3 m3	5.8 tonnes
Available Tank Capacity	99.5 m3	91.5 tonnes
Safe Working Tank Capacity	89.6 m3	82.4 tonnes

As can be seen from the above, the tank is only capable of safely storing 82.4 tonnes of bitumen that can be used for asphalt production and not 100 tonnes as implied. The use of a more rigorous statement of the capacity required would have prevented such a misunderstanding.

See the diagrams in Appendix 1 for representation of the above terminology for vertical and horizontal tanks.

2 Conversion Factors

C The Determination of Ullage

Following on from the definitions previously discussed, deciding whether there is sufficient space in a particular storage tank to safely receive a planned delivery of bitumen of known weight (expressed in tonnes) without overfilling involves :

Determination of the unused part of the safe working capacity in volumetric terms expressed in cubic metres

Conversion of this volume into the mass (or weight) of bitumen that can be safely stored, using the worst case density figure of 0.920 tonnes/m3.

Implicit in these calculations is the assumption that the tank shapes (either horizontal cylinders, vertical cylinders or rectangular cuboids) are uniform and remain so when the tanks are filled/emptied and that the tank dimensions provided by the manufacturer are accurate.

There is an obvious difficulty in expressing the capacity of a given tank in weight, as the weight of a particular grade of bitumen that can be stored in a given volume depends on the density of the bitumen, which can vary according to the storage temperature. Significantly, there are considerable differences, between both tank manufactures and operating sites, in the density values used for a given grade of bitumen being stored, often far too high, that could never be applicable for the range of temperatures at which it is normally stored.

Conversion from volumetric to mass units, should use the worst case density for the bitumen being stored, to avoid overfilling, ie. The density of the bitumen at its highest recommended storage temperature (the lowest value of density likely to be encountered), when a given mass of bitumen occupies its largest volume.

It turns out that the worst case density value for all grades of bitumen typically stored is around

920kg/m3 (or 0.920 tonnes/m3), which is the value that should be used when converting from volume to mass.

3 Tank Contents Measurement Instrumentation

In practice, measurement of the liquid level or ullage distance and the conversion of either of these into an expression of the tank contents are usually accomplished by some form of tank contents measurement instrumentation. The readings from which, according to their range of measurement and the units used, are interpreted by the operator, to decide whether there is sufficient room in a given tank, to safely receive a tanker delivery of bitumen.

To warn of abnormal conditions, which if left unheeded could lead to difficulties including the possibility of an overspill, various alarms are usually provided, either derived from the measurement equipment, or by independent means.

The *main report* (available through the RBA) provides information relating to the choice and application of various types of instrumentation, including details of instrumentation manufacturers and suppliers, who have the necessary applications expertise and who should always be consulted before the purchasing and installation of equipment.

A Measurement Derived Alarms

Measurement signals from the contents measuring instrumentation are often used to generate various alarms, usually to warn of abnormal operating conditions, typically high level *(HLA)*, or extra high level *(HHLA)* alarms, to prevent a potential overspill condition and less commonly low level *(LLA)* alarms to prevent a possible tank overheating condition. Also, they sometimes provide information as to whether or not there is room in a given tank to receive a new delivery of bitumen. *A measurement derived alarm should be fitted to all bitumen tanks.*

In the event of a malfunction of the contents measuring instrumentation, or as a result of incorrect setting up, these types of alarms could fail to provide any overspill safeguard.

On some of the tanks fitted with mechanical buoyancy level indicators, both of the Cat & Mouse and rotary types, high level and sometimes low level alarms are generated using micro or proximity type switches operated by a pointer mechanism.

B Independent High Level Alarm Devices

In an attempt to avoid overspills, some sites have equipped their tanks with high level alarm generating devices, that act independently from the contents measuring instrumentation, to provide an *'ultimate'* high level alarm *(HHLA)*.

These alarms are derived from fixed position switches or probes within the tank, which operate when the bitumen makes contact with them. These should be used in addition to the measurement derived high level alarms. *It is recommended Independent high level switch devices should be fitted to all bitumen storage tanks through out the industry,* to provide a safeguard from spills in the event of a fault or problem with the contents measuring instrumentation, or because of some error in the translation of level measurement into volumetric contents, due to possible tank dimensional or deformation abnormalities and/or the build up of product on the side walls of the tank.

Further, where the contents measurement is based on the use of hydrostatic instruments, then the fitting of independent high level switches should be considered an essential priority, as it is not possible with this technology, to provide with absolute certainty measurement derived alarms, that directly relate to the level of bitumen stored (for the reasons mentioned in the technical description in *Appendix II* of the main report).

The type of independent alarm devices available and the technical aspects relating to the technology exploited and their application on bitumen storage tanks are discussed in the *main report*.

C Setting Up of Tank Contents Instrumentation

Taking into account the earlier parts of the report relating to *available tank capacity* and *safe working tank capacity,* it is considered that the minimum tank contents instrumentation, to prevent overspills should include a contents measuring instrument, a measurement derived high level alarm *(HLA)* and an independent 'ultimate' fixed position point contact extra high level alarm *(HHLA)* switch. These should be arranged such that :

- Where possible the tank contents instrumentation should be installed with a measurement span set to cover the height range corresponding to the *available tank capacity.*
- A measurement derived high level alarm *(HLA)* should be provided, set at the height corresponding to the *safe working capacity,* that is *90%* of the *available tank capacity,* with instructions to the driver to stop loading, should it be initiated.
- An independent fixed position point contact extra high level alarm *(HHLA)* switch should be installed, set at the height in the tank corresponding to *92.5%* of the *available tank capacity,* providing the *ultimate* protection to prevent the tank overfilling, with instructions to the delivery driver to shutdown immediately, should it be initiated.

See the diagrams in Appendix 2 for examples of measurement and alarm set ups using non contact radar, contact radar (TDR) and hydrostatic pressure measurement systems.

4 Interpretation/Presentation of Tank Contents Measurement Information

The safe bitumen storage tank management requires the clear presentation of the information to both plant operating personnel for all aspects of the operation and to the delivery tanker driver during the delivery/offloading process.

A Delivery Tanker Driver Recommended Minimum Information Requirements

- Large individual amber indicator lamps, one per tank to provide HLA warning which is activated off the level measuring system and positioned to be easily visible by the driver from the normal loading point(s), linked to a common audible alarm klaxon, with a key operated audible mute push button switch.
- Large individual red indicator lamps, one per tank to provide "Ultimate" HHLA warning which is activated off the independent alarm and positioned above the HLA amber indicator lamps, linked to a common red flashing beacon with an integral audible siren, with a key operated audible mute push button switch, to enable operating personnel to silence the audible alarm.

- Large sign or signs easily visible to the driver explaining the meaning of these alarms and the action to be taken in the event of them being initiated.

It is recommended that the following should also be installed:

- For tanks greater than 30m3 *safe working capacity* large individual green indicator lamps, one per tank to provide confirmation that there is safe working capacity to accommodate a 30m3 load (approximately 28 tonnes) of bitumen, positioned below the HLA amber indicator lamps.
- Large sign or signs easily visible to the driver explaining the meaning of these indications.

B Site Operational Personnel Information Requirements

It is difficult to be too prescriptive with this, as it depends on the particular arrangement and layout of each site and the way in which the operation of the asphalt plant and its associated bitumen tanks is managed. However, the relevant site personnel need to be aware of the operational status of the bitumen tanks at all times, particularly during the potentially hazardous bitumen tanker delivery process and information regarding this must, therefore, be presented in the place or places where this can be achieved.

As a starting point, it is considered that tank contents measurement information, along with the alarm presentation equipment described, must be presented in the vicinity of the tanks. The minimum information to be provided should be as follows:

- Large sign on each tank stating the *Safe Working Capacity* in *Tonnes,* based on a density conversion factor of *0.920 tonnes/m3.*
- Large individual digital type display contents gauge, one per tank showing the amount of bitumen being stored within the *available* part of the tank expressed in *Approximate Tonnes,* to one decimal place, based on a density conversion factor of *0.920 tonnes/m3.*

With recommendations that the following also be supplied :

- Large individual digital type display gauge, one per tank, mounted alongside the contents gauge showing the amount of *Safe Ullage Space* in the tank, available for the next load, expressed in *Approximate Tonnes,* to one decimal place, based on a density conversion factor of 0.920 tonnes/m3.

Note: With modern microprocessor based digital signal conditioning/display instrumentation, this is capable of being provided at modest cost and could avoid errors in safe ullage determination. Also, this measurement readout would be of use to the delivery tanker driver, who would be able to more closely monitor the progress of the offloading operation.

Tank temperature display *(0^{C})* derived from a dedicated temperature transmitter positioned at the same level as the draw off pipework, to be as far as possible above the tank heating system.

C Centralised Presentation of Measurement & Alarm Information

In most instances it is considered that all of the measurement and alarm information presented in the vicinity of the tanks, as just described, should also be communicated to the asphalt plant control room, whether this be a separate "mixer cabin" type control room near to the asphalt plant, or within a control room shared with the weighbridge as on some sites, where there is likely to be an operator in attendance, who can monitor the bitumen tanker delivery off loading process.

On new plants it is envisaged that the alarm and measurement information communicated from the bitumen tankside instrumentation will be interfaced into the asphalt coating plants' computer based control and data acquisition system, for VDU display using the standard measurement and alarm data presentation packages available within the system.

See Appendix 3 that shows a schematic drawing of a possible model for the display of tankside information.

5 Communication Between the Delivery Tanker Driver and Asphalt Plant Operating Personnel

It is important that communication between drivers and plant personnel is clear to ensure correct selection of tank for the discharging of bitumen product. The driver must present the delivery documentation to plant personnel who must confirm grade and quantity is correct.

The plant personnel will confirm the appropriate storage tank and receiving flange for the delivery. All flanges must have independent padlock and keys that will be issued and controlled by plant personnel. *Under no circumstances should the keys and padlocks be common for different flanges / tanks.*

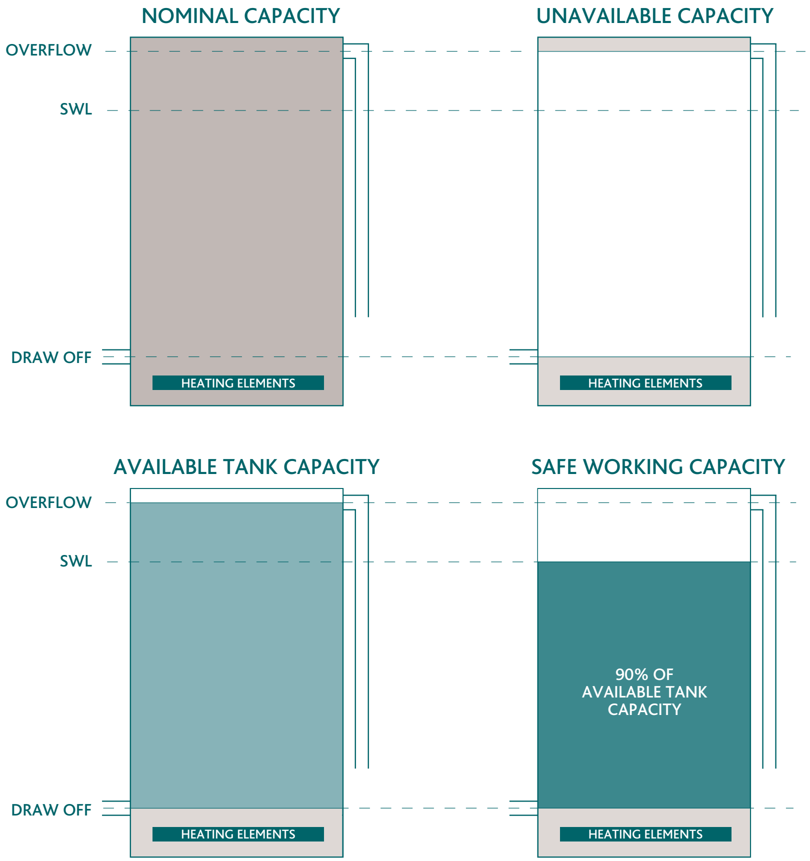
Summary

The safe management of bitumen storage tanks and the avoidance of overfilling involves a combination of:

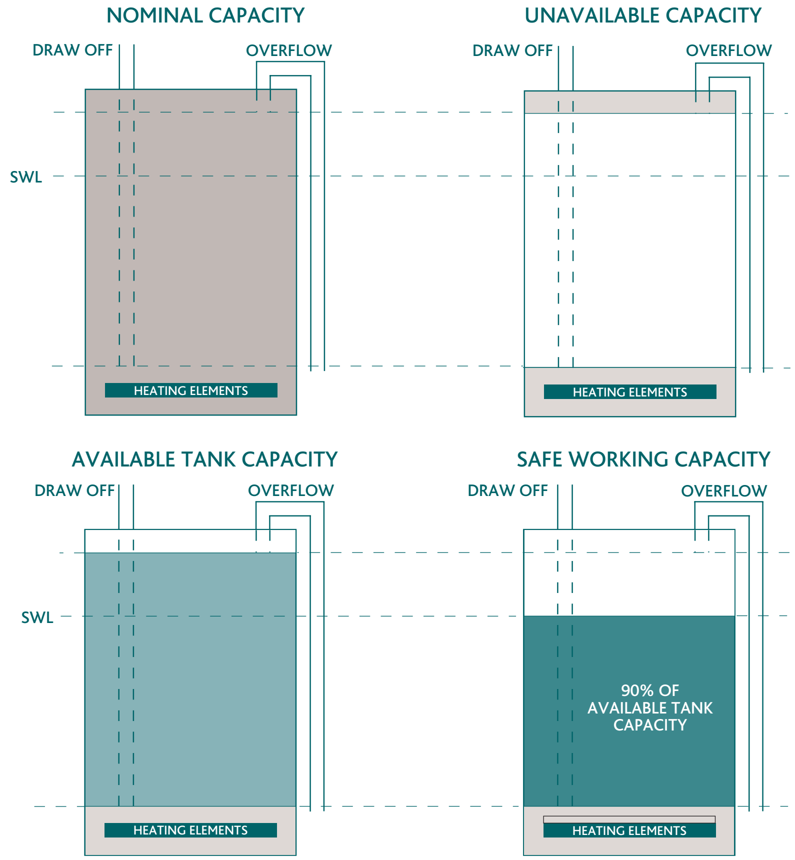
- The correct calculation of ullage using information from the tank contents instrumentation, to determine whether or not there is sufficient room in a given tank to allow a new load to be delivered, without overfilling.
- Accurate and reliable contents measurement, with unambiguous presentation of the salient information.
- The provision of suitable safeguards to warn of an impending overfill condition, should something go wrong.
- Participation and commitment from both the tanker driver and site operations personnel during the delivery/offloading process.

Appendices

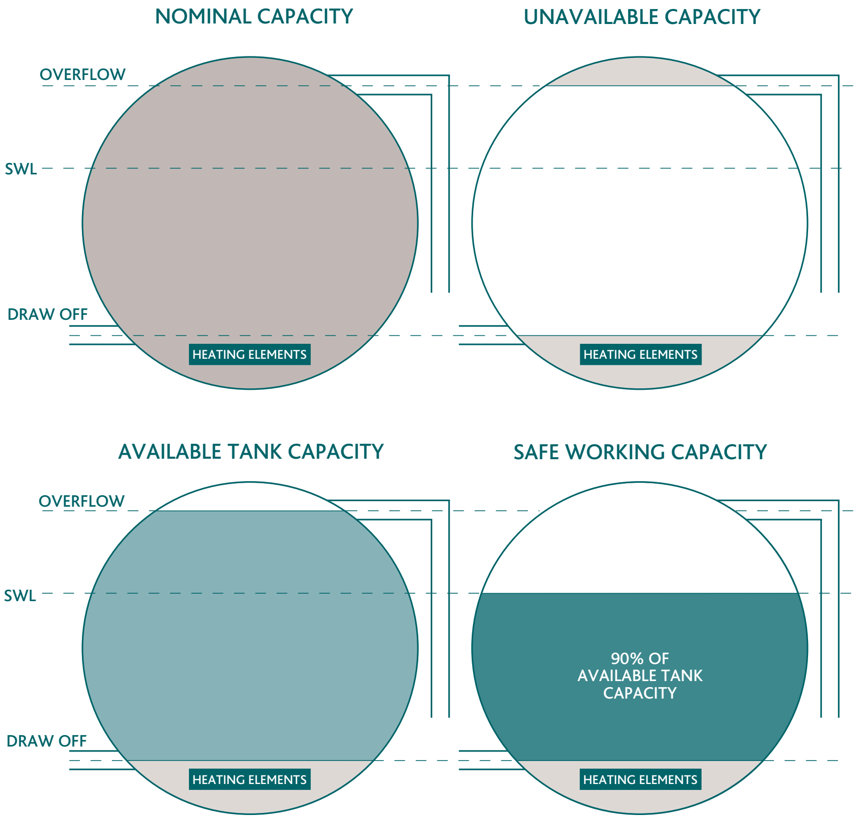
Appendix 1 Capacity of Vertical Cylindrical Bitumen Storage Tanks



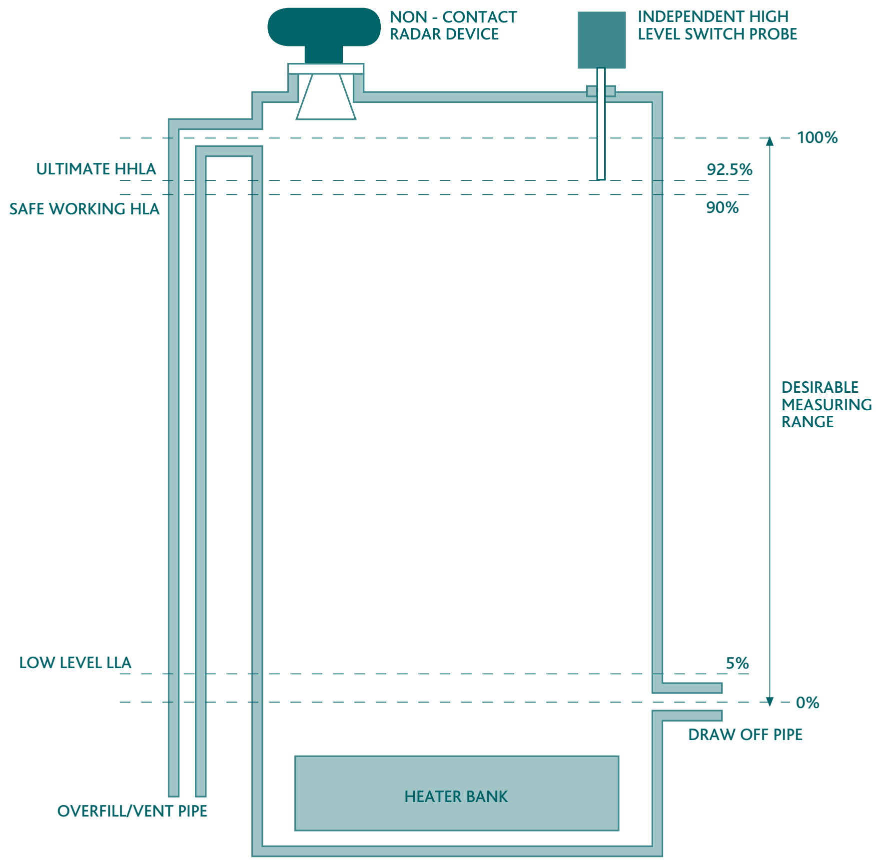
Appendix 1 Capacity of Cuboid Type Bitumen Storage Tanks



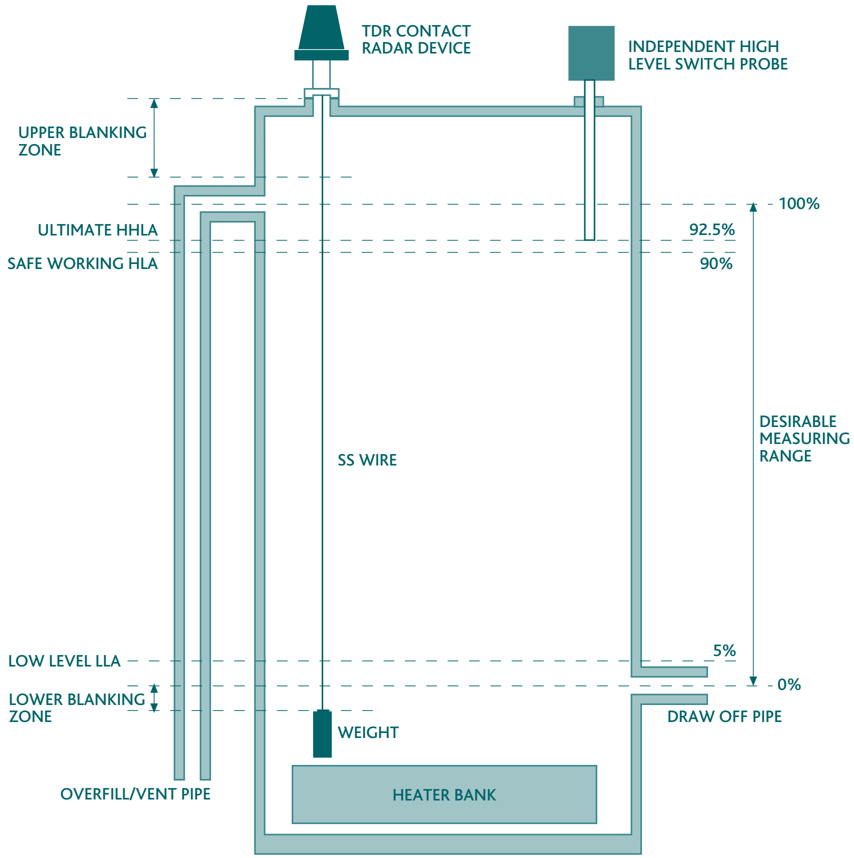
Appendix 1 Capacity of Horizontal Cylindrical Bitumen Storage Tanks



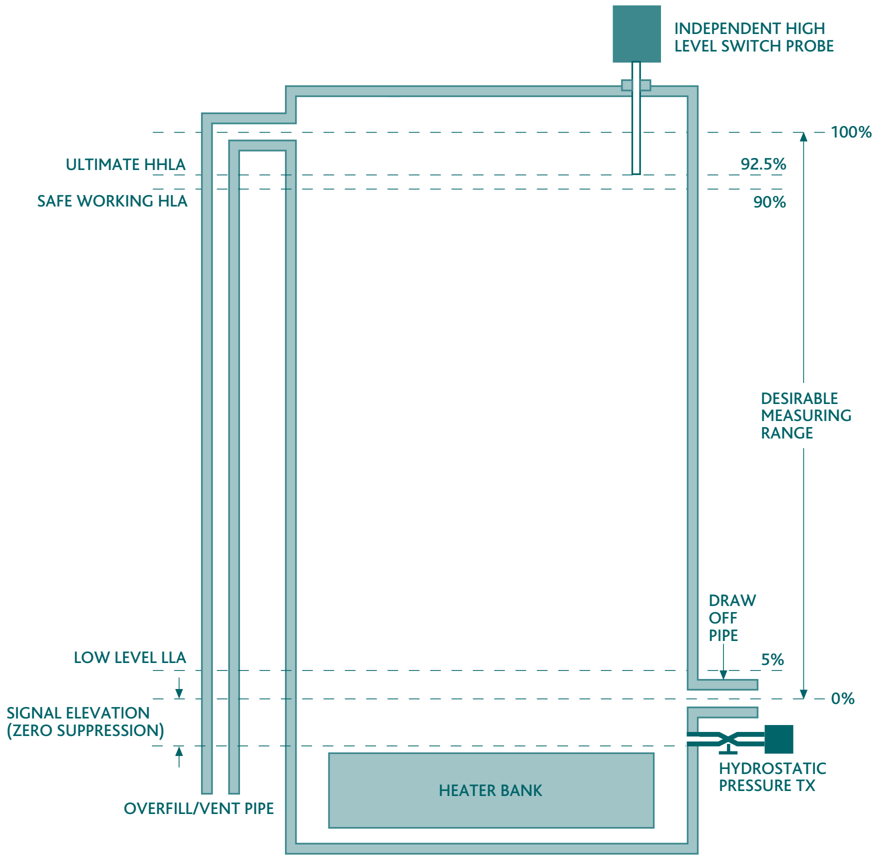
Appendix 2 Schematic Installation Diagram of Non-Contact Radar and Independent Ultimate High Level Alarm Switch



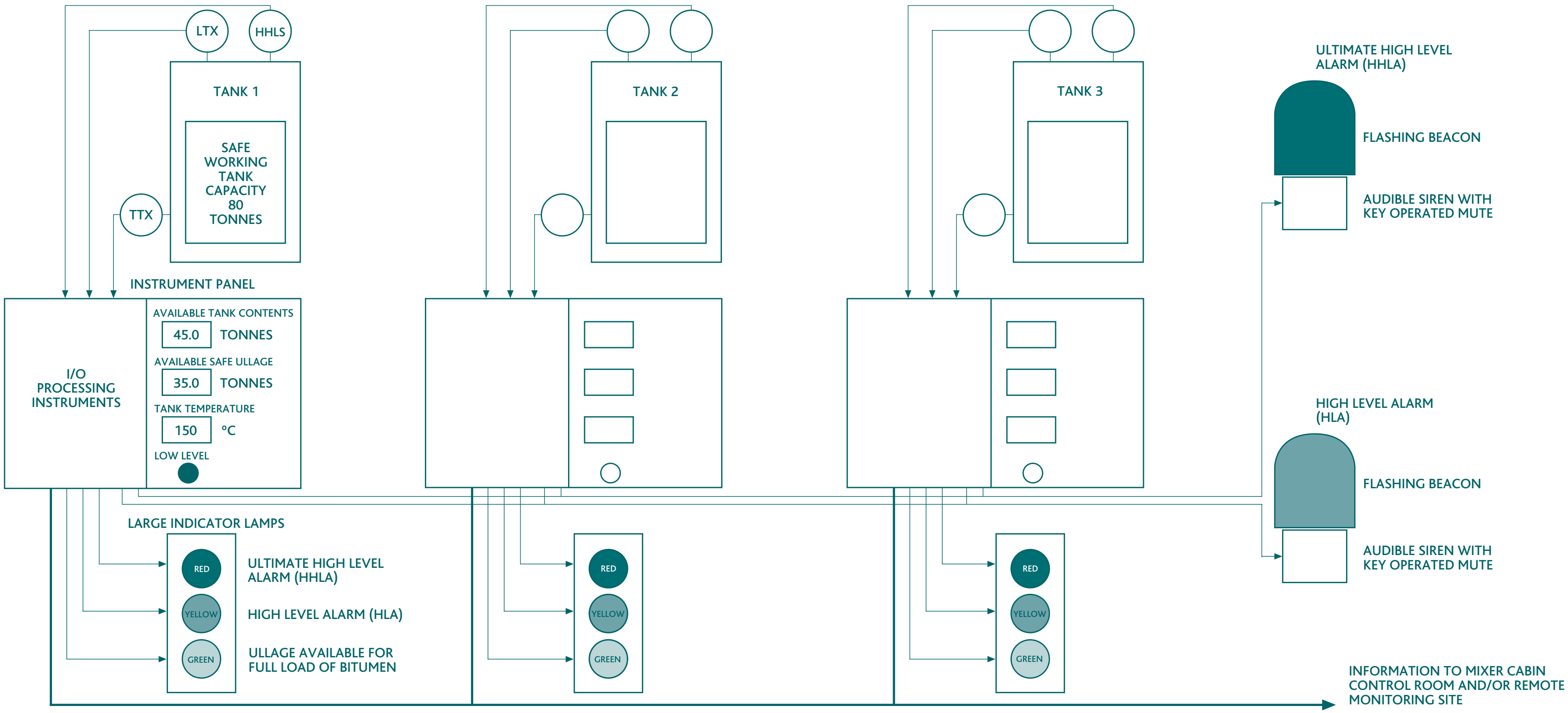
Appendix 2 Schematic Installation diagram of TDR Contact Radar & Independent Ultimate High Level Alarm Switch



Appendix 2 Schematic Installation Diagram of Hydrostatic Contents Gauge and Independent Ultimate High Level Alarm Switch



Appendix 3 Possible Model for the Display of Tankside Information



References

1 Study of Asphalt Industry Bitumen Storage Tank Measuring Systems

Published by Refined Bitumen Association, Hammerain House,
Hookstone Avenue, Harrogate, HG2 8ER

www.bitumenuk.com

Other Information on Safe Handling of Bitumen

1 Code of Practice for Safe Delivery of Bitumen Products

Published by Refined Bitumen Association, Hammerain House,
Hookstone Avenue, Harrogate, HG2 8ER

www.bitumenuk.com

**2 Model Code of Safe Practice for the Petroleum Industry:
Part II: Bitumen Safety Code**

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