GUIDANCE FOR THE DESIGN AND OPERATION OF GROUND-BASED PUMPS

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1. PURPOSE

This guidance document is to provide information to assist companies when specifying, designing, installing and operating new and existing ground-based pump systems used for the off-loading and transfer of bitumen.

Since the introduction of ground-based pumps in Europe there have been a number of incidents where delivery drivers and plant operators have been exposed to significant uncontrolled spills of bitumen. These have been due to poor planning, design and maintenance of ground-based pump delivery systems and, in some cases, the potential consequences of these incidents are very serious.

The intent of this document is to provide the operating companies with best practice as well as guidance for the minimum requirement when designing ground-based pump delivery systems.

2. SCOPE

This guidance is applicable to ground-based pump delivery systems associated with atmospheric pressure bitumen storage tanks that have a maximum design temperature of 260°C (500°F). Other forms of delivery vehicle discharge and transfer are not covered in this document.

Due to the potential hazards and the complexities involved with designing and constructing hot bitumen storage systems, operating companies are advised to consult a competent engineering company when initiating a new ground-based pump delivery system project. The competent engineering company will be knowledgeable in the design/ construction process of hot bitumen storage tanks and associated equipment, including all applicable specifications, codes, and regulatory requirements, thereby minimising the potential risks.

It does not cover other areas which should also be considered, such as the type of instrumentation, traffic light system, CCTV systems, communication links and tank engineering designs.

3. TERMS AND DEFINITIONS

Hazard **Id**entification Study (HAZID): A systematic approach to identify potential hazards that exist in the plant and to document it for later usage in assessments such as hazards and operability (HAZOP) studies.

Hazard and **Op**erability Study (HAZOP): The HAZOP study is a formal method of assessment, performed by a committee, which consists of fully experienced plant engineers, technical, laboratory and safety personnel, to identify hazards in the process plant by using specific procedures.

Functional Safety: Functional Safety is part of the overall safety of a plant that depends on a system or equipment operating correctly in response to its inputs.

Functional Safety Assessment (FSA): The purpose of a functional safety assessment is to identify the functional safety and safety integrity that has been achieved, and as such must as a minimum be carried out after installation and before the use of the system.

Independent Protection Layer: Independent mechanism that will prevent an unsafe scenario from progressing (prevention or mitigation) regardless of the initiating event or the performance of another layer of protection.

Safety Instrumented Function (SIF): Specific single set of actions and the corresponding equipment needed to identify a single hazard and act to bring the system to a safe state, e.g. detect high product level in a tank and prevent an overfill by shutting a valve.

Safety Instrumented System (SIS): The instrumented system used to implement one or more SIFs. Comprises a means of:

1) Detecting the hazardous condition.
2) Determining what needs to be done.
3) Taking effective action to control the hazard.

Here is an example of a SIS (including SIL, HHLA, and HLA):

- Safety Integrity Level (SIL): Level of performance required for a system to perform a required Safety Instrumented Function (SIF).
- High High Level Alarm (HHLA): Alarm to prevent a potential overspill condition.
- High Level Alarm (HLA): Alarm to warn of abnormal operating conditions for the tank level in relation to the safe working capacity of the tank.

4. GENERAL GUIDELINES

4.1. Risk assessment

During the design stage of any new plant and retrospectively for existing plant, a Hazard and Operability (HAZOP) and Hazard Identification (HAZID) studies should be carried out. The HAZOP and HAZID techniques are used universally across high hazard industries as a method of identifying hazards and operability problems in new and existing plant. These processes are very important with any installation and particularly relevant when installing ground-based pumps.

Before a HAZOP/HAZID study is started, detailed information on the process should be available including:

- Up-to-date process flow diagram (PFD).
- Process and instrumentation diagram (P&ID).
- Detailed equipment specifications.
- Construction materials.
- Mass and energy balance.
- Product characteristics and SDS.

A Functional Safety Assessment (FSA) must be carried in accordance with EN 61511.

The process ensures a systematic and well documented evaluation of potential problems or hazards and will assist in the identification of any:

- Potential safety instrumented functions that are required by EN 61511.
- ATEX Directives (see references on page 7).

4.2. System design

The ground-based pump system should comprise of a storage vessel with associated pipework, a pump, in-line valves, a tank gauging system with a High Level Alarm (HLA) and an independent High High Level Alarm (HHLA).

The system must be designed to fail-safe. For example, on activation of either alarm or any system failure the system will simultaneously and automatically stop the pump, close any in-line valves and stop any ancillary equipment. If any of these components fail the system must stop, e.g. if an in-line valve closes, the pump, additional valves and any ancillary equipment will stop.

4.3. Considerations

When designing a ground-based pump delivery system the following should be considered and implemented.

4.3.1. High High Level Alarm (HHLA)

The bitumen storage tank must have an independent HHLA. When the HHLA is activated, the stopping of the ground-based pump must be sequenced to simultaneously shut off both the pump and any in-line valves, and initiate an audible and visible alarm, as determined by the HAZOP/FSA. This Safety Integrated System must be independent of all other control systems, see the Eurobitume Guide to the Safe Delivery of Bitumen (reference on page 7).

4.3.2. High Level Alarm (HLA)

The bitumen storage tank must also have a HLA. As with the HHLA, when the HLA is activated the stopping of the ground-based pump must be sequenced to simultaneously shut off both the pump and any in-line valves, and initiate an audible and visible alarm, as determined by the HAZOP/FSA. The HLA system must operate independently from the HHLA system.

The activation of the HHLA and HLA must be set to trigger at the available capacity as defined in the Eurobitume Guide to the Safe Delivery of Bitumen (reference on page 7).

4.3.3. Ground-based pumps

The ground-based pump is an integral part of the bitumen storage plant and, as such, the characteristics of the pump must be considered in conjunction with the characteristics of the whole system to ensure compatibility and safe operation. This must only be undertaken by a competent person.

Consideration must be given to the rating of the installed pump, i.e. how many litres per minute. This needs to be measured against the vent line capacity of the bitumen delivery vehicle tank barrel to prevent underpressure, and of the bitumen storage system to prevent overpressure, see Appendix.

The ground-based pump should be situated at a level lower than and as close as is reasonably possible to the delivery flange, to minimise the amount of bitumen in the pipework.

The design should allow for the suction of the pump to be below the outlet flange of the bitumen delivery vehicle, to allow total clearance of the delivery line before the pump loses suction.

It is recommended that the pump and delivery lines are heat traced and lagged. A written operational procedure should be in place to ensure free flow of the bitumen in the pipeline and thereby avoid prolonged heating and potential coking (see Eurobitume Toolbox Talk 'Trace Heating of Bitumen Pipelines', reference on page 7).

4.3.4. Controls

The pump off-loading must be commenced by the delivery driver only after authorisation is given by the plant operator. In certain circumstances the pump is activated by the site operator from the control room when the driver has connected the hose.

The plant operator specifies which tank the bitumen will flow into and start the ground-based pump. (In the UK, the driver must not be able to start the ground-based pump until the plant operator specifies which tank the bitumen will flow into).

A panel should be positioned as close as possible to the pump showing the delivery driver the plant status and should include controls to start and stop the ground-based pump.

An Emergency Shut Down Device, i.e. an E-stop, must be fitted at the delivery point, readily accessible and clearly identified, so that in the event of an emergency the process can be stopped. This must not be self-resetting.

Consideration should be given to a hose detection system, being installed so that the system will not start until it detects a connected delivery hose.

4.3.5. System resets

4.3.5.1. HHLA reset

Activation of the HHLA must only be reset by a competent designated person, usually the site manager or maintenance personnel.

A thorough investigation to identify the cause of the HHLA activation and fault rectification must be completed before the system is reset.

4.3.5.2. HLA reset

Activation of the HLA must only be reset by competent and authorised plant staff. All HLA activations should be treated as an incident and investigated accordingly.

4.3.6. Compressors and Ancillary Equipment

Any compressor or ancillary equipment must be considered during the HAZOP/FSA, to ensure that they are included in any SIS as required.

4.3.7. Valves

A ground-based pump has the potential to generate significant upstream pressure if the pipeline or vent is blocked or partially blocked. To address this a pump pressure relief valve (PRV) must be fitted. It is strongly recommended that an upstream pressure transmitter is fitted interlocked with the ground-based pump so that the pump stops if excessive pressure is detected in the system.

Any valves must be considered during the HAZOP/FSA, to ensure that they are included in any SIS as required.

An automated fail-safe valve must be fitted in the line before the pump. This must be fully integrated into the system and self-closing in the event of any system failure or alarm activation.

All automated valves must be self-closing in the event of a failure (fail-safe).

A non-return valve must be fitted as close to the pump outlet as practicably possible or as an integral part of the pump.

4.3.8. Operations and Maintenance

Such a system should be designed to safely integrate with the ground-based pump system; the HAZOP/FSA must consider adequate control measures for by-passing the ground-based pump SIS.

For each new project and plant modification, the system is deemed to be a Safety Critical Independent Layer of Protection. The operating company must ensure that arrangements are in place for the operation, maintenance, system testing and inspection for the whole SIS and its subcomponents.

Written procedures should be agreed by the site management teams and personnel identified as responsible and competent for the plant's operation and maintenance.

The procedures must cover:

- The procedures, measures and techniques to be used for operations and maintenance.
- Schedule/frequency of proof testing in accordance with the requirements for each SIS.
- Preventative and corrective maintenance activities.
- The persons, departments and organisations responsible for these activities.

4.3.9. Procedures

4.3.9.1. Operating Companies

The receiving company must ensure that a safe and effective means of communication local to the discharge point exists between the delivery driver and the plant staff supervising the delivery.

An alarm management plan must be developed by the operating company to instruct all parties of the actions they must carry out in the event of an alarm activation.

The delivery driver must be trained in the unloading and emergency procedures prior to commencement of any delivery.

Procedures and facilities must be in place to allow the driver to clear his hose in the event of a system failure.

4.3.9.2. Delivery drivers

In the event of an alarm activation, the driver must close his delivery valve, contact the plant personnel and await further instruction.

The driver must not be able to reset the system after an activation of either the HHLA or the HLA.

In the UK an Authority to Continue Discharge (ATD) must be raised and if it is used, a new authorization (e.g. Bitumen Discharge Permit – BDP - or equivalent) completed if the delivery has been suspended for any reason.

4.3.9.3. Control of temperature in the delivery pipework

Before starting the bitumen delivery, it is strongly recommended that the delivery pipework is preheated using trace heating, to assist free flowing of the bitumen and thereby avoid blockages. Guidance on trace heating is given in the Eurobitume Toolbox Talk 'Trace Heating of Bitumen Pipelines' (see reference on page 7).

5. MAINTENANCE

To ensure the systems reliability and functionality a robust maintenance regime must be operated.

6. REFERENCES

Guide to the Safe Delivery of Bitumen, Eurobitume, July 2018

Guidance for Safe Bitumen Tank Management, Eurobitume

Model code of safe practice, Part 11, Bitumen safety code, (4th edition), Energy Institute

EN 61511: Functional safety - Safety instrumented systems for the process industry sector

Guidance document for the operational considerations for hot bitumen storage tanks and off-loading systems, Eurobitume

ATEX Directives (one for the manufacturer and one for the user of the equipment):

- Workplace: ATEX 137 Directive 1999/92/EC - Minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres
- Equipment: ATEX 214 Directive 2014/34/EU - Equipment and protective systems intended for use in potentially explosive atmospheres

Eurobitume Toolbox Talk – Trace Heating of Bitumen Pipelines

APPENDIX

GROUND-BASED PUMP BITUMEN DISCHARGE - AIR INLET CALCULATIONS

The table below can be used as guidance on the size of air inlet required to supply the minimum amount of air flow into a delivery vehicle tank barrel during ground-based pump discharge, thereby attempting to balance the air pressure within the tank barrel and not allowing a vacuum to build.

Pump Capacity litres / minute	Pump Capacity litres / hour	Road Tank AIr Inlet Pipe Size mm
750	45 000	50
800	48 000	
850	51 000	
900	54 000	
950	57 000	
1000	60 000	55
1050	63 000	
1100	66 000	
1150	69 000	
1200	72 000	
1250	75 000	
1300	78 000	60
1350	81 000	
1400	84 000	
1450	87 000	
1500	90 000	
1550	93 000	
1600	96 000	
1650	99 000	65
1700	102 000	
1750	105 000	
1800	108 000	
1850	111 000	
1900	114 000	
1950	117 000	
2000	120 000	75

NOTE: Companies or individuals are responsible for their own design and method of delivery of the air to the delivery vehicle tank barrel.

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