Guidance on conceptual design, selection and life cycle assurance of liners intended to improve integrity of bunds to above-ground storage tanks for bulk storage of petroleum, petroleum products or other fuels

energy institute

GUIDANCE ON CONCEPTUAL DESIGN, SELECTION AND LIFE CYCLE ASSURANCE OF LINERS INTENDED TO IMPROVE INTEGRITY OF BUNDS TO ABOVE-GROUND STORAGE TANKS FOR BULK STORAGE OF PETROLEUM, PETROLEUM PRODUCTS OR OTHER FUELS

1st edition

February 2014

Published by
ENERGY INSTITUTE, LONDON
The Energy Institute is a professional membership body incorporated by Royal Charter 2003
Registered charity number 1097899

The Energy Institute (EI) is the chartered professional membership body for the energy industry, supporting over 16 000 individuals working in or studying energy and 250 energy companies worldwide. The EI provides learning and networking opportunities to support professional development, as well as professional recognition and technical and scientific knowledge resources on energy in all its forms and applications.

The EI's purpose is to develop and disseminate knowledge, skills and good practice towards a safe, secure and sustainable energy system. In fulfilling this mission, the EI addresses the depth and breadth of the energy sector, from fuels and fuels distribution to health and safety, sustainability and the environment. It also informs policy by providing a platform for debate and scientifically-sound information on energy issues.

The EI is licensed by:
– the Engineering Council to award Chartered, Incorporated and Engineering Technician status;
– the Science Council to award Chartered Scientist status, and
– the Society for the Environment to award Chartered Environmentalist status.

It also offers its own Chartered Energy Engineer, Chartered Petroleum Engineer and Chartered Energy Manager titles.

A registered charity, the EI serves society with independence, professionalism and a wealth of expertise in all energy matters.

This publication has been produced as a result of work carried out within the Technical Team of the EI, funded by the EI's Technical Partners. The EI's Technical Work Programme provides industry with cost-effective, value-adding knowledge on key current and future issues affecting those operating in the energy sector, both in the UK and internationally.

For further information, please visit **http://www.energyinst.org**

The EI gratefully acknowledges the financial contributions towards the scientific and technical programme from the following companies

BG Group
BP Exploration Operating Co Ltd
BP Oil UK Ltd
Centrica
Chevron
ConocoPhillips Ltd
Dana Petroleum
DONG Energy
EDF Energy
ENI
E. ON UK
ExxonMobil International Ltd
International Power
Kuwait Petroleum International Ltd
Maersk Oil North Sea UK Limited
Murco Petroleum Ltd
Nexen
Phillips 66
Premier Oil
RWE npower
Saudi Aramco
Scottish Power
SGS
Shell UK Oil Products Limited
Shell U.K. Exploration and Production Ltd
SSE
Statkraft
Statoil
Talisman Energy (UK) Ltd
Total E&P UK Limited
Total UK Limited
Tullow
Valero
Vattenfall
World Fuel Services

However, it should be noted that the above organisations have not all been directly involved in the development of this publication, nor do they necessarily endorse its content.

ISBN 978 0 85293 671 9

Published by the Energy Institute

Further copies can be obtained from: Portland Customer Services, Commerce Way, Whitehall Industrial Estate, Colchester CO2 8HP, UK.
t: +44 (0)1206 796 351 e: **sales@portland-services.com**

Electronic access to EI and IP publications is available via our website, **www.energypublishing.org**.
Documents can be purchased online as downloadable pdfs or on an annual subscription for single users and companies.
For more information, contact the EI Publications Team.
e: **pubs@energyinst.org**

CONTENTS

Page

Contents cont...

Contents cont...

Contents cont...

Photographs

FOREWORD

Secondary containment, including the use of bunded areas, is an established requirement for bulk storage of petroleum, petroleum products or other fuels in above-ground storage tanks (ASTs). In Great Britain (GB), most such storage sites are regulated under the *Control of major accident hazards (COMAH) regulations*, and secondary containment is specified in *COMAH competent authority (CA) Policy on containment of bulk hazardous liquids at COMAH establishments ('Containment policy')* and its associated guidance *COMAH CA policy on containment of bulk hazardous liquids at COMAH establishments: Supporting guidance for secondary and tertiary containment and implementation principles for regulators ('Containment policy implementation principles')*. To a large extent, current requirements arise from the prominent discussion of secondary containment bunds during the investigation following the Buncefield incident and the subsequent practical interpretation of pertinent investigation recommendations.

Nevertheless, the detail and range of bund design and operation, including inspection and testing, have not been well documented. In recognition of the wide range of factors impinging on how to improve integrity of bunds to ASTs using liners, and the significant cost implications of installing or upgrading secondary containment bunds, the Energy Institute (EI) commissioned research examining bund liner conceptual design criteria and methods of appraising performance, particularly pertaining to the permeability of the containment, and its integrity performance over time. The research informed the development of this publication.

This publication is intended primarily for use by process safety specialists, designers, inspectors, regulators and operators and owners of facilities holding bulk stores of petroleum, petroleum products or other fuels in ASTs.

The information provided in this publication aims to explain the multi-layered aspects of bund design, and to categorise these aspects in such a way that proposed individual bund systems can be gauged against expected performance specifications. The aim is to provide a method for applying liner design criteria, the appraisal of liner options, planning and managing the installation, and the operation and decommissioning of lined bund containment features. In particular, consideration has been given to permeability specifications and known technical and practical constraints. Methods for the evaluation of bund performance (during both installation and operation) are also provided.

Following the principles set out in this publication should enable operating companies to efficiently and effectively design, implement and maintain liner systems with a high degree of integrity, without the need to resort to over-design or over-engineering. In addition, these principles should serve to assist the value engineering process, helping to drive efficiency and ensure compliance with the COMAH CA's requirements.

The information contained in this publication is for guidance only, and while every reasonable care has been taken to ensure the accuracy of its contents, the EI, and its technical committees, cannot accept any responsibility for any actions taken, or not taken, on the basis of this information. The EI shall not be liable to any person for any loss or damage that may arise from the use of any of the information contained in any of its publications.

ACKNOWLEDGEMENTS

The need for this publication was identified by UKPIA's Process Safety Leadership Network. The project to develop it was commissioned by EI's Containment Systems Working Group (CSWG), which is a working group of the EI's Process Safety Committee. Developmental work was contracted to IKM Consulting Ltd.: Liz Copland and David Cooke were authors, and Alistair Kean was project manager. Their work was steered by CSWG, whose members during the project also included:

Dr Irene Anders	Scottish Environment Protection Agency
David Athersmith	Consultant
Dr Hugh Bray	Tank Storage Association
Colin Cartwright	Atkins
Peter Davidson	UKPIA
Linda Dixon	Valero
Steve Flynn	Rawell Environmental Ltd
Ian Goldsworthy	Valero
Rex May (Chairperson)	BP
Felix Nelson	Shell
Mark Palmer	Esso Petroleum Company Ltd
Andy Rogers	Atkins
Barrie Salmon	Tank Storage Association
Dr Mark Scanlon	Energy Institute
Kerry Sinclair (Secretary)	Energy Institute
David Tarttelin	Environment Agency
Paul Watkins	Resource Protection International
John Wormald	Total Lindsey Oil Refinery
Dave Wright	BP

The Institute wishes to record its appreciation of the work carried out by the authors and also its gratitude for the valuable contributions made by CSWG members during the course of the project.

In addition, the EI acknowledges the following who responded to the surveys, provided case study information, or provided significant comments during the stakeholder technical review:

Russell Best	Phillips 66
Mike Boothman	Phillips 66 Humber Refinery
Daniel Brain	Murco Petroleum Limited
John Burton	BP
Mike Cook	Simon Storage
Alan Dainton	Centrica Energy
Anthea Day	Essar Oil UK Limted
Nick Hallale	Essar Oil UK Limted
Ivan Harling	Total
Peter Hill	Warwickshire Oil Storage Limited
Mark Manton	Essar Oil UK Limted
Shaun Morgan	Essar Oil UK Limted
Graham Neal	ExxonMobil
Gary Newman	PetroIneos
Dr Mike Nicholas	Environment Agency
Carol Pickard	Total Lindsey Oil Refinery
Mike Pye	Inver Energy UK Limited
Robbie Reid	PetroIneos
Simon Robson	Essar Oil UK Limted

The EI acknowledges the financial contributions towards this project made by the Scottish Environment Protection Agency (SEPA) and Tank Storage Association.

Dr Mark Scanlon managed the project, assisted by Kerry Sinclair.

Affiliations refer to the time of participation.

1 INTRODUCTION

1.1 INTRODUCTION

Secondary containment, including the use of bunded areas, is an established requirement for bulk storage of petroleum, petroleum products or other fuels in above-ground storage tanks (ASTs). In GB, most storage sites are regulated under the *Control of major accident hazards (COMAH) regulations*. These regulations implement most of the requirements of the EU *Directive on the control of major-accident hazards involving dangerous substances* ('*Seveso II directive*'), which aims to prevent major accidents involving dangerous substances, and limit the consequences to people and the environment.

Secondary containment is specified in COMAH Competent Authority (CA) *Policy on containment of bulk hazardous liquids at COMAH establishments* ('*Containment policy*') and associated guidance. To a large extent, current requirements arise from the prominent discussion of secondary containment bunds by the Buncefield Major Incident Investigation Board (BMIIB) during the investigation following the Buncefield incident (see HSE *Buncefield Major Incident Investigation Board – The Buncefield incident 11 December 2005: The final report of the Major Incident Investigation Board – Volume 1*) (HSE *BMIIB Final report Volume 1*). Subsequently, their recommendations were practically interpreted by the Buncefield Standards Task Group (BSTG) (see HSE *Buncefield Standards Task Group – Final report: Safety and environmental standards for fuel storage sites*) (HSE '*BSTG Final report*') and latterly by the Process Safety Leadership Group (PSLG) (see HSE *Process Safety Leadership Group Final report: Safety and environmental standards for fuel storage sites*) (HSE '*PSLG Final report*') (which replaces and supersedes HSE *BSTG Final report*).

Part 4 of HSE *PSLG Final report* provides information on bund liner systems and fire resistance. COMAH CA *Containment policy* defines a permeability performance requirement by stating that 'bunds shall … be impermeable'. However, neither provides information on permeability, longevity and how to evaluate performance in the long term. Given the significant capital expenditure involved for operating companies and the ongoing impacts on operations, assurance is required that available and practical bund lining options have a long term capability to meet the permeability performance requirement, and other performance and design requirements included in the current guidance and policy statements. This applies to both newly constructed facilities, and where secondary containment systems are being retrofitted to existing ASTs. This publication aims to address these gaps in knowledge.

This publication forms the key deliverable from the agreed research programme. The research upon which it is based was carried out in the latter part of 2011 and early 2012, and therefore references to current and existing circumstances and issues relating specifically to that time period.

The first part of the publication (sections 2 – 3) gives background information to the current situation and knowledge with a review of existing practices based on research findings, regulations and good practice requirements; it then continues with a review of the main available liner types.

The majority of the publication is aligned to the life cycle of a liner; from the consideration of design criteria and initial liner appraisal and selection process, through to installation, including development of pre-installation quality assurance/quality control (QA/QC) plans, an installation programme and post-installation testing. The guidance discusses the operational management and inspection of the liner *in situ*, and finally the end of life decommissioning process. Figure 1 shows this liner life cycle.

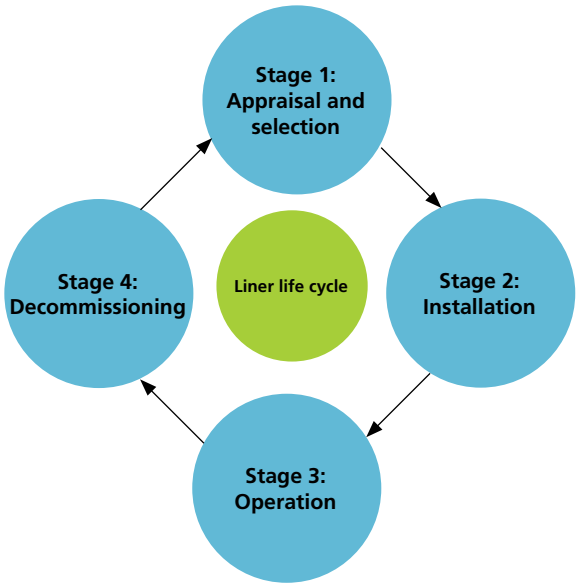

Figure 1 Liner life cycle

The information is provided as:

– Stage 1: Appraisal and selection (section 4).
– Stage 2: Installation (section 5).
– Stage 3: Operation (section 6).
– Stage 4: Decommissioning (section 7).

The intention is that the defined design criteria, inspection and performance appraisal methods should be used as a framework by any hazardous liquid bulk storage facility; in particular those storing petroleum, petroleum products or other fuels. They should also allow elements of an individual site design to be prepared or evaluated against accepted benchmarks, in terms of permeability performance and adaptation to site conditions and constraints.

It should be noted that in GB containment systems should comply with other pertinent legislative frameworks, in addition to the COMAH Regulations.

1.2 OVERVIEW OF BUND LINER LIFE CYCLE PROCESS

Consideration of the four stage bund liner life cycle process outlined in this publication should assist operating companies to maximise the performance of their lined bunds at all stages of the process, whether the bund is at the core of an effective secondary containment system, or as a part of tertiary containment or other facility system. There follows an explanation of each stage.

Stage 1 outlines the liner appraisal and selection process and introduces the categories of relevant design criteria. Prior to liner selection and design, an appraisal of liner options should be carried out, not only to demonstrate value for money, but also to ensure that the chosen liner meets fundamental performance requirements, and environmental and site-specific constraints. In order to inform the liner appraisal process, operating companies should consider the necessary design criteria, which in turn requires an understanding of site baseline conditions, and stakeholder and performance requirements.

Stage 2 develops the concept that any liner design is strongly reliant on effective and reliable installation for successful operation. Installation is also commonly the only time some features of the site or system can effectively be inspected or tested. Any evaluation of a lined bund system where there is an absence, or a deficit, of information and data relating to installation in accordance with an agreed design, will be subject to significant uncertainty. Where this is the case, there will also be an increased risk of significant flaws or potential failures being undetected or discounted. Fundamental to any liner installation is a three-phase plan covering pre-installation (preparatory) issues; the installation activities themselves, and establishing post-installation management and monitoring systems.

Stage 3 sets out a basis for systematically and comprehensively incorporating all secondary containment features, including lined bunds, into the site operating and management procedures, to at least the same degree as the storage tanks and pipework themselves. This should effectively protect the lined bunds and minimise the risk of failure should they be called into action. Secondary containment operating and management procedures should include an element of designed and documented operational performance appraisal for all bunded areas, in addition to any applied during construction/ installation. The key features should include: establishing a baseline; routine inspection and maintenance; testing and monitoring; establishing response procedures, and developing a workable documentation system to record the process.

Stage 4 discusses the final part of the life cycle, which is essentially the reverse of installation, although this decommissioning phase is currently little considered during Stage 1. Consideration should be given to removal methodology and how this impacts on tank farm operation and other site operations. Observations and tests undertaken during decommissioning could be a valuable source of information for feedback into the design, installation and operational aspects of lined areas and secondary containment in general, as well as improving the currently underdeveloped decommissioning process itself.

1.3 SCOPE

This publication is intended to provide a practical framework and source of information for those involved in the planning, management and operation of bulk storage facilities using ASTs, where lined bunds are expected as the principal type of secondary containment (see section 2). Whilst the guidance provided here is applicable to bulk storage of petroleum, petroleum products or other fuels, it should be similarly applicable to other hazardous liquids stored in ASTs and subject to the requirements of the COMAH CA *Containment policy*.

This guidance compiles available background information on the regulatory and practical constraints applying to bulk storage sites and introduces the concept of a staged life cycle process to the design, installation and operation of lined bund containment. The publication attempts to comprehensively describe the different factors that influence and impact upon the selection and installation of lined bunds, using a staged, categorised approach and making reference to established good practice and industry experience.

The guidance provided here has been informed by a literature review, surveys and discussions with professionals working within the petroleum and allied bulk storage sectors, its regulators and product suppliers. This work has taken cognisance of the reported findings of major investigations into significant industrial accidents and limited direct questioning of operating company site managers. The publication represents a compilation of what is currently considered to be practical and typical in terms of the specification, selection, design, installation and operation of lined bunds around bulk ASTs.

The publication does not attempt to justify secondary containment requirements; rather it is intended to explain the factors that should impact on the effective design,

installation and maintenance of a lined bund as part of a system of secondary containment, as currently required by GB legislation and regulatory guidance. Such factors would be expected to impact bunds being used for other purposes (like tertiary containment) in a similar manner.

In recognition of the site-specificity of secondary (and tertiary) containment design and the influence of different organisational policy and procedures, the publication purposefully does not provide a definitive liner selection approach or does not seek to replace site-specific design and optioneering studies. It should however provide a useful starting point and general guidance to such studies.

Excluded from the scope of this publication is the selection, installation and ongoing assurance for product options like under-tank liners and leak detection systems that are used to provide additional integrity underneath ASTs. This is subject to a separate EI technical development project.

The publication provides guidance only; it has no legislative standing and does not replace or modify any current legislative requirements or regulatory policy statement. The intent is that this publication is compatible with, and builds on them by providing additional information.

1.4 APPLICATION

This publication is intended primarily for use by process safety specialists, designers, inspectors, regulators and operators and owners of facilities holding bulk stores of petroleum, petroleum products or other fuels in ASTs, particularly those facilities in GB that fall under the COMAH regulations. It may also be applicable to facilities that contain other products within the scope of the COMAH CA *Containment policy*. This publication should be applicable both to new installations and those at existing facilities.

Whilst the focus of this publication is bulk storage facilities, the information provided here may also provide a useful reference for sites holding smaller quantities of petroleum, petroleum products or other fuels in ASTs. In applying the guidance to smaller sites, different emphasis may need to be placed on some of the issues.

Through explanation of the principles behind the design, maintenance and inspection of bund liners, the publication aims to provide stakeholders with an understanding of the requirements of the regulatory framework. It also covers the safety and environmental management principles invoked, and how these can be applied practically to the design and management of individual site facilities, to minimise the performance degradation of the installed liner system.

In line with recent legislation in GB, Europe and internationally, this publication does not set out prescriptive practices for adoption. Instead, it provides good practice guidance on options that may be needed to satisfy pertinent risk drivers; in particular, legislation, environmental protection, safety, reputation and business interruption.

This publication is based primarily on GB (and European) legislation and policy framework, publications and good practice. However, it is universally applicable provided it is read, interpreted and applied in conjunction with relevant national and local statutory legislation and publications. Where the requirements differ, the more stringent should be adopted.