Guidance on risk assessment and conceptual design of tertiary containment systems for bulk storage of petroleum, petroleum products, or other fuels
GUIDANCE ON RISK ASSESSMENT AND CONCEPTUAL DESIGN
OF TERTIARY CONTAINMENT SYSTEMS FOR BULK STORAGE OF
PETROLEUM, PETROLEUM PRODUCTS, OR OTHER FUELS

1st edition

July 2013
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 Premier Oil
BP Exploration Operating Co Ltd RWE npower
BP Oil UK Ltd Saudi Aramco
Centrica Scottish Power
Chevron Shell UK Oil Products Limited
ConocoPhillips Ltd Shell U.K. Exploration and Production Ltd
DONG Energy SSE
EDF Energy Statoil
ENI Statkraft
E. ON UK Talisman Energy (UK) Ltd
ExxonMobil International Ltd Total E&P UK Limited
International Power Total UK Limited
Kuwait Petroleum International Ltd Tullow
Maersk Oil North Sea UK Limited Valero
Murco Petroleum Ltd Vattenfall
NeXen World Fuel Services
Phillips 66

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.

Copyright © 2013 by the Energy Institute, London.
The Energy Institute is a professional membership body incorporated by Royal Charter 2003.
Registered charity number 1097899, England
All rights reserved

No part of this book may be reproduced by any means, or transmitted or translated into a machine language without the written permission of the publisher.

ISBN 978 0 85293 652 8

Published by the Energy Institute

The information contained in this publication is provided for general information purposes only. Whilst the Energy Institute and the contributors have applied reasonable care in developing this publication, no representations or warranties, express or implied, are made by the Energy Institute or any of the contributors concerning the applicability, suitability, accuracy or completeness of the information contained herein and the Energy Institute and the contributors accept no responsibility whatsoever for the use of this information. Neither the Energy Institute nor any of the contributors shall be liable in any way for any liability, loss, cost or damage incurred as a result of the receipt or use of the information contained herein.

Further copies can be obtained from: Portland Customer Services, Commerce Way, Whitehall Industrial Estate, Colchester CO2 8HP, UK.

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.

pubs@energyinst.org
## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreword</td>
<td>5</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>6</td>
</tr>
<tr>
<td>1  Introduction</td>
<td>7</td>
</tr>
<tr>
<td>1.1 Introduction</td>
<td>7</td>
</tr>
<tr>
<td>1.2 Scope</td>
<td>7</td>
</tr>
<tr>
<td>1.3 Application</td>
<td>8</td>
</tr>
<tr>
<td>1.4 Key concepts</td>
<td>8</td>
</tr>
<tr>
<td>1.4.1 Risk assessment</td>
<td>8</td>
</tr>
<tr>
<td>1.4.2 Containment</td>
<td>9</td>
</tr>
<tr>
<td>1.4.3 Integrated containment</td>
<td>10</td>
</tr>
<tr>
<td>1.4.4 ALARP</td>
<td>11</td>
</tr>
<tr>
<td>1.4.5 Cost benefit analysis</td>
<td>11</td>
</tr>
<tr>
<td>2  Risk assessment of containment to determine tertiary containment needs</td>
<td>12</td>
</tr>
<tr>
<td>2.1 Introduction</td>
<td>12</td>
</tr>
<tr>
<td>2.2 Risk assessment steps</td>
<td>14</td>
</tr>
<tr>
<td>2.2.1 Step 1 – Identify MAH scenarios</td>
<td>14</td>
</tr>
<tr>
<td>2.2.2 Step 2 – Determine quantity of liquid and rate of runoff to be contained in each MAH scenario</td>
<td>16</td>
</tr>
<tr>
<td>2.2.3 Step 3 – Review of efficacy of existing secondary (and tertiary) containment</td>
<td>18</td>
</tr>
<tr>
<td>2.2.4 Step 4 – Determine the quantity of liquid released from existing containment</td>
<td>20</td>
</tr>
<tr>
<td>2.2.5 Step 5 – Undertake source-pathway-receptor assessment</td>
<td>21</td>
</tr>
<tr>
<td>2.2.6 Step 6 – Review impacts to environmental receptors</td>
<td>22</td>
</tr>
<tr>
<td>2.2.7 Step 7 – Review containment requirements and the options available</td>
<td>23</td>
</tr>
<tr>
<td>2.2.8 Step 8 – Reiterate step 5 and step 6 for all secondary containment systems</td>
<td>23</td>
</tr>
<tr>
<td>2.2.9 Step 9 – Review emergency response measures required</td>
<td>24</td>
</tr>
<tr>
<td>2.2.10 Step 10 – Review outcome of risk assessment</td>
<td>24</td>
</tr>
<tr>
<td>3  Conceptual design of tertiary containment measures</td>
<td>26</td>
</tr>
<tr>
<td>3.1 Introduction</td>
<td>26</td>
</tr>
<tr>
<td>3.2 Tertiary containment measures</td>
<td>26</td>
</tr>
<tr>
<td>3.3 Criteria for tertiary containment measures</td>
<td>27</td>
</tr>
<tr>
<td>3.3.1 Independence and cellular configuration</td>
<td>27</td>
</tr>
<tr>
<td>3.3.2 Capacity</td>
<td>28</td>
</tr>
<tr>
<td>3.3.3 Impermeability</td>
<td>29</td>
</tr>
<tr>
<td>3.3.4 Robust operation (including emergency response)</td>
<td>30</td>
</tr>
<tr>
<td>3.3.5 Survivability</td>
<td>30</td>
</tr>
<tr>
<td>3.3.6 Clean-up and restoration</td>
<td>30</td>
</tr>
<tr>
<td>3.4 Components of a tertiary containment system</td>
<td>30</td>
</tr>
<tr>
<td>3.4.1 Overview of tertiary containment components</td>
<td>30</td>
</tr>
<tr>
<td>3.4.2 Passive measures</td>
<td>31</td>
</tr>
<tr>
<td>3.4.3 Active measures</td>
<td>32</td>
</tr>
<tr>
<td>3.4.4 Emergency response measures</td>
<td>33</td>
</tr>
<tr>
<td>3.5 Configuration of a tertiary containment system</td>
<td>33</td>
</tr>
</tbody>
</table>
Annexes

Annex A Calculation of dynamic overtopping of a bund .................. 35

Annex B Commentary on relevant GB and European legislation, and international publications ..................................................... 36

Annex C Glossaries of terms and acronyms ................................. 44
   C.1 Introduction ..................................................................... 44
   C.2 Glossary of terms ............................................................ 44
   C.3 Glossary of acronyms ...................................................... 51

Annex D References .................................................................... 53

Figures

Figure 1 Risk assessment of secondary and tertiary containment needs - decision tree ........................................ 13

Tables

Table B1 Relevant GB and European legislation .................................. 36
Table B2 Relevant international publications .................................. 40
FOREWORD

The Great Britain (GB) Control of major accident hazards (COMAH) competent authority (CA) ‘containment policy’ (Policy on containment of bulk hazardous liquids at COMAH establishments), which promotes increased standards for containment systems of bulk storage of hazardous liquids, requires that a risk assessment should be carried out to determine the extent of the requirements for tertiary containment. Previously not much information was available on how to address this issue, and nor was there adequate information on the conceptual design criteria for tertiary containment systems: this publication addresses both issues.

This publication is intended primarily for use by process safety specialists, environment risk assessment specialists, designers and operators and owners of installations holding bulk stores of petroleum, petroleum products, or other fuels. The information provided in this publication aims to assist in the decision making process for tertiary containment, so as to meet the requirements of the GB COMAH regulations. The risk assessment aims to assist with the installation-specific identification of tertiary containment needs. A decision making tree is also included to help in this process. Information is provided covering how those needs may be achieved on a conceptual design basis. This publication is not site-specific.

The information contained in this publication is provided as guidance only. Whilst every reasonable care has been taken to ensure the accuracy of its contents, the Energy Institute and the representatives listed in the Acknowledgements, cannot accept any responsibility for any actions taken, or not taken, on the basis of this information. The Energy Institute (EI) shall not be liable to any person for any loss or damage that may arise from the use 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 progressed by EI's Containment Systems Working Group (CSWG), which is a working group of EI's Process Safety Committee. Developmental work was contracted to Atkins: Colin Cartwright was author; Andy Rogers was project manager, and Natalyn Ala was the technical project director. Their work was steered by CSWG, whose members during the project included:

- Dr Irene Anders  Scottish Environment Protection Agency
- David Athersmith  Consultant
- Dr Hugh Bray  Tank Storage Association
- David Cooke  IKM Consulting Ltd
- Liz Copland  IKM Consulting Ltd
- Peter Davidson  UKPIA
- Linda Dixon  Valero
- Steve Flynn  Rawell Environmental Ltd
- Ian Goldsworthy  Valero
- Alistair Kean  IKM Consulting Ltd
- Rex May (Chairperson)  BP
- Felix Nelson  Shell
- Mark Palmer  Esso Petroleum Company Ltd
- 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

Affiliations refer to the time of participation.

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, EI acknowledges the following who also provided significant comments during the stakeholder technical review:

- Graham Neal  ExxonMobil
- Dr Mike Nicholas  Environment Agency
- Mark Broome  Environment Agency

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.
1 INTRODUCTION

1.1 INTRODUCTION

This publication is intended to provide clarification for the bulk storage sector and its regulators on the requirements for tertiary containment systems for bulk hazardous liquid storage installations, so as to enable operating companies to assess the need for, and conceptual design of, such systems, as part of a site’s overall containment strategy.

Users of this publication should note that other guidance is available from the Environment Agency (EA), Scottish Environment Protection Agency (SEPA), Health and Safety Executive (HSE), etc.; however, these do not provide as much detail on tertiary containment systems as is provided here. Further information on these sources of guidance is presented in Tables B.1 and B.2. Of these publications, the key ones are:

− COMAH CA Containment of bulk hazardous liquids at COMAH establishments – Containment policy: Supporting guidance for secondary and tertiary containment (‘Containment policy supporting guidance’). The COMAH CA’s primary guidance, establishing the requirements for primary, secondary and tertiary containment.

− HSE Process Safety Leadership Group, final report: Safety and environmental standards for fuel storage sites (‘PSLG final report’). Specifies the minimum standards of controls that should be in place at all sites storing large volumes of gasoline.

Further information may also be found in EI Environmental risk assessment of bulk storage facilities: A screening tool. This Microsoft Access-based tool provides a simple qualitative assessment of the risk to the environment of above-ground storage tanks (ASTs).

It should be noted that containment systems also may need to comply with several other legislative frameworks, in addition to the GB COMAH regulations (e.g. Environmental permitting (England and Wales) regulations). It is for operating companies to demonstrate compliance with the requirements of pertinent legislation.

1.2 SCOPE

This publication is intended primarily for use by process safety specialists, environment risk assessment specialists, designers, and operators and owners of installations holding bulk stores of petroleum, petroleum products, or other fuels. It may also be applicable to facilities that contain other products within the scope of the COMAH CA Containment policy. Bulk stores are considered to be storage tanks, rather than drums or intermediate bulk containers (IBCs).

Whilst the focus of this publication is bulk storage facilities, the information provided here may also provide a useful reference to sites holding smaller quantities of such products. In applying the guidance to these smaller sites, different emphasis may need to be placed on some of the issues considered in the risk assessment process.

The objectives of this publication are to provide readers with practical good practice information and guidance on:

− Risk assessment of liquid containment to determine tertiary containment needs – reviewing the containment provided by existing secondary and tertiary systems, to identify the need for tertiary containment, by using a decision tree.

− Conceptual design of tertiary containment measures – covering how the tertiary containment requirements identified by the risk assessment may be achieved.
Here, 'liquid' refers to product (as held within the primary containment), firewater or rainwater.

Whilst the intent of this publication is to better protect environmental receptors from losses of containment of liquids from storage tanks and containment systems, the risk assessment also considers impacts to people, e.g. offsite populations. However, this publication purposefully does not provide a methodology for human health risk assessment (HHRA).

The publication purposefully does not provide information on detailed designs and layout of containment systems, or specific construction methods and materials. These are driven typically by site-specific considerations, which differ between sites as a consequence of variation in site layout and environmental setting.

1.3 APPLICATION

In line with recent UK, European and international legislation, this publication is not intended to be prescriptive in terms of what tertiary containment should or should not be applied at an individual site. The publication has been developed to give site operators a process through which they can review their site's containment requirements, identify the need for tertiary containment, and understand the good practice options available for their bulk storage installation.

There is no absolute requirement for any particular tertiary containment component. Selection should meet the containment requirements of the individual site as determined by the risk assessment (see section 2), and the good practice criteria (see 3.3).

'Tertiary containment is as much about risk assessment as it is about properly designed containment' (COMAH CA – Containment policy supporting guidance).

In applying this publication the following general points should be noted:

− The objective of the tertiary containment system is to prevent or minimise effects to the environment from a release of product or firewater that occurs as a result of a loss of primary or secondary containment.
− The tertiary containment system forms part of a site's integrated containment system and pollution prevention measures (PPM).
− There is no set requirement for the composition or layout of the tertiary containment system: this should be determined by risk assessment.
− The objective of the risk assessment is to identify the tertiary containment system that is appropriate for the considered site.

This publication is based primarily on GB legislation, publications and good practice; however, in developing it account also has been taken of international legislation, publications and good practice. The guidance in this publication should be 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 applied.

1.4 KEY CONCEPTS

1.4.1 Risk assessment

Risk assessment describes the process to determine the level of risk posed by a hazard: here risk assessment focuses on the risk of bulk storage of liquids on the surrounding environment.