

Guidelines on the corrosion management
of offshore oil and gas production facilities:
Addressing asset ageing and life extension (ALE)

GUIDELINES ON THE CORROSION MANAGEMENT OF
OFFSHORE OIL AND GAS PRODUCTION FACILITIES:
ADDRESSING ASSET AGEING AND LIFE EXTENSION (ALE)

First edition

June 2017

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 23 000 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

Apache North Sea	Repsol Sinopec
BP Exploration Operating Co Ltd	RWE npower
BP Oil UK Ltd	Saudi Aramco
Centrica	Scottish Power
Chevron North Sea Ltd	SGS
Chevron Products Company	Shell UK Oil Products Limited
CLH	Shell U.K. Exploration and Production Ltd
ConocoPhillips Ltd	SSE
DCC Energy	Statkraft
DONG Energy	Statoil
EDF Energy	Tesoro
ENGIE	Taqva Bratani
ENI	Total E&P UK Limited
E. ON UK	Total UK Limited
ExxonMobil International Ltd	Tullow Oil
Innogy	Uniper
Kuwait Petroleum International Ltd	Valero
Maersk Oil North Sea UK Limited	Vattenfall
Nexen CNOOC	Vitol Energy
Phillips 66	Woodside
Qatar Petroleum	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.

Copyright © 2017 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 976 5

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.

Hard copies and electronic access to EI and IP publications is available via our website, <https://publishing.energyinst.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
Foreword	7
Acknowledgements	8
1 Summary	9
2 Introduction	11
2.1 Purpose	11
2.1.1 Introduction	11
2.1.2 Guidance overview	11
2.2 Scope	12
2.2.1 Ageing and life extension	12
2.2.2 Production facilities	13
2.2.3 Deterioration processes	13
3 Policy and strategy	14
3.1 Purpose	14
3.2 General	14
3.3 Policy	14
3.4 Strategy	15
4 Organisational factors	16
4.1 Purpose	16
4.2 General	16
4.3 Roles, responsibilities and accountability	16
4.4 Competence	16
4.5 Communication	16
4.6 Cooperation	17
5 Corrosion risk assessment and planning	18
5.1 Purpose	18
5.2 General	18
5.3 Corrosion risk assessment	18
5.4 Planning	18
6 Implementation and analysis	20
6.1 Purpose	20
6.2 General	20
6.3 Implementation	20
6.4 Reporting, analysis and corrective action	20
7 Monitoring and measuring performance	22
7.1 Purpose	22
7.2 General	22
7.3 Performance reviews	22
8 Performance review	23
8.1 Purpose	23
8.2 General	23
8.3 Performance measurement	23

Contents continued

		Page
9	Audit	24
	9.1 Purpose	24
	9.2 General	24
	9.3 Scope and frequency	24
10	References	25
11	Bibliography	26

Annexes

Annex A	Guidance on stages and considerations for ageing assets, including requirements for formal life extension	27
	A.1 Introduction	27
	A.1.1 Purpose	27
	A.1.2 Background	27
	A.1.3 Why consider ALE issues for corrosion management?	29
	A.1.4 Can ALE corrosion management expenditure be justified?	30
	A.2 Policy and strategy	30
	A.2.1 Purpose	30
	A.2.2 Key requirements	31
	A.2.3 Policy	31
	A.2.4 Strategy	33
	A.3 Organisational factors	34
	A.3.1 Purpose	34
	A.3.2 General	34
	A.3.3 Roles, responsibilities and accountability	34
	A.3.4 Competence	35
	A.3.5 Communication	38
	A.3.6 Cooperation	38
	A.4 Corrosion risk assessment and planning	40
	A.4.1 Purpose	40
	A.4.2 Corrosion risk assessment	40
	A.4.3 Planning	41
	A.4.4 Field life planning	42
	A.4.5 Specialist NDT	44
	A.5 Implementation and analysis	45
	A.5.1 Purpose	45
	A.5.2 General	45
	A.5.3 Implementation	46
	A.5.4 Reporting, analysis and corrective action	47
	A.5.5 Life extension	51
	A.6 Monitoring and measuring performance	52
	A.6.1 Purpose	52
	A.6.2 General	52
	A.6.3 Performance measures	53
	A.7 Performance review	53
	A.7.1 Purpose	53
	A.7.2 General	53
	A.7.3 Performance review	54

Contents continued

		Page
A.8	Audits	55
	A.8.1 Purpose	55
	A.8.2 General	55
	A.8.3 Scope and frequency	55
Annex B	Practical threat guidance on ageing and life extension	57
B.1	Introduction	57
B.2	CO ₂ corrosion.	58
	B.2.1 Introduction.	58
	B.2.2 ALE checklist	58
	B.2.3 General guidance.	58
	B.2.4 Monitoring and inspection strategy guidance.	59
B.3	H ₂ S corrosion and cracking.	59
	B.3.1 Introduction.	59
	B.3.2 ALE checklist	59
	B.3.3 General guidance.	60
	B.3.4 Monitoring and inspection strategy guidance.	61
B.4	O ₂ corrosion.	61
	B.4.1 Introduction.	61
	B.4.2 ALE checklist	61
	B.4.3 General guidance.	61
	B.4.4 Monitoring and inspection strategy guidance.	62
B.5	MIC and deadlegs	62
	B.5.1 Introduction.	62
	B.5.2 ALE checklist	62
	B.5.3 General guidance.	63
	B.5.4 Monitoring and inspection strategy guidance.	64
B.6	Galvanic corrosion	64
	B.6.1 Introduction.	64
	B.6.2 ALE checklist	64
	B.6.3 General guidance.	64
	B.6.4 Monitoring and inspection strategy guidance.	65
B.7	Weld corrosion.	65
	B.7.1 Introduction.	65
	B.7.2 ALE checklist	65
	B.7.3 General guidance.	65
	B.7.4 Monitoring and inspection strategy guidance.	66
B.8	Grooving corrosion of pipelines	66
	B.8.1 Introduction.	66
B.9	Flange face corrosion	66
	B.9.1 Introduction.	66
	B.9.2 ALE checklist	66
	B.9.3 Monitoring and inspection strategy guidance.	66
B.10	Atmospheric external corrosion	67
	B.10.1 Introduction.	67
	B.10.2 ALE checklist	67
	B.10.3 General guidance.	67
	B.10.4 Monitoring and inspection strategy guidance.	67

Contents continued

		Page
B.11	Corrosion under insulation	68
	B.11.1 Introduction	68
	B.11.2 ALE checklist	68
	B.11.3 General guidance.	68
	B.11.4 Monitoring and inspection strategy guidance.	69
B.12	SCC and localised corrosion of stainless steels in chloride environments	69
	B.12.1 Introduction	69
	B.12.2 ALE checklist	69
	B.12.3 General guidance.	70
	B.12.4 Monitoring and inspection strategy guidance.	70
B.13	Erosion/corrosion	70
	B.13.1 Introduction	70
	B.13.2 ALE checklist	70
	B.13.3 General guidance.	71
	B.13.4 Monitoring and inspection strategy guidance.	71
B.14	Pipe supports	72
	B.14.1 Introduction	72
	B.14.2 ALE checklist	72
	B.14.3 General guidance.	72
	B.14.4 Monitoring and inspection strategy guidance.	73
B.15	Chemical treatment management	73
	B.15.1 Introduction	73
	B.15.2 ALE checklist	73
	B.15.3 General guidance.	73
	B.15.4 Monitoring and inspection strategy guidance.	74
B.16	Mitigation by coatings	75
	B.16.1 Introduction	75
	B.16.2 ALE checklist	75
	B.16.3 General guidance.	75
	B.16.4 Monitoring and inspection strategy guidance.	76
B.17	Mitigation by cathodic protection.	76
	B.17.1 Introduction	76
	B.17.2 ALE checklist	76
	B.17.3 General guidance.	77
	B.17.4 Monitoring and inspection strategy guidance.	78
B.18	Corrosion monitoring systems	78
	B.18.1 Introduction	78
	B.18.2 ALE checklist	78
	B.18.3 General guidance.	78
B.19	Cleaning and inspection pigs	79
	B.19.1 Introduction	79
	B.19.2 ALE checklist	79
	B.19.3 General guidance.	79
Annex C	Audit/performance checklist	81
Annex D	Abbreviations	86

FOREWORD

Development of this publication was commissioned by the Energy Institute (EI) as part of its STAC Technical programme.

The principal aims of this engineering guidance publication are to raise awareness of, and to highlight and reinforce the specific effects of, ageing and life extension in the appropriate corrosion management of offshore Oil and Gas facilities.

A substantial number of facilities today have either reached the end of their nominal design life or are rapidly approaching this position. The effects of ageing and more careful management should be high on everyone's agenda as this is not solely the province of equipment and installations.

The key considerations as to effective and proper management are to understand how it can go wrong, where it can go wrong and also understand the timescale in which appropriate review and monitoring should take place.

Some key aspects not always considered directly and of an even higher level are the influences of policy, commitment of stakeholders and managers and also organisational factors which are key in ensuring effective prioritisation and a robust and all encompassing approach.

Introduction of new standards, guidance or good practice and industry learnings afford the opportunity to review condition assessment and indeed whether previously utilised historical approaches are adequate or may require substantial update.

The appropriate management of risk relies fundamentally on being able to properly use and interpret relevant information and ensuring a high confidence in assessment or testing for sensitivity. The management of risks associated with deferment of any key remedial activities needs to be considered in detail and in particular any cumulative effect which may arise.

Consideration is required of not only current operation but also all expected future conditions and any significant process changes over time.

Some aspects of life limited applications are clear but other aspects are perhaps not quite so apparent and are also influenced by the time dependent loss of functionality and also secondary equipment in addition to obsolescence. Life limited equipment specifically should require formal re-assessment for continued operation.

Ultimately it is assumed the principles and approach illustrated in this guidance shall be incorporated within the next update of the EI publication *Guidance for corrosion management in oil and gas production and processing*.

The information contained in this publication is provided for guidance only and while every reasonable care has been taken to ensure the accuracy of its contents, the Energy Institute and the technical representatives listed in the Acknowledgements, cannot accept any responsibility for any action taken, or not taken, on the basis of this information. The Energy Institute shall not be liable to any person for any loss or damage which may arise from the use of any of the information contained in any of its publications.

John MacDonald, Steering Group Chair

ACKNOWLEDGEMENTS

The EI wishes to record its appreciation of the work carried out by the following individuals over the project duration:

Steering Group Members

Fran Chalmers	Centrica
Sue Cushnaghan	Shell
Andy Duncan	HSE
Dave Hillis	Total
Phil Ligertwood	Chevron
John MacDonald (Chair)	Chevron
Zeinab Marsh	Taqqa
Edgar Rodrigues	Taqqa
Catriona Smith	BP

Review only Members

Mike Swidinski	ConocoPhillips
----------------	----------------

Technical drafting and editing: Steven Plant, PIM Ltd

This edition guidance was coordinated and managed by Dr Cameron Stewart, EI, Upstream Technical Manager.

1 SUMMARY

This publication provides engineering guidance on corrosion management practices recommended for aged plant. The guidance introduces a combination of additional practices, and emphasises where existing practice EI *Guidance for corrosion management in oil and gas production and processing*, might require refinement to achieve optimised management of aged plant.

The guidance has been produced by a dedicated subgroup of the EI's Corrosion Management Committee on behalf of Scientific and Technical Advisory Committee (STAC). The principal objectives of the guidance are to:

- Raise awareness that corrosion management systems need to evolve (in late life) if risk is to continue to be managed successfully.
- Identify industry good practice for corrosion management of aged plant.
- Provide additional guidance on how the dominant corrosion threats might vary during the ageing process.

The publication has been structured to align with the EI's *Guidance for corrosion management in oil and gas production and processing*; this guidance should be consulted and understood before considering the practices recommended in this publication.

The normative sections of this publication introduce the key issues needing to be considered as illustrated in Figure 1.



Figure 1: Outline of normative sections within publication

These normative sections are supported by three Annexes which provide more detailed guidance and reference material.

Annex A provides informative guidance on how the normative requirements may be implemented; it provides a combination of techniques and examples.

Annex B provides further Ageing and Life Extension (ALE) guidance specifically on corrosion threats and barriers; it provides a checklist and commentary on issues to consider in aged plant. This Annex may be used during risk assessment to support threat evaluation and during development of corrosion management schemes.

Annex C provides a checklist against the ALE requirements for corrosion management; it should be used in combination with the existing EI *Guidance for corrosion management in oil and gas production and processing*, checklist to verify the suitability of an asset's corrosion management system.

2 INTRODUCTION

2.1 PURPOSE

2.1.1 Introduction

Guidance on corrosion management within the oil and gas industry already exists, see *EI Guidance for corrosion management in oil and gas production and processing*, and has helped drive industry improvements in recent years. While this guidance remains valid, additional focus is now required on issues associated with the ageing infrastructure and the additional challenges this presents to the industry. This requires a combination of reinforcing existing practice and introducing additional management processes where existing approaches are not considered adequate for late life asset demands.

Since 2010, the Health and Safety Executive (HSE) has been driving industry improvements on managing aged plant through their Key Programme 4 (KP4). The programme involves several distinct elements, one of which specifically addresses corrosion management.

The aim of this publication is to bridge the gap between the existing corrosion management guidance and that required to support the industry step change being driven by the HSE KP4. The publication should therefore help duty holders identify potential gaps and provide guidance on how improvements might be implemented, where required, to their existing corrosion management system. The publication also provides reference material to practising corrosion engineers, particularly to support threat management practices in late life.

2.1.2 Guidance overview

A structured framework for how the publication may be used is illustrated in Figure 2.

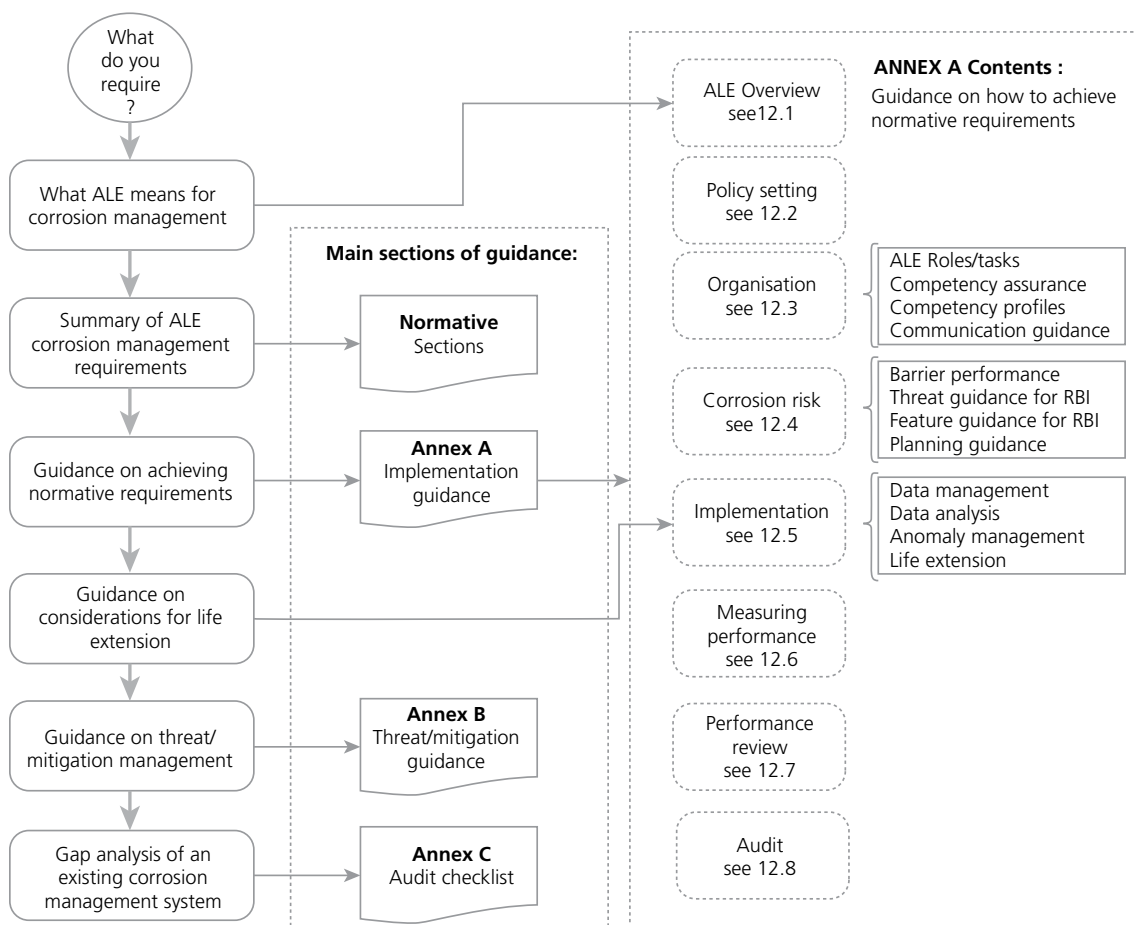


Figure 2: Publication user guidance

The format of this publication mirrors the EI's original corrosion management guidance *EI Guidance for corrosion management in oil and gas production and processing*, to support referencing between the two publications, and to help merging the guidance at a future date.

The normative section of the publication (illustrated in Figure 1), captures the essential requirements to achieve successful management of ALE for corrosion; these should be used in combination with requirements cited in the EI, original corrosion management guidance *EI Guidance for corrosion management in oil and gas production and processing*. The normative section is also supported by the Annex sections of this publication, as illustrated in Figure 2.

2.2 SCOPE

2.2.1 Ageing and life extension

In this publication the corrosion management expectations associated with ageing and life extension (ALE) are introduced, with specific reference to good practice examples. This includes guidance on management processes and how threat assessment and associated monitoring activity may need to change during the ageing process. Further background material on ALE for corrosion management is available in Annex A.

2.2.2 Production facilities

This publication applies to offshore installations (including process plant, utilities and supporting structures), pipelines, risers and subsea gathering, manifolds and processing systems, and onshore plant for reception, separation and stabilisation.

It excludes wells, trees and drilling equipment.

2.2.3 Deterioration processes

This publication builds on the knowledge presented previously in *EI Guidance for corrosion management in oil and gas production and processing*, to introduce key threat issues¹ associated with ALE and ways in which they can be managed. It excludes non-metallic materials, welding, vibration and other mechanically induced failure modes. Existing industry guidance and other ageing related publications are available for reference against these issues.

¹ DNV GL DNV RP-G103 (HOIS) *Non-intrusive inspection*
HSE RR320 – *Elastomers for fluid containment in offshore oil and gas production: Guidelines and review*
HSE RR509 *Plant ageing – Management of equipment containing hazardous fluids or pressure*
HSE *Managing ageing plant HSE supplement to RR509*
HSE *KP4 ageing and life extension report Nov 2012*
