

European Federation of Corrosion Publications

NUMBER 32

A Working Party Report on

The Life Cycle Costing of Corrosion in the Oil and Gas Industry: a Guideline

Edited by P. S. Jackman



M A N E Y

*Published for the European Federation of Corrosion
on behalf of The Institute of Materials, Minerals and Mining*

B0761
First published in 2003 by
Maney Publishing
1 Carlton House Terrace
London SW1Y 5DB

on behalf of
The Institute of Materials Minerals and Mining
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ISBN 1-902653-85-8

Typeset in the UK by
Maney Publishing
Printed and bound in the UK by
The Charlesworth Group, Huddersfield

Preface

This EFC publication addresses the important subject of the analysis of life cycle cost of corrosion as it may be applied in the oil and gas production industries. The publication is not intended to be a stand-alone document but to guide the analyst to corrosion-specific subjects for inclusion in an overall analysis. The process of life cycle costing has recently been standardised in ISO 15663, Parts 1 to 3.

While this publication has been produced by EFC Working Party 13 on Corrosion in Oil and Gas Production much of the preparatory work was carried out by a group of experts from NACE Italy lead by Domenico Condanni to whom due acknowledgement is made. Also, the content has drawn from former NORSOK standards, now withdrawn, which are acknowledged at various places in the publication. The Nickel Development Institute is thanked for its support of EFC Working Party 13.

Philip S. Jackman
(Consultant to NiDI)
Chairman of EFC Working Party 13 on
Corrosion in Oil and Gas Production,
1998 to 2001.

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European Federation of Corrosion Publications Series Introduction

The EFC, incorporated in Belgium, was founded in 1955 with the purpose of promoting European co-operation in the fields of research into corrosion and corrosion prevention. Membership is based upon participation by corrosion societies and committees in technical working parties. Member societies appoint delegates to working parties, whose membership is expanded by personal corresponding membership.

The activities of the working parties cover corrosion topics associated with inhibition, education, reinforcement of concrete, microbial effects, hot gases and combustion products, environment-sensitive fracture, marine environments, surface science, physico-chemical methods of measurement, the nuclear industry, computer-based information systems, corrosion in the oil and gas industry, and coatings. Working parties on other topics are established as required. The working parties function in various ways, e.g. by preparing reports, organising symposia, conducting intensive courses and producing instructional material, including films. The activities of the working parties are co-ordinated through a Science and Technology Advisory Committee, by the Scientific Secretary.

The administration of the EFC is handled by three secretariats: DECHEMA e.V. in Germany, the Société de Chimie Industrielle in France, and the Institute of Materials, Minerals and Mining in the United Kingdom. These three secretariats meet at the Board of Administrators of the EFC. There is an annual General Assembly at which delegates from all member societies meet to determine and approve EFC policy. News of EFC activities, forthcoming conferences, courses, etc. is published in a range of accredited corrosion and certain other journals throughout Europe. More detailed descriptions of activities are given in a newsletter prepared by the Scientific Secretary. The output of the EFC takes various forms. Papers on particular topics, for example, reviews or results of experimental work, may be published in scientific and technical journals in one or more countries in Europe. Conference proceedings are often published by the organisation responsible for the conference.

In 1987 the then Institute of Metals was appointed as the official EFC publisher. Although the arrangement is non-exclusive and other routes for publication are still available, it is expected that the working parties of the EFC will use the Institute for publication of reports, proceedings, etc. wherever possible. The name of the Institute of Metals was changed to the Institute of Materials in 1992 and to the Institute of Materials, Minerals and Mining (IOM³) in 2002 following its merger with the Institution of Mining and Metallurgy. The series is now published by Maney Publishing on behalf of the Institute of Materials, Minerals and Mining.

A. D. MERCER, EFC Series Editor, The Institute of Materials, Minerals and Mining, UK

EFC Secretariats are located at:

Dr B. A. Rickinson, European Federation of Corrosion, The Institute of Materials, Minerals and Mining, 1 Carlton House Terrace, London SW1Y 5DB, UK

Mr R. Mas
Fédération Européenne de la Corrosion, Société de Chimie Industrielle,
28 rue Saint Dominique, F-75007 Paris, FRANCE

Professor Dr G. Kreysa
Europäische Föderation Korrosion, DECHEMA e.V., Theodor-Heuss-Allee 25,
D60486, Frankfurt, GERMANY

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1 Definitions and Abbreviations

1.1 Definitions

1.1.1 Capital expenditure (Capex)

The costs normally associated with the design, purchase, construction and commissioning of a new facility but may also include costs of major refurbishment work.

1.1.2 Corrosion

Interaction between a metal and its environment that results in changes in the properties of the metal and which may lead to significant impairment of the function of the metal, the environment or the technical system of which these form a part. [ISO 8044].

1.1.3 Corrosion allowance

A designed addition to the thickness of a component to allow for reduction in thickness of that component by corrosion during its design life, while ensuring continued safe operation.

1.1.4 Corrosion cost

Increase in cost through the life of a plant due exclusively to corrosion or corrosion protection. Total corrosion cost is given by the sum of the corrosion costs associated with four aspects of the life of a facility: Capex, Opex, cost of lost production caused by equipment failure and material residual value.

1.1.5 Cost contributor

Each item that contributes to the formation of corrosion costs in a specific phase of the facility's life. (Examples: corrosion allowance in the construction phase; corrosion inhibitor injection in the operating phase).

Note: Throughout this guideline, for convenience, the European unit of currency is used, the Euro, €.

1.1.6 Critical failure

A component or system failure giving rise to costs together with production

losses and/or facility shut-down.

1.1.7 Discounting

The method used in investment appraisal where future costs, revenues and benefits are reduced to their value as seen in present day terms. The discount rate is applied to the cost, revenue and benefit streams, which will have been normally expressed in terms of current economic conditions.

1.1.8 Life cycle cost

The discounted sum after tax of investment, operating cost and cost of lost production due to equipment failure and/or maintenance during the lifetime of the field. Also known as 'Net present value'.

1.1.9 Lost production costs

The costs or penalty charges associated with losing production. Lost production costs are the costs associated with lost revenue and/or the lost revenue itself. For gas contracts, costs may also be associated with penalty charges.

1.1.10 Net present value

See 'life cycle cost'.

1.1.11 Operating expenditure (Opex)

The costs associated with operating and maintaining a facility.

1.1.12 Operational level

Different efficiencies of operation of a facility each requiring different power consumption and having related levels of production. The maximum operational level, having the maximum production, is 100 %.

1.1.13 Regularity

A measure of a system's capability to meet the demand for deliveries. In the context of this document the term has been used to represent the ratio of actual to planned delivery from a system.

1.1.14 Risk

The probability of the failure of a component or system.

1.1.15 Risk, consequences of

Costs, resulting from a failure of a component or system, of such factors as lost production, injury to personnel, environmental impact and safety issues.

1.2 Abbreviations

AC

Cost of chemicals added to mitigate corrosion (additives cost)

bbl

Barrel of oil

C

Cost

C_{DP}

Cost of one hour downtime per year throughout the lifetime calculated as the difference in Net Present Value between a production profile with the full simulated availability and one with one hour lower availability per year

CA

corrosion allowance

CAs

corrosion allowance for the shell side of heat exchangers

CA_t

corrosion allowance for the tube side of heat exchangers

CAC

Cost of the corrosion allowance (corrosion allowance cost)

Capex

Capital expenditure

CLP

Cost of lost production

 CIC

Cost of installing and operating a corrosion inhibition system (corrosion inhibitor cost).

 CN_t Net cost in year t d

Optimum dosage of inhibitor or additive

 D

Internal diameter

 D_{RP}

Duration of reduced production

 E

Average number of critical failures per year

 EC

Cost of energy consumption

 G

Mass flow rate of inhibited fluid

 h

Hour

 k

The discount rate/interest rate to be used for the LCC evaluation

 L

Length

 LCC

Life cycle cost or life cycle costing

m

The number of years in operation

 n

The lifetime of a facility or function

 N

Number of operating days in a year

 NPV

Net present value

 O_1

Average fraction of time equipment will be operated at level 1

 $Opex$

Operating expenditure

 P

Probability of reduced production

 POF

Probability of failure

 Q_1

Power requirement at operational level 1 for equipment requiring power (for example, a pump)

 Q_{PL}

Quantity of production loss per unit time

 S

Active surface area of heat exchangers

 SM^3

Standard cubic metre of gas (SM^3 is the industry usage, where M^3 denotes m^3).

 sd

Average over-dosage of inhibitor, technically justified, with respect to the optimum dosage

y

1) The year under evaluation

2) Year

 β

A dosage factor for an anti-corrosion additive

 β'

An over-dosage factor of an anti-corrosion additive

 μ_{in} Efficiency at operation level n ρ

Density of material

 σ_T

The total standard deviation

 σ_e The standard deviation for cost element e

2. Standards Referred to in this Document

ISO 15663-1: Petroleum and natural gas industries: Life cycle costing – Part 1: Methodology.

ISO 15663-2: Petroleum and natural gas industries: Life cycle costing – Part 2: Guidance on application of methodology and calculation methods.

ISO 15663-3: Petroleum and natural gas industries: Life cycle costing – Part 3: Implementation guidelines.

Withdrawn standards (replaced by ISO 15663):

NORSOK O-CR-001: Life cycle cost for systems and equipment, Rev 1, 1996.

NORSOK O-CR-002: Life cycle cost for production facility.

3 Introduction

3.1 Compilation and prediction

In this guideline, analysis of life cycle cost of corrosion is dealt with in two separate but related and complementary parts:

- (a) Compilation and analysis of cost of corrosion data from service experience.
- (b) The prediction of the life cycle cost from cost data from suppliers and service experience and using the experience of the analyst.

3.2 Published standards

The prediction of life cycle costs is a developed science which is documented in the published standard ISO 15663 Parts 1 to 3.

In preparing this guideline, reference has been made to NORSOK standards O-CR-001 and O-CR-002 (now withdrawn and replaced by ISO 15663). However this guideline looks specifically at the life cycle cost of corrosion and does not deal as extensively with the whole subject as the published standards. In like manner, the above standards do not deal specifically with the cost of corrosion.

It is not intended that this guideline should replace the published standards and full reference should be made to them.

3.3 Compilation of data

No guideline previously existed for the compilation of cost of corrosion data from service experience from an operating facility. The application of the guideline provided in this document will lead to a database of corrosion related information to aid the analyst in predicting life cycle costs of corrosion more accurately.

3.4 Analysis of the life cycle cost of corrosion

3.4.1

This document provides guidance for the analysis of life cycle costs for a new