

Hydrocarbon management

HM 68

Procedures for bulk liquid fatty acid methyl esters (FAME) and blended biodiesel cargo inspections

2nd edition

HM 68

PROCEDURES FOR BULK LIQUID FATTY ACID METHYL ESTERS (FAME) AND  
BLENDED BIODIESEL CARGO INSPECTIONS

2<sup>nd</sup> edition

January 2020

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 20 000 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, 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

BP Exploration Operating Co Ltd	Qatar Petroleum
BP Oil UK Ltd	Repsol Sinopec
Centrica	RWE npower
Chevron North Sea Ltd	Saudi Aramco
Chevron Products Company	Scottish Power
Chrysaor	SGS
CLH	Shell UK Oil Products Limited
ConocoPhillips Ltd	Shell U.K. Exploration and Production Ltd
DCC Energy	SSE
EDF Energy	TAQA Bratani
ENI	Total E&P UK Limited
E. ON UK	Total UK Limited
Equinor	Tullow Oil
ExxonMobil International Ltd	Uniper
Innogy	Valero
Kuwait Petroleum International Ltd	Vattenfall
Nexen CNOOC	Vitol Energy
Ørsted	Woodside
Perenco	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 © 2019 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 1 78725 161 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.

Hard copy 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](mailto:pubs@energyinst.org)

## CONTENTS

	Page
<b>Foreword</b> .....	<b>7</b>
<b>Acknowledgements</b> .....	<b>8</b>
<b>Preface</b> .....	<b>9</b>
<b>1 Scope</b> .....	<b>10</b>
1.1 General .....	10
1.2 The biofuel industry and the need for this standard .....	10
1.3 Measurement stages .....	11
1.4 Quality control .....	12
1.5 Summary of data to be reported .....	12
<b>2 General principles</b> .....	<b>13</b>
2.1 The process of a cargo inspection .....	13
2.2 General responsibilities .....	13
2.2.1 Communications, capabilities and performance .....	13
2.2.2 Equipment .....	14
2.2.3 Letters of protest/notices of apparent discrepancy .....	14
2.2.4 Reporting .....	14
2.3 Potential measurement error .....	15
<b>3 Safety recommendations</b> .....	<b>16</b>
3.1 General .....	16
3.2 Safety aspects of equipment .....	16
3.3 Safety at sampling points .....	17
3.4 Static electricity .....	17
3.5 Health hazards .....	18
3.6 Enclosed spaces .....	18
3.7 Personnel transfer offshore .....	19
<b>4 Operation planning (loading and discharge)</b> .....	<b>20</b>
4.1 Key meeting .....	20
4.2 Information to be determined before a loading or discharge operation commences .....	20
<b>5 Inspection, sampling and quality control procedures</b> .....	<b>23</b>
5.1 Load procedures .....	23
5.1.1 Shore tanks .....	23
5.1.2 Dynamic measurement (metering) .....	25
5.1.3 Sampling .....	26
5.1.4 Manual sampling of shore tanks .....	28
5.1.5 Pipelines .....	28
5.1.6 Vessel procedures – before loading .....	29
5.1.7 Vessel procedures at start of loading .....	33
5.1.8 Vessel procedures after loading .....	34
5.1.9 Calculations .....	36

**Contents continued**

	<b>Page</b>
5.1.10 Vessel experience factor . . . . .	36
5.1.11 Reconciliation of measured quantities . . . . .	36
5.2 Discharge procedures . . . . .	36
5.2.1 Vessel measurements before discharge . . . . .	37
5.2.2 In-transit difference . . . . .	37
5.2.3 Sampling . . . . .	37
5.2.4 Tank stripping operations/ROB . . . . .	38
5.2.5 Shore tank gauging and sampling . . . . .	39
5.2.6 Reconciliation of measured quantities . . . . .	39
5.3 Bunker surveys . . . . .	40
5.4 Blending . . . . .	40
<b>6 Calculation of quantities . . . . .</b>	<b>41</b>
6.1 Calculation methods . . . . .	41
6.1.1 Blends of 50 % v/v to 100 % FAME (B50+) . . . . .	41
6.1.2 Blends below 50 % v/v FAME (B0–B50) . . . . .	41
6.1.3 General data requirements . . . . .	42
6.2 Examples of shore tank and marine tank calculations . . . . .	42
6.2.1 Weight calculations using density correction factors for use on blended biodiesel containing more than 50 % v/v FAME (B50+) . . . . .	42
6.2.2 Weight calculation using volume correction factors for use on blended biodiesel containing up to 50 % v/v FAME (B0–B50) . . . . .	43
<b>7 Final report . . . . .</b>	<b>44</b>
7.1 Inspection data . . . . .	44
 <b>Annexes</b>	
<b>Annex A Guidelines for verifying the accuracy of manual gauging equipment . . . . .</b>	<b>45</b>
A.1 Introduction . . . . .	45
A.2 Liquid-in-glass thermometers . . . . .	45
A.2.1 Laboratory inspection . . . . .	45
A.2.2 Field inspection . . . . .	45
A.3 Portable electronic gauging devices . . . . .	45
A.4 Manual gauging tapes . . . . .	46
A.5 Density determination . . . . .	46
A.5.1 Hydrometers . . . . .	46
A.5.2 Densitometer . . . . .	46
<b>Annex B Monitoring metering system performance . . . . .</b>	<b>47</b>
B.1 Introduction . . . . .	47
B.2 Metering and proving calculations . . . . .	47
B.2.1 Meter factor . . . . .	47
B.2.2 Meter proving . . . . .	48
B.2.3 Linearity . . . . .	49
B.3 Monitoring procedures . . . . .	50

**Contents continued**

	<b>Page</b>
<b>Annex C Wedge formula calculation . . . . .</b>	<b>51</b>
C.1 Calculation of the trim factor . . . . .	51
C.2 Calculation of the length of the wedge . . . . .	51
C.3 Calculation of $D_A$ . . . . .	52
C.4 Wedge formula based on the tank width . . . . .	53
C.5 Wedge formula based on theoretical tank width . . . . .	53
<b>Annex D Cargoes blended on-board or in-line additives . . . . .</b>	<b>55</b>
D.1 On-board blending . . . . .	55
D.1.1 Introduction . . . . .	55
D.1.2 Before loading . . . . .	55
D.1.3 During loading . . . . .	56
D.1.4 After loading . . . . .	56
D.1.5 Before discharge . . . . .	57
D.2 Part cargoes . . . . .	57
D.3 In-line blending . . . . .	57
D.4 Additives . . . . .	58
<b>Annex E Offshore and ship-to-ship transfer operations . . . . .</b>	<b>59</b>
E.1 General . . . . .	59
E.2 Safety – personnel transfers . . . . .	59
E.3 Inspection . . . . .	59
E.4 Reconciliation of figures . . . . .	59
E.5 Reporting and final report . . . . .	60
<b>Annex F Glossary of terms, abbreviations and acronyms . . . . .</b>	<b>61</b>
F.1 Glossary of terms . . . . .	61
F.2 Abbreviations and acronyms . . . . .	63
<b>Annex G Guidelines regarding quality and properties of FAME . . . . .</b>	<b>64</b>
G.1 Water contamination . . . . .	64
G.2 Microbiological contamination . . . . .	65
G.3 Stability issues . . . . .	65
G.4 Cold temperature behaviour . . . . .	65
G.5 Material compatibility . . . . .	65
G.6 Solvent behaviour . . . . .	67
G.7 Static electricity hazards . . . . .	67
<b>Annex H Production of FAME – aspects affecting quality and handling . . . . .</b>	<b>68</b>
<b>Annex I References . . . . .</b>	<b>70</b>

**LIST OF FIGURES AND TABLES**

	<b>Page</b>
<b>Figures</b>	
Figure 1	Overall analysis of outturn difference . . . . . 11
Figure 2	Total physical and apparent losses including measurement error . . . . . 39
Figure H.1	The difference in fatty acid composition for different feedstocks (data from <i>Biodiesel: The comprehensive handbook, Mittlebach and Remschmidt</i> ) . . . . . 68
<b>Tables</b>	
Table 1	Checklist for loading and discharging . . . . . 20
Table G.1	Recommendations of materials for use with FAME . . . . . 66

## FOREWORD

The Energy Institute's (EI's) Hydrocarbon Management Committee (HMC) is responsible for the production and maintenance of standards and guidelines covering various aspects of static and dynamic measurement of petroleum. The Hydrocarbon Management Subcommittee 3 (HMC-3) deals primarily with the independent inspection issues, focusing in particular on marine cargoes.

HMC-3 is made up of experts from independent inspection companies, oil companies, service companies and loss control consultants. Additional participation in document development is also provided by members of the EI Hydrocarbon Management Asian Forum, based in Singapore.

The EI maintains liaison with parallel working groups of the American Petroleum Institute's (API's) Committee on Petroleum Measurement, and other organisations concerned with quantitative measurement in other countries and in other industries.

The EI hydrocarbon management guidelines are widely used by the petroleum industry and have received recognition in many countries by consumers and the authorities. In order to promote their wide adoption internationally, it is the policy to submit selected standards via the British Standards Institute (BSI) to the International Organization for Standardization's (ISO's) technical committee TC-28 Petroleum Products and Lubricants, as potential International Standards.

A full list of hydrocarbon management guidelines is available on request from the EI.

The EI hydrocarbon management guidelines are recommended for general adoption, but should be read and interpreted in conjunction with safety, environmental, weights and measures, customs and excise and other regulations in force in the particular country in which they are to be applied. Such regulatory requirements have precedence over corresponding clauses in the EI document, except where the requirements of the latter are more rigorous, when its use is recommended. Users should also consider contractual constraints imposed by charterers, cargo owners, ship owners and any other interested party.

Although it is believed that adoption of the recommendations of this guideline will assist the user, the EI cannot accept any responsibility, of whatsoever kind, for damage or alleged damage arising or otherwise occurring on vessels or in or about premises where this document has been applied, as final responsibility for adequate preparation of the vessel to receive a cargo lies with the parties controlling this task.

Users of these guidelines are invited to send comments, suggestions, or details of relevant experience to:

Technical Department  
Hydrocarbon Management  
Energy Institute  
61 New Cavendish Street  
London  
W1G 7AR  
United Kingdom  
**[www.energyinst.org](http://www.energyinst.org)**



## ACKNOWLEDGEMENTS

Members of the EI HMC-3 have been associated with the production of these guidelines. Membership at the time of publication is as follows:

AmSpec  
BP Oil International Ltd  
Cargo & Marine Consultants SAS  
Cargo Inspection Group  
Chevron Products Company  
CWA International Limited  
Inspectorate International  
Intertek Caleb Brett  
Koch  
Marine Cargo Experts  
Minton Treharne and Davies  
OBQS Ltd  
Oil Express  
Petrus  
Phillips 66 Limited  
Saudi Aramco  
Saybolt  
SGS  
Shell

Sincere thanks also go to The Federation of Oils, Seeds and Fats Associations (FOSFA) who have provided a significant contribution to the development of the original document.

## PREFACE

The documents published by the EI dealing with procedures for cargo measurements are:

- *HM 28. Procedures for crude oil cargo inspections.*
- *HM 29. Procedures for petroleum product cargo inspections.*
- *HM 30. Procedures for LPG cargo inspections.*
- *HM 51. Procedures for bulk liquid chemical cargo inspections.*
- *HM 68. Procedures for bulk liquid fatty acid methyl esters (FAME) and blended biodiesel cargo inspections.*

# **1 SCOPE**

## **1.1 GENERAL**

The purpose of this document is to provide systematic cargo measurement procedures directed at minimising cargo contamination and losses, for use primarily by cargo inspectors. In the absence of, or in conjunction with, specific client guidelines, the following document should be considered a summary of best practices used within the industry.

This document is applicable to bulk liquid fatty acid methyl esters (FAME) for use as fuel (FAME, biodiesel or B100) and blends of these materials with petroleum-derived fuel cargoes (blended biodiesel).

This document does not apply to FAME cargoes for food use or for use in pharmaceuticals, cosmetics or personal care applications. These are carried under FOSFA or similar food chain contracts. The final use of the cargo should be confirmed by reference to the client. FOSFA contracts require that the cargo is controlled by accredited superintendents who will ensure that the FOSFA qualifications and operational procedures are followed. These rules cover tank design, including coating and heating systems, maintenance, documentation and cargo history, which is an important issue in the transportation of foodstuffs and oleochemicals.

Where the term 'measurement' is used in a general sense, it should be taken to include all aspects of cargo inspection including (but not limited to) tank inspection, sampling, laboratory analysis and other cargo inspection activities, as required by the inspector's principal(s). The points at which cargo inspectors are required to make their measurements are described and definitions of the terms used throughout this document are provided in Annex F. Whenever possible, terms approved by API, EI and ISO have been adopted. The document also explains the purpose of a cargo survey and summarises general responsibilities which cargo inspectors will be held to accept when they are appointed. Safety matters and related responsibilities are defined and emphasis is placed on the need for cargo inspectors to be continually aware that safety requirements take precedence over all other considerations.

The document describes detailed procedures which inspectors are required to follow and provides references to analytical test methods and calculations. Reference is made to alternative methods, since the procedures recognise that within the industry opinions may vary regarding the use of test methods, especially where different methods may be specified by parties and contractors.

## **1.2 THE BIOFUEL INDUSTRY AND THE NEED FOR THIS STANDARD**

In recent years there has been a marked increase in the production and use of transport fuels derived from nominally renewable resources. These increases have been driven by legislation, and the incorporation of biofuels derived from renewable matter looks set to continue in the coming years.

At present, the two most common commercially viable biofuels are FAME and bioethanol. FAME is produced from vegetable oils or animal fats and, whilst it can be used directly as a fuel, is typically blended with conventional petroleum diesel. Bioethanol, which can again be used directly as fuel, is typically blended with conventional petroleum gasoline.

It has been the introduction of FAME into the transport fuel infrastructure that has brought with it the greatest challenges for those involved in the industry, and this document will therefore focus on the particular issues that arise for inspectors involved in the measurement of these cargoes.

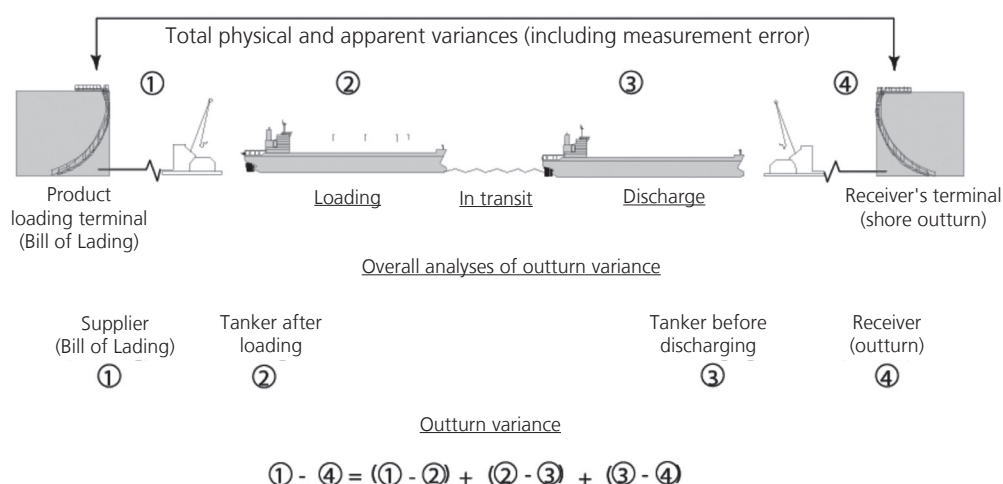
In the future, other bio-derived blending components for middle distillate fuels; for example, biomass to liquid (BTL) fuels, hydrogenated vegetable oils (renewable diesel), FAME produced from novel feedstocks and fatty acid ethyl esters (FAEE) may become more widely commercially available and therefore warrant inclusion in this document. However, at this stage these guidelines are applicable only to cargoes of FAME and blends of FAME with conventional petroleum diesel.

### 1.3 MEASUREMENT STAGES

When a cargo is transported by vessel from one terminal to another, measurements are normally made at four points as shown in Figure 1, for the purpose of establishing:

- the quantity of cargo loaded from the loading terminal (i.e. to confirm the quantity of cargo shown on the Bill of Lading);
- the quantity of cargo loaded to the vessel;
- the quantity of cargo discharged by the vessel;
- the quantity of cargo received by the receiving terminal, and
- the difference between the quantities established under (a) to (d) above.

Note: for a particular voyage involving more than one loading terminal or discharge terminal, measurements should be made at all such additional ports in order that a reliable comparison can be made between the quantities shown on the Bill of Lading, the cumulative outturn and ship's figures.



**Figure 1: Overall analysis of outturn difference**

#### **1.4 QUALITY CONTROL**

Contamination may occur during the various transfer and transportation stages of a cargo movement. Procedures and recommendations for a sampling and testing schedule are given which will minimise such contamination risk and identify potential problems at the earliest opportunity.

#### **1.5 SUMMARY OF DATA TO BE REPORTED**

It is recognised that cargo inspection companies and their principal(s) each have their preferred way of recording the data to be reported, particular forms; therefore, they are not prescribed by this procedure. However, for information, a listing of the typical information sufficient to define a cargo loading or discharge operation is provided in section 7. This listing represents a consensus of several cargo inspection companies and their principal(s). The detailed format of these forms should be agreed with principal(s) when contracts are being arranged.