

AN INTRODUCTION TO FUEL ANALYSIS

Nigel Draffin





AN INTRODUCTION TO FUEL ANALYSIS



Dedication

This book is dedicated to Chris, my wife and
the one person who never criticised the content.

Nigel Draffin



AN INTRODUCTION TO FUEL ANALYSIS

by

Nigel Draffin

M.I.Mar.E.S.T.

First Edition

Foreword by
Angus Ogilvie
Technical Director
Cockett Marine Oil Ltd

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Foreword

No two fuels are exactly the same, even though they may appear to be identical. Fuel quality can change depending on the crude oil and feedstocks from which it is derived, on the type of processing it receives at the refinery and on the way it is stored, blended and delivered to ships. Until the early 1970s, and in some areas well beyond that, shipowners never worried unduly about the quality of the fuel they were buying. Since then, once the quality of the fuel started to deteriorate as a result of ‘enhancements’ to the refining process, bunker buyers have become all too aware of the operational, financial and legal difficulties associated with buying and using poor quality fuels.

In the 1980s, in response to increasing concern over the steady deterioration of the quality of bunker fuels, the first dedicated specialist fuel testing services began to appear. Now, these services, with testing laboratories in all the main bunkering centres, play a vital role in determining whether a fuel is suitable for burning in a diesel engine or whether it should be offloaded – or debunkered – to become subject to yet another bunker claim.

Nowadays, for many owners, it is standard practice to send a bunker sample off to a laboratory for testing before the fuel oil is used onboard, and this process is well established and understood by buyers and suppliers alike.

However, often the problems start when a testing laboratory has analysed the fuel and returned the results. What do those results mean? How should they be interpreted? What happens if the fuel is slightly outside the agreed specifications? What if other – as yet unknown or unspecified – substances show up on the analysis? How can an owner or charterer, or a supplier or trader find out what the lab results actually mean and what to do about them?

On the basis that prevention is always better than cure, everyone involved in the supply or purchasing of bunker fuels should be aware of the many parameters that are covered in marine fuel specifications and know what is reasonable to expect and possible to accept. Armed with this information, many routine problems can be avoided and costly mistakes can be averted.

Nigel Draffin’s book, *An Introduction to Fuel Analysis*, brings home the importance of knowing the fuels you are dealing with in a bright, simple and effective way. In this book lies a wealth of information that will enable everyone from the newcomer to the ‘old hand’ to understand bunker fuels and what they contain, how to test each key parameter and what the test results actually mean, and what happens when problem results appear. Although never a substitute for the huge amount of detail that can be obtained from a professional analyst using a fully-equipped modern laboratory, this book certainly provides a substantial amount of information that should be welcomed and absorbed by anyone involved in any way with marine fuels.

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In *An Introduction to Fuel Analysis*, Nigel Draffin offers numerous detailed diagrams, tables, charts and photographs which will certainly help anyone who has any doubts about what can be found in marine fuels and, once found, what to do about it. In addition, some very useful appendices provide places to go for help, lists of abbreviations and a multi-lingual glossary of the words and terms most often found in fuel test analysis reports.

I believe that *An Introduction to Fuel Analysis* is an important addition to the growing library of bunker-specific books now being published by Petrosport, and complements Nigel Draffin's previous best seller, *An Introduction to Bunkering*.

Angus Ogilvie
Technical Director
Cockett Marine Oil Ltd

June 2009



Preface

After the effort of producing my only other book to date, *An Introduction to Bunkering*, in 2008, I was expecting to wait until after retirement before once again ‘picking up the pen’. However, I was then asked to consider writing another practical book on bunkering, this time focused on a single important area of the industry.

I tried to recall the questions that I have been asked by colleagues and clients over the many years that I have been involved in this industry. The greatest number of questions concerned fuel analysis and the results of that analysis. Many of those asking the questions were from a commercial, general technical or operational background and wanted information, guidance and comment to help them deal with potential problems. My hope is that this book will bridge the gap between the general level of information on offer and that available from specialised sources.

An Introduction to Fuel Analysis is intended to provide a guide and reference for those who, whilst not specialists in the technical aspects of marine fuels, need to understand the terminology and the reporting used in fuel analysis as part of their work.

This book is not intended as a definitive reference work on fuel analysis or fuel technology. In many cases, descriptions and explanations have been simplified to aid general understanding.

Readers need to be aware that the professionals in this field do not always agree with each other. The test methods are under constant review and changes are inevitable, so the information contained inside is the best I could provide at time of publishing.

Furthermore, the definitive references to the standards and to the test methods mentioned in this book can only be found in the latest published editions of the standards concerned.

Understanding fuel analysis need not be as complicated as it may seem, and if this book sheds some light on the processes involved and the reasons behind them, I feel the effort will have been very worthwhile.

Nigel Draffin

June 2009

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About the author

Nigel Draffin has been involved in shipping for over 43 years and with the commercial bunker market for over 23 years. After joining Shell Tankers as an apprentice engineer in 1966, he progressed through the ranks, serving on all classes of vessel including very large crude carriers (VLCCs) and liquefied natural gas (LNG) tankers.

He came ashore in 1979 to join the newbuilding department of Shell International Marine. After two years of new construction in Ireland, South Korea and the Netherlands, he transferred to Shell's Research & Development unit, specialising in control systems, fuel combustion and safety systems.

In 1986, Nigel moved to the commercial department as a bunker buyer and economics analyst. In 1988, he was promoted to be Head of Operational Economics, responsible for all of the fuel purchased for the Shell fleet, the operation of the risk management policy and the speed / performance of the owned fleet. In March 1996, he joined the staff of E.A.Gibson Shipbrokers Ltd in the bunker department, and became the manager. In 2006, this department merged with US-based broking house LQM Petroleum Services, where Nigel is currently Senior Broker and Technical Manager.

Nigel is a founder member of the International Bunker Industry Association (IBIA) and has served twice on its council of management, most recently as Honourary Treasurer. He currently serves as co-ordinator of the Education Working Group and is the author of IBIA's *Basic Bunker Course*. He is a member of the Institute of Marine Engineering Science and Technology and Past Master of the Worshipful Company of Fuellers.

Nigel is a born communicator and dedicated teacher, whose simple style and vast knowledge of the subject mean that he is consistently voted one of the most effective lecturers on the courses he teaches. His contributions to the well-established *Oxford Bunker Course* over the past decade or so stand out for particular attention, as much for his teaching abilities as for his undeniable social skills.

Nigel's first book, *An Introduction to Bunkering* (published by Petrosport, May 2008) proved that he is capable of translating the most complex of issues into terms that are easily understood by readers everywhere, even those for whom English is not their mother tongue.

Llewellyn Bankes-Hughes
Managing Director
Petrosport Limited

June 2009

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The author extends his thanks to everyone who has helped in the creation of *An Introduction to Fuel Analysis*, particularly Wanda Fabrick, John Stirling, Geoff Jones, Jan K. Paulsen and Chris Fisher, who have cast an eye over different parts of the text and suggested many additions and changes which hopefully make the book better. He also thanks Angus Ogilvie for writing the foreword and for his help and encouragement over many years working together on training courses.

He has special thanks for all those who have allowed their photographs to appear and enliven the text.

The author also extends his thanks to Llewellyn Bankes-Hughes and his team at Petrosport for being willing to tackle a second book and seeing it through. In particular, he thanks Alison Jane Cutler (née Parsons), who has, once more, seamlessly designed and produced the finished article.

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Please note: The numerical data in all of the tables except for ISO 8217 in this book is intended for guidance only and may be subject to minor errors of 'rounding' up or down and may be superseded by new methods or precision data as published from time to time.

Chapter 1 - Fuel analysis

Owners have always had concerns about the quality of fuel for their ships but, before the 1980s, the only analysis made was by the use of on board test equipment. A small number of owners kitted out their vessels with sufficient equipment to measure viscosity, density and flash point but nothing else. It was only once the fuel quality started to deteriorate as a consequence of the advent of modern refinery techniques that engineers started to have concerns about the product that they were receiving. These concerns led to the production of formal specifications, fuel standards and, in the 1980s, the creation of specialist fuel testing services.

Selecting and verifying quality

Fuel oils supplied to ships are ordered according to the requirements of the machinery on the ship and the storage and treatment plant on the ship. Over the years, technology has changed, leading to more detailed and stringent limits on the quality of the fuel. The days of ordering 'Bunker C' or 'Any commercial grade fuel oil (ACGFO)' are long gone.



Figure 1. Ship's officer using hydrometer

Photograph courtesy of Shell Photographic Unit

Shipowners and bunker buyers will generally stipulate grades in accordance with an international standard for fuel oil quality, possibly with additional requirements specific to their company's policy or to meet a particular need on an individual ship. In order

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to verify that the quality received is in compliance with the ordered specification, a significant number of buyers arrange for the quality to be assessed by analysing a sample drawn at the time of delivery. Most of this analysis is performed by one of a number of specialist fuel analysis organisations, such as Lloyd's Register's FOBAS, DnVPS, Viswa Lab, Lintec, Inpechem, Inspectorate and a number of others. These organisations have the ability to process a high volume of samples and have agreements with international courier services to arrange the transport of samples.

International survey companies such as SGS, Saybolt and Intertek OCA, have the ability to perform all of the tests needed but usually only get involved with referee analysis after an initial test has highlighted a problem.

The report sent by the specialist companies will usually have a commentary highlighting any deviations from international standards and specific comment and guidance on fuel handling and treatment. As part of the commercial agreements with their clients, the specialist fuel testing services provide a standard service covering a pre-agreed range of tests which will be, at the least, the parameters cited in the international standards. They will test for additional parameters if requested by their client.

The reports sent by laboratories performing any specific tests or a referee analysis will only report on the tests they are instructed to undertake.

Example of a typical analysis report

```
Very Good Petroleum Services
- Fuel Report dated: 31-May-09

Vessel : Optimist (9123456)

Sample No           K27814
Sample Type         ( HFO )
Bunker Port         Houston
Bunker Date         29-May-09
Sampling Point      SHIP MANIFOLD
Sent From           HOUSTON, TX
Date Sent           30-May-09
Arrived at Lab     30-May-09
Supplier            Megalarge
Loaded From         Gopher 3
Quantity per C.Eng 720

Seal Data           VGPS
                   9420405
                   INTACT

Related Samples
Supplier            9420406
Ship                9420407/9420408
Ship (DNVPS MARPOL) 9420409
MARPOL              7171483
```

continued...

<u>Receipt Data</u>		<u>BDN</u>	
Density @ 15°C	kg/m ³	989.7	
Viscosity @ 50°C	mm ² /s	348	
Sulphur	%m/m	2.85	
Volume @ 60F	bbbl	4626.400	
Quantity	MT	726.9	
<u>Tested Results</u>		<u>Units</u>	<u>Sample</u> RMG380
Density @ 15°C	kg/m ³	990.0	991.0
Viscosity @ 50°C	mm ² /s	348.6	380.0
Water	%V/V	0.1	0.5
Micro Carbon Residue	%m/m	13	18
Sulphur	%m/m	2.94	4.50
Total Sediment Potential	%m/m	LT 0.01	0.10
Ash	%m/m	0.07	0.15
Vanadium	mg/kg	223	300
Sodium	mg/kg	16	
Aluminium	mg/kg	7	
Silicon	mg/kg	12	
Iron	mg/kg	15	
Nickel	mg/kg	52	
Calcium	mg/kg	5	
Potassium	mg/kg	LT 1	
Pour Point	°C	LT 24	30
Flash Point	°C	GT 70	60
<u>Calculated Values</u>			
Net Specific Energy	MJ/kg	40.20	
CCAI (Ignition Quality)	-	852	
Aluminium + Silicon	mg/kg	19	80
Quantity (Weight)	MT	727.09	
Quantity Difference	MT	0.19	
Note: LT means Less Than, GT means Greater Than.			
Quantity (Weight) is based on BDN Volume, VGPS Density and a weight factor of 1.1 kg/m ³ (ASTM D1250-80 Table 56).			
Specification Comparison:			
Results compared with ISO 8217:2005 specification RMG380. Based on this sample, the specification is met.			
Operational Advice:			
Approximate fuel temperatures:			
- injection: 140°C for 10 mm ² /s, 125°C for 15 mm ² /s			
- transfer: 40°C			
Regards, Ever B Nad, Houston, USA			
END OF REPORT FOR Optimist			

Figure 2. Example text of a typical analysis report

Units

In this book I have tried to use Système International (SI) units throughout. This is a metric system and accepted worldwide. However, in the United States and some other countries, different units are used. Where appropriate, I have included reference to those.

Note that the SI units for Kinematic viscosity are mm^2/s but as the bunker industry uses centiStokes (cSt) as a routine, I have used these for clarity.

The SI naming convention uses lower case letters for all abbreviations except names of individuals and multipliers of 10^6 (M or Mega) or greater. The single exception is the Litre which can be l or L.

Standard prefixes for the SI units of measure

Multiples	Name		deca-	hecto-	kilo-	mega-	giga-
	Symbol		da	h	k	M	G
	Factor	10^0	10^1	10^2	10^3	10^6	10^9
Subdivisions	Name		deci-	centi-	milli-	micro-	nano-
	Symbol		D	c	m		n
	Factor	10^0	10^{-1}	10^{-2}	10^{-3}	10^{-6}	10^{-9}

Figure 3. Table of standard prefixes for the SI units of measure

Examples

- CentiStokes (cSt), 100^{th} of a Stoke. Stoke is the name of a famous physicist.
- MegaJoules per kilogramme (MJ/kg). Joule was another famous physicist.
- Milligrams per kilogramme (mg/kg).

Other abbreviations

- Parts per million (ppm). It is better to use mg/kg for anything except volume-based measurement.
- Percentage by mass (% m/m).
- Percentage by volume (% v/v).

AN INTRODUCTION TO FUEL ANALYSIS

Hot on the heels of his best-selling book, *An Introduction to Bunkering*, published in May 2008, Nigel Draffin has produced this second practical book on bunkering, focused on the key area of fuel analysis. The book is intended to provide a guide and reference for those who, whilst not specialists in the technical aspects of marine fuels, need to understand the terminology and the reporting used in fuel analysis as part of their work.

It is full of photographs, diagrams, tables and data designed to help the reader unravel some of the complexities of fuel specifications and fuel analysis. *An Introduction to Fuel Analysis* is simply written and easy to read, and helps bridge the gap between the general level of information available and that offered by the testing agencies and other specialised sources.

Understanding fuel analysis need not be as complicated as it may seem, and this book will shed some light on the processes involved and the reasons behind them. *An Introduction to Fuel Analysis* will be just as relevant and useful to vessel owners and charterers, marine lawyers and port agents as it will be to bunker suppliers, traders and brokers.

Nigel Draffin has been involved in shipping for over 43 years and with the commercial bunker market for over 23 years. He is a founder member of the International Bunker Industry Association (IBIA) and has served several times on its council of management and executive board, most recently as Honorary Treasurer.



He is co-ordinator of IBIA's Education Working Group and author of IBIA's *Basic Bunkering Course*. Nigel Draffin is also the Technical Director of the *Oxford Bunker Course*, a member of the Institute of Marine Engineering Science and Technology and Past Master of the Worshipful Company of Fuellers.

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