Guidelines for the investigation of the microbial content of liquid fuels and for the implementation of avoidance and remedial strategies

3rd edition

energy institute

GUIDELINES FOR THE INVESTIGATION OF THE MICROBIAL CONTENT OF LIQUID FUELS AND FOR THE IMPLEMENTATION OF AVOIDANCE AND REMEDIAL STRATEGIES

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FOREWORD

In 1996, the Institute of Petroleum published *Guidelines for the investigation of the microbial content of fuel boiling below 390 °C and associated water*, which was updated in 2008 by the Energy Institute (EI), under the title *Guidelines for the investigation of the microbial content of petroleum fuels and for the implementation of avoidance and remedial strategies*, as it became a frequently referenced industry standard. The first edition was weighted towards microbial problems in the supply and distribution of distillate fuels, particularly diesel fuel, and its target readers were the many professionals who worked in the industry and those who had access to laboratory facilities.

Since then, the oil industry has seen changes in infrastructure, ownership and management of refining, supply and distribution facilities and in the type of fuels supplied. Bio-derived fuel components, notably the most commonly used fatty acid methyl esters (FAME), are generally more readily biodegraded than conventional fossil fuels. Consequently, when present at sufficient concentration as a blend component or as an unintentional cross-contaminant, FAME can increase the susceptibility of fuels to microbial growth. This has raised new challenges for successful microbial contamination management. Control measures previously effective had to be augmented and supplemented. Although problems due to microbial growth in liquid fuels remain relatively rare, fuels users have become more aware of its impact on operations, for example due to premature filter blockage, engine failure and corrosion. Modern engines have increasingly lower tolerance to the presence of fuel contaminants, including those derived from microbial growth. This has led to an increased demand on fuel suppliers to provide microbiological 'quality' assurances of the product they supply. Some fuel user interest groups, notably in the aviation sector, have published their own guidance and standards, which place a strong onus on microbiological risk assessment and routine condition monitoring in the fuel supply and distribution chain.

Consequently, this third edition seeks to serve as an information resource, providing practical advice for controlling, monitoring, investigating and remediating microbial contamination. It is targeted at operational staff and product quality managers responsible for all liquid fuels including those used in aviation, marine, ground transportation, power generation and heating. It addresses all stages of fuel production, distribution, and use, including considerations for refineries, supply and distribution facilities, pipelines, local suppliers, retail outlets, bunker suppliers and major fuel users such as ships, offshore platforms, aircraft operators, power stations, and road and rail fleet operators.

These updated guidelines were commissioned by the EI Microbiology Committee, chaired by Joan Kelley and previously chaired by Elaine McFarlane.

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

Suggested revisions are invited and should be submitted in writing to technical@energyinst.org, Energy Institute, 61 New Cavendish Street, London W1G 7AR.

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The work was carried out by Graham Hill, Gareth Williams, and Leon O'Malley from ECHA Microbiology and steered by members of the Microbiology Committee, who during the project included:

Brian Crook	HSE
Carol Devine	NECE
Clara Di Iorio	ENI
Bob Eden	Rawwater
Alex Few	ExxonMobil
Graham Hill	ECHA Microbiology
Richard Johnson	Oil plus
Joan Kelley (Chair)	Conidia Bioscience Ltd
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Geert Van der Kraan	Dupont
Leanne Walker	Rawwater
Neil Whitehead	Minton, Treharne & Davies (MTD)
Gareth Williams	ECHA Microbiology

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The project coordination was carried out by Kerry Sinclair (EI) and technical editing by Marcela Betancur-Diaz (EI).

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1 INTRODUCTION

It has been known for over a century that, in the presence of free water, hydrocarbon fuels will support the growth of microorganisms, also known as microbes or 'bugs'. In some sectors microbiological contamination is abbreviated as MBC, or microbiological growth as MBG. Although fuel is sterile when refined, microbes are ubiquitous, and can enter fuel during subsequent storage and distribution. Ingress and accumulation of only small amounts of water can then promote microbial proliferation in fuel storage tanks at refineries and distribution terminals, in pipelines, ships' cargo tanks, road and rail tankers, depot tanks, retail tanks and end user tanks. If left unchecked, that growth can lead to degradation of fuel quality due to contamination by microbial particulates and by-products of microbial activity. Consequent operational problems for fuel users and distributors may be severe and incur costly remediation and system downtime. For example, one United Kingdom (UK) ship operator estimated the cost of cleaning microbially contaminated fuel bunker tanks in their fleet to be more than £1 million per year, without including incidental costs and disruption caused by having key vessels unavailable for scheduled operations. Diesel fuel contamination has also caused failure of power generators on offshore platforms, leading to demanning and several weeks' delay in oil and gas production, with consequent incidental costs running into many millions of dollars.

The problems caused by microbial growth in fuel tanks and systems can include blockage of fuel lines and filters, with consequent fuel starvation to the engine, fouling, and malfunction of fuel tank gauges and corrosion of fuel tanks and system components. The inherent susceptibility of any fuel or fuel component to microbial degradation and spoilage is dependent on its chemical composition, the chemistry of its additives, and their concentration. Problems of microbial growth are mostly associated with middle distillate fuels, including aviation turbine fuels, automotive diesel, marine distillate fuel, gas oil, burner fuels and fuels for heating, power generation and non-road mobile machinery.

Other fuel types may be affected to a lesser extent. Heavy residual fuels can be prone to microbial contamination although the consequences are generally less severe than for middle distillate fuels. Microbial growth and associated problems are also reported in automotive gasolines and bioethanol blends, although these would appear to be less prevalent in Europe and the rest of the world, compared to North America. Microbial growth in aviation gasoline has historically been very rare, due primarily to the toxicity of the lead anti-knock additives, but the introduction of unleaded aviation gasoline could require a reassessment of the associated risks.

To date, little work has been done to fully investigate the susceptibility of synthetic fuels and biofuels, other than those produced by transesterification of fats and oils. Synthetic fuels and biofuels which are considered as 'drop-in' fuels share similarities in chemistry to the conventional fossil fuels they supplement or replace, and consequently they could have similar susceptibility to microbial growth, but this is currently unproven. Conversely, the most commonly used biodiesels produced by transesterification of plant and animal fats and oil (e.g. FAME) are inherently more readily degraded by microbes, although ultimate susceptibility will depend on the blend ratio with conventional diesel. Introduction of biodiesel as a blend component in automotive diesel, marine distillate fuels and fuels for power generation and heating, has made these fuels more susceptible to microbial growth. Experience with automotive biodiesel blends suggests that once microbial growth commences, the onset of operational issues can be considerably faster than historically experienced for conventional fossil fuels. The introduction of significant amounts of FAME as a cross-contaminant during fuel distribution also raises the prospect that fuel could be inadvertently rendered more susceptible to microbial growth. If fuel meets a specification where FAME is limited to typical *de minimis* levels, the impact is unlikely to be significant. However, not all specifications provide a limit on FAME and fuel users may be unaware of presence or concentration of FAME in fuel they purchase.

Marine fuels are notably prone to microbial contamination because difficulties in keeping on-board fuel systems free of water; a worldwide trend of increasing levels of FAME in marine distillate is likely to compound the potential for microbial growth. Formation of water in aircraft fuel tanks, due to condensation as aircraft ascend and descend, is a well-recognised problem and presents a risk of microbial growth, with potentially severe operational and safety consequences. The aviation industry has led the way in the introduction of rigorous fuel handling and quality control procedures, primarily targeted at control and removal of water contamination at all stages of fuel distribution and use. Whilst aviation industry standards of water removal will not be appropriate or practical for all fuel types, they provide a useful reference point.

Since the turn of the century, there has been some evidence of a resurgence of microbial contamination problems across a range of fuel types. The reasons have not been fully established, but are likely to be related to increased use of biodiesel and/or fuel additives, which may provide additional nutrients for microbial growth, changes in fuel processing and handling practice, increasing complexity of the supply chain and custody transfer, increased use of fuel in warm humid environments conducive to microbial growth and reduced tolerances of modern engines to particulates and contamination. This has led to a need for increased diligence and awareness and, where appropriate, refinement of preventative control measures and condition monitoring by routine microbiological testing.

This guideline provides an overview of the factors which cause and exacerbate microbial growth and the problems caused, offering detailed procedures for good housekeeping to avoid microbial growth, and describes the indicators of contamination and appropriate analytical methods for investigation. It outlines suitable plans for routine condition monitoring including procedures for sampling and use of on-site tests, and emphasises that the primary mechanism for control of microbial growth is through regular and rigorous attention to good housekeeping and system maintenance. Prevention and problem avoidance are by far the most cost-effective and safe strategies, but for those incidents where control of microbial growth is lost, this document outlines options for remedial action. Selection of the most appropriate remedial actions will depend on the particular circumstances of the incident and will need careful consideration and assessment of the impact on fuel quality, safety and the environment. It is not intended that this document provides all necessary information to implement remedial actions and additional expert advice may be needed.

Fortunately, because of well-established good industry practice and attention to good fuel housekeeping and system maintenance, serious problems due to microbial growth in liquid fuels remain relatively rare. This publication provides the practical basis to ensure that attention to best practice is maintained. It is intended to provide the fuels industry with the knowledge to fully understand the risks and successfully maintain and implement procedures to meet the existing and future challenges presented by microbial growth in fuel tanks and systems.