

# Development of criteria for acceptable previous cargoes for fats and oils

Technical Report

A Joint FAO/WHO Technical Meeting  
Bilthoven, Netherlands  
7–9 November 2006

***rivm***  
National Institute  
for Public Health  
and the Environment

  
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Organization



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**Food and Agriculture Organization of the United Nations and  
World Health Organization**  
in collaboration with the  
**National Institute for Public Health and the Environment (Netherlands)**

Rome, 2007

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## Acknowledgements

The Food and Agriculture Organization of the United Nations and the World Health Organization would like to express their appreciation to the experts who contributed to the preparation of the criteria for acceptable previous cargoes for fats and oils. Special recognition is also given to the governments, institutions and researchers that responded to the call for data issued by FAO and WHO. Their collaboration provided data not readily available in mainstream literature and official documentation, and which were essential for the discussions.

The work was implemented by the Food Quality and Standards Service, FAO, and the Department of Food Safety, Zoonoses and Foodborne Diseases, WHO, with the collaboration of the Dutch National Institute of Public Health and the Environment (RIVM), which also prepared a technical document used as a basis for the expert discussions.

The meeting report was prepared by the FAO/RIVM/WHO Secretariat, comprising Mary Kenny and Maria de Lourdes Costarrica (FAO); Wim Mennes and Trijntje van der Velde-Koerts (RIVM); and Jenny Bishop (WHO). The technical expertise and support of Wim Mennes and Trijntje van der Velde-Koerts throughout the process are gratefully acknowledged.

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## Foreword

Edible fats and oils from vegetable, animal and marine sources have been traded and shipped for thousands of years, as they form an important part of the human diet. Increasing global food trade has meant that the geographical source of these commodities has been broadening steadily. The availability of sea-going vessels reserved for the transport of foodstuffs is insufficient to serve the continuing trade in oils and fats intended for or likely to be used for human consumption. It is also impractical to expect sea-going bulk tankers to return empty to the original loading ports upon delivery of their cargo of fats and oils.

A practical solution has been adopted by the industry and involves the bulk transport of fats and oils in sea-going vessels in tanks that are not exclusively reserved for the transport of foodstuffs. This trade practice means that many chemicals are potential previous cargoes to edible fats and oils. Efforts are ongoing to ensure cargoes of fats and oils are not contaminated with previous cargoes.

The Codex Alimentarius Commission (CAC) has adopted the recommended international code of practice for the storage and transport of edible fats and oils in bulk (CAC/RCP 36 – 1987 [Rev. 3 – 2005]). This code applies to the handling, storage and transport of all crude or processed edible oils and fats in bulk. An integral part of the code of practice will be the Codex List of Acceptable Previous Cargoes, to be included as Appendix 2.

This list would allow the transportation of fats and oils in bulk tanks which have previously been used to transport substances included in the list of acceptable previous cargoes. A draft list has been discussed at length at the Codex Committee on Fats and Oils (CCFO) and at relevant sessions of the CAC. To date, member countries have been unable to finalize the Codex List of Acceptable Previous Cargoes. A significant problem identified has been the lack of criteria for the evaluation of substances. At the 19<sup>th</sup> session of the CCFO (and in line with the request of the 26<sup>th</sup> session of the CAC), it was agreed that FAO and WHO would provide advice on the establishment of criteria for substances to be included in the Codex List of Acceptable Previous Cargoes.

In response to the request of the CCFO, FAO and WHO requested the collaboration of the Dutch National Institute for Public Health and the Environment (RIVM) to provide advice on this matter. A call for experts and data was issued to facilitate the selection of the experts to attend a technical meeting, and to ensure that all relevant information be considered. In advance of the meeting, on request of FAO and WHO, RIVM prepared a background paper, taking into account all relevant data, including the previous CCFO reports and discussions. An e-mail group (comprising the selected experts and the FAO/WHO Secretariat) was formed to review the background paper and the revised version was presented at the meeting as a basis for discussions. An edited version of this background paper is provided in Annex II. Relevant data submitted as a result of the call for data and additional information received prior to and during the meeting are attached in Annex II and Annex III, respectively.

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## Abbreviations

ADI	Acceptable daily intake
AOCS	American Oil Chemists' Society
ARfD	Acute reference dose
CAC	Codex Alimentarius Commission
CCFO	Codex Committee on Fats and Oils
COD	Chemical oxygen demand
EU	European Union
FAO	Food and Agricultural Organization of the United Nations
FEDIOL	EU Oil and Proteinmeal Industry
FFA	Free fatty acid
FOSFA	Federation of Oils, Seeds and Fats Associations
GC	Gas chromatography
GC-MS	Gas chromatography linked to mass spectrometry
GEMS/Food	Global Environment Monitoring System/Food Contamination Monitoring and Assessment Programme
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
IBC Code	International Bulk Chemical Code
ILSI	International Life Sciences Institute
IMO	International Maritime Organization
IPCS	International Program on Chemical Safety
ISEO	Institute of Shortening and Edible Oils
ISO	International Organization for Standardization
ITERG	French Institute for Fats and Oils
IUPAC	International Union of Pure and Applied Chemistry
JECFA	Joint FAO/WHO Expert Committee on Food Additives
JMPR	Joint FAO/WHO Meeting on Pesticide Residues
LC	Liquid chromatography
LOD	Limit of determination
LOQ	Limit of quantitation
MARPOL	International Convention for the Prevention of Pollution from Ships
MEIC	Ministry of Economy, Industry and Commerce (Costa Rica)
ML	Maximum level
MPOB	Malaysian Palm Oil Board
MVO	Dutch Production Board for Margarines, Fats and Oils

NIOP	National Institute of Oilseed Products
NOAEL	No Observed Adverse Effect Level
N-PAL	NP Analytical Laboratories
NVM	Non-volatile matter
OECD	Organisation for Economic Co-operation and Development
PAH	Polycyclic aromatic hydrocarbon
PB	Persistent and bioaccumulative
PBT	Persistent, bioaccumulative and toxic
PORAM	Palm Oil Refiners Association of Malaysia
RfD	Reference dose
RIVM	Dutch National Institute for Public Health and the Environment
SCF	Scientific Committee for Foods
SIR	Centre for Substances and Integrated Risk Assessment
TBA	Thiobarbituric acid
TDI	Tolerable daily intake
TTC	Threshold of toxicological concern
UN	United Nations
WHO	World Health Organization

## Executive Summary

In response to the request from the Codex Alimentarius Commission (CAC), FAO and WHO convened a technical meeting, with the collaboration of the Dutch National Institute of Public Health and the Environment (RIVM), to establish criteria for substances to be included in the Codex List of Acceptable Previous Cargoes. It is recommended that these criteria are considered by the Codex Committee on Fats and Oils (CCFO) when finalizing the Codex List of Acceptable Previous Cargoes as referenced in Appendix 2 of the Code of Practice (CAC, 1987).

When developing the criteria, the experts mainly considered the assessment of previous cargoes for the transport of edible fats and oils as bulk liquids by sea, and agreed to only consider the safety implications of the presence of residues from previous cargoes for human health. In the case of storage or transport by road, railway or inland waterways, the proposed criteria may also be applicable if no other regulations are present. Changes in quality of the fats and oils during shipment do occur (due to hydrolysis and oxidation) and this loss in quality is taken into account when edible fats and oils are processed further into food (during refining).

Typical previous cargoes for edible fats and oils are liquid chemical substances (sometimes at raised temperatures), slurries of solid particles, and solutions of solids in water. The term “edible” includes fats and oils which are destined for the oleo-chemical industry for use in personal care products.

During the deliberations, the experts considered the background information and discussions from past CCFO sessions, including the topics proposed to be considered when developing the criteria. These topics included toxicological properties, cleaning procedures, dilution factor of any residues in the cargo, solubility of contaminating residues, refining of the fat, availability of analytical methods, reactivity and allergenicity.

The experts decided that the only practical way to decide if a substance is acceptable as a previous cargo should be generic, assuming worst-case conditions, as it would be impractical to develop a system that would take into account every possible combination of previous cargo, type of tank construction, cleaning regime and further processing of the subsequent fat or oil cargo.

In conclusion, the experts identified four criteria as particularly important in the consideration of acceptable previous cargoes for edible fats and oils for bulk liquid transport:

1. The substance must be transported/stored in an appropriately designed system, with adequate cleaning routines, followed by effective inspection and recording procedures.
2. Residue of the substance in the subsequent cargo of fat or oil should not result in adverse human health effects. The ADI (or TDI) of the substance should be greater than or equal to 0.1 mg/kg bw/day. Substances for which there is no numerical ADI (or TDI) should be evaluated on a case-by-case basis.
3. The substance should not be a known allergen.

4. Most substances do not react with edible fats and oils under normal shipping and storage conditions. However, if the substance does react with edible fats and oils, any reaction products must comply with criteria 2 and 3.

The supporting justification for the derivation of these criteria is as follows:

- The industry follows strict protocols to ensure efficacy of cleaning procedures, which when followed should ensure minimum contamination of the subsequent cargo of fat or oil. However, it is known that some residue from the previous cargo can remain in the tank and its associated pipework after cleaning and may also be absorbed onto the tank wall. To achieve a worst-case situation, it was estimated that the residue after cleaning would be a maximum 100 mg/kg of fat or oil in coated tanks or in relatively small tanks. This estimate was used in the derivation of the toxicological criterion.
- Residues of the substance in the subsequent cargo of fat or oil should not result in adverse human health effects. Taking into account that an ADI (or TDI) can be based on the effects of relatively short-term exposure, and that the ARfD is developed to evaluate exposure on a single day, but that the possibility of repeated exposure to the chemical cannot be excluded, it was considered necessary to refer to the ADI (or TDI) in order to be sufficiently protective of public health. Based on the estimation above, a previous cargo could be present at a concentration of 100 mg/kg of fat or oil. When estimating dietary exposure to a previous cargo contaminant in edible fats and oils, the meeting estimated a dietary intake of 25 g/day of a single type of fat or oil (based on the WHO GEMS/Food (Global Environment Monitoring System/Food Contamination Monitoring and Assessment Programme) Consumption Cluster Diets. Taking into account a safety factor of 2.5 for high-intake consumers, the experts agreed that for the evaluation of previous cargoes, an ADI (or TDI) of 0.1 mg/kg bw/day would be the minimum requirement to provide sufficient protection for children and high-intake consumers.
- Allergenicity of the previous cargo was considered to be important in the consideration of the acceptable previous cargo.
- Reactions most likely to occur in edible fats and oils include oxidation and hydrolysis (normally considered as changes in quality). Otherwise, edible fats and oils are chemically quite inert under normal storage and handling conditions. However consideration must be given to the possibility that the chemical substance from the previous cargo can react with the fat or oil, and in the event of such a reaction, the criteria for previous cargoes must also be applied to the reaction products.



## 1. Introduction

A Food and Agricultural Organization of the United Nations (FAO) and World Health Organization (WHO) Technical Meeting on the Development of Criteria for the Acceptability of Previous Cargoes for Edible Fats and Oils being transported in bulk was held in Bilthoven, the Netherlands from 7 to 9 November 2006. The meeting was hosted by the Dutch National Institute for Public Health and the Environment (RIVM).

The meeting was opened by Dr Adrienne Sips, Head of the Method and Model Development Section of the Centre for Substances and Integrated Risk Assessment (SIR), RIVM, who expressed RIVM's interest in supporting the successful outcome of the meeting. An overview of RIVM as a centre of expertise in serving public interests was provided, with core expertise covering public health, nutrition, environment and food safety. In addition to its participation in international fora and networks, RIVM is a source of sound and independent scientific advice, and it provides support for the monitoring and rapid detection of threats, as well as for integrated risk assessment.

On behalf of FAO and WHO, Dr Maria de Lourdes Costarrica, Senior Officer, Food Quality and Standards Service, FAO, presented the meeting objectives and described the background of the request received from the Codex Alimentarius Commission (CAC). The underlying principles of FAO/WHO scientific advice were stressed, highlighting the need for confidentiality, inclusiveness, soundness, independence, transparency and consensus according to FAO/WHO rules and procedures. Dr Costarrica thanked the experts and the host organization for their support in collaborating with FAO/WHO.

Dr Wim Mennes from the host organization chaired the meeting, enabling the experts to focus on the deliberations. A total of five experts from four countries participated in the meeting.

Two of the five experts declared a potential conflict of interest:

- Mr Thin Sue Tang is a Senior Research Fellow in the MPOB (Malaysian Palm Oil Board), which receives funding through a taxation system from the industry to carry out research on palm oil products.
- Dr John Hancock is an employee of FOSFA International (Federation of Oils, Seeds and Fats Association), an international contract-issuing and arbitral body for the oilseeds and edible oils and fats trade.

The meeting considered that neither situation constituted a conflict of interest and that both experts had practical experience required for the deliberations. Therefore, both experts were able to participate fully in the meeting.

Participants were advised that Dr Diane Benford would join the meeting on the second day due to a prior work engagement.

The meeting agenda was adopted without comment and is attached in Annex I. An edited version of the background paper used to orientate discussion at the meeting is provided in Annex II. In addition to the references included at the end of this report and to those incorporated in and listed at the end of the background paper, a

complete list of documents and data provided just before or during the meeting is provided in Annex III.

## **1.1 BACKGROUND**

Edible fats and oils are often produced in one region of the world and consumed in another. Thus, they must be transported by road, railroad, via inland waterways and by sea, and they may be stored in tanks on land. Industry asserts that it is not economically viable to operate a fleet of ships engaged only in the carriage of edible fats and oils as they would have to return empty to their original loading ports. The edible fats and oils trade and the shipping industry rely on the ability of transport vessels to carry other non-food cargoes before and after the carriage of edible fats and oils. This trade practice means that there are many chemicals that could be carried as previous cargoes to edible fats and oils.

Within the CAC, the Codex Committee on Fats and Oils (CCFO) is mandated to elaborate worldwide standards for fats and oils of animal, vegetable and marine origin, including margarine and olive oil.

The 23<sup>rd</sup> session of the CAC adopted the Recommended International Code of Practice for the Storage and Transport of Edible Oils and Fats in Bulk (ALINORM 99/37, para. 165 and Appendix VII). It includes Appendix 2 (under development), the Codex List of Acceptable Previous Cargoes.

Considerable progress has been made by the CCFO on the development of this list, taking into consideration lists provided by specialist organizations and interested parties. A short summary of the achievements in Codex on developing the list is as follows:

- During the 17<sup>th</sup> session of the CCFO (February 2001), the Committee agreed to forward the Draft List of Acceptable Previous Cargoes (Appendix III ALINORM 01/17) to the 24<sup>th</sup> session of the CAC for its adoption at Step 5/8 with the omission of Steps 6 and 7.
- A number of countries considered this list incomplete, which resulted in a second list – Proposed Draft List of Acceptable Previous Cargoes (Appendix VI, ALINORM 01/17) – being developed for discussion at Step 3 at the 18<sup>th</sup> session of the CCFO.
- At the 24<sup>th</sup> session of the CAC, the opinion was expressed that there are no clearly defined criteria and procedures for the evaluation of the substances to be included as acceptable previous cargoes; consequently, the CAC could not reach a consensus on the adoption of the list at Step 8. The CAC decided to adopt the List of Acceptable Previous Cargoes only at Step 5 and proceed it to Step 6 for further consideration by the Committee of the issues raised.
- Delegates at the 18<sup>th</sup> session of the CCFO discussed both lists under consideration; however, the discussions were inconclusive and it was recognized that the difficulty in developing criteria for evaluation of the compounds was a significant obstacle to progress.

The 18<sup>th</sup> session of the CCFO and the 26<sup>th</sup> and 27<sup>th</sup> sessions of the CAC requested that FAO and WHO provide scientific advice on acceptable previous cargoes. The 19<sup>th</sup> session of the CCFO agreed to retain the Draft List and the Proposed Draft List of Acceptable Previous Cargoes at Steps 7 and 4, respectively, for further consideration by the 20<sup>th</sup> session in the light of the FAO/WHO scientific advice and of any other information that could become available in the meantime.

In response to this request, FAO and WHO convened a technical meeting, in collaboration with the Dutch National Institute for Public Health and the Environment (RIVM), to establish criteria for substances to be included in the Codex List of Acceptable Previous Cargoes as referenced in Appendix 2 of the Code of Practice (CAC, 1987).

The criteria developed by this meeting will be presented at the 20<sup>th</sup> session of the CCFO, scheduled to take place in February 2007.

## **1.2 OBJECTIVES OF THE MEETING**

- To provide advice to the CCFO by developing criteria to be used to determine the acceptability of previous cargoes for edible fats and oils in bulk transport.
- To propose to the CCFO, as necessary, any additional scientific advice on this matter.

## **1.3 SCOPE OF THE MEETING**

The basis for all discussions during the meeting is included in the background paper as attached in Annex II. The background paper should be consulted for further details of the technical information on which discussions and conclusions were based.

The meeting agreed that the criteria for the acceptability of previous cargoes were to be developed only for the carriage of edible fats and oils as bulk liquids by sea. In the context of this document, the term “edible” includes fats and oils which are destined for the oleo-chemical industry for use in personal care products (e.g. soaps, creams). This inclusion requires that both the oral and the dermal allergenicity of a previous cargo need to be considered.

The meeting noted that storage and land transport of fats and oils are covered by national regulations or legislation and are limited to tanks used exclusively for food purposes; it was proposed that if no other regulations are present, the criteria may also be applicable to land transport systems and storage tanks. Typical previous cargoes for edible fats and oils are liquid chemical substances (sometimes at raised temperatures), slurries of solid particles, and solutions of solids in water.

In determining the criteria, the meeting agreed to only consider the safety implications of the presence of residues of previous cargoes for human health. Contamination with foodstuffs and food additives, including flavouring and colouring substances, were considered changes in food quality and therefore beyond the scope of the document. Changes in quality of fats and oils during shipment do occur (due to hydrolysis and oxidation) and are anticipated by traders. This loss of quality is taken into account when edible fats and oils are processed further into food (during refining). In addition, measures are taken to avoid or reduce as much as possible such losses in quality (CAC, 1987). Furthermore, edible fats and oils should comply with the quality criteria indicated in the Codex Standards (e.g. Codex Standards 1981a, 1981b, 1981c, 1999a, 1999b).

## **2. Determining the key criteria**

Following the recommendations of the CCFO, the meeting considered previous CCFO work, as well as data submitted in response to the call and scientific information gathered by RIVM. Special attention was paid to issues formulated by the 17<sup>th</sup> and 18<sup>th</sup> sessions of the CCFO to be considered when developing criteria:<sup>1</sup>

- Toxicological properties, including genotoxic and carcinogenic potential (account may be taken of the opinions of JECFA – Joint FAO/WHO Expert Committee on Food Additives – or other recognized bodies).
- Efficacy of cleaning procedures between cargoes.
- Dilution factor in relation to the potential amount of residue of the previous cargo and any impurity which the previous cargo might have contained, and the volume of fat or oil transported.
- Solubility of possible contaminating residues.
- Subsequent refining/processing of the fat or oil.
- Availability of analytical methods for the detection of trace amounts of residue or for verifying the absence of contamination.
- Reactivity of edible fats and oils with contaminating residues, where appropriate.
- Allergenicity.

The meeting decided that the only practical way to decide if a substance is acceptable as previous cargo is generic, assuming worst-case conditions; it would be impractical to develop a system taking into account every possible combination of previous cargo, type of tank construction, cleaning regime and further processing of the subsequent fat or oil cargo. The main findings of the meeting are outlined below to illustrate how the final criteria were determined.

### **2.1 TOXICOLOGICAL PROPERTIES**

The toxicological aspects of the substances were considered to be particularly important when considering acceptable previous cargoes and the meeting identified this as a criterion.

The meeting concluded that it was possible to identify a criterion based on the ADI (acceptable daily intake) or TDI (tolerable daily intake) concept, and proposed that this would provide adequate human health protection even taking into account possible exposure to the same substance from other sources. The meeting noted that the ADI (or TDI) is developed to evaluate lifetime exposures, but also noted that it was highly unlikely that an individual would consume the same type of fat or oil contaminated with a particular residue of a previous cargo on a regular basis. Given that acute toxic effects may occur, the need for a criterion based on an acute reference dose (ARfD) was discussed. Taking into account that an ADI (or TDI) can be based on the effects of relatively short-term exposure (e.g. toxic effects during pregnancy), and that the ARfD is developed to evaluate exposure on a single day but that the possibility of repeated exposure to the chemicals could not be excluded, it was considered necessary to refer to the ADI (or TDI) in order to be sufficiently protective of public health.

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<sup>1</sup> CL 2000/44-FO.

For estimation of exposure to a previous cargo contaminant in edible fats and oils, the meeting estimated a dietary intake of 25 g/day of a single type of fat or oil. This value is based on the rounded maximum intake estimate for one single type of fat or oil (i.e. refined soybean oil) of 22 g/person per day. This estimate is taken from the WHO GEMS/Food (Global Environment Monitoring System/Food Contamination Monitoring and Assessment Programme) Consumption Cluster Diets, which are based on imports/exports and use quantities of various fats or oils in 13 regional clusters, divided by the number of inhabitants in each separate cluster. Although food consumption data as generated by the United Kingdom or the Netherlands, for example, would be more appropriate, it is recognized that such data are only available for a very limited number of countries. For this reason, preference is given to the WHO GEMS/Food Consumption Cluster Diets (WHO, 2006a).

In a worst-case scenario, a previous cargo residue could be present at a concentration of 100 mg/kg of fat or oil (see efficacy of cleaning procedures). Assuming an individual eats on average a maximum of 25 g of fat or oil from a single type of fat or oil per day, this concentration would result in a residue intake of about 0.04 mg/kg of bodyweight (bw) per day in a 60 kg adult. However, this calculation is based on consumption data for adults. As a result of their higher caloric intake per kg bw, dietary exposure of children to contaminants is frequently 2.5 times that of adults. A factor of 2.5 would also cover high-intake consumers. The meeting therefore agreed that for the evaluation of previous cargoes, an ADI (or TDI) of 0.1 mg/kg bw/day would be the minimum requirement to provide sufficient protection for children and high-intake consumers.

For substances which are both mutagenic and carcinogenic, or which are mutagenic and for which no carcinogenicity data are available, ADIs (or TDIs) cannot be allocated and these substances are excluded as acceptable previous cargoes.

The meeting recognized that persistence and bioaccumulation are implicitly covered by the ADI (or TDI).

Account was taken of the fact that there are potential previous cargoes for which insufficient toxicity data are available to derive an ADI (or TDI). In an attempt to cover this, the TTC (threshold of toxicological concern) approach was considered, but it was decided that this approach was not helpful in the evaluation. Therefore, substances where there are insufficient data should be evaluated on a case-by-case basis. This could lead either to a request for further toxicity data or to an evaluation of well-documented toxicity data for structural analogues of the previous cargo under consideration. Any such evaluation should be undertaken by JECFA.

## **2.2 EFFICACY OF CLEANING PROCEDURES**

Tank cleaning was considered to be particularly important in the consideration of acceptable previous cargoes and the meeting identified this as a criterion.

All cleaning agents used on board chemical tankers are evaluated by the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) Committee for IMO (International Maritime Organization). The effect on sea life and the threat posed to seafarers by the cleaning agents is a major consideration. The meeting considered contamination by cleaning agents to be outside the scope of the meeting.

It is possible for some residue to remain in the tank and its associated pipework after cleaning. Chemical carrier tanks are constructed either of stainless steel or of mild steel coated with a suitable material to protect it from corrosion. The level of contamination depends upon the type of tank employed. The main difference between the two tank types is the degree of absorption of the previous cargo being carried in coated tanks compared to hardly any absorption in stainless steel tanks. The absorbed material is desorbed or displaced at various rates into subsequent cargoes, thus contaminating them. To achieve a worst-case situation, coated tanks were used to estimate the quantity of the previous cargo which could be present in the subsequent cargo of edible fats and oils.

It was considered that any contamination from a previous cargo in seagoing vessels after cleaning is unlikely to be greater than 10 mg/kg of fat or oil, and is generally in the order of 1 mg/kg of fat or oil for stainless steel tanks (Hancock, 2006a). However, contamination from previous cargoes carried in coated tanks could be as high as 100 mg/kg of fat or oil (Chemserve, 2006; Coutts, 1991; Woods, 2000). The meeting considered that the worst-case maximum concentration of residue after cleaning would be 100 mg/kg of fat or oil. This value was based on possible contamination levels in coated tanks or in relatively small tanks. This estimate is used in the derivation of the toxicological criterion, i.e. criterion 2 (section 3).

### **2.3 DILUTION FACTOR**

The dilution factor regards the remainder<sup>2</sup> of the previous cargo left after unloading but before tank cleaning. In a worst-case scenario, it was estimated that the maximum residue level of the previous cargo would be 100 mg/kg of fat or oil after tank cleaning – also applicable to relatively small tanks. Given that cleaning is an essential criterion (criterion 1 – section 3), it is not necessary to include the dilution factor as a criterion.

### **2.4 SUBSEQUENT REFINING/PROCESSING OF FATS AND OILS**

To meet consumer acceptance, fats and oils are further refined (usually post shipment) to remove products of oxidation and hydrolysis. The vast majority of vegetable oils shipped by sea are refined on arrival to meet food-grade specifications. Water soluble compounds, colour pigments, gums and free fatty acids are removed by degumming, neutralization and the use of bleaching clays. The final step in the manufacture of an edible oil is deodorization. This is a steam distillation process taking place at temperatures above 220°C and under vacuum. Thus, a wide range of substances, even some with a saturated vapour pressure as low as 1 mPa, are easily removed during the deodorization step.

However, it was noted that some oils are not refined (e.g. virgin olive oil), while others are transported by sea after refining (e.g. palm oil); therefore, as a worst-case scenario, it was decided not to take refining into consideration in the estimation of possible exposure to previous cargo residues. Omission of the refining step is implicitly taken into account in the worst-case estimate for contamination of edible fats and oils (i.e. 100 mg/kg fat or oil).

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<sup>2</sup> “Remainder” in the context of this document refers to the amount of previous cargo left in the tank after the previous cargo is emptied.

## **2.5 SOLUBILITY OF POSSIBLE CONTAMINATING RESIDUES**

Removal of residues of previous cargoes is facilitated by high solubility in water and high vapour pressure. Both parameters are relevant for cleaning and refining processes. Solubility and vapour pressure are taken into account when deciding on the appropriate cleaning procedures, and therefore they are implicitly taken into account in the worst-case estimate for contamination of edible fats and oils (i.e. 100 mg/kg fat or oil). As refining was considered to be outside the scope of the discussion, solubility and vapour pressure are not included in the criteria.

## **2.6 AVAILABILITY OF ANALYTICAL METHODS**

Suitable analytical methods are available to determine residues in the range of the assumed maximum concentration, consistent with a residue level of 100 mg/kg of previous cargo in fats or oils.

It was acknowledged that contamination can occur; the meeting developed an approach (i.e. the criteria) to ensure that such contamination will not pose a toxicological risk when the criteria are met. It is not proposed or considered necessary to set maximum levels (MLs) to support these criteria; as a result, analytical methods for the determination of previous cargoes in fats and oils are not included in the criteria.

## **2.7 REACTIVITY WITH EDIBLE FATS AND OILS**

The reactivity of the previous cargo with edible fats and oils was considered to be particularly important in the consideration of acceptable previous cargoes and the meeting identified this as a criterion.

Edible fats and oils are chemically quite inert under normal handling conditions. Reactions likely to occur during transport are oxidation and hydrolysis. Elevated temperature, moisture and the presence of catalysts such as copper promote hydrolysis and/or oxidation. However, small changes in oil quality are anticipated and are dealt with during further refining. Standard practices, such as loading from the bottom of the tank, the addition of antioxidants prior to loading, or the nitrogen blanketing of high-quality oils during carriage, may reduce the deterioration of quality parameters.

However, consideration must be given to the possibility that the chemical substance can react with edible fats and oils under transport conditions. Possible reactions covered by normal quality aspects are oxidation (peroxidation), hydrolysis and saponification. However, reactions with triglyceride or fatty acid impurities in the fat or oil (e.g. methylation or ethylation) must be evaluated on a toxicological basis (i.e. criteria 2 and 3, section 3).

## **2.8 ALLERGENICITY**

Exposure to allergenic substances in pre-sensitized individuals may trigger severe adverse reactions, even at very low levels. Allergenicity of the previous cargo was considered to be particularly important in the consideration of acceptable previous cargoes and the meeting identified this as a criterion.

In addition, the meeting considered further issues to be relevant:

- **Organoleptic changes.** Changes in oil which may result in a deterioration of organoleptic quality (e.g. oxidation, hydrolysis) were discussed as a possible criterion, but were dismissed because such affected oils were considered unlikely to enter the food-chain without further refining. Quality aspects were considered to be outside the scope of the discussion.
- **Microbiological contamination.** Chemical previous cargoes are not a potential source of microbiological contamination of subsequent cargoes of edible fats and oils. Furthermore, edible fats and oils are poor substrates for the growth of microorganisms. For these reasons, the meeting considered that microbiological contamination was not a potential health risk and hence not a criterion.
- **Homogeneity.** Consideration was given to whether there was a possibility of inhomogeneity of residue levels in more viscous edible fats and oils, giving rise to regions of elevated concentrations of residue of the previous cargo. Edible fats and oils are shipped at 10°–15°C above their melting points to ensure low viscosity. It was concluded that inhomogeneity of edible fats and oils cargoes during shipment is not likely to occur, due to efficient mixing caused by pumping during loading and discharge, convection currents and the ship's movements. Therefore, the estimated maximum residue level of 100 mg/kg of fat or oil will apply to all subsamples within a tank load.
- **Previous cargoes.** The meeting discussed whether immediate, second or third previous cargoes need to be considered. The estimated maximum residue level of 100 mg/kg of fat or oil applies to the immediate previous cargo. Residue levels from second and third previous cargoes will be lower and therefore all previous cargoes (immediate, second or third) are implicitly taken into account in the worst-case estimate for contamination of edible fats and oils (i.e. 100 mg/kg fat or oil).

### 3. Proposed list of criteria

When assessing the acceptability of previous cargoes for fats and oils, a substance is considered acceptable when it complies with the four criteria listed in Box 1.

BOX 1

<b>Proposed criteria for the assessment of acceptable previous cargoes for fats and oils</b>	
1.	The substance must be transported/stored in an appropriately designed system; with adequate cleaning routines, followed by effective inspection and recording procedures.
2.	Residue of the substance in the subsequent cargo of fat or oil should not result in adverse human health effects. The ADI (or TDI) of the substance should be greater than or equal to 0.1 mg/kg bw/day. Substances for which there is no numerical ADI (or TDI) should be evaluated on a case-by-case basis.
3.	The substance should not be a known allergen.
4.	Most substances do not react with edible fats and oils under normal shipping and storage conditions. However, if the substance does react with edible fats and oils, any reaction products must comply with criteria 2 and 3.

#### 3.1 TECHNICAL JUSTIFICATION FOR EACH CRITERION

##### 3.1.1 Criterion 1

*The substance is transported/stored in an appropriately designed system, with adequate cleaning routines, followed by effective inspection and recording procedures.*

Recent changes in the regulations governing the carriage of edible fats and oils in bulk by sea require that these commodities are transported in tankers which are intended to carry one cargo on a particular voyage, discharge it, clean out the tank, and load the next cargo for transport to another port. Thus, tanks are designed to drain efficiently, to be cleaned effectively and to facilitate inspection.

The procedure for tank cleaning of sea-going vessels is rigorous and generally includes the following stages:

- Choice of cleaning regime
- Pre-cleaning (spraying with cold seawater)
- Cleaning (spraying with hot seawater or seawater and cleaning agents)
- Final treatments: rinsing/flushing with freshwater, steaming, draining, venting/mopping/drying
- Verification of the results by a superintendent (inside the tank)

The tanks, pumps and filling and emptying lines are cleaned simultaneously in a similar manner. The ship operator must maintain a historical record of the contents of each tank. Similarly, the ship's surveyor keeps an inspection record for each tank inspected prior to loading of the next cargo.

The meeting recommended that for a substance to be included in the Codex List of Acceptable Previous Cargoes, a recognized cleaning procedure (e.g. Chemserve, 2006; Verwey, 1998) must be followed to remove any residue of this cargo and that a record of the inspection of the tank following cleaning must be maintained for verification of cleanliness and suitability.

It is possible for some residue to remain in the tank and its associated pipework, even after cleaning. Chemical carrier tanks are constructed of either stainless steel or mild steel coated with a suitable material to protect it from corrosion, and the level of contamination depends upon the type of tank employed. With coated tanks, there is a degree of absorption of the previous cargo, while there is hardly any absorption in stainless steel tanks. The absorbed material is then desorbed or displaced into the subsequent cargoes, which are contaminated as a consequence. In order to achieve a worst-case situation, coated tanks were therefore used to estimate the quantity of the previous cargo which could be present in the subsequent cargo of edible fats and oils. The meeting considered that the worst-case maximum concentration of residue is 100 mg/kg of oil. This estimate is used in the derivation of the toxicological criterion (i.e. criterion 2).

### **3.1.2 Criterion 2**

*Residue of the substance in the subsequent cargo of fat or oil should not result in adverse human health effects. The ADI (or TDI) of the substance should be greater than or equal to 0.1 mg/kg bw/day. Substances for which there is no numerical ADI (or TDI) should be evaluated on a case-by-case basis.*

The health risks associated with human exposure to residues of previous cargoes in edible fats and oils can be covered by a toxicological risk assessment.

For every possible previous cargo, the two major data required are:

- a reference dose below which exposure to that chemical can be considered as safe (e.g. ADI or TDI);
- an estimate of exposure.

On the basis of a worst-case exposure, it is possible to identify a minimally required ADI (or TDI) at which previous cargoes would not pose a toxicological risk. This can be used as a criterion for the evaluation of previous cargoes for a subsequent cargo of edible fats and oils.

It is noted that the ADI (or TDI) is developed to evaluate lifetime exposures. It is highly unlikely that an individual would consume the same type of oil or fat contaminated with a particular residue of a previous cargo every day throughout his/her lifetime. Short-term exposure reference doses, rather than lifetime exposure limits, are derived in some circumstances. However, taking into account that some toxic effects may occur over a shorter time period (e.g. during pregnancy), and that the possibility of repeated exposure to the chemicals cannot be excluded, it is

considered necessary to refer to the ADI (or TDI) in order to be sufficiently protective of public health.

For substances which are both mutagenic and carcinogenic, or which are mutagenic and for which no carcinogenicity data are available, ADIs (or TDIs) cannot be allocated and these are excluded as acceptable previous cargoes. Substances for which there is no ADI (or TDI) should be reviewed on a case-by-case basis.

The information provided earlier in this document estimates that, as a worst case, a previous cargo residue could be present at a concentration of 100 mg/kg of fat or oil. Assuming an individual eats on average a maximum of 25 g of fat or oil from a single type of fat or oil per day, this concentration would result in a residue intake of about 0.04 mg/kg bw/day in a 60 kg adult. However, this calculation is based on consumption data for adults. As a result of their higher caloric intake per kg bw, dietary exposure of children to contaminants is frequently 2.5 times that of adults. The factor of 2.5 would also cover high-intake consumers. The meeting therefore agreed that for the evaluation of previous cargoes, an ADI of 0.1 mg/kg bw/day is the minimum requirement to be sufficiently protective also for children and high-intake consumers.

In conclusion, substances with an ADI (or TDI) of less than 0.1 mg/kg bw/day would not be considered acceptable as previous cargoes from a toxicological point of view.

### **3.1.3 Criterion 3**

*The substance should not be a known allergen.*

Exposure to allergenic substances in pre-sensitized individuals may trigger severe adverse reactions, even at very low levels. If a JECFA evaluation has noted evidence that a substance is allergenic, then the ADI (or TDI) is not applicable to pre-sensitized individuals and the substance should not be considered acceptable as a previous cargo.

### **3.1.4 Criterion 4**

*Most substances do not react with edible fats and oils under normal shipping and storage conditions. However if the substance does react with edible fats and oils, any reaction products must comply with criteria 2 and 3.*

Edible fats and oils are chemically quite inert under normal handling conditions. During transport, likely reactions are oxidation and hydrolysis, promoted by elevated temperature, moisture and the presence of catalysts (e.g. copper). However, small changes in oil quality are anticipated and are dealt with during further refining. There are standard practices to reduce the deterioration of quality parameters, for example, loading from the bottom of the tank, addition of anti-oxidants prior to loading, or nitrogen blanketing of high-quality oils during carriage.

However, it is important to consider the possibility that the chemical substance can react with edible fats and oils under transport conditions. In the event of a reaction, the criteria for previous cargoes must also be applied to the reaction products.

## **4. Conclusions and recommendations**

The meeting discussed several possible criteria for acceptability of previous cargoes for edible fats and oils for bulk liquid transport by sea and concluded that in the worst-case scenario only four criteria are relevant. These criteria concern: cleaning, toxicological properties, allergenicity and reactivity with edible fats and oils. The criteria were designed to cover transportation of edible fats and oils by sea-going vessels. However, in the case of storage, or transport by road or railway or via inland waterways, these criteria may also be applicable if no other regulations are present.

The meeting recommended the consideration of the proposed criteria by the CCFO when finalizing the Codex List of Acceptable Previous Cargoes as referenced in Appendix 2 of the Code of Practice (CAC, 1987).

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## References<sup>3</sup>

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- Chemserve.** 2006. Miracle tank cleaning database (available at: <http://www.chemserve-marine.com> – accessed October 2006).
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- Woods, B.** 2000. Cargo tank coatings and cargo contamination. Milbros Shipping AS. Confidential data.

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<sup>3</sup> The references cited in the main report are listed here. Note that additional information provided just before and during the meeting is listed in Annex III.



**Annex I**

**Meeting agenda**

**Development of criteria for acceptable previous cargoes  
for fats and oils**

Bilthoven, the Netherlands

7–9 November 2006

Welcome and introduction	<i>Adrienne Sips</i>
Introduction of participants	<i>Wim Mennes</i>
Adoption of agenda	<i>Wim Mennes</i>
Apologies for absence	<i>Wim Mennes</i>
Declarations of interest	<i>Wim Mennes</i>
Confidentiality issues	<i>Wim Mennes</i>
Introduction to the meeting (outline of previous work within CCFO, clarification of the required outcome of the meeting)	<i>Maria de Lourdes Costarrica</i>
Outline of e-mail discussion, indications of major topics; presentation of core criteria and technical/scientific basis	<i>Wim Mennes</i>
Meeting set-up, overview of procedures and discussion	<i>Wim Mennes</i>
Discussions of criteria and technical/scientific background	<i>All experts</i>
Finalization of technical paper and paper on criteria for CCFO	<i>All experts</i>

## Background paper<sup>4</sup>

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<sup>4</sup> A background paper was prepared prior to the meeting based on data received in the call for data and on scientific information gathered by RIVM in addition to data submitted by experts. The background paper was discussed through e-mail and ideas and questions raised were included in the revised draft of the background paper. Additional comments received from the experts before the start of the meeting were then included. This background paper provided the main technical paper at the meeting and was used to orientate the discussions.

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## **1. Background**

The Codex Alimentarius Commission (CAC) sets international food standards to protect the health of consumers and ensure fair practices in the food trade. The standards, guidelines and recommendations established by Codex are recognized by the World Trade Organization as the “benchmark” standards for food safety and are the reference in the event of a dispute in international food trade. Under the Codex system, the Codex Committee on Fats and Oils (CCFO) is mandated to elaborate worldwide standards for fats and oils of animal, vegetable and marine origin, including margarine and olive oil.

The 23<sup>rd</sup> session of the CAC adopted the Recommended International Code of Practice for the Storage and Transport of Edible Oils and Fats in Bulk (ALINORM 99/37, para. 165 and Appendix VII). It includes Appendix 2, the Codex List of Acceptable Previous Cargoes, which still has to be developed.

Considerable progress has been made by the CCFO in the development of this list, taking into consideration lists provided by specialist organizations and interested parties. A short summary of the achievements in Codex in developing the list is as follows:

- During the 17<sup>th</sup> session of the CCFO (February 2001), the Committee agreed to forward the Draft List of Acceptable Previous Cargoes (Appendix III, ALINORM 01/17) to the 24<sup>th</sup> session of the CAC for its adoption at Step 5/8 with the omission of Steps 6 and 7.
- A number of countries considered this list incomplete, which resulted in a second list – Proposed Draft List of Acceptable Previous Cargoes (Appendix VI, ALINORM 01/17) – being developed to be discussed at Step 3 at the 18<sup>th</sup> session of the CCFO.
- At the 24<sup>th</sup> session of the CAC, the opinion was expressed that there are no clearly defined criteria and procedures for the evaluation of the substances to be included as acceptable previous cargoes; consequently, the CAC could not reach a consensus on the adoption of this list at Step 8. The CAC decided to adopt the List of Acceptable Previous Cargoes only at Step 5 and proceed it to Step 6 for further consideration by the Committee of the issues raised.
- Delegates at the 18<sup>th</sup> session of the CCFO discussed both lists under consideration; however, their discussions were inconclusive and it was recognized that the difficulty in developing criteria for evaluation of the compounds was a significant obstacle to progress.

Subsequently, the 18<sup>th</sup> session of the CCFO and the 26<sup>th</sup> and 27<sup>th</sup> sessions of the CAC requested that FAO and WHO provide scientific advice on this matter. The 19<sup>th</sup> session of the CCFO agreed to retain the Draft List and the Proposed Draft List of Acceptable Previous Cargoes at Steps 7 and 4, respectively, for further consideration by the 20<sup>th</sup> session in the light of the FAO/WHO scientific advice and of any other information becoming available in the meantime. The proposed lists for acceptable previous cargoes as prepared by CCFO are included in Appendix 1 of this document.

Criteria were proposed by the 17<sup>th</sup> and 18<sup>th</sup> sessions for the inclusion of substances in the Codex List of Previous Cargoes.<sup>5</sup> Additional substances may be included following an appropriate risk assessment evaluation, taking into consideration:

- toxicological properties, including genotoxic and carcinogenic potential (account may be taken of the opinions of JECFA – the Joint FAO/WHO Expert Committee on Food Additives – or other recognized bodies);
- the efficacy of cleaning procedures between cargoes;
- the dilution factor in relation to the potential amount of residue of the previous cargo; any impurity which the previous cargo might have contained; and the volume of fat or oil transported;
- the solubility of possible contaminating residues;
- any subsequent refining/processing of the fat or oil;
- the availability of analytical methods to detect trace amounts of residue or to verify the absence of contamination;
- the reactivity of edible fats and oils with contaminating residues, where appropriate; and
- allergenicity.

The current working group has been convened by FAO and WHO, assisted by the Dutch National Institute for Public Health and the Environment (RIVM), to establish criteria for substances to be included in the Codex List of Acceptable Previous Cargoes as referenced in Appendix 2 of the Recommended International Code of Practice for the Storage and Transport of Edible Fats and Oils in Bulk (CAC, 1987). It is hoped that the Committee will thus be able to develop risk management principles with evaluation criteria for the inclusion of substances in lists of acceptable cargoes.

The criteria developed by this meeting will be presented at the 20<sup>th</sup> session of the CCFO, scheduled to take place in February 2007.

## 2. Introduction

Edible fats and oils are often produced in one region of the world and consumed in another. Thus, they must be transported by road or railroad, via inland waterways and by sea, and may be stored in tanks on land. Industry asserts that it is not economically viable to operate a fleet of ships engaged only in the carriage of edible fats and oils as they would have to return empty to their original loading ports. The edible fats and oils trade and the shipping industry rely on the ability of transport vessels to carry other non-food cargoes before and after the carriage of edible fats and oils. This trade practice means that many chemicals are potential previous cargoes to edible fats and oils.

At present, cargoes may be classified as:

- banned (Codex has already approved the banned list);
- acceptable (the list is still pending in Codex); or
- neither (i.e. the majority of all chemicals).

The reason there are three types is a result of how edible fats and oils are traded. The Federation of Oils, Seeds and Fats Associations (FOSFA International) is a professional international contract-issuing and arbitral body concerned exclusively

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<sup>5</sup> CL 2000/44-FO.

with world trade in oilseeds, oils, fats and edible groundnuts. About 85 percent of ships carrying oil cargoes operate under a FOSFA contract. The other 15 percent have equivalent contracts, but with other organizations.

A standard FOSFA contract is a “banned list terms” contract. This means that the buyer will accept delivery of the oil as long as the previous cargo in the ship’s tank was not on the banned list. The contract can be converted into an “acceptable list terms” contract by the inclusion of an optional clause within the contract, as agreed by both parties. This is known as the “AS9” clause:

*The following clause becomes effective on and from 1<sup>st</sup> October 2005 and is for use when agreed between Buyers and Sellers. The immediate previous cargo in the tank/s, lines and pump systems receiving the oils or fats shall have been a product on the FOSFA List of Acceptable Previous Cargoes in force at the date of the Bill/s of Lading. The Restrictions beyond the Immediate Previous Cargo on the FOSFA List of Acceptable Previous Cargoes shall apply. The statements referring to previous cargoes called for under the Payment and Shipping Documents Clause shall certify to this effect. The reference therein relating to the Banned List shall not apply.*

This means that the receiver will accept the cargo only if the previous cargo in the tank was on the FOSFA acceptable list. Although some regions and countries (e.g. European Union and United States) have adopted the acceptable list terms into their national legislation, the majority of countries have carried out a government or industry risk appraisal and accepted that the banned list terms are satisfactory. Thus, the majority of the edible fats and oils traded worldwide have had a previous cargo which is on neither list. The main reason for using an acceptable terms contract is to reduce the potential risk to the product from any residue of the previous cargo.

The Recommended International Code of Practice for the Storage and Transport of Edible Fats and Oils in Bulk (CAC, 1987) already contains the Banned List of Previous Cargoes. The Codex List of Acceptable Previous Cargoes as referenced in Appendix 1 to this document is under development. Two matters are outstanding:

- Draft List of Acceptable Previous Cargoes at Step 7
- Proposed Draft List of Acceptable Previous Cargoes at Step 4

### **3. Development of criteria for previous cargoes**

#### **3.1 TRANSPORT/STORAGE SYSTEMS**

Edible fats and oils can be transported by road, railroad, inland waterways and sea or they can be stored in storage tanks before or after transport.

Following the e-mail discussion, two options were identified to restrict the scope of the discussion when considering the development of criteria for previous cargoes.

#### **Option 1. Bulk transport by sea only**

For the development of criteria for the addition of a substance to the accepted list of previous cargoes, only bulk transport by sea is considered for the following reasons:

- It is not economically viable for a fleet of vessels engaged in commodity trade to return to their original ports empty. The shipping trade relies on the

flexibility to contract both the route and the cargoes carried. Land transport does not have the same economic need for non-food use as sea transport.

- National authorities should already have regulations/guidelines concerning the safety and security of food products (including edible fats and oils) in land transport.
- In the European Union (EU), edible fats and oils may only be transported in tanks used exclusively for food purposes; the only exception made is for bulk transport by sea (EU, 1996, 2004a, 2004b).

CCFO's work over the last 6 years on previous cargoes has been confined to the carriage of edible fats and oils in bulk by sea. By basing its Draft Acceptable Previous Cargo List on the EU, FOSFA and NIOP (National Institute of Oilseed Products) lists, which all apply to sea carriage in bulk, the CCFO has confirmed that this is the area to be considered. Barges, rail cars, road tankers and ISO (International Organization for Standardization) tank containers dedicated to food products are much less problematic, as many countries (e.g. EU, USA and Malaysia) have their own laws in place regarding foodstuffs and such types of transport. The same criteria could be applied to storage tanks. Most storage tank farms separate their food and non-food tanks, and do not change their use. However, if these tanks are changed from chemical to food use, then the FOSFA list is generally used.

### **Option 2. Bulk transport by sea or land**

The Code of Practice (CAC, 1987) covers the handling, storage and transport of edible fats and oils in bulk and includes land storage tanks, ships' tanks, road and rail tankers and bulk liquid containers (ISO tank containers). Even though most bulk fats and oils in international trade are transported by sea, the full scope of the adopted code of practice may need to be considered.

Different dilution factors apply which affect the estimation of contaminant residues. Surface-volume ratios are less favourable for rail and road traffic than for ship transport, and tanker-cleaning procedures vary for ship and rail or road transport. Very little information is available concerning land transport (tank volumes, tank surface areas, tank-cleaning procedures etc.).

## **3.2 PREVIOUS CARGOES**

At present, edible fats and oils can be carried in any type of ship, and their carriage is subject to very little regulation. There is insufficient shipping capacity for the designation of dedicated cargoes.

However, during the last 10 years, the International Maritime Organization (IMO, a UN Agency) has been revising the international regulations concerning maritime pollution and the safety of seafarers. IMO regulations apply to all sea-going vessels and all countries, and ships are classified as type 1, 2 or 3. Type 1 may carry the most noxious substances, type 3 the least noxious substances. The main outcome of this revision is that edible fats and oils must be carried in type 2 chemical tankers as of 1 January 2007. Concern was expressed that there might not be sufficient type 2 tonnage available to ensure no disruption to trade in these high-volume products. In response to this concern, Annex II of MARPOL 73/78 (International Convention for the Prevention of Pollution from Ships), which regulates the control of pollution by noxious liquid substances carried in bulk by ships (except mineral oils), was revised. Regulation 4.1.3 of Annex II was developed,

allowing unmodified edible fats and oils displaying the footnote (k) in column (e) in chapter 17 of the amended International Bulk Chemical Code (IBC Code) to be carried on type 3 chemical tankers, on condition that these chemical tankers meet all type 3 requirements and are provided with double bottom and double sides meeting the specifications laid out in regulation 4.1.3 (IMO, 2002, 2006a).

Type 2 and type 3 chemical tankers with double bottom and double sides are designed to carry liquids on one leg of a voyage, discharge at port and load with another liquid cargo (with different properties) before continuing on their voyage. They are designed to be easily cleaned and all have integral cleaning systems in place. The new regulations mean that these tanks must be separate from the hull of the ship and at least 1 metre from the ship's moulding. In other words, they do not follow the sometimes awkward shapes within the ship – a factor which aids cleaning. They must also be able to pump out almost the entire contents of the tank and therefore are equipped with deep-well pumps. This reduces any residue left in the tank and minimizes any possible contamination.

Cargoes categorized as type 1 in chapter 17 of the IBC Code are listed below (IMO, 2006b):

- alkylaryl phosphate mixtures
- alkyldimethylamines
- calcium hypochlorite solutions
- chlorinated paraffins
- chlorosulphonic acid
- 1,5,9-cyclododecatriene
- decyl acrylate
- di-n-hexyl adipate
- N,N-dimethyldodecylamine
- tert-dodecanetriol
- metam sodium solution
- methylcyclopentadienyl manganese tricarbonyl,
- N-(2-methoxy-1-methyl ethyl)-2-ethyl-6-methyl chloroacetanilide
- methylcyclopentadienyl manganese tricarbonyl
- motor fuel antiknock compounds (containing lead alkyls)
- nonylphenol
- noxious liquid NF ST1 or F ST1
- yellow or white phosphorus
- polycyclic aromatics
- molten 1,2,3-trichlorobenzene
- tricresyl phosphate

Also restricted to IMO type 1 ships are mineral oils (handled in Annex I of the MARPOL convention) (IMO, 2002).

Substances carried exclusively in type 1 ships will never come into contact with edible fats and oils cargoes transported in type 2 and type 3 ships. It is likely that substances requiring IMO type 1 ships are not suitable for any acceptable list. A possible criterion for inclusion in the list could therefore be that previous cargoes are not transported by type 1 ships.

Kaolin (china clay) slurry is transported in ships which carry edible fats and oils. These types of cargo are circulated round the tank, usually bottom to top, to stop them settling during the voyage. Such cargoes, as well as solutions of chemicals which are soluble in water, should be included.

Foodstuffs (other oils, fruit juice concentrates), food additives and flavours, transported as liquids, may be previous cargoes. Such cargoes are not on the list in chapter 17 of the IBC Code.

### 3.3 EDIBLE FATS AND OILS

The issue of contamination by previous cargoes is not relevant for shipments of (solid or liquid) fats and oils which are shipped in packed forms (drums, cartons, bottles, cans) and stacked in 20-tonne containers or palletized. Packaging “prevents” contamination and, what is more, such fats and oils are not transported in tankers suitable for the transportation of (liquid) chemicals. Therefore the criteria proposed in this document do not apply to previous cargoes for fats and oils transported in packaged form.

For the development of criteria for the addition of a substance to the accepted list of previous cargoes, only edible fats and oils transported as liquids in bulk (at an appropriate temperature) are considered. “Edible” includes fats and oils destined for the oleo-chemical industry for use in personal care products. Table 1 of Appendix 1 of the Code of Practice (CAC, 1987) includes non-edible oils, such as castor oil, fish oil and linseed oil, which are used in animal feed, pharmaceuticals and personal care products. In addition, many fats and oils for human consumption are also used in personal care products, e.g. cocoa butter, illipe butter, olive oil, sheanut butter and tallow. The oils and fats under consideration are often re-sold and bought by several parties, often while they are “afloat”. Although crude oils (e.g. coconut oil) may be bought by an oleo-chemical company, they could then be sold on to a food manufacturer. Given that the fats and oils under consideration are traded before the final destination is known and as they may become food or oleo-chemicals, it is necessary to ensure the safety of all food grade materials.

## 4. Contamination levels in edible fats and oils

### 4.1 CONTAMINATION

- **Codex Code of Practice (CAC, 1969).** Contamination is defined as the introduction or occurrence of a contaminant in food or a food environment; a contaminant is defined as any biological or chemical agent, foreign matter or other substance not intentionally added to food which may compromise food safety or suitability.
- **Codex Code of Practice (CAC, 1987).** Undesirable contamination may come from residues of a previous material handled in the equipment, dirt, rain or seawater, or from the accidental addition of a different product.
- **EU (EU, 1993).** Contaminant means any substance not intentionally added to food which is present in such food as a result of the production (including operations carried out in crop husbandry, animal husbandry and veterinary medicine), manufacture, processing, preparation, treatment, packing, packaging, transport or holding of such food, or as a result of environmental contamination. Extraneous matter, for example, insect fragments and animal hair, is not covered by this definition.

Only contamination caused by previous cargoes needs to be considered. Contamination from cleaning agents should not be considered. All cleaning agents used on board chemical tankers are evaluated by the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) committee for IMO. GESAMP was established in 1967 by a number of UN Agencies. Its purpose was to provide advice to the agencies, and through them their Member

Governments, on a problem that was just beginning to be recognized as a major threat. Since then, GESAMP has met regularly and in 1993 its role was extended to cover all scientific aspects on the prevention, reduction and control of the degradation of the marine environment to sustain life support systems, resources and amenities. The effect on sea life and the threat posed to seafarers by cleaning agents is a major consideration.

## 4.2 OPTIONS

Following the e-mail discussion, two options were identified for consideration.

### **Option 1. Contamination from tanks undergoing cleaning procedure**

It is not necessary to consider what residues may be left in ships' tanks without cleaning. Tanks are always cleaned between cargoes except in extremely unusual circumstances, for example, if a ship had been carrying methanol (highly volatile solvent) and was loading another chemical which was compatible with methanol. Ships' tanks are always cleaned before the loading of edible fats and oils. Cargo owners/shippers carrying edible fats and oils are aware that they are part of the food-chain. The sellers and the buyers obviously know that the products are edible fats and oils. An average size tank (e.g. 3 000 tonnes) of edible fats and oils is worth at least US\$1.5–2.5 million. No buyer, seller or shipper would ever consider jeopardizing the integrity of the cargo, not to mention the value, by not washing the tank before loading – a process which may cost about US\$250. No insurance company would insure the load, or pay for a contamination caused by not cleaning the tank. No ship's surveyor would allow his client's cargo to be loaded into a tank that was not clean and dry. It is, of course, possible that the cleaning process is not carried out correctly – for example, a small amount of previous cargo could be left in a leg of the pipework from the pump to ship's manifold. The superintendent cannot see these areas, although he does inspect each end of the lines. Even though the wash water is recirculated through all the lines, it is believed that this is a potential source of residue in the subsequent cargo.

### **Option 2. Contamination from tanks not undergoing cleaning procedure**

Assessing exposure to (residue of) previous cargoes could be done on a case-by-case basis for every combination of previous cargo and vessel. However, it is preferable to follow a more general approach, beginning with the assumption that a certain amount of a previous cargo load is left in the tanks and transportation leads.

## 4.3 EXPECTED CONTAMINATION LEVELS WITHOUT TANK CLEANING

### 4.3.1 Calculation of contamination levels without tank cleaning

For the estimation of worst-case concentration levels (in g/kg) of previous cargoes in edible fats and oils (without cleaning) the following formula is proposed:

$$\text{Conc} = \frac{\text{Density}_{\text{previous\_cargo}} \times \text{Remainder} \times 1000}{\text{Density}_{\text{oil}} \times \text{Volume}_{\text{tanker}} \times \text{fraction}_{\text{filled}}} \quad (\text{formula 1})$$

The remainder<sup>6</sup> in the tank and supply lines is on the one hand dependent on the pumping efficiency and on the other hand dependent on the physico-chemical properties of a substance.

The amount left behind on the walls of the tank and supply lines can be calculated from the surface area of the tank and supply lines and the thickness of the layer of previous cargo left behind.

The remainder in the tank (in m<sup>3</sup>) is calculated using the following formula:

$$\text{Remainder} = \text{Remainder}_{\text{pump}} + (\text{SurfaceArea}_{\text{tank}} + \text{SurfaceArea}_{\text{supply\_line}}) \times \text{Layer} \quad (\text{formula 2})$$

#### 4.3.2 Specifications of tanks and supply lines

As can be seen from formula 1, the concentration level without cleaning depends on the dimensions of the tank compartment. If the specifications of tankers and supply lines are taken into consideration, a range of contamination levels can be calculated.

- Sea-going vessels carrying edible fats and oils range from small coasters of 1 000 tonnes dead weight to ocean-going chemical tankers of about 50 000 tonnes dead weight. They have many individual tanks ranging from 200 to 6 000 tonnes, each having its own (un)loading pump and lines. Assuming 1 tonne = 1 m<sup>3</sup>, volumes range from 200 to 6 000 m<sup>3</sup> (IMO, 2002; Tankers, 2006; CAC, 1987).
- Tanks are assumed to have a rectangular shape (assumption made by the experts). The corresponding surface area for sea-going vessel tank compartments is estimated to be 232–4 564 m<sup>2</sup> (fictitious length = 12.5–187.5 m, height = 4 m, depth = 4–8 m – assumptions made by the experts).
- Vessels for inland waterways range from 20 tonnes to over 3 000 tonnes with a typical loading capacity of 1 000–1 500 tonnes. Volumes are estimated to be between 20 and 3 000 m<sup>3</sup> (Scheldenet, 2000).
- No data are available for railroad and storage tanks.
- Road transport of liquid cargo can be done in barrels (30–450 litres), containers (450–3 000 litres) or tankers (30 m<sup>3</sup>) (CIW, 2002). Road vehicles can take loads of up to 40 tonnes and consist of separate 5-tonne compartments (Karlshamms, 2006). Road vehicles have a capacity of 20–58 m<sup>3</sup> with a maximum of eight compartments (2.5–7.25 m<sup>3</sup> per compartment) (De Rijke, 2006). The capacity of mobile tanks (road/rail vehicles, portable tanks) generally does not exceed 100 tonnes (Hancock, 2006b). The focus should be on bulk transport in tankers. Volumes are estimated to be 5–100 m<sup>3</sup>.
- Tanks are assumed to have a rectangular shape (assumption made by the experts). The surface area of road/railroad/inland waterway/storage tank compartments is estimated to be 18–166 m<sup>2</sup> (fictitious length = 1.25–12.5 m, height = 2 m, depth = 2–4 m – assumptions made by the experts).
- Supply lines are assumed to have a cylindrical shape. There are two supply lines to be considered: for introduction and for removal of fats and oils. Assuming the same supply line is used for the removal of previous cargo and the introduction of the fat or oil in the same tank system, the highest contamination levels are expected during the introduction of the fats and oils. Therefore, only the surface areas of the supply lines used for the introduction of the fats and oils need to be considered. The surface area for a ship's tanker

<sup>6</sup> "Remainder" in the context of this document refers to the amount of previous cargo left in the tank after the previous cargo is emptied.

supply line is estimated to be 79 m<sup>2</sup> (fictitious length = 50 m, diameter = 0.5 m – assumptions made by the experts).

- The surface area for a road/railroad/inland waterway/storage tank supply line is estimated to be 6 m<sup>2</sup> (fictitious length = 10 m, diameter = 0.2 m – assumptions made by the experts). The diameter for supply lines for road vehicles is 0.08 m (Karlshamms, 2006).
- Fraction-filled = 0.60. FOSFA requires that tanks in sea-going vessels are filled to more than 60 percent (FOSFA, 2005a).

It is surprising that smaller and larger tanks have comparable ratios for surface area and volume. Although surface to volume ratios do decrease with increasing tank size, given that tanks for transportation have limited volumes (minimum as well as maximum), it can be shown that for all realistic tank sizes, surface to volume ratios are within one order of magnitude. For general calculations it is reasonable to assume that all tanks have the same relative proportion of 1 m<sup>2</sup>/1 m<sup>3</sup> (Chemserve, 2006).

The worst-case concentration levels of previous cargoes without cleaning (density<sub>previous cargo</sub> = 1 800 kg/m<sup>3</sup>, density<sub>oil</sub> = 900 kg/m<sup>3</sup>, fraction<sub>filled</sub> = 0.60, remainder<sub>pump</sub> = 1 m<sup>3</sup>, layer = 2 × 10<sup>-3</sup> m for a highly viscous cargo of 10 000 mPa.s) are estimated to be (*formula 1* and *formula 2*):

- 5.7–27 g/kg oil for sea-going vessel tank compartments (200–6 000 m<sup>3</sup>, surface area 232–4 564 m<sup>2</sup> for tanks and 79 m<sup>2</sup> for supply lines).
- 45–700 g/kg oil for road tank compartments (5–100 m<sup>3</sup>, surface area 18–166 m<sup>2</sup> for tanks and 6 m<sup>2</sup> for supply lines).

Assuming an average chemical carrier tank cargo of 1 000 tonnes, if 10 g/kg (1 percent) of the previous cargo were allowed to carry over into the subsequent cargo, there would be a contamination of 10 tonnes in the subsequent cargo, in which case nobody would ship anything by sea. It is very unlikely that any seller or receiver would accept the loss of 1 percent of a cargo. Therefore the above-mentioned contamination levels are highly unlikely.

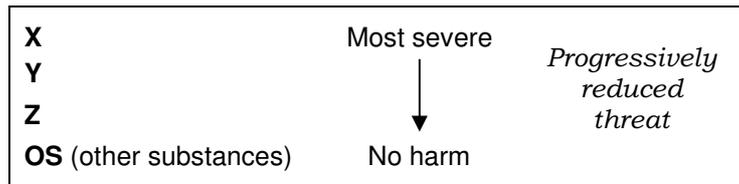
It is impractical to consider the individual technical aspects of transportation and storage. Therefore a decision must be made about which tank volume (and corresponding surface areas for tank and supply lines) is considered appropriate for assessments on the acceptability of previous cargoes. The smaller tank compartments comprise the worst-case situation.

#### 4.3.3 Physico-chemical properties in relation to tank residues

The physico-chemical properties of a substance should be taken into account when evaluating a particular “candidate” for a previous cargo.

For a substance with low viscosity, it is the pumping efficiency alone which determines the remainder in the tank and supply lines. For a substance with high viscosity, both the pumping efficiency and the amount left behind on the tank walls and supply lines determine the remainder.

Under the 2007 Revisions to MARPOL 73/78 Annex II, chemical cargoes considered to pose an environmental threat have been divided into four MARPOL 73/78 Annex II pollution categories (X, Y, Z, OS) on the basis of their potential impact:



OS products are deemed to present no harm to the marine environment and are therefore not regulated. The stripping quantity requirements differ, according to when the ship was built and what cargoes the ship is certified to carry:

- Ships with keels laid on or after 1 January 2007 should not exceed 75 litres in each tank plus the associated pumping and piping system (note that no tolerance is permitted).
- Ships with keels laid on or after 1 July 1986 but before 1 January 2007 should achieve 100 litres for categories X and Y, and 300 litres for category Z, with a tolerance of 50 litres.
- Ships with keels laid before 1 July 1986 should achieve 300 litres for categories X and Y, and 900 litres for category Z, with a tolerance of 50 litres (Lloyd's Register, 2005).

Edible fats and oils are carried in ship types 2 or 3, and these ships may carry each of the pollution categories X, Y, Z or OS. Therefore the maximum residue is 75 litres for new ships and 950 litres for old ships. The maximum residue is determined in a so-called "stripping test" using water as the cargo. The maximum residue is therefore based on a non-viscous substance.

No data are available on the pumping efficiency for road/railroad/inland waterway/storage tanks; therefore the same amount is taken for these tanks and the default Remainder<sub>pump</sub> is set at 1 m<sup>3</sup> (rounded from 950 litres for old ships).

The thickness of the layer depends on the physico-chemical properties of the previous cargo at the temperature of unloading: viscosity, volatility (vapour pressure) and absorption into the surface of the tanker or supply line. Absorption is considered to be important for mild steel tanks with organic coatings, not for stainless steel tanks. Absorption is discussed in the section on cleaning and is not considered here. No data are available on the amount adsorbed or absorbed. Data on viscosity and vapour pressure are generally available for substances at 20° to 25°C. At higher temperatures, the viscosity becomes lower and the vapour pressure higher. Data at the unloading temperature are therefore preferable.

### Viscosity of the previous cargo

The viscosity of a liquid is defined as a measure of the forces that work against a flow when a shearing stress is applied. OECD 114 (OECD, 1981) indicates measurement principles for Newtonian liquids and non-Newtonian liquids. Viscosity (dynamic viscosity) is measured in mPa.s (milliPascal second). Kinematic viscosity is the ratio of (dynamic) viscosity to density at a given temperature. Several other units exist for viscosity (IMO, 2002):

Dynamic viscosity:	0.01 P (Poise) = 1 cP (centiPoise) = 0.01 g cm <sup>-1</sup> s <sup>-1</sup> = 0.001 N s m <sup>-2</sup> = 1 mPa.s
Kinematic viscosity:	1 cSt (centistoke) = 1 mm <sup>2</sup> s <sup>-1</sup>

Viscosity for liquid cargoes varies between: 0.2 and 10 000 mPa.s at 20°C (Table 1).

TABLE 1  
Viscosity of liquid cargoes

Liquid cargo	Viscosity at 20°C (mPa.s)
Diethyl ether	0.233
Water	1.00
Ethanol	1.2
Sulphuric acid	28
Olive oil	84
Castor oil	986
Glycerol	1 490
Honey	2 000–3 000
Blackstrap molasses	5 000–10 000

At higher temperatures, the viscosity becomes lower (Table 2).

TABLE 2  
Temperature/viscosity relationship

	20°C	40°C	60°C
Viscosity (mPa.s)			
Water:	1.00	0.66	0.47
Castor oil:	986	231	80

The viscosity of a cargo is a very important parameter when considering carriage by sea. The revised IMO regulations state that a cargo is considered to be a “high viscosity cargo” if its viscosity exceeds 50 mPa.s at 20°C. IMO requires that the captain of the vessel be informed of the viscosity of the cargo at 20°C prior to loading. If the viscosity is greater than 50 mPa.s, the captain must be informed of the temperature at which it drops below 50 mPa.s. If the cargo is discharged at a lower temperature, the first washings of the tank cannot be pumped to sea, but must be pumped ashore for disposal. Most vegetable oils are loaded and discharged at 10° to 15°C above their melting point (AFOA, 2006).

### Vapour pressure of the previous cargo

Vapour pressure is defined as the pressure exerted when a solid or a liquid is in equilibrium with its own vapour. At thermodynamic equilibrium, the vapour pressure is a function of temperature only. The OECD 104 guideline (OECD, 2006) lists seven methods for determining the vapour pressure of a substance. From vapour pressures at three different temperatures, the vapour pressure at 25°C is calculated by inter- or extrapolation.

Vapour pressure is measured in Pa (Pascal). Several other units exist for vapour pressure (IMO, 2002):

1 cm Hg = 1.333 × 10 <sup>3</sup> Pa	1 bar = 10 <sup>5</sup> Pa
1 atm = 1.01325 × 10 <sup>5</sup> Pa	1 mbar = 1 kPa

Vapour pressure is higher at higher temperatures. The following descriptive terms of vapour pressure apply (IMO, 2002):

no evaporation:	< 0.3 kPa
partial evaporation:	0.3–3 kPa
rapid evaporation:	≥ 3 kPa

A default layer of 0.002 m (assumption made by the experts) is assumed for a substance with very high viscosity (10 000 mPa.s) and low vapour pressure (< 0.3 kPa). If information on viscosity and vapour pressure of the substance (at the unloading temperature) is available, the default value for the thickness of the layer may be adapted. Because viscosity is expected to have a higher impact on the thickness of the layer, the exact value of viscosity is taken into account, while vapour pressure is indexed as 1.0–0.75–0.50. The following formula is proposed for calculation of the layer:

<u>Vapour pressure</u>		<u>Layer (expressed in m)</u>
≤ 0.3 kPa	=	$1.00 \times 0.002 \times \text{Viscosity}_{\text{substance}} / 10\,000$
0.3–3 kPa	=	$0.75 \times 0.002 \times \text{Viscosity}_{\text{substance}} / 10\,000$
≥ 3 kPa	=	$0.50 \times 0.002 \times \text{Viscosity}_{\text{substance}} / 10\,000$

(formula 3)

### Density of the previous cargo

The density during unloading of a previous cargo may vary between 700 and 1 800 kg/m<sup>3</sup>. For example, at 20°C, density of ether = 710 kg/m<sup>3</sup>, oil = 900 kg/m<sup>3</sup>, water = 998 kg/m<sup>3</sup>, wax or H<sub>2</sub>SO<sub>4</sub> = 1 800 kg/m<sup>3</sup>. The temperature during unloading can change the density of the substance. The OECD 109 guideline (OECD, 1995a) indicates that a wide variety of methods can be used to determine the density of a substance and refers to the specific guidelines for their applicability.

If the physical properties of the previous cargo are taken into account (density<sub>previous cargo</sub> = 700–1 800 kg/m<sup>3</sup>; viscosity = 0.233–50 mPa.s and vapour pressure < 0.3 to > 3 kPa), the worst-case concentration levels of previous cargoes without cleaning (remainder<sub>pump</sub> = 1 m<sup>3</sup>, density<sub>oil</sub> = 900 kg/m<sup>3</sup>) are estimated to be:

- 6.5–17 g/kg oil for the smallest tank in sea-going vessels (200 m<sup>3</sup>, surface area 232 m<sup>2</sup> for tanks and 79 m<sup>2</sup> for supply lines).
- 260–670 g/kg oil for the smallest tank in road carriers (5 m<sup>3</sup>, surface area 18 m<sup>2</sup> for tanks and 6 m<sup>2</sup> for supply lines).

Substances with high density, high viscosity and low vapour pressure comprise the worst-case situation.

## 4.4 Tank cleaning

### 4.4.1 General considerations

Cleaning of the tanks before loading of fats and oils is a very important process – effectively a critical control point. The maximum possible contamination level is

determined by the extent of the cleaning process. The efficiency of cleaning the transport/storage system and supply lines depends on the removability of the previous cargo with water, solvents and/or cleaning agents, the cleaning temperature, the cleaning time and the number of rinsing steps.

No cleaning data are available for railroad/road tankers, inland water vessels or storage tanks. Cleaning data are only available for sea-going vessels. The procedure for tank cleaning for sea-going vessels is rigorous and well described (Chemserve, 2006; Verwey, 1998).

Cleaning generally includes the following stages:

- Choice of cleaning regime
- Pre-cleaning (spraying with cold seawater)
- Cleaning (spraying with hot seawater or seawater and cleaning agents)
- Final treatments: rinsing/flushing with freshwater, steaming, draining, venting/mopping/drying
- Verification of the results by a superintendent (inside the tank)

Tanks are cleaned by automatic cleaning machines. These high pressure spraying machines – called Butterworth – are of a special design and are mounted inside the tank (Butterworth, 2006). In a modern chemical tanker, the tanks are designed so that the Butterworth can spray all areas of the walls. The pumps, filling and emptying lines are cleaned simultaneously in a similar manner, ensuring that positive pressure is maintained (Chemserve, 2006).

#### 4.4.2 Physico-chemical properties in relation to cleaning

The physico-chemical properties of a cargo determine which cleaning steps are required to clean the tanks to appropriate standards.

**Water soluble and water miscible substances** are easy to clean with water and the solubility of the substances might increase at higher temperatures. The use of a cleaning agent is only advisable for reduction of the cleaning time or for odour removal for substances such as phenol (Chemserve, 2006).

Solubility in water is defined as the maximum amount of substance that will dissolve in water at a specified temperature (usually 20°C). The OECD 105 guideline (OECD, 1995b) recommends one of two methods: the shake flask method or the column elution method. Solubility in water (at 20°C) ranges between infinite (sulphuric acid) to insoluble (waxes). The following descriptive terms of solubility for a liquid in water apply (IMO, 2002):

Infinite, completely soluble, soluble in all proportions, miscible, very soluble, soluble:	≥ 5% (w/v) or ≥ 50 g/litre
Partially soluble, moderately soluble, slightly soluble:	0.1–5% (w/v) or 1–5 g/litre
Insoluble, barely soluble, immiscible, almost insoluble:	< 0.1% (w/v) or < 1 g/litre

**Products with a high melting point** should be washed at a temperature of 15°–20°C above melting point. During washing, there should be no ballast water or cold cargoes adjacent to the tank to be cleaned. During cleaning, special attention should be given to liquid and vapour line systems to avoid freezing/solidification at

cold line segments. Washing as soon as possible after discharge is recommended (Chemserve, 2006).

**Products with high viscosity** generally require a pre-wash at higher temperatures using tank cleaning additives. Some viscous substances are pumped off tankers at elevated temperatures and the pre-wash is not always mandatory. In general, viscosity is closely related to temperature and it decreases at higher temperatures. During washing there should be no ballast water or cold cargoes adjacent to the tank to be cleaned. Washing as soon possible after discharge is recommended. Some highly viscous cargoes (lube additives or polyols) need to be pre-cleaned with lower or moderate temperatures, because they tend to have undesired reactions at higher temperatures (Chemserve, 2006).

**Products with high vapour pressure** (> 50 kPa at 20°C) can be removed from the tank by evaporation (ventilation). Products which leave residue (crude products) should never be cleaned by evaporation. The non-volatile matter content in the specification of the product is a good indication to determine whether a product will leave residue. Products containing inhibitors must be washed thoroughly. Any inhibitor left in the tank is difficult to remove and nearly always has a negative influence on the wall-wash and on the next product to be loaded. Cargoes consisting of mixtures with different vapour pressures should be neither cleaned by evaporation nor pre-washed hot. The evaporation of the light substances from a mixture could result in non-volatile residues which are very difficult to remove (Chemserve, 2006).

**Products with a low flashpoint** require the pre-cleaning temperature to be well below (at least 10°C) the flashpoint to avoid flammable mixtures. If this is not possible, because the flashpoint is lower than the ambient temperature, any ignition source must be eliminated (Chemserve, 2006).

**Products with limited or no solubility in water** and a specific gravity below 1.0 will float on water; a specific gravity above 1.0 indicates that the product will sink in water. Cleaning agents are required to improve the water solubility of the cargo. Selection of the appropriate cleaning agent depends on the non-water soluble product residue's ability to form emulsions or soaps or to be acid soluble. A soap is formed if a fat or oil reacts with potassium hydroxide (KOH) to form glycerol and fatty acid ions. Cleaning agents often have elaborate names and consist of complexing agents, surface active agents, additives (emulsifiers), KOH (saponifiers) or phosphoric acid (acid soluble) (Chemserve, 2006).

**Products that tend to polymerize** (vinyl, vinylidene, acrylic, or carbonyl compounds, styrene, ethylene oxide, propylene oxide, ethylene, propylene, isobutylene, butadiene, isoprene) require cold (ambient) water. Washing with hot water may result in polymeric residues left behind in tanks and lines, and these are very difficult to remove. To avoid any polymerization by loss of inhibitor-protection, it is also recommended to wash immediately after discharge (Chemserve, 2006).

**Products that may not come into contact with water** must be washed with a suitable solvent which does not contain any water. Cleaning is carried out with a suitable solvent (e.g. butylglycoether, methanol, acetone, toluene, or 50/50 v/v mixtures of methanol and acetone). Solvents with a low flashpoint (e.g. methanol, acetone) have been banned by some shipping companies following serious accidents or explosions. Inertization down to less than 5 percent oxygen is mandatory. Isocyanates (MDI/TDI) must never come into contact with water, nor must their

residues, because the reaction product and insoluble urethane are very difficult to remove. MDI or TDI need to be cleaned by methylene chloride. Lube additives need to be cleaned with baseoil or gasoil. Sometimes a solvent is combined with an emulsifying cleaning agent (mixture of solvent, surface active agents and additives) (Chemserve, 2006).

**Drying and semi-drying vegetable and animal oils** react with oxygen to form a varnish-like polymeric film. This is very difficult to remove from the bulkheads. Heat increases the reaction speed. Therefore the initial washing of these products must be done with water at ambient temperature without any delay after unloading the cargo. Heated cargoes in adjacent tanks should be avoided (Chemserve, 2006).

**Fatty acids and vegetable oils with a high free fatty acid content** form white sticky residues (calcium and magnesium soaps) if they are cleaned with hard water (e.g. seawater). Heat increases these reactions: a 10°C increase in temperature doubles the chemical reaction rate. The best method for pre-cleaning is to prepare the required amount of freshwater in a separate and clean tank and to add a suitable water hardness remover. If seawater or untreated freshwater must be used for cleaning, the formation of white residues or a white powdery film cannot be avoided (Chemserve, 2006).

**Sodium silicate solution** will form calcium and magnesium silicates if washed with hard water and these are very hard to remove. Sodium silicate solution should therefore be washed with freshwater only and never with seawater (Chemserve, 2006).

**Odour-producing cargoes** can contaminate a sensitive cargo, even if there is only a small amount of residue left in the lines, valves, pumps or gaskets. To neutralize the odour of some chemicals (e.g. acrylate, nitrobenzene, Pygas), the use of an odour remover may be recommended. An odour remover (containing NaOH, soap, phosphates, silicates) should be used in combination with an emulsifier (containing complexing agents, surface active agents and additives). The tank should be cleaned by recirculation to guarantee complete removal of the odour-producing cargo (Chemserve, 2006).

#### **4.4.3 Cleaning procedures**

##### **Choice of cleaning regime**

After careful review of the properties and conditions, the cleaning steps can be planned in detail. Each step should be described in terms of the operating parameters (cleaning method, temperature, cleaning medium and duration). Tank-cleaning guides suggest the cleaning regime for each individual substance (cleaning medium, temperature, duration) to be used before loading edible fats and oils. Typically there are two cleaning standards to distinguish: water white and high purity. The high purity standard is required for food and pharmaceuticals (Chemserve, 2006).

##### **Pre-cleaning**

Pre-cleaning is the first cleaning step, usually carried out with seawater or freshwater without cleaning agents in order to remove the majority of product residue. The cleaning temperature and the temperature of the adjacent tanks are important parameters for successful cleaning. When water is not allowed, pre-cleaning is carried out with a suitable solvent. Pre-cleaning generally takes several hours and the sooner pre-cleaning is done after discharge, the easier it is to remove

the product residue. Pre-cleaning is very important, because it is very difficult to obtain a satisfactory result following an initial mistake (Chemserve, 2006).

### **Cleaning**

Cleaning is the sequence of steps which should be carried out in order to remove virtually all product residue. Cleaning can be carried out by combinations of ventilation (volatile products only), spraying, recirculation and/or steaming.

Some cargoes require the use of a cleaning agent for efficient cleaning. Most cleaning agents are additives which are used in combination with water to improve the water solubility of the cargo to be cleaned. Only very few cargoes which cannot be cleaned with water-based systems require a non-water-based solvent as a cleaner (sometimes in combination with an emulsifier). To neutralize the odour of some chemicals, the use of an odour remover may be recommended in combination with an emulsifier. For most cargoes a variety of cleaning agents are available. Cleaning agents must be IMO-approved. Cleaning concentrations, times and temperatures in the final cleaning steps are recommended in the cleaning guides to achieve a satisfactory result. Cleaning generally takes several hours.

Steaming is the introduction of saturated steam into the tank to evaporate volatile residue (odour removal). The steam will condense on the tank surfaces. The temperature should normally be as high as possible during steaming. This is enhanced if the adjacent tanks (including ballast tanks) are empty (Chemserve, 2006).

### **Final treatments**

A sequence of steps are necessary in order to remove trace product residues, cleaning agents, solvents and seawater to reach the required cleaning standard:

- **Rinsing/flushing.** Spraying of water (usually freshwater) with an automatic cleaning machine onto the tank walls in order to rinse chloride-containing water and traces of contamination from the tank surface. A sanitizing solution can be used if necessary. For optimal results the chloride content of the water must be less than 0.1 mg/litre (distilled water, deionized water, demineralized water by microfiltration).
- **Steaming.** Introduction of saturated steam into the tank to reduce the chloride levels. If the chloride level of the water is too high, the use of steam for removal of chloride is often the only feasible option. Clearly the steam quality depends on the construction of the boiler. If the steam has acceptable low chloride levels, steaming is a good method to reduce chloride levels. If the steam is used to remove chloride, the wall temperatures should be cool (in contrast to the evaporation method described above) – this results in condensation and water film running down the tank walls to wash the chlorides off.
- **Venting/mopping/drying.** Ventilation removes water, moisture and odour, which is usually done by forced air circulation; mopping reduces drying time if there are water pools on the tank bottom; drying must be done very carefully (Chemserve, 2006).

#### **4.4.4 Verification of cleaning**

The cleaning procedure is mandated in the contract and assured by (visual) inspection of the inside of the tank. Thus the maximum possible extent of contamination is determined by the minimum visible volume or the extent of adherence/absorption after the cleaning process.

The FOSFA Code of Practice for Superintendents requires that the cleaned ship tanks are inspected by authorized and independent superintendents prior to the loading of the vessel with oil. This can only be performed by entering the tank. The tank and all other equipment (cleaning machine, pumps, supply lines, dead ends, gaskets, heating coils) coming into contact with the cargo must be inspected. The entire tank should also be checked for odour and moisture. A hand spray method can also be applied to correct unsatisfactory cleaning results identified during tank inspection.

If the subsequent cargo requires a high purity standard (as is the case with edible fats and oils), a wall-wash test (see below) must be carried out. The test requirements are usually defined by the loader. If stainless steel tank walls are discoloured or show rust stains it might be necessary to carry out a dye out, pickling or passivation operation (Chemserve, 2006).

- **Dye out.** Discoloration of the tank or the coating can be removed by the “dye out” method. For azogroups (-N=N-) it can be removed by spraying or recirculation with 0.5 to 2 percent sodium hypochlorite solution. If this does not work, steaming or solvent steaming could help.
- **Pickling.** Pickling is the removal of any high temperature scale and any adjacent chromium layer of metal from the surface of stainless steel by nitric acid (HNO<sub>3</sub>) and hydrofluoric acid (HF) to restore the corrosion resistance of the stainless steel. Pickling solutions also remove contaminants such as ferrous and ferric oxide particles.
- **Passivation.** Passivation is the treatment of the surface of stainless steels, often with nitric acid (HNO<sub>3</sub>) solutions or pastes, to remove contaminants and promote the formation of the passive film on a freshly created surface (through grinding, machining or mechanical damage).

It is essential that all acids are thoroughly removed by rinsing the component after completing the process.

If the inspection is satisfactory, the superintendents complete a “tank cleanliness certificate”, which also includes a section on the suitability of the tank to receive the oil. This certificate is sent to both the seller and the buyer of the oil and guarantees that the cleaning has been carried out to a satisfactory standard. Unclean tanks or tanks in poor condition are rejected in accordance with contractual obligations (Chemserve, 2006).

- **Wall-wash test.** Analytical testing of tank cleanliness is not easy, because it is difficult to obtain a representative sample from the tank surface. Usually the sample is generated by the so-called wall-wash test. This involves spraying of a highly active solvent (100 ml methanol) against a limited segment of the cleaned tank surface. As a minimum, four sites of approximately 10 × 120 cm (1.2 square feet) each must be chosen in each tank. Any area that appears to have crystalline deposits or discoloured patches should definitely be tested.

The liquid is collected with a funnel and can be analysed using the method required by the charterer (Chemserve, 2006).

- **Permanganate time test.** The permanganate time test is used to judge the presence of oxidizable materials. It is based on the ability of potassium permanganate ( $\text{KMnO}_4$ ) to oxidize hydrocarbon impurities that could be present in the wall-wash liquid. If there is a reaction in a neutral solution, the potassium permanganate is reduced and changes its colour from pink-orange to yellow-orange. After the time, which is typically specified by the loader of the next product, the change of sample colour compared to the reference colour indicates whether or not impurities are present in the sample.
- **Water miscibility (hydrocarbon test).** The purpose of this test is the qualitative detection of non-water-soluble contaminants. It works on the basis that many impurities are soluble in the wall-wash liquid (methanol, acetone), but not in water. A small amount of wall-wash liquid is poured into clear water and the impurities present will lead to cloudiness or turbidity. The water with wall-wash liquid is compared with pure water. Turbidity after 30 minutes means there are still hydrocarbons on the tank surface.
- **Chloride test.** The chloride test is used to judge the presence of chlorides on bulkheads. Chloride levels vary from 0.1 to 0.5 mg/kg depending on the requirement of the charterer. Chlorides will react with silver nitrate/nitric acid solution forming silver chloride ( $\text{AgCl}$ ) which makes the solution turbid. By comparing the sample solution with the various prepared standard solutions, it is possible to establish the chlorides (ppm) in the wall-wash.
- **UV test.** The UV test is used to identify certain hydrocarbons and chemicals. Many hydrocarbons and chemicals have the ability to absorb UV-light when they are exposed to such light. Certain molecular electrons will get excited if exposed to light. The excitation results in absorbance of light which can be measured. Absorbance at a specific wavelength is a measure for concentration of specific compounds.
- **Acid wash.** The acid wash test is used to determine the presence of benzene, toluene, xylenes, refined solvent naphthas and similar industrial aromatic hydrocarbons. This test is also used to detect impurities in methanol. Compounds which cause darkening in the presence of concentrated sulphuric acid due to carbonization can be detected with this test.
- **Colour test.** Certain impurities result in discoloration of the wall-wash sample. The colour of the wall-wash liquid is compared with unused wall-wash solvent. Mostly, the so-called Alpha colour is measured.
- **NVM test.** This test is used to determine if there are non-volatile impurities on the tank surface. A defined quantity of the wall-wash liquid is evaporated. The weight of the residue, the so-called NVM (non-volatile matter), is detected by weighing. This is then divided by the original weight of the sample. The NVM content must not exceed the value specified by the loader.
- **COD test.** Some companies have implemented a so-called COD (chemical oxygen demand) test to determine the presence of impurities. The impurities are extracted by means of a solvent and analysed with an oxidizer, such as potassium chromate.

#### **4.4.5 Cleaning of coated tanks**

For the cleaning of coated tanks (as opposed to stainless steel tanks), a number of further issues need to be taken into consideration.

##### **Zinc silicate coating**

Zinc silicate coating is an anti-corrosive paint system that is based on zinc dust (86 percent wt) with some additives and a binder. Zinc silicate coatings are inherently porous, which results in a variety of cleaning problems. It is believed that the cargo migrates into the pores and capillaries. Zinc silicate coatings have good resistance to solvents, but are not resistant to strong acids and bases. Volatile cargoes are desorbed very fast, non-volatile oil-like cargoes are retained. The cleaning of the coating is similar to the regeneration of an adsorber bed. This is typically performed by heating preferably close to or if possible above the boiling point of the liquid. Desorption takes place relatively fast, provided that the required parameters (temperature and medium to transport the substance) prevail.

The removal of volatile liquids (measurable vapour pressure, low boiling point) can be achieved relatively easily by pre-cleaning with warm to hot water or steaming, depending on the volatility of the liquid.

Non-volatile liquids (negligible vapour pressure, high boiling point) are extremely difficult to remove, as a very high temperature would have to be reached to evaporate the liquid (e.g. mineral oils, vegetable oils). The cargo must therefore be dissolved in the pores and capillaries, for which a cleaner with a high solvency power (methanol) is typically required. The major difficulty when dissolving a non-volatile cargo during tank cleaning is the relatively short contact time of the liquid. The ideal solution is to transport a cargo with high solvency power and a low cleanliness requirement.

In certain cases, especially for zinc silicate coatings contaminated with non-volatile residues, it is necessary to use solvent steaming to remove tenacious residues. The most common solvent employed for this purpose is toluene. The concentrations needed for effective cleaning of non-volatile residues will always exceed the low electrical conductivity of toluene, thereby resulting in a flammable mixture in the tank. The tank must be inerted down to an oxygen content of less than 5 percent prior to toluene steaming in order to eliminate the risk of explosion (Chemserve, 2006).

##### **Epoxy coatings**

The different epoxy types (pure epoxy, phenolic epoxy, isocyanate epoxy) form cross linkages to different degrees resulting in relatively good resistance to a wide range of cargoes. Phenolic epoxy (Epoxy Novolac) resin films have the highest resistance to chemicals. Epoxy systems are resistant to many strong acids and alkalies and do not absorb oil-like substances. Epoxy coatings tend to absorb solvent-like cargoes. This absorption is caused by swelling and subsequent softening of the coating. The swelling reduces the density of the coating and enables the cargo molecules to migrate into the coating. Some cargoes may even be chemically bonded to the coating by molecular forces. Typically, the cargo is absorbed within a couple of days to the maximum level (equilibrium) and stays constant for the remainder of the voyage. The absorption rate and the amount of cargo absorbed depend on the type of cargo. After transporting aggressive cargoes (methanol, EDC, acetone, vinyl acetate monomer, cyclohexanone), the coated tank has to be ventilated until the cargo has been desorbed (released) from the coating film, which results in

hardening and decreasing swelling. The desorption (removal) of the cargo residue from the coating by ventilation begins rapidly. After a couple of days, there is no significant further loss of the retained cargo. The desorption comes to a standstill before all cargo has been released by the coating. The amount remaining varies, depending on coating type, film thickness and type of cargo. Water may not be used for cleaning until this ventilation process is finalized. If residues remain they will probably be solved during a wall-wash with methanol, because the methanol causes the coating to swell again and the high solvency power will extract the residues.

If the coating is not soft, ventilation is not necessary and normal cleaning procedures apply. If the coating is soft, the tank should be ventilated for at least 24 hours after discharge, or longer if the coating system has not fully recovered. The desorption of a cargo can be accelerated by higher temperatures. Cargoes with a vapour density higher than air have to be removed by forced circulation, to avoid accumulation at the tank bottom. Ventilation must provide moisture-free dehumidified air to the lowest point of the tank. Likewise, extraction dusts must also reach the lowest point of the tank to help remove the solvent vapours. Water and steaming should not be used before full recovery of the coating system to avoid adverse effects on the coating (Chemserve, 2006).

#### **4.5 EXPECTED CONTAMINATION LEVELS AFTER TANK CLEANING**

##### **4.5.1 Stainless steel tanks**

About 10 kg of any product remaining in the tank of a sea-going vessel after cleaning would be obvious to the inspecting superintendent. An additional 1 kg of previous cargo could remain trapped in the associated pumping lines. The product seen by the superintendent is the volume of the rinse water, not the previous cargo. The concentration of the rinse water is probably less than 1 percent (w/w) or, in a worst case, 10 percent (w/w) as a result of poor cleaning practices. The maximum level of 10 percent (w/w) previous cargo in the rinse water corresponds to  $0.1 \times (10 + 1)$  kg of previous cargo which may remain in the tank after cleaning.

For the smallest tank of a sea-going vessel of 200 m<sup>3</sup>, filled to 60 percent volume with oil, this results in a maximum contaminant level of  $0.1 \times (10 + 1)$  kg per  $(0.6 \times 200 \text{ m}^3) = 0.0092 \text{ kg/m}^3$  in the subsequent cargo. Assuming a density of 900 kg/m<sup>3</sup> for oil, this is equivalent to a contamination level of 10 mg/kg.

Experiments have been carried out where stainless steel tanks from three different vessels were loaded with a certain cargo, discharged, cleaned and re-loaded with another cargo (not an oil). The contamination level in the second cargo was analysed before loading, at several intervals during loading and at discharge. Contamination levels in the three different vessels at discharge were < 0.01, 0.045 and < 0.05 mg/kg (Hancock, 2006a).

Any contamination from a previous cargo in sea-going vessels is unlikely to be greater than 10 mg/kg, and is generally much lower. Cleaning efficiency tests have shown that the order of magnitude is likely to be about 1 mg/kg.

The same concentration level is achieved, regardless of the physico-chemical properties of the substance. Although this is contrary to expectations, the cleaning process is adapted for each individual substance in such a way that for every previous cargo the same final concentration level is achieved.

The ruling body (Council) of FOSFA agreed many years ago that any member who experienced a cargo contamination were to inform FOSFA of the circumstances using a standard form. This requirement has been regularly reinforced through circulars issued to members. The log of these contaminations shows that there have been no more than 20 cases of residues from previous cargoes in edible fats and oils since 1992. Most of these have been at levels of less than 10 mg/kg and are frequently from second previous cargoes of EDC and Styrene monomer, which are exceptionally persistent substances in coated tanks. There are a few cases of higher contaminations due to the cracking of a bulkhead between tanks, and there have also been two cases of deliberate adulteration of the cargoes, which is fraud and outside the scope of any regulations.

In summary, the expected contamination levels after cleaning lie somewhere in the range of 1–10 mg/kg for stainless steel tanks.

#### **4.5.2 Coated tanks**

Organic coatings may exhibit some absorption of the cargo during a voyage, which is one of the main reasons for trading on acceptable list terms. Various information was available from which an indication of the extent of absorption and desorption processes could be obtained.

The absorption of a cargo into organically coated tanks (usually epoxy resin) is one of the main reasons why some receivers require that the previous cargo in the tank is on the acceptable list. While much of the adsorbed cargo is desorbed again during the tank-cleaning process – with the help of high temperatures – there is no doubt that some of the previous cargo remains in the coating and may be desorbed into the subsequent cargo. Whether this happens depends on the solubility of the residue of the previous cargo in the subsequent edible fats and oils cargo.

Experiments have been carried out where coated steel panels were immersed in a cargo, cleaned according to Verwey's cleaning protocols and then immersed in oil. Contamination levels were generally in the order of 1–15 mg/kg of oil, although higher levels were produced by some solvent-type chemicals (Couts, 1991).

Coated tanks can absorb the cargo in question. The absorption rate and the amount of previous cargo absorbed by the coating depend on the type of previous cargo. For epoxy-coated tanks the desorption (removal) of the cargo residue from the coating by ventilation (as part of the cleaning process) starts rapidly, but after a couple of days desorption comes to a standstill before all the cargo has been released by the coating. The remaining amount varies depending on coating type, film thickness and type of cargo. The retained amount can lead to concentrations of 50–100 mg/kg in the subsequent cargo.

This concentration level is calculated using the following assumptions:

Typical weight of coating:	1 kg coating/m <sup>2</sup> tank wall
Typical surface to volume ratio:	1 m <sup>2</sup> surface : 1 m <sup>3</sup> tank volume
Typical density of cargo:	1000 kg/m <sup>3</sup> (specific gravity = 1.0)

$$\text{Concentration (mg/kg)} = \{\% \text{ absorbed} \times 10^{-2} \times \text{surface} / (\text{volume} \times 1\,000)\} \times 10^6$$

From this formula a general rule can be derived: 1 percent absorbed previous cargo could cause a concentration of 10 mg/kg in the subsequent cargo, if completely dissolved (Chemserve, 2006) (Table 3).

TABLE 3  
Percentage absorbed for epoxy coated tanks

Cargo	% absorbed (kg cargo/kg coating)	Maximum in subsequent cargo (mg/kg)
EDC (ethylene dichloride)	3	30
Methanol	4	40
Vinyl acetate monomer	5	50
Styrene monomer	6	60

Therefore, the expected concentration levels after cleaning will lie somewhere in the range of 10–100 mg/kg for coated tanks.

#### 4.6 HOMOGENEITY

In addition, the inhomogeneity of residues due to the viscosity of the fat or oil should be considered. If contaminants may be inhomogeneously distributed in a shipload of fats or oils, this needs to be taken into account in the estimation of worst-case concentration levels.

#### 4.7 MICROBIAL OR PATHOGENIC CONTAMINATION

Microbiological growth requires the right combination of conditions: moisture, temperature and nutrients. Edible fats and oils contain very low levels of proteins and carbohydrates, if any. In addition, a 1 000-tonne tank of most edible fats and oils will contain about 500 kg of water, but this is well dispersed and does not promote microbiological growth. As edible fats and oils are low in protein and moistures (normally < 0.5 percent for crude edible fats and oils and < 0.1 percent for refined edible fats and oils), microorganism contamination is not an issue.

Because microbiological aspects are part of the normal quality procedure in the edible fats and oils industry and the shipping industry, additional microbial contamination as a result of previous cargoes (e.g. molasses, concentrated fruit juices) need not be considered. Chemical substances causing microbial or pathogenic contamination are not known.

#### 4.8 ALLERGENIC CONTAMINATION

Products known to contain or be food allergens (or trigger food intolerance) are cereals containing gluten, crustaceans, eggs, fish, peanuts, soybeans, milk, tree nuts, celery, mustard, sesame seeds – and products thereof – animal products, sulphur dioxide and sulphite (EU, 2003).

Vegetable oil and vegetable oil products derived from peanuts and soybeans are subject to refinement processes prior to shipment that virtually eliminate the presence of allergenic protein (Mogerley, 2006). Groundnut oil is largely exported in drums, ISO tanks or other modes of packaging. Thus, the risk of exposure to

allergens posed by these two oils as a previous cargo is not an issue, considering the thorough cleaning procedure prior to loading into the tank (Mogerley, 2006).

Dairy products are very rarely, if at all, carried by ocean tankers due to the need to refrigerate them to prevent spoilage. Furthermore, dairy products are carried in dedicated vessels/tanks only, thereby eliminating the problem of residues of previous cargoes (Mogerley, 2006).

Apart from these known examples, however, it cannot be excluded that previous cargoes (or reaction products thereof) would by definition not be a cause of allergenic or food intolerance reactions. It is important to take into consideration both oral and dermal allergenicity because “edible” fats and oils may be destined for use by the cosmetic industry.

## **5. Reactivity of previous cargoes with edible fats and oils**

### **5.1 POSSIBLE REACTIONS**

Edible fats and oils are chemically quite inert under normal handling conditions. Concern should be focused on those reactions with residues of previous cargoes that can give rise to products that are not removable by further processing and are hazardous to health. Consideration must also be given to:

- which chemical substances can react with edible fats and oils; and
- the conditions under which these reactions can occur.

The susceptibility of edible fats and oils to react with previous cargoes depends on a number of factors including the type of fat or oil, whether it is crude, partially or fully refined, and whether impurities are present. Reactions likely to occur during transport are oxidation and hydrolysis.

#### **5.1.1 Oxidation**

When lipids are removed from their natural protective environment (oleiferous cells for vegetable oils and adipocytes for animal fats) and stored or used, they undergo a reaction known as autoxidation. The autoxidation processes are generally considered to occur in three phases: an initiation or induction phase, a propagation phase, and a termination phase (ITERG, 2006a).

During the initiation phase, molecular oxygen (active oxygen) attacks the double bonds of unsaturated fatty acids to produce peroxides, hydroperoxides and free radicals, each of which are very reactive. The structure of these compounds depends on the nature of the fatty acids under attack. For this phase to occur at any meaningful rate, some type of oxidative initiators must also be present, such as chemical oxidizers, transition metals (iron or copper) or enzymes (lipoxygenases). The reactive products of this initiation phase will, in turn, react with additional lipid molecules to form other reactive chemical species, e.g. alcoxyl radicals, produced through fission. The propagation of further oxidation by lipid oxidation products gives rise to the term autoxidation. In the final termination phase of lipid oxidation, relatively unreactive compounds are formed whose type and quantity depend on various parameters. The terminal volatile oxidation compounds include aldehydes, hydrocarbons, ketones, acids and smaller amounts of epoxides and alcohols. The terminal non-volatile oxidation compounds are mainly monomer triglyceride oxides with at least one altered fatty acid containing a hydroxyl, carbonyl or epoxy functional group. Because many compounds produced during the termination

phase are volatile, their concentration in the product may also begin to decrease over time. The reaction products continue to increase until:

- storage conditions change;
- one or more initiators are depleted;
- available oxygen is consumed; or
- the lipid substrate is exhausted (ITERG, 2006a; ISEO, 2006; N-PAL, 2006).

Although oxidation is a spontaneous phenomenon, its kinetics can be accelerated or decelerated under the effects of different parameters (ITERG, 2006a):

- Type of fat or oil, in particular the type of fatty acid. The more unsaturated the fat or oil, the greater its susceptibility to oxidative rancidity (ISEO, 2006).
- Old oils. Fresh oil should never be mixed with old, as the older oil catalyses oxidation in fresh oil extremely quickly. Pumps should therefore always be cleared of older oils, and the pipes should be inclined so that oil never remains in them (Karlshamms, 2006).
- Temperature. Oxidation proceeds more rapidly as temperature increases, so each operation should be carried out at the lowest practicable temperature. The higher the temperature, the greater the extent of oxidation. A rule of thumb is that a temperature rise of 10°–15°C reduces shelf-life by half. By the same token, shelf-life is doubled if the temperature is reduced by the same amount. An oil should never be stored at more than 10°–15°C above its melting point. Also, the external temperature of heating coils should never exceed 80°C, in order to prevent local overheating of the oil. By storing at the lowest possible temperature, taking into account the oil's setting point, oxidation can be kept to a minimum (CAC, 1987; Karlshamms, 2006).
- Time. The greater the storage time, the greater the extent of oxidation. By minimizing the oil's storage time, oxidation can be kept to a minimum (Karlshamms, 2006).
- Light. Light, in particular UV, increases the rate of oxidation. Fats and oils should therefore always be stored and handled protected from light (Karlshamms, 2006; ISEO, 2006).
- Transition metals. The rate of oxidation is greatly increased by the catalytic action of copper or copper alloys; such metals (exposed or plated copper alloys, brass, bronze, gun metal) must therefore be rigorously excluded from the systems. Other metals, such as iron, also have catalytic effects although less than copper. For this reason, pumps, tanks, pipes, valves, heating coils and other equipment coming into contact with the oil should never be made of or contain such metals (CAC, 1987; MEIC, 2006).
- Oxidizer elements
- Glyceride hydrolysis
- Activity of certain catalysing enzymes (lipoxidase and lipoxygenase).
- Accelerators, such as pigments.
- Presence of decelerators, such as antioxidants (or antioxygens), metal chelators, oxygen absorbers. Fats and oils may be treated with chelating agents such as citric acid to complex transition metals (thus inactivating their pro-oxidant effect) (ISEO, 2006).

Previous cargoes that might be able to induce/accelerate the autoxidation of edible fats and oils are:

- substances able to form radicals like peroxides (structure R-O-O-R), e.g. hydrogen peroxide; or
- solutions of transition metals, e.g. copper, iron, manganese.

### **5.1.2 Hydrolysis**

Hydrolysis is a reaction of oil with water to yield free fatty acids. Partial hydrolysis of triglycerides will yield mono- and diglycerides and free fatty acids. When hydrolysis is carried to completion with water in the presence of an acid catalyst, the mono-, di- and triglycerides will hydrolyse to yield glycerol and free fatty acids (acid hydrolysis). With aqueous sodium hydroxide, glycerol and the sodium salts of the component fatty acids (soaps) are obtained (alkaline hydrolysis). Hydrolysis does not normally cause any problems, as long as the products are handled hygienically and have not come into contact with water (ISEO, 2006; Karlshamms, 2006; N-PAL, 2006). The hydrolysis of edible fats and oils is promoted by (CAC, 1987; ISEO, 2006; N-PAL, 2006; MEIC, 2006):

- the presence of water, particularly at higher temperatures.
- enzymes (lipases): lipases are often found in connection with contamination by organic material; they are present in the digestive tracts of humans and animals and in bacteria, and are also present in some edible oil sources (palm fruit, coconut); any residues of these lipolytic enzymes (present in some crude edible fats and oils) are deactivated by the elevated temperatures normally used in oil processing.
- chemical catalysts (acids, bases, reactive metals).

Previous cargoes that might be able to induce/accelerate hydrolysis of edible fats and oils are:

- acids and bases (substances having a  $pK_a$  or  $pK_b$ ), e.g. acetic acid, acetic anhydride, fatty acids, phosphoric acid, sulphuric acid, citric acid solution and sodium hydroxide solution.
- previous cargoes containing water (> 5 percent water), e.g. fruit juices and potable water.
- crude edible fats and oils containing lipases (palm fruit oil, coconut oil, animal fats); currently, almost 20 million tonnes of crude palm oil are shipped around the world each year; the first stage of producing palm oil is steaming to kill the lipases which are present in the fruit.

Hydrolysis reactions are not relevant in the context of the evaluation, because acids and/or bases are added to edible fats and oils during the refining process. Sodium hydroxide (basic) is added during saponification to remove the free fatty acids, while phosphoric and citric acids (acidic) are added during the degumming stage to remove phospholipids.

### **5.1.3 Spanish toxic oil syndrome**

In 1981 in Spain, rapeseed oil which had been denatured for industrial use by the addition of aniline was fraudulently re-introduced into the food-chain after it had been processed in an attempt to remove the aniline. The ingestion of this oil caused an outbreak of toxic oil syndrome (TOS), clinically characterized by intense incapacitating myalgias, marked peripheral eosinophilia and pulmonary infiltrates. Of the 20 000 people affected, approximately 300 died shortly after the onset of the disease and a larger number developed chronic disease. The commonly accepted hypothesis states that toxic compounds developed during the refinement process were used to remove the aniline, which is used to denature oils intended for industrial use. For more than 15 years, a scientific committee supported by WHO has guided investigation intended to identify the causal agent(s), to assess toxicity and mode of action, to establish the pathogenesis of the disease, and to detect late consequences. Attempts to reproduce the condition in laboratory animals have been unsuccessful, and no condition similar to TOS has been reported in scientific

literature. Laboratory findings suggest an auto-immune mechanism for TOS, such as high levels of seric soluble interleukin-2 receptor. Epidemiologic studies integrated with chemical analyses of case-related oils have shown that the disease is strongly associated with the consumption of oils containing fatty acid esters of 3-(N-phenylamino)-1,2-propanediol (PAP). These chemicals have also been found in oils synthesized under conditions simulating those hypothesized to have occurred when the toxic oil was produced in 1981 (Gelpi *et al.*, 2002; WHO, 2004).

#### 5.1.4 Other possible reactions

Other possible reactions with the double bond in edible fats and oils are hydrogenation, hydroxylation, oxidative fission, halogenation, oxymercuration, metathesis isomerization (stereomutation), metathesis, double bond migration, cyclization, dimerization and polymerization. These reactions require high temperatures (above 200°C) and/or defined conditions with special reagents/catalysts which are not available under the transport conditions (Gunstone, 1996; ITERG, 2006a; ISEO, 2006).

Other possible reactions with the carboxylic ester group of edible fats and oils are esterification and decarboxylation. These reactions require raised temperatures (80°–150°C) and/or defined conditions with special re-agents/catalysts which are not available under the transport conditions (Gunstone, 1996).

The reaction of the previous cargo with triglyceride and fatty acid impurities in crude edible fats and oils must be considered, e.g. ethylation and methylation. A simple way of dealing with the reaction products could be: “Any reaction products should comply with the criteria which are applied to previous cargoes.”

## 5.2 TYPICAL CONDITIONS DURING LOADING/UNLOADING AND TRANSPORT/STORAGE

Deterioration of edible fats and oils is dependent on the conditions during transport/storage (temperature), the materials of the tankers (possibility of leaching of tanker materials), the shape of the system itself (air/oil ratio and possibility of mixing with air) and the duration/residence time of edible fats and oils in the transport/storage system.

The following conditions are assumed:

- Ships' tanks are usually constructed from mild steel, coated mild steel or stainless steel. The coatings are either organic (e.g. epoxy resins or highly cross-linked polymers) or inorganic (e.g. zinc silicate). Zinc-silicate-coated tanks are not used for crude edible fats and oils, unless the acid value is 1 or under (CAC, 1987; FOSFA, 2005a). For crude edible oils and fats, aluminium or black iron is also used (MEIC, 2006).
- Heating coils within tanks, tubes and the internal shell of heat exchangers are made of stainless steel. Valves and pipelines (supply lines) that come into contact with edible fats and oils are made of stainless steel or aluminium (CAC, 1987; FOSFA, 2005a; MEIC, 2006). Aluminium may only be used when the acidity of the oil is low (Hancock, 2006b).
- The temperature during loading/discharge is 10°–70°C, depending on the fat or oil type. Heating should be applied such that average oil temperature increases at a rate of not more than 5°C in a 24-hour period (CAC, 1987).
- The temperature during storage/transport is between ambient and 45°C, depending on the fat or oil type (CAC, 1987).

- The air/oil ratio in a storage tank is 20:80 (v/v). This is based on 5 tonnes of oil (5.6 m<sup>3</sup>) in a volume of 7 m<sup>3</sup>, allowing for splashing space (Karlshamms, 2006). The air/oil ratio in a transport tank is between 5:95 and 40:60, depending on the filling rate (95 to 60 percent).
- The possibility of mixing with air during loading/unloading and during transport/storage should be minimized. A storage tank should be constructed in such a way that the actual surface area of any fat or oil exposed to the air at any one time is as small as possible. Packaging and seals should be checked regularly to ensure no air is leaking. Stirrers inside tanks should be designed so as not to form whirlpools, and should be used as little as possible. It is also preferable to transfer an amount of the oil into a smaller tank for day-to-day use, rather than constantly taking fat or oil from the main storage tank, which generates a certain amount of agitation. Fat or oil should not be transferred back into the main storage tank once it has been taken out. Tanks should be filled from the bottom, rather than pouring an exposed stream of oil from the top (CAC, 1987; Karlshams, 2006).
- The possibility of mixing with contaminants other than previous cargoes (e.g. water, microorganisms, cleaning agents) during loading/unloading and transport should be minimized. Tanks should always be clean and dry before use (CAC, 1987).
- The general duration/residence time is estimated at 2–8 days for road or railroad or inland waterways, 1 month for sea ships, and 7 days to 6 months for storage tanks (assumptions made by the experts).
- Maximum levels of previous cargoes are estimated to be 1–100 mg/kg (see previous sections).

### **5.3 SAFETY VERSUS QUALITY OF EDIBLE FATS AND OILS**

With respect to quality aspects, the following two options need to be considered:

#### **Option 1. Reactivity of previous cargoes with edible fats and oils not considered**

Deterioration of the quality of the edible fats and oils due to oxidation, hydrolysis etc. is not within the scope of the development of criteria for acceptable previous cargoes. If the fats and oils industry had not sorted out these issues over the last 60 years, then they would not be shipping 45 million tonnes each year. It is accepted in most food auditing systems that there is a clear difference between food quality and food safety. The scope of the development of criteria for acceptable previous cargoes is to investigate the food safety aspects of the carriage of fats and oils in bulk by sea. Quality aspects, such as loading from the bottom of the tank, addition of anti-oxidants prior to loading, or nitrogen-blanketing of high-quality oils during the voyage, are matters for the buyers, shippers and sellers. These protocols have been established for many years.

The general loss of quality due to oxidation (increase in peroxide values) or hydrolysis (increase in free fatty acid [FFA] content) during a voyage has always been present in the shipping of edible fats and oils in bulk by sea. If crude palm oil is shipped from Malaysia to Europe at about 45°C at a starting FFA of about 5 percent, the increase in FFA has been found to be less than 0.3 percent. There are ways of reducing this as required – for example, nitrogen-blanketing the tank, if the cargo is refined oil to be used directly in the food-chain without re-refining. Given that these quality aspects are normal procedure in the edible fats and oils

industry and the shipping industry, additional oxidation and hydrolysis reactions as a result of previous cargoes need not be considered.

There are already existing guidelines and codes of practice in handling and surveying – including those drafted by the CCFO (CAC, 1987) and FOSFA, PORAM's Code of Practices, and MPOB's Standard Surveying Procedures and Practices for Palm Oil and its Derivatives (currently being updated) – to help minimize such deterioration.

### **Option 2. Establishment of additional levels for reaction products**

As oxidation and hydrolysis are normal reactions during transport, an experimental set-up has to be proposed, whereby additional levels of these reaction products caused by contamination from previous cargoes can be established.

## **6. Analytical issues**

The declaration of the identity of previous cargoes is an integral component of sales/contractual documentation under FOSFA terms and it makes clear what kind of laboratory analysis is required.

Under FOSFA conditions, samples of a fat or oil are taken at three stages: pre-shipment, loading and discharge. At least five pre-shipment samples of the fat or oil loaded are taken at the ship's rail or the nearest practical point prior to loading. At least five samples representative of the fat or oil are taken from each ship's tank. At least five representative samples are taken during discharge at the ship's rail or the nearest practicable point thereafter. Sampling is done in accordance with ISO 5555. In general, one of the samples taken at loading and one of the samples taken at discharge is analysed, and therefore data are available on the fat or oil contamination and quality change during transport (FOSFA, 2005b).

For usual quality and compositional parameters in the trade specifications, official methods (e.g. AOCS, AOAC INTERNATIONAL,<sup>7</sup> ISO, IUPAC and MPOB) are available for identification and quantification of the level of the contamination in the fat or oil. The most generally used method is GC-MS (gas chromatography linked to mass spectrometry), the availability of which is now increasing. ISO has several methods for detecting contaminants (ISO, 2006):

- ISO 6656 for polyethylene type polymers;
- ISO 16035 for low boiling halogenated hydrocarbons; and
- ISO 15303 for volatile organic contaminants.

For other contaminants where there are no official methods, they have to be developed or modified (from other published literature) according to the validation procedures laid down in ISO 17025 for Laboratory Quality Management System or according to accepted guidelines (e.g. IUPAC protocols or the Codex Alimentarius Criteria Approach [CAC, 2005]). Analytical methods used need to be available worldwide (Gunstone, 1996; ITERG, 2006a; Mogerley, 2006; MEIC, 2006).

In general, if a level of 100 mg/kg of residue is expected, the required LOQ (limit of quantitation) must be half this (i.e. 50 mg/kg), while the required LOD (limit of

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<sup>7</sup> AOAC INTERNATIONAL refers to the association previously known as the Association of Official Analytical Chemists.

determination) must be one-tenth (i.e. 10 mg/kg). Expected worst-case concentration levels are 10 mg/kg for stainless steel tanks and 100 mg/kg for coated tanks. Therefore, an LOD of 0.1 mg/kg and an LOQ of 0.5 mg/kg would suffice for both tank types. These levels are easily obtained with GC (gas chromatography) or LC (liquid chromatography) techniques.

Oxidation affects the colour and flavour (taste, odour) of the oil, producing oxidative rancidity. Analytical methods for autoxidation are based on determination of the oxidation products. The most important test methods are based on the determination of: allylic hydroperoxide concentrations (peroxide value) for the initial stage of autoxidation; aldehyde concentrations (anisidine value, thiobarbituric acid [TBA] test, carbonyl value, hexanal value) for the secondary stage of autoxidation; and short-chain acids (Rancimat test) for the tertiary stage of autoxidation. The peroxide value, anisidine value, TBA test and Rancimat test are the most used test methods. Refined unsaturated oils are most susceptible to autoxidation (Gunstone, 1996; N-PAL, 2006; MEIC, 2006).

Hydrolysis affects the flavour (taste, odour) and acidity of the oil, producing hydrolytical rancidity. Analytical methods for hydrolysis are based on determination of the hydrolysis products. Hydrolysis tests are based on the determination of the FFA content, humidity, acid value (or saponification value) or hydroxyl value. The acid value is the most widely used test method. Refined oils for domestic consumption are most susceptible to hydrolysis (Gunstone, 1996; N-PAL 2006; MEIC, 2006).

Edible fats and oils should comply with the quality criteria indicated in the Codex Standards (Codex Stan, 1981a, 1981b, 1981c, 1999a, 1999b). Normal values for refined oils in the Codex Standards indicative for oxidative or hydrolytic rancidity status are:

- peroxide value: up to 10 meq active oxygen/kg oil; and
- acid value/saponification value: up to 0.6 mg KOH/g oil.

Levels in cold pressed, virgin and crude edible oils and animal fats are higher.

Previous cargoes with a colour, odour or strong taste might have an organoleptic effect on edible fats and oils (e.g. the odour of fish oil could affect the odour of other oils). All superintendents smell the tanks before they are loaded or unloaded and look into them during loading and unloading. Smell is a very sensitive sense.

## **7. Oil refining**

### **7.1 OPTIONS**

Some of the deterioration of oils (e.g. oxidation, hydrolysis, contamination by previous cargoes) can be cancelled by refining the oils.

The vast majority of vegetable oils shipped by sea require refining on arrival to meet food-grade specifications. The term “majority” implies that there are cases where a refined oil, transported by sea, is consumed as such. There are a few edible fats and oils, such as cocoa butter, olive oil and palm oil, which are not refined, because the organoleptic qualities would be lost after refining. Peanut oil and soybean oil are refined before transport to avoid allergenicity.

### **Option 1. Oil refining not a possible criterion**

Oil refining needs not to be considered as a criterion for acceptability of previous cargoes, because there are oils and fats that are consumed as such after transportation/storage.

### **Option 2. Oil refining a possible criterion**

Oil refining needs to be considered as criterion for acceptability of previous cargoes.

## **7.2 REFINING PROCESSES**

There are two main refining processes used on crude edible oils and fats: chemical/alkali refining and physical refining. They differ principally in the way free fatty acids are removed (FEDIOL, 2006).

- Chemical refining consists of degumming, neutralization, winterization, bleaching and deodorization.
- Physical refining consists of degumming, winterization, bleaching and deodorization.

### **7.2.1 Degumming**

Crude edible fats and oils have relatively high levels of phosphatides (e.g. soybean oil) and may be degummed prior to refining. The purpose of degumming is to remove seed particles, impurities, phosphatides (phospholipids), pigments, carbohydrates, proteins and traces of metals. The crude edible fats and oils are treated with food-grade processing aids (0.1 percent phosphoric acid) and water at a temperature of 60°–100°C, which leads to hydration of the phosphatides, proteins, carbohydrates and traces of metals. The hydrated material precipitates from the oil and is removed by centrifugation. After the degumming process, the crude edible fats and oils are dried (Gunstone, 1996; ISEO, 2006; FEDIOL, 2006).

A relatively new process is enzymatic degumming. Crude edible fats and oils, pre-treated with a combination of sodium hydroxide and citric acid, are mixed with water and the enzyme phospholipase by a high shear mixer, creating a very stable emulsion. The emulsion allows the enzyme to react with the phospholipids, transforming them into water-soluble lysophospholipids. The emulsion is broken by centrifugation, separating the gums and phospholipids from the oil. This process generates a better oil yield than traditional degumming/refining. Enzymatic degumming is currently not widely commercialized (ISEO, 2006; FEDIOL, 2006).

### **7.2.2 Neutralization**

Neutralization (sometimes referred to as refining or alkali refining) is generally performed on edible fats and oils to reduce the content of free fatty acids, oxidation products of free fatty acids, residual protein, mucilaginous substances, phosphatides (phospholipids), carbohydrates, sulphur compounds, traces of metals, pigments, oil-insolubles and water solubles. The most important and widespread method of refining is the treatment of the edible fats and oils with an alkali solution (caustic soda). This results in a large reduction in free fatty acids through their conversion into soap stocks which separate from the oil. Most phosphatides and mucilaginous substances are soluble in the fat or oil only in an anhydrous form; upon hydration with the alkali solution, they are readily separated from the fat or oil. The oil phase is then separated from a layer phase of soap, alkali solution and other impurities. Finally, the fat or oil is washed with water to remove any remaining soap, alkali solution and other impurities, and dried to remove remaining water. Edible fats and oils low in phosphatide content (palm and coconut) may be

physically refined (i.e. steam stripped) to remove free fatty acids (Gunstone, 1996; ISEO, 2006; FEDIOL, 2006).

### **7.2.3 Winterization**

Winterization is a process whereby edible fats and oils are subjected to controlled temperature decrease. During this process, waxes are crystallized and removed from the fat or oil by filtration to avoid clouding of the liquid fraction at cooler temperatures. Kieselguhr, a biogenic sedimentation mineral, is normally used as a filter aid. A similar process – dewaxing – is utilized to clarify edible fats and oils containing trace amounts of clouding constituents (ISEO, 2006; FEDIOL, 2006).

### **7.2.4 Bleaching**

The purpose of bleaching (or decolorizing) is to reduce the levels of pigments, such as carotenoids and chlorophyll, but it also further removes residues of phosphatides, traces of soap, traces of metals, oxidation products, sulphur compounds and proteins. The usual method of bleaching is by adsorption of these substances on an adsorbent material. Acid-activated bleaching earth or clay, sometimes called bentonite, is the most extensively used adsorbent material; it consists primarily of hydrated aluminium silicate. Anhydrous silica gel is used as a bleaching adsorbent to a limited extent. If edible fats and oils contain unacceptable levels of polycyclic aromatic hydrocarbons (PAH), activated carbon is added to absorb and eliminate the PAHs. The dosage of these adsorption agents is adjusted to ensure the removal of the specific substances. The bleaching clay/earth, silica gel or activated carbon are separated by filtration. Bleaching is partly done under vacuum and at temperatures between 90° and 120°C (although sometimes between 80° and 180°C) (Gunstone, 1996; ISEO, 2006; FEDIOL, 2006).

### **7.2.5 Deodorization**

The purpose of deodorization is to reduce the level of free fatty acids and to remove odours, off-flavours and other volatile components, such as pesticides and light polycyclic aromatic hydrocarbons. Further removal of the proteins is achieved at this step. The deodorization of edible fats and oils is accomplished by distillation. The process is carried out under vacuum (0.5–8 kPa) and at temperatures of between 170° and 270°C, using a stripping medium, such as steam or nitrogen. Conditions are adapted within these ranges as appropriate for ensuring the removal of specific substances. Deodorization is carried out under vacuum to facilitate the removal of the volatile substances, to avoid undue hydrolysis of the fat or oil, and to make the most efficient use of the steam. Deodorization does not have any significant effect upon the fatty acid composition of most fats or oils. Depending upon the degree of unsaturation of the fat or oil being deodorized, small amounts of trans fatty acids may be formed. In the case of vegetable oils, sufficient tocopherols remain in the finished oils after deodorization to provide stability (Gunstone, 1996; ISEO, 2006; FEDIOL, 2006). Deodorization is a necessary step in the manufacture of an edible fat or oil for sale to food manufacturers or consumers.

## **7.3 REMOVABILITY OF RESIDUES DURING REFINING**

The refining of the oil at its destination is the final critical control point in the sea transportation chain for the vast majority of edible fats and oils shipped worldwide.

Experiments have been carried out where edible oils and fats spiked with pesticides with different physico-chemical properties are subjected to chemical or physical refining, testing various steps, such as degumming, neutralization, bleaching and

deodorization. From these experiments it is clear that the deodorizing step is the most effective in removing contaminants from oil. Furthermore, it may be concluded that solubility in water of > 1 mg/litre (although 0.1 or 0.01 may be satisfactory) and saturated vapour pressure of > 1 mPa (although again 0.1 may be suitable) could be useful criteria for acceptance of a substance as previous cargo, provided refining is considered an aspect within the scope of the development of criteria for acceptable previous cargoes (ITERG, 2006b).

## 8. How can public health be protected?

### 8.1 GENERAL CONSIDERATIONS

The health risks associated with human exposure to residues of previous cargoes in edible fats and oils can be covered by a toxicological risk assessment. Such an assessment would be applicable to all possible previous cargoes, including industrial chemicals, as well as food additives or even foodstuffs. The outcome of the assessment could be that if an exposure to a chemical does not exceed a certain level which is considered toxicologically safe, the exposure resulting from the “use” of this chemical as previous cargo could in principle be acceptable.

For every possible previous cargo, the above consideration requires two major data:

- a reference dose below which exposure to that chemical can be considered as safe; and
- an estimate of exposure.

### 8.2 REFERENCE DOSE

The fundamental principle in toxicology is that every substance may trigger a toxic response, provided that the exposure to that substance is sufficiently high to do so; expressed in other terms, one can be exposed to a substance without toxic effects, provided that the exposure to that substance does not exceed a certain threshold. Due to lack of data, human thresholds cannot be found for the vast majority of substances. Therefore it is very common to define reference doses – usually indicated with ADI (acceptable daily intake) or TDI (tolerable daily intake) – which are obtained by extrapolation from animal data.

To derive a reference dose, careful evaluation of the available animal toxicity data is needed. From the available studies, an overall NOAEL (No Observed Adverse Effect Level) in an animal species is derived, which should cover all possible toxic responses. From this animal NOAEL, a reference dose is derived by dividing the NOAEL through uncertainty factors which are supposed to cover interspecies and intraspecies variability in sensitivity (IPCS, 1987, 2006).

It has been recognized for several decades that the “threshold principle” does not apply to all toxic responses. In particular, mutagenicity (~ genotoxicity) may be elicited by non-thresholded mechanisms, and when this mutagenicity is associated with carcinogenicity, the latter effect is also considered to be non-thresholded. Hence, for substances which are both mutagenic and carcinogenic, it is assumed that no exposure can be identified at which no increased risk for the development of tumours will occur. However, if a *de minimis* level of additional risk (e.g. 1 per million lifetime-exposed people) were considered acceptable (a risk management decision), that level could be used to evaluate the acceptability of exposures to such

substances when used as previous cargoes. If the *de minimis* level is not considered acceptable, this would automatically lead to the exclusion of mutagenic and carcinogenic substances from the list of acceptable previous cargoes.

Derivation of reference doses requires a fair amount of toxicity data, which in many cases are not available. In the absence of a reference dose, for data-poor substances, acceptability of exposure could be assessed on the basis of their not exceeding the "threshold of toxicological concern" (TTC) (e.g. ILSI, 2005). In principle, this method assigns substances to one of three structural classes for each of which a threshold of concern is defined based on toxicity data from about 600 different chemicals. For substances that belong to several closely defined groups, such as dioxins, azoxy- or N-nitroso compounds, or for substances that bear a structural alert for genotoxicity, a special fourth threshold of concern is derived (with an anticipated risk of cancer less than 1 per million lifetime-exposed people), or a straightforward need for compound-specific toxicity data is identified.

The following aspects have been raised as issues for discussion:

- With respect to the TTC, there is no consensus for the special categories mentioned (dioxins and potent mutagens), and these should be considered unacceptable as previous cargoes. The dioxin-like compounds were excluded from the general TTC approach because they are highly accumulative, not because of a cancer risk. It would be appropriate for bioaccumulation to be considered in the criteria – substances considered as persistent, bioaccumulative and toxic (PBT) are already widespread contaminants of the food-chain and additional contamination should be avoided.
- With regard to dioxins and potent mutagens, discussion took place at the ILSI (International Life Sciences Institute) workshop (ILSI, 2005). These substances in particular are mentioned in the ILSI TTC decision tree to trigger compound-specific toxicity data (thus excluding them from the TTC as such). Such compounds should not be on any list of acceptable previous cargoes for foodstuffs.
- A problem is that PBT criteria have been developed for environmental toxicants and it is not easy to define what bioaccumulativity or persistence mean. For fish, bioaccumulation is simply the ratio of body and environmental concentration, and persistency is defined as resistance to chemical or biological breakdown in the environment. For mammals, it is less simple. Furthermore, bioaccumulation and persistency are not adverse effects by themselves. There are no strong objections to incorporating PB (persistent and bioaccumulative) criteria, but to do so a clear cut-off point should be necessary. Biological half-life could be helpful (e.g. any substance with a half-life in mammals > 30 days is bioaccumulative/persistent), but for many substances there are no adequate kinetics data. The toxic criteria can be covered by ADI (or TDI) or TTC.
- It is noted that the above-mentioned toxicological criteria (ADI/TDI or TTC) have been developed to evaluate lifetime exposures. It is highly unlikely that an individual would consume the same type of fat or oil contaminated with a particular residue of a previous cargo every day throughout his/her lifetime. If this aspect is taken into account, it may be necessary to develop short-term exposure reference doses, rather than lifetime exposure limits.

- Other sources of dietary exposure also need to be taken into account, and not all of an ADI (or TDI) should be allocated to the previous cargo. For the sake of discussion, an allocation of 10 percent of the ADI (or TDI) is proposed, which would mean that this particular source would not make a significant difference if other dietary exposure was close to the ADI (or TDI).
- Allocation is not an uncommon procedure and it could be applicable to the previous cargoes. Differentiation of the type of previous cargo considered might be needed. Allocation might not be applicable to purely industrial chemicals, for example, but it could be applicable to substances which are also commonly used as food additives.

### 8.3 EXPOSURE ESTIMATE

In order to obtain an exposure estimate to any contaminant in a fat or oil, the contamination level in the fat or oil should be multiplied by the intake of the fat or oil. It is assumed that the shipload is not further refined. If refining of edible fats and oils is a step in the processing of the fat or oil into food for human consumption, this could be taken into account.

The following formula would apply:

$$\text{Dose} = \frac{C \times A \times R_f}{B_w} \quad (\text{formula 4})$$

in which:

Dose =	exposure estimate (kg/kg bw/day)
C =	concentration of the contaminant (kg/kg fat or oil)
A =	daily amount of fat or oil consumed (kg/person/day)
R <sub>f</sub> =	refinement factor, i.e. 1 for edible fats and oils used without any further refinement and (theoretically) 0 for fats and oils which are completely refined before use. (As refinement is not taken into account for the criteria, in all cases R <sub>f</sub> = 1, by definition.)
B <sub>w</sub> =	body weight (60 kg)

The amount of fat or oil consumed can be taken from Table 3. It may be concluded that it is highly unlikely that a person would cover his/her complete daily intake of edible fats and oils from only one type of fat or oil. Hence, the most appropriate starting point would be the highest intake of one single type of fat or oil: 22 g/person/day for refined soybean oil. This estimate has been taken from the WHO GEMS/Food Consumption Cluster Diets which are based on import/export/use quantities of various edible fats and oils in 13 regional clusters. Five-year average intakes for edible fats and oils in the 13 GEMS/Food Consumption Cluster Diets were available from FAO Food Balance Sheet data for the period 1997–2001. The average intake for each food item at the cluster level was weighted by the population size of the reporting country (WHO, 2006a).

Although food consumption data, as generated by the United Kingdom or the Netherlands, for example, would be more appropriate, it is recognized that such data are only available for a very limited number of countries. Hence, preference is given to the GEMS/Food Consumption Cluster Diets.

For the calculation, the exposure from a subsequent load of refined soybean oil is taken here as the final criterion, because when drafting lists of acceptable previous cargoes, there is no indication as to what the type of a subsequent cargo of fat or oil might be. Also, as subsequent loads of fats or oils should be suitable for human consumption anywhere in the world, it is justified to take the highest intake of any

single type of fat or oil anywhere in the world (i.e. 22 g refined soybean oil/person/day for consumption cluster diet M).

For example: a previous cargo contaminant, present in a concentration of 100 mg/kg of fat or oil (i.e. the very worst case as described for coated tanks) would (according to *formula 4*) result in a daily dose of 0.037 mg/kg bw/day based on a consumption of 22 g refined soybean oil per person per day and no effective removal of the residue by refining. If it is further assumed that this dose is experienced every day throughout a lifetime, then this contaminant would be an unacceptable previous cargo if it had an ADI (or TDI) below this dose. Conversely, if the previous cargo had an ADI (or TDI) above 0.037 mg/kg bw/day, the previous cargo could be considered acceptable (from a toxicological point of view).

TABLE 4  
Overview of fat or oil consumption data

Type of fat or oil	Quantity of fat or oil consumed (g/person/d)	Background	Source
– Food balance sheet data –			
Total vegetable (+ margarine and shortening)	78.5	Highest from 13 consumption cluster diets	WHO GEMS Food Consumption Cluster Diets
Total animal (excl. dairy)	27.4	Highest from 13 consumption cluster diets	WHO GEMS Food Consumption Cluster Diets
Single type vegetable (soybean oil refined)	22	Highest from 13 consumption cluster diets	WHO GEMS Food Consumption Cluster Diets
Single type animal (lard – of pigs)	10.4	Highest from 13 consumption cluster diets	WHO GEMS Food Consumption Cluster Diets
– National food consumption survey data –			
Total vegetable General population <sup>a</sup> : Child <sup>b</sup> :	27.0 16.4	Mean	NL food consumption survey
Total animal General population <sup>a</sup> : Child <sup>b</sup> :	2.1 1.2	Mean	NL food consumption survey
Total vegetable > 18 yrs: 4–6 yrs:	19.9 13.9	Mean	UK food consumption survey
Total animal > 18 yrs: 4–6 yrs:	2.2 2.1	Mean	UK food consumption survey
Total vegetable > 18 yrs: 4–6 yrs:	52.4 31.8	97.5 percentile	UK food consumption survey
Total animal > 18 yrs: 4–6 yrs:	13.0 8.8	97.5 percentile	UK food consumption survey

<sup>a</sup> General population = 1–65 years.

<sup>b</sup> Child = 1–6 years.

If the subsequent cargo were another type of edible fat or oil, this would result in a lower exposure. For example, from a subsequent cargo of lard, a maximum daily dose of 0.017 mg/kg bw/day can be calculated, which for the same substance would also be considered to be of no toxicological concern if it had an ADI (or TDI) > 0.037 mg/kg bw/day.

The following aspects have been raised as issues for discussion.

- It is stated above that “this dose is experienced every day throughout a lifetime”. This seems rather unrealistic. A contamination is a very rare event. Consider the following: The most likely maximum quantity of contaminated fat or oil would be a tank of 3 000 tonnes. If this contamination was not detected by the refiner, and it was not removed at the deodorization stage, then it would be delivered to many food manufacturers in 20-tonne tankers. It would, therefore, be contained in many different food products. It is unlikely that somebody would eat more than one type of each product in any one day. To illustrate this: when an individual consumes 100 g of contaminated fat or oil, this is equivalent to about 1.5 litres of ice cream or ten packets of potato chips (crisps) in one day and is an overestimate. It may be that the fat or oil is made into margarine and that several tubs of these are bought in a supermarket at the same time. This could mean that a small quantity, say 50 g, could be consumed every day for about 1 month. These are realistic estimates of the maximum daily intake of contaminated fats or oils and the time period over which they would be consumed.
- If only incidental exposures are covered, a large portion size is a better starting point for the calculations, i.e. 144 g pork fat (2.15 g/kg bw, for a general population of 67 kg bw); but then an acute reference dose (ARfD) should be used, rather than the ADI (or TDI) (WHO, 2006b).
- In considering high-intake consumers, to be sufficiently protective, an additional factor of  $\times 3$  should be included in the chronic intake assessment (WHO, 1985). However, probably only 5 percent of the total fats and oils traded by sea-going vessels are contaminated. It is, therefore, very unlikely that consumers are high-intake consumers of a fat or oil contaminated with a particular previous cargo during their whole life. It is more common practice to compare the 95 percent percentile largest portion size of consumers on a single day to the ARfD rather than to correct for life-long high-intake consumption. Therefore the meeting concluded that an additional factor of 3 should not be included to cover high-intake consumption.
- There are concerns about short-term reference doses for many reasons. It is not possible to make assumptions of how short the exposure would be, certainly not a single occasion. Reproductive effects occurring *in utero* are not related to life-long exposure. Teratogenicity or acetylcholine (ACh) esterase inhibition can be relevant short-term effects and any short-term reference dose (RfD) should certainly be sufficiently low to cover those or similar effects. If not, the whole concept of short-term RfDs would not be very helpful at all. However, the concept of short-term (read here “acute”) RfDs has been an element in JMPR (Joint FAO/WHO Meeting on Pesticide Residues) evaluations of pesticides, and guidance on how they should be derived has been published (Solecki *et al.*, 2005). Therefore this concept cannot be set immediately aside. A major problem could indeed be the definition of “short-term”: related to one single 24-hour exposure; or related to a longer exposure, e.g. 1 month.

Furthermore, there is the problem of how to estimate possible concentrations of previous cargoes in subsequent loads of fats and oils. Not using the short-term RfD concept might indeed be a preferable "safety-first" approach.

## 9. Criteria for acceptable previous cargoes

It is impractical to develop a system taking into account every possible combination of previous cargo, type of tank construction, cleaning regime and further processing of the subsequent fat or oil cargo. The only practical way to decide if a substance is acceptable as previous cargo is generic, assuming worst-case conditions, such as standardized methods of transportation/storage and tanker cleaning to be applied in a more or less guaranteed way (according to Standard Operation Procedures and Good Hygiene Practices) and default exposure estimates.

A draft list of criteria can be extracted which could be applied for the evaluation of the acceptability of a possible previous cargo to a subsequent shipment for edible fats and oils. These criteria have been listed under the assumption that the fat or oil subsequently shipped or stored is not further refined. This is a worst-case approach, but it cannot be assumed that all shipments of edible fats and oils will be refined after shipment.

The draft list of proposed criteria to be discussed at the meeting is presented in Box 1.

It is noted that the criteria in Box 1 are vague. The final list of criteria must be applied to any relevant substance before it can be added to the list of acceptable previous cargoes. The aim should be a list of physical, chemical and toxicological parameters and maximum or minimum values. The criteria listed do not have any values. They could be presented in the alternative format presented in Table 5.

TABLE 5  
Possible values for the proposed criteria

Parameter	Value	Units	Comments
Viscosity	< 100	mPa.s	At 80 °C
Solubility in water	> 1	mg/litre	At 20 °C
Solubility in detergent solution			
Saturated vapour pressure	> 1	mPa	
ADI			
Limit of detection	≤ 0.1	mg/kg	In oil

BOX 1

**A substance may be considered acceptable as previous cargo for a subsequent cargo of edible fats and oils:**

1. only if it is impossible to transport the substance in anything other than in tankers reserved for foodstuffs only.
2. under the condition that it is transported/stored in an appropriately designed system with adequate cleaning routines and effective inspection procedures (see section 2.1.3 of the Code of Practice [CAC, 1987]).
3. if it can be efficiently cleaned from the tanks.
4. if residues of the substance in the subsequent cargo of fat or oil do not give rise to an unacceptable degree of oxidation or hydrolysis of subsequent fats and oils cargoes.
5. if the substance does not give rise to other chemical reactions with the subsequent cargo of fats and oils.
6. if residues of the substance in the subsequent cargo of fat or oil do not result in unacceptable organoleptic changes (odour, colour, taste).
7. if residues of the substance in the subsequent cargo of fat or oil do not result in the elicitation of human health effects, including allergenicity, food intolerance, genotoxic or carcinogenic events (account may be taken of the opinions of JECFA or other recognized bodies) – in this respect, size of tanks in relationship to total amounts remaining after cleaning are of paramount importance.
8. If substances do not bioaccumulate and are not persistent in human tissues.
9. if the substance in the subsequent cargo of fat or oil is traceable by commonly available analytical methods which are sufficiently sensitive to detect trace amounts of the particular chemical or to verify the absence of contamination.
10. if agreed upon by the competent authorities of the importing country (see section 2.1.3 of the Code of Practice [CAC, 1987]).

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<sup>8</sup> The references listed here are cited in the background paper. Note that Annex III lists the sources of additional information provided before and during the meeting.

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## Appendix 1

**Draft List of Acceptable Previous Cargoes<sup>9</sup>**  
(at Step 7 of the Procedure)

Substance (synonyms)	CAS number
Acetic acid (ethanoic acid; vinegar acid; methane carboxylic acid)	64-19-7
Acetic anhydride (ethanoic anhydride)	108-24-7
Acetone (dimethylketone; 2-propanone)	67-64-1
Acid oils and fatty acid distillates – from animal, marine and vegetable fats and oils	
Ammonium hydroxide (ammonium hydrate; ammonia solution; aqua ammonia)	1336-21-6
Ammonium polyphosphate	68333-79-9
Animal, marine and vegetable fats and oils (including hydrogenated fats and oils) – other than cashew shell nut oil and tall oil	
Beeswax – white	8006-40-4
Beeswax – yellow	8012-89-3
Benzyl alcohol (pharmaceutical and reagent grades)	100-51-6
1,3-Butanediol (1,3-butylene glycol)	107-88-0
1,4-Butanediol (1,4-butylene glycol)	110-63-4
Butyl acetate, n-	123-86-4
Butyl acetate, sec-	105-46-4
Butyl acetate, tert-	540-88-5
Calcium chloride solution	10043-52-4
Calcium lignosulphonate liquid (lignin liquor; sulphite lye)	8061-52-7
Candelilla wax	8006-44-8
Carnauba wax (Brazil wax)	8015-86-9
Cyclohexane (hexamethylene; hexanaphthene; hexahydrobenzene)	110-82-7
Ethanol (ethyl alcohol; spirits)	64-17-5
Ethyl acetate (acetic ether; acetic ester; vinegar naphtha)	141-78-6
2-Ethylhexanol (2-ethylhexy alcohol)	104-76-7
Fatty acids	
Arachidic acid (eicosanoic acid)	506-30-9
Behenic acid (docosanoic acid)	112-85-6
Butyric acid (n-butyric acid; butanoic acid; ethyl acetic acid; propyl forinic acid)	107-92-6
Capric acid (n-decanoic acid)	334-48-5
Caproic acid (n-hexanoic acid)	142-62-1
Caprylic acid (n-octanoic acid)	124-07-2
Erucic acid (cis-13-docosenoic acid)	112-86-7
Heptonic acid (n-heptanoic acid)	111-14-8
Lauric acid (n-dodecanoic acid)	143-07-7
Lauroleic acid (dodecenoic acid)	4998-71-4
Linoleic acid (9,12-octadecadienoic acid)	60-33-3
Linolenic acid (9,12,15-octadecatrienoic acid)	463-40-1
Myristic acid (n-tetradecanoic acid)	544-63-8
Myristoleic acid (n-tetradecenoic acid)	544-64-9
Oleic acid (n-octadecenoic acid)	112-80-1

<sup>9</sup> CAC/RCP 36-1987, Recommended International Code of Practice for the Storage and Transport of Edible Fats and Oils in Bulk (CAC, 1987).

Substance (synonyms)	CAS number
Palmitic acid (n-hexadecanoic acid)	57-10-3
Palmitoleic acid (cis-9-hexadecenoic acid)	373-49-9
Pelargonic acid (n-nonanoic acid)	112-05-0
Ricinoleic acid (cis-12-hydroxy octadec-9-enoic acid; castor oil acid)	141-22-0
Stearic acid (n-octadecanoic acid)	57-11-4
Valeric acid (n-pentanoic acid; valerianic acid)	109-52-4
Fatty alcohols	
Butyl alcohol (1-butanol; butyric alcohol)	71-36-3
Caproyl alcohol (1-hexanol; hexyl alcohol)	111-27-3
Capryl alcohol (1-n-octanol; heptyl carbinol)	111-87-5
Cetyl alcohol (alcohol C-16; 1-hexadecanol; cetylic alcohol; palmityl alcohol; n-primary hexadecyl alcohol)	36653-82-4
Decyl alcohol (1-decanol)	112-30-1
Iso decyl alcohol (isodecanol)	25339-17-7
Enanthyl alcohol (1-heptanol; heptyl alcohol)	111-70-6
Lauryl alcohol (n-dodecanol; dodecyl alcohol)	112-53-8
Myristyl alcohol (1-tetradecanol; tetradecanol)	112-72-1
Nonyl alcohol (1-nonanol; pelargonic alcohol; octyl carbinol)	143-08-8
Iso nonyl alcohol (isononanol)	27458-94-2
Oleyl alcohol (octadecenol)	143-28-2
Stearyl alcohol (1-octadecanol)	112-92-5
Tridecyl alcohol (1-tridecanol)	27458-92-0
Fatty acid esters – combination of above fatty acids and fatty alcohols	
e.g. Butyl myristate	110-36-1
Cetyl stearate	110-63-2
Oleyl palmitate	2906-55-0
Fatty alcohol blends	
Cetyl stearyl alcohol (C16-C18)	67762-27-0
Lauryl myristyl alcohol (C12-C14)	
Formic acid (methanoic acid; hydrogen carboxylic acid)	64-18-6
Glycerine (glycerol, glycerin)	56-81-5
Heptane	142-82-5
n-Hexane	110-54-3
Iso-butyl acetate	110-19-0
Iso-octyl alcohol (isooctanol)	26952-21-6
Iso-propyl alcohol (isopropanol; dimethyl carbinol; 2-propanol)	67-63-0
Limonene (dipentene)	138-86-3
Magnesium chloride solution	7786-30-3
Methanol (methyl alcohol)	67-56-1
Methyl ethyl ketone (2-butanone; MEK)	78-93-3
Methyl isobutyl ketone (4-methyl-2-pentanone; iso propylacetone; MIBK)	108-10-1
Methyl tertiary butyl ether (MTBE)	1634-04-4
Molasses	57-50-1
Montan wax	8002-53-7
Pentane	109-66-0
Petroleum wax (parafin wax)	8002-74-2
Phosphoric acid (ortho phosphoric acid)	7664-38-2
Potable water – only acceptable where the immediate previous cargo is also on the list	7732-18-5
Polypropylene glycol	25322-69-4
Potassium hydroxide solution (caustic potash)	1310-58-3
Propyl acetate	109-60-4

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<b>Substance (synonyms)</b>	<b>CAS number</b>
Propyl alcohol (propane-1-ol; 1-propanol)	71-23-8
Propylene glycol, 1,2- (1,2-propylene glycol; propan-1,2-diol; 1,2-dihydroxypropane; monopropylene glycol (MPG); methyl glycol)	57-55-6
Propylene tetramer (tetrapropylene; dodecene)	6842-15-5
Silicon dioxide (microsilica)	7631-86-9
Sodium hydroxide solution (caustic soda, lye; sodium hydrate; white caustic)	1310-73-2
Sodium silicate (water glass)	1344-09-8
Sorbitol (D-sorbitol; hexahydric alcohol; D-sorbite)	50-70-4
Soybean oil epoxidized	8013-07-8
Sulphuric acid	7664-93-9
Urea ammonia nitrate solution (UAN)	
White mineral oils	8042-47-5

**Proposed Draft List of Acceptable Previous Cargoes<sup>10</sup>**  
(at Step 4 of the Procedure)

Substance (synonyms)	CAS number
2,3-Butanediol (2,3-butylene glycol)	513-85-9
iso-Butanol (2-methyl-1-propanol)	78-83-1
Calcium ammonium nitrate solution	6484-52-2
Calcium nitrate (CN-9) solution	35054-52-5
Cyclohexanol	108-93-0
Cyclohexanone	108-94-1
Fatty acid methyl esters. These include for example:	
Methyl laurate (methyl dodecanoate)	111-82-0
Methyl oleate (methyl octadecenoate)	112-62-9
Methyl palmitate (methyl hexadecanoate)	112-39-0
Methyl stearate (methyl octadecanoate)	112-61-8
Hydrogen peroxide	7722-84-1
Kaolin slurry	1332-58-7
1,3 -Propylene glycol	504-63-2
Unfractionated fatty acid mixture or mixtures of fatty acids from natural fats and oils	
Unfractionated fatty alcohol mixture or mixtures of fatty alcohols from natural fats and oils	
Unfractionated fatty esters or mixtures of fatty esters from natural fats and oils	
Vegetable oil – epoxidised	

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<sup>10</sup> CAC/RCP 36-1987, Recommended International Code of Practice for the Storage and Transport of Edible Fats and Oils in Bulk (CAC, 1987).

## Additional sources of information

In addition to the references cited in the main report and those incorporated in the background paper, further information was provided just before and during the meeting:

- Woods, B.** 2000. Cargo tank coatings and cargo contamination. Milbros Shipping AS. Confidential data.
- Moy, G.** 2006a. E-mail to Dr Costarrica, FAO, d.d. 1 November 2006. Subject: FAO/WHO consultation on previous cargo. Contains comments on background paper.
- MVO (Dutch Production Board for Margarines, Fats and Oils).** 2006. E-mail to Dr Mennes, RIVM, d.d. 6 November 2006 and fax d.d. 7 November 2007. Subject: FAO/WHO/RIVM Expert Meeting on previous cargoes fats and oils. Contains comments on background paper and data sheets for various substances on the draft list of acceptable previous cargoes. Confidential data.
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