International Civil Aviation Organization

**WORKING PAPER**

# DANGEROUS GOODS PANEL (DGP) WORKING GROUP MEETING (DGP-WG/19)

**Montréal, 1 to 5 April 2019**

**Agenda Item 1: Harmonizing ICAO dangerous goods provisions with UN Recommendations on the Transport of Dangerous Goods**

**1.2: Develop proposals, if necessary, for amendments to the *Technical Instructions for the Safe Transport of Dangerous Goods by Air* (Doc 9284) for incorporation in the 2021-2022 Edition**

## FISH MEAL

(Presented by D. Brennan)

**SUMMARY**

This working paper proposes that the status of UN 2216, **Fish meal, stabilized** as being forbidden in air transport be reviewed and that instead should be permitted as cargo on both passenger and cargo aircraft.

**Action by the DGP-WG:** The DGP-WG is invited to consider the revisions to the Technical Instructions as shown in Appendix A to this working paper.

## 1. INTRODUCTION

1.1 The Technical Instructions, in Table 3-1 shows UN 2216, **Fish meal, stabilized** as forbidden / forbidden with Special Provision A2 assigned that identifies that it can be transported on a cargo aircraft with the approval of the State of Origin and the State of the Operator. UN 2216 is assigned to Class 9 and when stabilized does not pose a risk of self-heating.

1.2 Fish meal is typically transported in bulk, and as a relatively low-value product, there is no demand for air transport. However, there is a demand for the transport of samples of fish meal by air for the purposes of customer evaluation, i.e. a potential customer wants to be able to analyse and evaluate suitability of the product prior to committing to a contract and for research purposes. Air transport is necessary to be able to move the material in a timely manner to meet these needs.

1.3 The UN Model Regulations assign Special Provision 117, among others, to UN 2216. Special Provision 117 states that fish meal is subject to the Regulations only when transported by sea. Notwithstanding the inaccuracy of this statement, what this does identify is that fish meal is not subject to the Regulations when transported by road or rail.

1.4 While UN 2216 is not classified in Division 4.2, the risk in sea transport is the potential for self-heating particularly due to the long duration of a journey in maritime transport and the loss, over time, of the antioxidant that is used to stabilize the fish meal to prevent self-heating. This is not a factor in air transport.

1.5 Attached to this working paper is information provided by the Marine Ingredients Organisation (IFFO) that demonstrates the stability of fish meal in very large quantities, up to 1,000 kg, over a duration of up to 1 year where there was no evidence of self-heating.

1.6 Based on this information it is proposed to remove the forbidden / forbidden status of UN 2216, **Fish meal, stabilized** and to assign it to Packing Instruction 956, which is the packing instruction that applies to a number of solids in Class 9. It is proposed to permit both combination and single packagings with a net quantity of 100 kg per package on a passenger aircraft and 200 kg on a cargo aircraft. For consistency with the UN Model Regulations it is proposed to assign new special provisions to UN 2216, bringing into the Technical Instructions Special Provision 300, although this has been shown in square brackets, and Special Provision 308 from the UN Model Regulations.

## 2. ACTION BY THE DGP-WG

2.1 The DGP-WG is invited to consider the revisions to the Technical Instructions as shown in Appendix A to this working paper.

2.2 With respect to the proposed A2XX, which aligns to Special Provision 300 from the UN Model Regulations, the DGP-WG is invited to consider if there is a need to bring this special provision into the Technical Instructions given that:

a) the transport duration is much shorter than sea transport;

b) the temperature in aircraft cargo compartments during flight will decrease over the duration of the flight and therefore any potential for self-heating will be reduced; and

c) based on the data submitted by IFFO, there is an extremely low, to no risk of self-heating of the product in transport.

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## APPENDIX A

### PROPOSED AMENDMENT TO PART 3 OF THE TECHNICAL INSTRUCTIONS

# Part 3

# DANGEROUS GOODS LIST, SPECIAL PROVISIONS AND LIMITED AND EXCEPTED QUANTITIES

Revise Table 3-1 as shown:

**Table 3-1. Dangerous Goods List**

| | | | | | | | | | Passenger aircraft | | Cargo aircraft | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Name* | *UN No.* | *Class or divi-sion* | *Sub-sidiary hazard* | *Labels* | *State varia-tions* | *Special provi-sions* | *UN packing group* | *Excepted quantity* | *Packing instruction* | *Max. net quantity per package* | *Packing instruction* | *Max. net quantity per package* |
| *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* | *9* | *10* | *11* | *12* | *13* |
| **Fish meal, stabilized** | 2216 | 9 | | Miscellaneous | ~~AU 1~~<br>~~IR 3~~<br>~~NL 3~~<br>~~US 3~~ | ~~A2~~<br>[A2XX]<br>A2XY | III | E1 | ~~FORBI~~<br>956 | ~~DDEN~~<br>100 kg | ~~FORBID~~<br>965 | ~~DEN~~<br>200 kg |
| . . . | | | | | | | | | | | | |

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# Chapter 3

# SPECIAL PROVISIONS

**Table 3-2. Special provisions**

| *TIs* | *UN* | |
|---|---|---|
| . . . | | |
| [A2XX | 300 | Fish meal, fish scrap and krill meal must not be transported if the temperature at the time of loading exceeds 35°C or 5°C above the ambient temperature, whichever is higher.] |
| A2XY | 308 | Stabilization of fish meal must be achieved to prevent spontaneous combustion by effective application of ethoxyquin, BHT (butylated hydroxytoluene) or tocopherols (also used in a blend with rosemary extract) at the time of production. The said application must occur within twelve months prior to shipment. Fish meal must contain at least 50 ppm (mg/kg) of ethoxyquin, 100 ppm (mg/kg) of BHT or 250 ppm (mg/kg) of tocopherol-based antioxidant at the time of consignment. |

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# Part 4

# PACKING INSTRUCTIONS

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## Packing Instruction 956

Passenger and cargo aircraft for UN 1841, UN 1931, UN 2216, UN 3432, UN 2969, UN 3077, UN 3152 and UN 3335 only

**General requirements**

Part 4, Chapter 1 requirements must be met, including:

1) **Compatibility requirements**

— Substances must be compatible with their packagings as required by 4;1.1.3.

2) **Closure requirements**

— Closures must meet the requirements of 4;1.1.4.

| COMBINATION PACKAGINGS | | | | | SINGLE PACKAGINGS | |
|---|---|---|---|---|---|---|
| *UN number and proper shipping name* | *Inner packaging (see 6;3.2)* | *Inner packaging quantity (per receptacle)* | *Total quantity per package — passenger* | *Total quantity per package — cargo* | Quantity — passenger | Quantity — cargo |
| UN 1841 **Acetaldehyde ammonia** | Glass | 10.0 kg | 200 kg | 200 kg | 200 kg | 200 kg |
| | Fibre | 50.0 kg | | | | |
| | Metal | 50.0 kg | | | | |
| | Paper bag | 50.0 kg | | | | |
| | Plastics | 50.0 kg | | | | |
| | Plastic bag | 50.0 kg | | | | |
| UN 1931 **Zinc dithionite** or **Zinc hydrosulphite** | Glass | 10.0 kg | 100 kg | 200 kg | 100 kg | 200 kg |
| | Fibre | 50.0 kg | | | | |
| | Metal | 50.0 kg | | | | |
| | Paper bag | 50.0 kg | | | | |
| | Plastics | 50.0 kg | | | | |
| | Plastic bag | 50.0 kg | | | | |
| UN 2216 **Fish meal, stabilized** | Glass | 10.0 kg | 100 kg | 200 kg | 100 kg | 200 kg |
| | Fibre | 50.0 kg | | | | |
| | Metal | 50.0 kg | | | | |
| | Paper bag | 50.0 kg | | | | |
| | Plastics | 50.0 kg | | | | |
| | Plastic bag | 50.0 kg | | | | |

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# APPENDIX B

# INFORMATION FROM THE MARINE INGREDIENTS ORGANISATION (IFFO) ON THE STABILITY OF FISH MEAL

## Description

This document contains the amendments that were adopted into the IMDG CODE (International Maritime Dangerous Goods Code) based on proposals submitted by IFFO and that have been incorporated into the newest edition of the IMDG code 2018. As a result of this work manufacturers of fish meal around the world can transport safely fish meal in bags of 50 kg and >1 tonne bags and without any restrictions of 3,000 kg following the deletion of SP945 and amendment to SP 308.

IFFO has written this document to support the proposed amendments to permit the transport of fish meal by air. Currently fish meal is forbidden in air transport possibly due to a misunderstanding in the definition of "stabilized fish meal" and "not stabilised fish meal", which prevents the possibility to transport stabilised fish meal in a faster and also safe way.

In the IMO codes, fish meal can be classified in two:

- ✓ UN 1374 Class 4.2 Fish meal, unstabilized or Fish scrap, unstabilized
- ✓ UN 2216 Class 9 Fish meal, stabilized or Fish scrap, stabilized

IFFO has worked arduously and successfully to provide measures to transport fish meal safely stabilised with antioxidants and has presented this work before International Maritime Organization and United Nations Subcommittee of Experts on the Transport of Dangerous Goods and the corresponding codes of transportation have been amended in the newest edition (2018).

Additionally, IFFO is working in a broad selection of natural antioxidants to continue proposing more ways to stabilize fish meal.

## Introduction

Fish meal has been stabilised by the addition of the antioxidant ethoxyquin (EQ) for many years. The current addition and residue levels of ethoxyquin listed in the IMDG Code were decided on more than 40 years ago and are at levels well in excess of those that will achieve stabilisation. A 12-month fish meal stability trial undertaken by IFFO compared the stability of fish meal treated with lower inclusion rates of ethoxyquin, as well as other antioxidants, butylated hydroxytoluene (BHT) and a natural tocopherol/rosemary extract blend. It is important to consider alternative antioxidants in order to provide greater choice in the market.

## Experimental Trials

As previously notified to the UN Subcommittee at the meeting held in Dec 2015, IFFO commenced with a fish meal stability trial on 9$^{th}$ July 2015 that was to continue for 12 months until July 2016. The aim of the trial was to compare the stability of fish meal treated with lower inclusion rates of ethoxyquin, as well as other antioxidants, butylated hydroxytoluene (BHT) and a natural tocopherol/rosemary extract blend. All five of the sampling intervals have been performed (Day 0, Week 2, Month 3, Month 6 and Month 12) with the last analyses interval being in July 2016. The reactive anchovy fish meal for the trial was provided by a producer from within the IFFO membership, and the trials were conducted under standard conditions, but also comparing storage volume through a comparison of 50 kg and regular 1 tonne bags. The concentrations and analyses are detailed in the treatment plan in Table 1 along with the content of the active component in the treatments calculated from the percentage in the dosing solution.

The specifications of the antioxidants are as follows:

- ✓ Ethoxyquin (EQ): Minimum 95% solution
- ✓ 23.2% tocopherols and <1% rosemary extract (containing ≈ 5% carnosic acid)
- ✓ 20% BHT solution

| *Treatments* | *Antioxidant content (active component) (ppm)* | *Sampling intervals* | | | | |
|---|---|---|---|---|---|---|
| | | **Day** | | **Month** | | |
| | | **0** | **14** | **2** | **6** | **12** |
| *EQ: 300 ppm* | 285 | AO x 5<br>PV, AV, FFA, PUFA | AO, PV, AV, FFA. | AO, PV, AV, FFA | AO, PV, AV, FFA.<br>Self-heating test to 50 kg bags | AO,<br>PV, AV, FFA, PUFA<br>Self-heating test (50 kg and 1 tonne bags) |
| *EQ: 600 ppm* | 570 | | | | | |
| *BHT solution: 2,000 ppm* | 400 | | | | | |
| *BHT solution: 4,000 ppm* | 800 | | | | | |
| *Tocopherol/ rosemary extract blend: 2,000 ppm* | 460 ppm tocopherols + < 20 ppm rosemary extract (containing 1ppm carnosic acid) | | | | | |
| *Tocopherol/ rosemary extract blend: 4,000 ppm* | 920 ppm tocopherols + < 40 ppm rosemary extract (containing 2 ppm carnosic acid) | | | | | |

**Table 1: Antioxidant treatments, content of the active component and analyses plan**

Where AO = antioxidant; PV = Peroxide value; AV = Anisidine value; FFA = Free Fatty Acid value; PUFA = polyunsaturated fatty acids

All the fish meal treatments were stored in two sizes: 50 kg bags as well as 1 tonne bags. The two sizes will show whether there is a difference in the deterioration rate of fish meal in different storage volumes.

## Discussion and Results

| Treatments | | Sampling intervals | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Day 0** | **6 months** | | | **12 months** | |
| | | **Antioxidant level (ppm)** | **Antioxidant level (ppm)** | **Self heating test** | **Oxygen Bomb induction period** (hrs) | **Antioxidant level (ppm)** | **Self heating test** |
| **EQ: 300 ppm** | 50 kg bag | 318 | 259 | Neg (pass) | 9.5 | 151 | Neg (pass) |
| | 1 tonne bag | 297 | | | 9.5 | 213 | Neg (pass) |
| **EQ: 30-50 ppm** | 50 kg bag | 28 | <15 | | 1.2 | <15 | Neg (pass) |
| | 1 tonne bag | 48 | | | 2.7 | 36 | Neg (pass) |
| **BHT solution: 2,000 ppm** | 50 kg bag | 438 | 368 | Neg (pass) | 2.4 | 290 | Neg (pass) |
| | 1 tonne bag | 438 | | | 2.6 | 342 | Neg (pass) |
| **BHT solution: 4,000 ppm** | 50 kg bag | 858 | 751 | | 2.8 | 659 | Neg (pass) |
| | 1 ton | 866 | | | 2.9 | 775 | Neg (pass) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | ne bag | | | | | | |
| **Tocopherol/ rosemary extract blend: 2,000 ppm** | 50 kg bag | 385 | 243 | Neg (pass) | 2.5 | 209 | Neg (pass) |
| | 1 tonne bag | 400 | | | 3.8 | 280 | Neg (pass) |
| **Tocopherol/ rosemary extract blend: 4,000 ppm** | 50 kg bag | 628 | 488 | | 3.4 | 277 | Neg (pass) |
| | 1 tonne bag | 752 | | | 3.5 | 598 | Neg (pass) |

**Table 2: Results of the treatments at Day 0, 6 months and 12 months storage.**

Unfortunately, there was a problem with the dosing of the 600 ppm ethoxyquin treatment and the fish meal was dosed with ≤ 50 ppm ethoxyquin, but this material remained in the trial as a comparison.

The results show that the antioxidant levels after 12 months of storage have decreased to levels that are still sufficient to provide continued protection to the fish meal. It appears that the antioxidant levels in the 1 tonne bags decreased at a slower rate indicating less consumption of the antioxidant and therefore potentially a slower rate of oxidation. The percentage remaining antioxidants for each treatment along with the corresponding percentage reduction is shown in Table 3. The antioxidant levels in the 50 kg bags decreased in order from fastest to slowest by < 54.4% (ethoxyquin 30 ppm), 55.8% (Natural blend 4,000 ppm), 52.4% (ethoxyquin 300 ppm), 45.7% (Natural blend 2,000 ppm), 33.8% (BHT 2,000 ppm) and the slowest decrease of 23.2% (BHT 4,000ppm). Similarly, the antioxidants in the 1 tonne bags decreased by 29.9% (Natural blend 2,000 ppm), 28.3% (ethoxyquin 300 ppm), 24.2% (50 ppm ethoxyquin), 21.9% (BHT 2,000 ppm), 20.4% (Natural blend 4,000ppm) and 10.6% (BHT 4,000ppm). The highest decrease in antioxidant of roughly 55% still leaves sufficient antioxidant remaining to protect fish meal for another period of up to 6 months or more.

| Antioxidant treatment | Storage bag size | 6 months | | 12 months | |
|---|---|---|---|---|---|
| | | Residual antioxidant content (%) | Decrease in antioxidant content (%) | Residual antioxidant content (%) | Decrease in antioxidant content (%) |
| **Ethoxyquin: 300 ppm** | 50 kg | 81.4 | 18.6 | 47.6 | 52.4 |
| | 1 tonne | | | 71.7 | 28.3 |
| **Ethoxyquin: 30-50 ppm** | 50kg | < 53.6 | < 46.4 | < 45.6 | < 54.4 |
| | 1 tonne | | | 75.8 | 24.2 |
| **BHT: 2,000 ppm** | 50 kg | 84.0 | 16.0 | 66.2 | 33.8 |
| | 1 tonne | | | 78.1 | 21.9 |
| **BHT: 4,000 ppm** | 50 kg | 87.5 | 12.5 | 76.8 | 23.2 |
| | 1 tonne | | | 89.4 | 10.6 |
| **Natural blend: 2,000 ppm** | 50 kg | 63.1 | 36.9 | 54.3 | 45.7 |
| | 1 tonne | | | 70.1 | 29.9 |
| **Natural blend: 4,000 ppm** | 50 kg | 77.7 | 22.3 | 44.2 | 55.8 |
| | 1 tonne | | | 79.6 | 20.4 |

**Table 3: Percentage residual antioxidant and reduction after 6 and 12 month's storage**

The self-heating test performed on the lowest antioxidant concentration in the 50kg (i.e. 300 ppm EQ, 2,000 ppm BHT and 2,000 ppm Natural blend) bags at 6 months were all negative which indicated that none of the treatments had self-heating properties after 6 months of storage. The low ethoxyquin dosage of 300 ppm passed at 6 months which indicates that lower dosage levels of ethoxyquin would effectively stabilise fish meal.

After 12 months storage, all the samples passed the self-heating test but for some the temperature increased by > 10°C (when stored at 140°C) and unfortunately, the 100°C test was not performed as we had not realised that it may be necessary. The antioxidant levels have decreased considerably after 12 months storage and therefore slightly higher temperatures being reached during the test are understandable. Fish meal is generally shipped within a 1-5 month period after production. The maximum temperature reached during the self-heating test for the relevant treatments after 12 months storage was 157.8°C (a temperature increase of only 17.8°C) for the Tocopherol 630 ppm 1tonne treatment and 154°C for the Ethoxyquin 300ppm 1 tonne treatment, which is far away from the 60°C increase (maximum sample temp of 200°C) that is the fail criterion. These temperature increases are low enough to demonstrate that the proposed amendments are safe for fish meal >3, 000kg and there is therefore no justification to apply the restriction to 3,000kg. To demonstrate that these temperatures are safe after 12 months for the requested dosage levels, it can be seen that the BHT treatments, at levels proven to be safe after > 30 years of use, also reached a maximum temperature of 161.2°C.

In addition, the BHT dosage format needs to be clarified. BHT is available in varying concentrations of dosage solutions (of around 20-30% BHT) that is used when fish meal is treated (BHT cannot be applied in powder form). The concentration of BHT in solutions therefore may vary and the initial BHT content (the active component) should be stipulated, if necessary, rather than the dosage solution.

Furthermore, the IMO E&T increased the minimum BHT dosage to 2,000 ppm (from 1,000ppm) since those were the dosages used in the stability trial. The 1,000 ppm level has historically proven to have been used safely from the time that it was written into the IMDG and there is no need to change it because of alternative levels used in the stability trial. The BHT levels used in the trial were intended as comparative values against tocopherols and ethoxyquin and not as new proposed dosage levels. The industry is aiming to reduce the dosage levels of synthetic antioxidants, not to increase them. The actual active ingredient

BHT dosage levels needs to be (so that it is in line with original 1,000 – 4,000ppm of a 20% BHT solution) 200 – 800 ppm BHT. The levels used in the stability trial were 440 – 860ppm. Similarly, tocopherols are also applied in formulations containing varying concentration of tocopherols. In fact, SP 945 is not used in the industry and creates confusion. The residual levels specified in SP 308 determines the dosage levels and SP 945 are therefore superfluous. The dosage levels in fish meal are not controlled. In addition, the dosage levels result in uncertainty of the actual antioxidant dosage due to varying antioxidant formulations with different concentrations.

On the other hand, the Oxygen Bomb Test is used to predict stability and evaluate antioxidant systems in fats and finished products. The oxygen uptake of the sample is measured in a closed system. The rate at which oxygen is consumed indicates the oxidative stability of the tested product and measures the stability of the complete product without prior extraction of the fat. A short induction period (in hours) indicate quicker uptake of oxygen and a less stable product whereas a longer uptake period for oxygen indicates a more stable product. The Oxygen Bomb test has shown to correlate well with shelf life and the Schaal Oven accelerated test[1].

Ethoxyquin (even at a low dosage level of 300 ppm) has shown to be the most effective antioxidant with the longest induction period of 9.5 hrs. [Here we can clearly see the low level of antioxidant in the 600 ppm ethoxyquin treatment although the one tonne 600 ppm sample had a similar induction time (2.7 hrs) to the 2,000 ppm and 4,000 ppm BHT treated samples (2.4; 2.6; and 2.8; 2.9 hrs respectively). The difference between the two 600 ppm ethoxyquin treatments (1.2 hrs and 2.7 hrs) could be due to uneven distribution of the antioxidant in the fish meal or the slightly higher antioxidant content in the 1 tonne bag of 50ppm compared to 30 ppm in the 50kg bag.] Surprisingly, the natural antioxidant blend seemed to have performed slightly better than BHT.

Heat is generated when there is rapid and significant oxidation of fish meal due to the exothermic reaction of oxygen with the highly polyunsaturated fatty acids (in particular eicosapentaenoic, EPA and docosahexaenoic acids, DHA) which result in the spontaneous combustion of fish meal. In order for spontaneous combustion to occur there must be extensive oxidation of the fish meal since without oxidation or with a low oxidation rate, fish meal will not heat up sufficiently to combust. Antioxidants act by slowing down the rate of oxidation by reacting with the free radicals, which are formed after reaction with oxygen, thereby stopping the oxidation chain reaction.

Analyses that indicate the oxidative status of fish meal therefore provides important information on the potential for combustion of fish meal. Spontaneous combustion will not occur if oxidation level of the oil is low. A useful measure of the oxidation of fish meal is to determine the decrease in polyunsaturated fatty acids during storage[2]. A comparison of the omega-3 polyunsaturated fatty acid contents for the different antioxidant treatments during storage can be seen in Figure 1 along with the omega-3 fatty acid values and % decrease in Table 4.

The 300ppm ethoxyquin treatment (50kg and 1 tonne bags) clearly protected the fish meal against oxidation showing negligible decrease (0.6% and 1.1%, respectively) in omega-3 fatty acids during the 12-month storage period due to oxidation. The EQ treatment that measured 30ppm EQ in the 50kg bags at the start of the trial showed a marked decrease (51%) in omega-3 fatty acids indicating significant oxidation. However, the EQ treatment that measured 50ppm EQ in the 1 tonne bags indicated that even the slightly higher EQ content along with the bigger storage size bags, resulted in only a 0.6% decrease in omega-3 fatty acid content. The efficacy of the 50ppm EQ treatment clearly indicates how effective EQ is as antioxidant even at low dosage levels.

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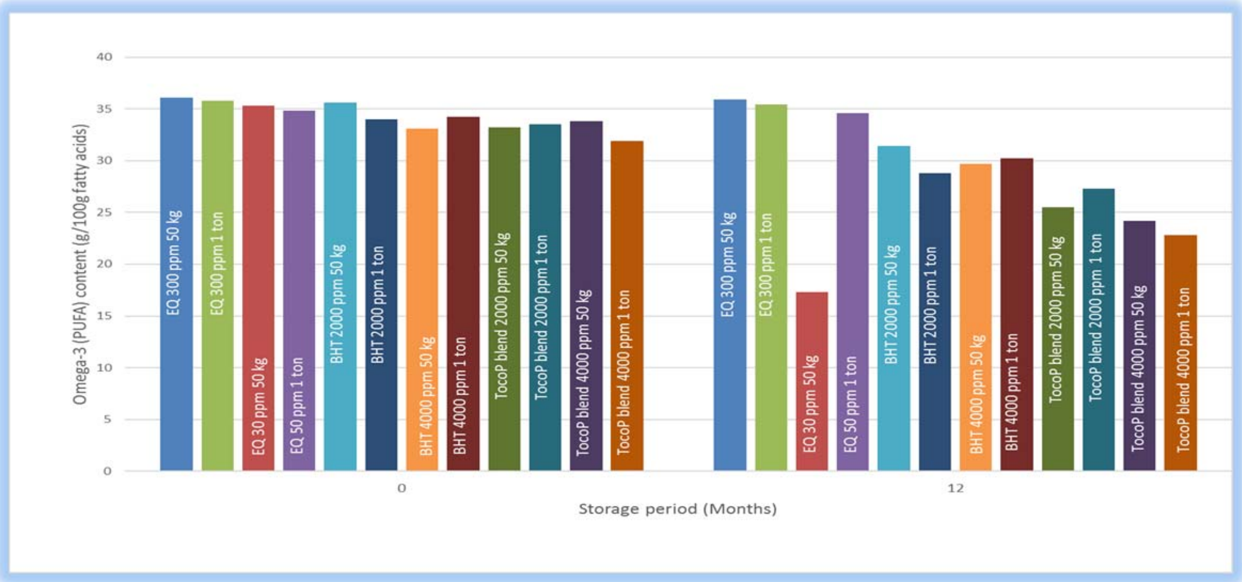
[1] Methods to Access Quality and Stability of Oils and fat-containing Foods, (1995). Eds: Warner, K and Michael Eskin, N.A., AOCS Press, Champaign, Illinois, pp 183-184

[2] De Koning, A.J., (1998). A new method for measuring efficacies of antioxidants in fishmeal. International Journal of Food Properties, Vol 1, Issue 3, pp 255 - 261

**Figure 1: Change in Omega-3 content of all the antioxidant treatments during 12 storage period**




| Antioxidant treatment | Storage bag size | Day 0 | 12 months | |
|---|---|---|---|---|
| | | Omega-3 content (g/100g fatty acids) | Residual omega-3 content (g/100g fatty acids) | Decrease in omega-3 content (%) |
| **Ethoxyquin: 300 ppm** | 50 kg | 36.1 | 35.9 | 0.6 |
| | 1 tonne | 35.8 | 35.4 | 1.1 |
| **Ethoxyquin: 30-50 ppm** | 50kg 30 ppm EQ | 35.3 | 17.3 | 51.0 |
| | 1 tonne 50 ppm EQ | 34.8 | 34.6 | 0.6 |
| **BHT: 2,000 ppm** | 50 kg | 35.6 | 31.4 | 11.8 |
| | 1 tonne | 34.0 | 28.8 | 15.3 |
| **BHT: 4,000 ppm** | 50 kg | 33.1 | 29.7 | 10.3 |
| | 1 tonne | 34.2 | 30.2 | 11.7 |
| **Natural blend: 2,000 ppm** | 50 kg | 33.2 | 25.5 | 23.2 |
| | 1 tonne | 33.5 | 27.3 | 18.5 |
| **Natural blend: 4,000 ppm** | 50 kg | 33.8 | 24.2 | 28.4 |
| | 1 tonne | 31.9 | 22.8 | 28.5 |

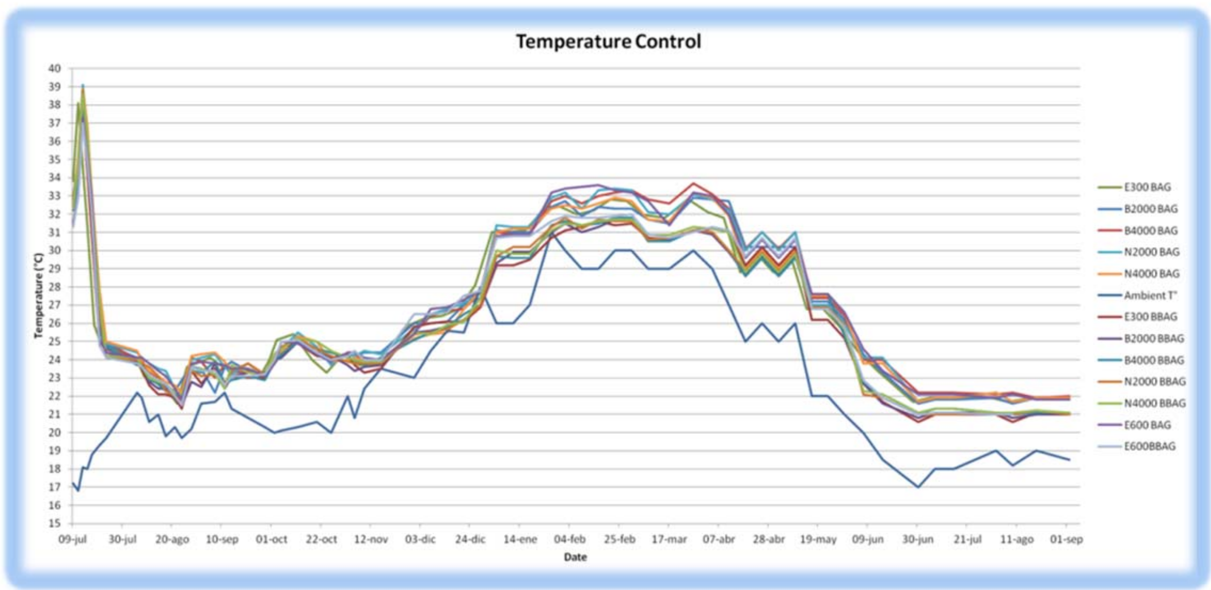
**Table 4: The omega-3 fatty acid values and decrease during 12-month storage period**

The omega-3 fatty acids in the BHT treated fish meal samples decreased by between 10.3 and 15.3% with little difference shown between the two treatment concentrations (2,000 ppm and 4,000 ppm) as well as the storage size.

The omega-3 fatty acids in the Natural blend treated fish meal samples decreased by between 18.5 % and 28.5% with the higher dosage level (4,000 ppm) showing slightly higher oxidation of the omega-3 fatty acids. According to the oxidation levels of the omega-3 fatty acids the Natural blend is slightly less effective than BHT.

A temperature graph of the fish meal treatments taken during the storage period along with the ambient temperature reading can be seen in Figure 2. Apart from the normal initial spike in temperature after production none of the fish meal treatments heated to a temperature higher than 35°C or higher than roughly 5°C higher than the ambient temperature as prescribed by SP 300. Even the low ethoxyquin dosage samples (30 – 50 ppm) samples did not overheat during the 12 month storage period. The lower ethoxyquin dosage level, the BHT as well as the natural antioxidant blends all protected fish meal against overheating and possible combustion.

**Figure 2: Temperature graph of all the fish meal treatments along with the ambient temperature. (BAG = 50 kg bag; BBAG = 1 tonne**




**bag; E = Ethoxyquin; B = BHT; N = Natural blend)**

The results therefore indicate that due to the very low rate of oxidation of the 300 ppm ethoxyquin treatment will effectively stabilise fish meal over a 12-month period. The alternative antioxidants tested can also be used to stabilise fish meal because of the high levels of remaining antioxidant as well as the effective protection against oxidation as shown by the low levels of decrease in omega-3 fatty acids during the 12-month storage period.

Ethoxyquin has been shown to be the most efficacious of the available synthetic antioxidants[3,4,5.] The high efficacy of ethoxyquin is not only because of its chemical nature but also due to the fact that its oxidation products also possess strong antioxidant properties[6,7]. Two of its oxidation products, ethoxyquin-dimer

[3] Aquaculture development and coordination programme, (1980). Fish feed technology, FAO Fisheries and Aquaculture department. Downloaded on 23 March 2016 from http://www.fao.org/docrep/x5738e/x5738e0b.htm

[4] Blaszczyzk, A., Augustyniak, A. and Skolimowski, J. Ethoxyquin: An antioxidant used in animal feed., International Journal of Food Science, Volume 2013 (2013), Article ID 585931, 12 pages http://dx.doi.org/10.1155/2013/585931

[5] Lundebye, A.-K., Hovea, H., Mage, A., Bohne, V.J.B. and Hamre, K., (2010). Levels of synthetic antioxidants (ethoxyquin, butylated hydroxytoluene and butylated hydroxyanisole) in fish feed and commercially farmed fish. Food Additives and Contaminants, Vol. 27, No. 12, 1652–1657

[6] De Koning, A.J., (2002). The antioxidant ethoxyquin and its analogues: A Review. International Journal of Food Properties, Vol 5, Issue 2, pp 451 - 461

[7] Thorrison, S., (1987). Antioxidant properties of ethoxyquin and some of its oxidation products. PhD Thesis, Faculty of Science, University of St Andrews, United Kingdom

and a quinolone have shown to have efficacy values of 69% and 80% of the value of ethoxyquin respectively[5,8].

The low 50ppm ethoxyquin dosage has shown to actively protect fish meal against oxidation as can be seen by the similar induction period to BHT in the oxygen bomb test (Table 2) and the limited decrease in omega-3 fatty acids similar to the 300ppm ethoxyquin. A residual of 60 ppm ethoxyquin, which is nearly 2/3 of the amount of less active alternative antioxidants such as BHT, would therefore provide safe protection against further oxidation.

IFFO amendments were incorporated in the IMDG code and the following Special Provisions were changed:

*SP 308 Stabilization of fish meal shall be achieved to prevent spontaneous combustion by effective application of ethoxyquin, BHT (butylated hydroxytoluene) or tocopherols (also used in a blend with rosemary extract) at the time of production. The said application shall occur within twelve months prior to shipments. Fish scrap or fish meal shall contain at least 50 ppm (mg/kg) of ethoxyquin, 100 ppm (mg//kg) of BHT or 250 ppm (mg/kg) of tocopherol-based antioxidant at the time of shipment.*

*SP 945 It was deleted, due to the weight limit of 3,000 kg written in both SP 308 and SP 945 for the proposed amendment poses a serious concern for the fish meal producing industry since a significant volume of fish meal is shipped in bulk in containers as well as in bulk in the ship's hold. According to a recent survey on our members to ascertain the format that fish meal is shipped in, more than 35% of fish meal is shipped in bulk (in container or ship's hold).*

**Conclusions**

The IFFO 12-month fish meal stability trial provided proof for the following amendment to be accepted into the Model Regulations by the UN Sub-Committee of Experts on the Transport of Dangerous Goods.

As a result of the proposed amendments and the trials that IFFO did, the **IMDG code edition 2018** reads as follows:

SP 308 read as follows: "Stabilization of fish meal shall be achieved to prevent spontaneous combustion by effective application of ethoxyquin, BHT (butylated hydroxytoluene) or tocopherols (also used in a blend with rosemary extract) at the time of production. The said application shall occur within twelve months prior to shipments. Fish scrap or fish meal shall contain at least 50 ppm (mg/kg) of ethoxyquin, 100 ppm (mg//kg) of BHT or 250 ppm (mg/kg) of tocopherol-based antioxidant at the time of shipment"[9].

SP 945 was eliminated due to it only created confusion[9].

The IMDG Code has apart from the SPs above, the following additional SPs:

SP 907 The consignment shall be accompanied by a certificate from a recognized authority stating:

- Moisture content
- Fat content
- Details of antioxidant treatment for meals older than 6 months (for UN 2216 only)
- Antioxidant concentration at the time of shipment, see special provision 308 (for UN2216 only)

[8] De Koning, A.J., (1996). Determination of the antioxidant efficacies in fish meal of two oxidation products of ethoxyquin. International Fishmeal and Fish oil manufacturers Association, Research Report, 1996-4.

[9] International Maritime Organisation (IMO). (2018). IMDG CODE International Maritime Dangerous Goods Code. Volume 2. International Maritime Organisation, London.

- Packing, number of bags and total mass of the consignment
- Temperature of fish meal at the time of despatch from the factory
- Date of production

No weathering/curing is required prior to loading. Fish meal under UN 1374 shall have been weathered for not less than 28 days before shipment.

When fish meal is packed into containers, the containers shall be packed in such a way that the free air space has been restricted to the minimum[9].

SP 928 The provisions of this Code shall not apply to:

- Fish meal when acidified and wetted with more than 40% water, by mass, irrespective of other factors
- Consignments of fish meal which are accompanied by a certificate issued by a recognized competent authority of the country of shipment or other recognized authority stating that the product has no self-heating properties when transported in packaged form; or
- Fish meal manufactured from "white" fish with a moisture content of not more than 12% and a fat content of not more than 5% by mass[9].

— END —