

FuelClear™ AV15: Development of a Non-Salt Stabilised CMIT/MIT Aviation Fuel Biocide

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1.0 Abstract

Recent Aircraft Incident Reports^{1 2} highlight suspected engine corrosion following addition of a fuel biocide additive into jet fuel during maintenance. It is speculated the engine corrosion may be related to the presence of metallic salts and the temperature/solubility characteristics of the biocide³. Procedural & dosing technology factors concerning aviation biocides are also being reviewed outside the scope of this document.

2.0 Introduction

A new fuel biocide is required to satisfy aviation industry requirements. Only one other biocide remains approved and this may lead to potential safety risks concerning microbial growth in jet fuels. Fuelcare distribute a fuel biocide which has now been removed for use for aviation. It is not expected that this product will return to the aviation market.

3.0 Development

Fuelcare began working on a new fuel biocide product in Q2, 2020. The composition was initially decided to be identical to the existing CMIT/MIT biocide whose patent has since expired, but this pathway was abandoned. The results of the recent aviation incident report as well as commercial & regulatory considerations meant a new formulation would be better candidate. A wide range of stakeholders with expertise in biocide chemistry, jet fuels, jet fuel additives and microbial testing were consulted in the development process.

3.1 Active Ingredient

CMIT/MIT (3:1) was selected as the suitable active ingredient against the following criteria:

- Familiarity, Existing knowledge & confidence in CMIT/MIT compound.
- Low toxicity, non-carcinogenic at 1.5% concentration.
- Simplified approval prospect (i.e. EU BPR approval).
- Low dosage rates.
- Low risk to fuel systems & infrastructure.
- Partitioning characteristics between fuel & water phases within fuel tanks.
- Rapid microbial efficacy.

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Other Isothiazalone biocidal chemistries were considered, but did not meet the requirements for end use (BIT, MIT for example). Their use, whilst widespread in industry applications, do not have a long track record in fuels, nor the required partitioning characteristics between water and fuel found in aircraft fuel tanks.

3.2 Stabilisers

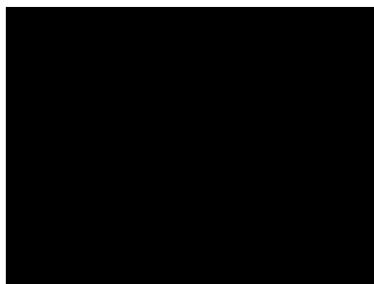
CMIT/MIT biocides are naturally unstable when mixed with certain chemicals, exposed to high temperatures or UV light. Water is typically used with Magnesium salts to achieve stability; however, the side-effects of salt inclusion are not always suitable for some end uses. These salts have “potential for solids formation caused by interactions with other salts in the system, interaction with certain salt forming organics, by the conversion to organic salts, or simply by incompatibility with the system...eliminating salts is to avoid an environment in which corrosion can occur. For example, chloride salts (among others) have a corrosive effect on many metals and are to be avoided where possible.”⁵ Stabilising CMIT/MIT biocides without metallic salts, therefore requires the removal of water from the formulation. ‘Stabiliser A’, ‘B’ & ‘C’ are used instead, which wipe off water traces.⁶

3.3 Solvent

Research into suitable solvents was initiated that meet published criteria for a non-salt stabilised CMIT/MIT compound: “Preferred solvents are capped polyols, wherein the free hydroxy is at least partly replaced with an ether or ester function.” The characteristics required were:

- Improved physical characteristics over DPG (existing CMIT/MIT biocide solvent) where viscosity & solubility issues at low temperatures are suspected of causing recent incidents.
- Physical characteristics matching or improving DPG for aviation fuels.
- Existing use & understanding within the aviation fuels industry.
- Low Toxicity (i.e. safe for handling).
- EPA & ECHA ease of approval.

An initial list of eleven suitable candidates was established. With the assistance of a specialist jet fuel additive consultancy⁴ this was shortened to six (that have existing jet fuel usage) and finally four (that highlight improved physical characteristics over DPG):



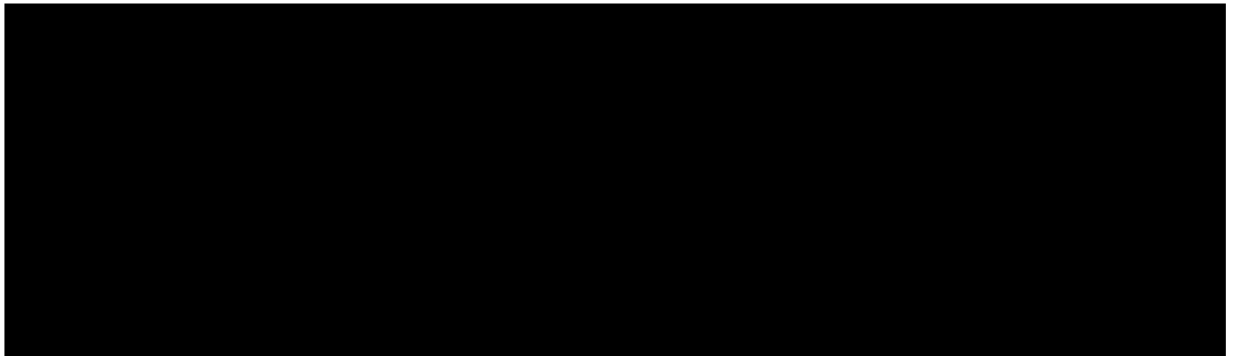
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The key physical characteristics comparisons of the final four solvents are presented in Table 1, with a focus on viscosity, solubility, density & temperature-related considerations:

| Solvent | Density (kg/L) | Dyn. Viscosity (mPas) @ 20 °C | pH | Boiling Point (°C) | Freezing Point (°C) | Flash Point (°C) | Solubility in Water |
|---------|----------------|-------------------------------|----|--------------------|---------------------|------------------|---------------------|
| | | | | | | | |

Table 1



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4.0 Conclusion

4.1 Final Composition

The final composition following development is therefore:

| Type | Ingredient | Value |
|--|---|-------------|
| Active Ingredients | 5-chloro-2-methyl-4-isothiazolin-3-one (CMIT) | 1.125% |
| | 2-methyl-4-isothiazolin-one (MIT) | 0.375% |
| | Total Active Ingredients | 1.5% |
| Inert Ingredients (Approximate Value) | [REDACTED] | 94.0% |
| | [REDACTED] | |

Table 2

4.2 Microbial Efficacy

The final product is recommended only for aviation application and at one dosage rate – 100ppm v/v (100ml of FuelClear AV15 per 1,000 Litres of fuel). This is designed to reduce the risk introduced by products with multiple dosing rates (i.e. other fuels). A minimum retention time of 8-12 hours is recommended. These values are determined by previous ASTM E1259 tests of similar 1.5% CMIT/MIT biocides. This new formulation is currently on test (ASTM E1259) with an aviation fuels microbiology lab in the UK.

4.3 Regulatory Status

The regulations required for such a biocide are wide-ranging. In the EU these include REACH registration and Biocides Products Regulation approval. The costs and time to achieve these are high. In the US, EPA and TSCA regulatory approval is required. Many other country approvals around the world would be required. ASTM D1655 as well as wide-ranging OEM approvals would also be required in due course.

FuelClear AV15 at present has an approved active ingredient under both US & EU schemes (and in the E.U. 'Article 95' approval status) but not the biocidal product itself – this process can take many years for approval.

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The product has the only 'Article 95' biocide manufacturer willing to share the CMIT/MIT efficacy data package in order to secure future EU approval.

4.4 Future Development

Fuelcare have distributed the incumbent CMIT/MIT fuel biocide for over 20 years. There is a possibility that the biocide will be reapproved by the aviation industry, however the reputational risk, perception and business risk to the manufacturer we believe remains too high for resumption of aviation usage.

There is therefore an opportunity to bring to market a new CMIT/MIT biocide for approval in aviation. However, the global annual volumes, margins and potential prices make the business case challenging when considering the high approval costs (\$2-\$5m). No large business will wish to invest into a relatively poor business case, and no small business has the capital to fund the approval or regulatory processes. Only wide-ranging industry support (financial or otherwise) will enable such a product to come to market. Fuelcare wish to bring FuelClear AV15 to market but will await further industry requirements.

5.0 References

1. Bulletin S1/2020 SPECIAL, Air Accidents Investigation Branch, April, 2020.
2. Aircraft Serious Incident Investigation Report AI2020-2, Japan Transport Safety Board, June, 2020.
3. Fuel Biocide Dosing: Evaluation, Specification & Best Practices for Aviation, Fuelcare, May, 2020.
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- [REDACTED]
6. Email from Biocide Manufacturer 'B', Technical Director, September, 2020.

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7.0 Acknowledgments

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