To whom it may concern.

Subject: 2022 Organic Chlorides, marine fuels incidents

The CIMAC Fuels working group consists of experienced stakeholders representing refiners, suppliers, OEMs, ship operators, fuel testing labs, classification societies and other related stakeholders.

This statement is made to update the maritime industry on how we, as specialists, see the 2022 marine fuel incidents that occurred earlier this year.

The Cases

In February and March 2022, more than 100 ships[1] reported operational problems using high sulphur residual fuels bunkered in Singapore.

Ships, using these bunkers, reported sticking fuel pumps and engine performance failures (high wear in injection equipment) with some ships also reporting separator sludging and filter blocking.

Review of the reported cases has shown that the incidences were not isolated to any specific machinery, component make or brand of affected separators, filters, two-stroke engines, or four-stroke engines.

The analysed fuels met the ISO 8217 Table 2 requirements however, prompted by the reported problems, further investigative analysis was carried out revealing the presence of high concentrations of various chlorinated organic compounds (COCs), with 1,2-dichloro-ethane showing the highest concentrations.

Concentrations of individual COCs were found up to 6000 mg/kg with the less contaminated fuels having levels of individual COCs in the 70-100 mg/kg range.

Those vessels that used fuels with high concentrations of COCs reported severe operating problems on both main and auxiliary engines.

[1] CIMAC WG7 data

Once the industry became aware of the issue, most fuels containing COCs were de-bunkered, irrespective of the concentration of the COCs, some even before consumption of the fuel started.

Correlating presence of chemical species with operational issues

According to the most widely used marine fuel standard, ISO 8217, marine fuels consist of a wide range of hydrocarbons from sources such as petroleum crude oil, synthetic or renewable sources, shale oil, oil sands and Fatty Acid Methyl Ester (FAME). The standard is largely based on parameters related to operational performance/experience rather than a detailed chemical composition.

Due to the nature of marine fuels with a wide range of blend components of different origin, no one can confidently say which chemical species can be found in a marine fuel; nor in which concentration; nor in which combination. It is generally accepted though that marine fuels can contain a significant number - and combination - of different organic compounds in various concentrations.

When marine fuels claiming to meet ISO 8217 cause operational issues, despite the ship having followed best industry practice, investigative testing[2] can be considered to check if the fuel contains chemical species which can be correlated to the experienced problems.

Once an unusual compound and its concentration have been identified and its presence has been confirmed by other testing labs, the next step is to evaluate if that component – or combination of species – can be the cause of the operational issues.

The most practical way to identify a correlation between the presence of the component(s) and the experienced operational issues is to perform a cause-and-effect analysis. This is unfortunately not a simple task as it not only requires significant testing work but more importantly, industry collaboration and knowledge sharing. Typically, though, when the same batch of fuel is supplied to numerous ships, it enables a meaningful cause-and-effect evaluation.

The following lists essential items for consideration when cause-and-effect is established:

- The ship followed industry best practice for fuel storage and treatment
- The fuel containing the specific chemical specie(s) was in use at the time the ship experienced problems
- Presence of the specific chemical specie(s) has caused similar operational issues on other ships

[2] Gas Chromatography Mass Spectrometry (GCMS) is the analytical method typically used to identify the individual components of marine fuels. The GCMS standard, ASTM D7845, applies to marine fuels.

- Non-problematic fuels do not contain the specific chemical specie(s), or only contain insignificant amounts of the component(s)
- If available, historical records of similar issues related to presence of same component(s)
- A hypothesis which explains the experienced issues

Cause-and-effect evaluation of COCs in marine fuels

During the investigation, CIMAC WG7 Fuels came across the following case:
A ship having bunkered high sulphur fuel oil supplied in February 2022 in Singapore, experienced deteriorated performance of the fuel pump after having changed over to the fuel that contained various COCs with 1,2-dichloro-ethane at 3629 mg/kg. The ship decided to replace all fuel pumps with new pumps before continuing to consume the same fuel. Within a week the new fuel pumps and injectors failed again.

Subsequent reports from investigating engineers reported that rapid degradation of the fuel pumps and injectors had occurred, evidenced through surface analysis and measurements of the sliding components in contact with the fuel (Figure 1), along with poor atomisation performance of the injectors. The cause was evidentially linked to chemical and corrosive attack from the subject fuel in use.

Similar reports and operational experiences were received from other ships having used fuel of same origin.

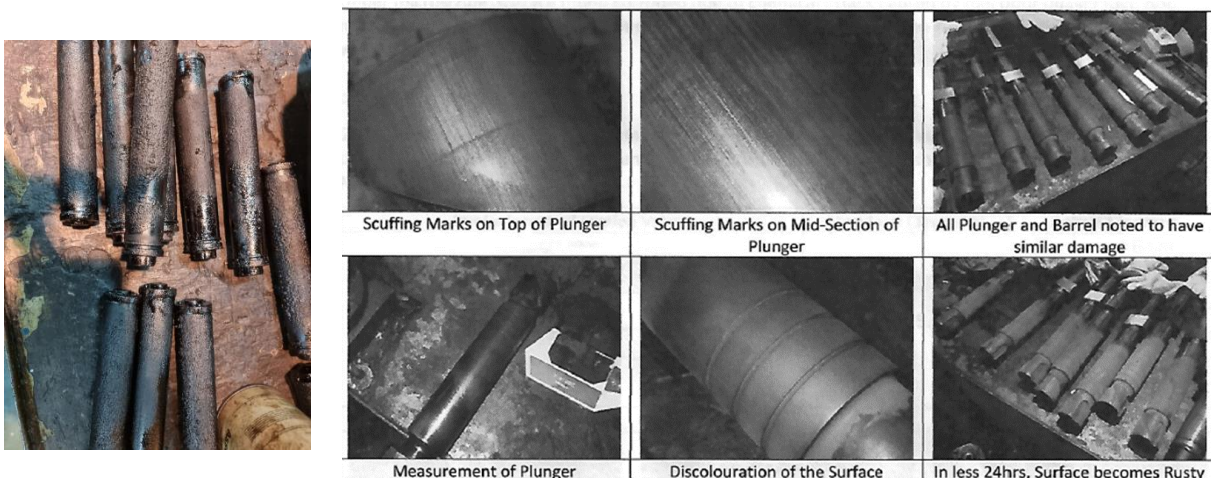

Figure 1: Photos showing candle filter elements and damaged fuel pumps and after one week's operation on fuel containing high concentrations of organic chlorides

The observations from this case would be supported by initial hypothesis that the following mechanisms have possibly been involved in the encountered issues:

- COCs are good solvents.
  Due to these properties, the COCs picked up sediments and dirt from the fuel tanks/system which later deposited in the filters resulting in filter clogging and resulted in separator sludging

- COCs may react under certain conditions.
  The high temperatures and pressures combined with shear forces in the engine fuel pumps led to formation of hydrochloric acid. This strong acid attacked the sliding surface of the fuel system components resulting in rapid corrosive damage

Fuel testing laboratory findings

Fuel testing labs have also in 2004, 2012, 2015, 2018 and 2019 alerted on suspected COCs in marine fuels. Several ships that bunkered in Fujairah in 2004 experienced similar issues as the Singapore 2022 cases. At the time, analysis revealed presence of various COCs although concentrations were not reported.

Fuel testing agencies have included COCs in their investigative analytical test scope for decades and rarely find presence of COCs. In the rare cases where they have been identified, it has usually been as individual compounds rather than in a combination of several COCs.

As a result of the Singapore COCs incidents, bunkers from key ports around the world have been tested for COCs as a precautionary measure. The review of this data confirms previous observations that for the most part marine bunkers do not contain COCs.

This cause-and-effect evaluation therefore has established a correlation between elevated levels of COCs and equipment failure.

Test methodology to detect presence of COCs and evaluation of test results

The total organic chlorine content correlate with the presence and concentration of organic chlorides. As such, fuels can be screened for presence of organic chlorides by testing for total organic chlorine, e.g. through test method EN 14077 (“Determination of organic halogen content”). At the time of writing of this document, EN 14077 is the only standardised method with precision statement to detect presence of total organic chlorine.

Identification of specific COCs would require additional investigative testing such as the use of GCMS. The list of chemical species in the standardised test method ASTM D7845 (“Determination of Chemical Species in Marine Fuel Oil”) does not include organic

chlorides according to the scope of method, however, the test method can be used with correct calibration using the appropriate standards for the determination of other species, e.g. organic chlorides. Work is ongoing through the ISO 8217 committee with ASTM to develop a new GCMS standardised test method to include organic chlorides.

In view of the findings, marine fuels shall not contain COCs.

Analysis of data and operational feedback received to date from ships suggests that fuels with a total organic chlorine content below 50 mg/kg (EN 14077) can be considered as containing de-minimis levels of organic chlorides.

CIMAC WG7 Fuels further advises the importance of the following;

Ship operator
An operator experiencing fuel related issues should make certain to duly log the case in detail, documenting the evidence leading up to, during and after the operational problems were experienced, along with any mitigating actions taken. This should include the current status of Remaining On Board (ROB) management, engine machinery maintenance, temperature management and fuel handling and treatment practices routinely applied.

Thus, by keeping a log of the encountered issues and ensuring system samples are taken at the time of the incident in the event they are needed for later analysis, their case can be more effectively pursued.

Fuel supplier
Whilst Clause 5 of ISO 8217 does not prescribe specific test methods, it is an all-encompassing requirement specifying that it is unacceptable to supply, blend or allow even an accidental ingress of any product(s) that would render the fuel unacceptable for its intended use.

This is more definitively explained in the informative Annex B of ISO/PAS 23263:2019 and ISO 8217:2017, respectively, which states the impracticability of carrying out chemical analysis and so expresses its expectation of the supply chain to have in place adequate quality assurance and management procedures to ensure that the resultant fuel is compliant with the requirements of Clause 5.2: "*The fuel shall be free from any material at a concentration that causes the fuel to be unacceptable for use in accordance with clause 1 (i.e. material not at a concentration that is harmful to personnel, jeopardises the safety of the ship, or adversely affects the performance of the machinery*".

It should remain clear that fuel oil suppliers have an obligation to comply with the ISO 8217 standard in its entirety which, in addition to the scope in Clause 1 as well as Table 1 and 2,

includes Clause 5 to ensure that no unacceptable material which might cause an adverse effect to the ship's machinery enters the fuel.

If proven that the fuel, as supplied, is responsible for experienced operational problems, it would point to the bunkers not having met the ISO 8217 standard.

Conclusions

Based on the cause-and-effect study and the fuel analyses collated to date, CIMAC WG 7 Fuels have concluded that all the examined and reported cases are pointing to a correlation between elevated levels of COCs in marine fuels and operational issues.

It is therefore the opinion of CIMAC WG7 that marine fuels shall be free of COCs where de-minimis levels of COCs are to be taken as when the concentration of total organic chlorine does not exceed 50 mg/kg (EN 14077).

It remains the responsibility of the fuel supplier to ensure that requirements for COC's are met.

Potential long-term effects on engine condition of continuous operation on fuels containing de-minimis levels of COCs are unknown. As such, the experts of CIMAC Fuels will continue the investigation in support of the industry towards final conclusions on the subject matter.

Best regards,

CIMAC WG7 - Fuels
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