## AMP 133 FUEL Oil Chemistry (VERSION 2020)

### Programme Description

All substances in power stations are subject to ageing during storage and exploitation by thermal, mechanical or chemical loads. The programme includes (a) surveillance and maintenance procedures to mitigate corrosion of mechanical equipment exposed to fuel oil and (b) measures to verify the effectiveness of the mitigation actions and confirm the insignificance of an ageing effect. Fuel oil quality is maintained by monitoring and controlling fuel oil contamination in accordance with the plant’s technical specifications and international guidelines. Some useful references are ASTM D 0975-04, D 1796-97, D 2276-00, D 2709-96, D 6217-98, D 4057-95, API 653 [1-7]. Besides the general approach in the NRC Guides [8-9], in order to detail the plant procedures, other references can be used, such as EN 590, EN ISO 12185, EN ISO 3104, EN ISO 3405, DIN EN 116, EN ISO 14596, EN ISO 10370, EN ISO 4264, EN ISO 6245, EN 12662, EN ISO 12205 [10-20]. Exposure to fuel oil contaminants, such as water, microbiological organisms and impurities, is minimized by periodic draining or cleaning of tanks and by verifying the quality of new oil before its introduction into the storage tanks. The plant procedures to verify the new fuel oil and the used one are in constant evolution to contemplate new knowledge and operational experience. Some references used to these new procedures are ASTM D56 - 16a, ASTM D482 – 19, ASTM D1744-13 (2016), ASTM D2274 - 14(2019), ASTM D5453 - 19a, ASTM D4737 - 10(2016), ASTM D4052 - 18a, DIN 51365, ISO 3771:2011, ISO 2592:2017, ISO 3733:1999 [21-31]. However, corrosion may occur at locations in which contaminants may accumulate, such as tank bottoms. Accordingly, the effectiveness of the programme is verified to ensure that significant degradation is not occurring and that the component’s intended function is maintained. Thickness measurement of tank bottom surfaces is an acceptable verification programme, to be carried out according to the applicable international guidelines and codes (e.g. [7]).

The fuel oil chemistry programme is generally effective in removing impurities from intermediate and high flow areas. Its report identifies those circumstances in which the fuel oil chemistry programme is augmented to manage the effects of ageing. For example, the fuel oil chemistry programme may not be effective in low flow or stagnant flow areas. Accordingly, in certain cases as identified in this programme, verification of the effectiveness of the chemistry programme is to be undertaken to ensure that significant degradation is not occurring and that the component’s intended function is maintained during the period of operation. As discussed in this programme for specific cases, an acceptable verification programme is a one-time inspection of selected components at susceptible locations in the system.

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### Evaluation and Technical Basis

1. ***Scope of the ageing management programme based on understanding ageing:***

Components within the scope of the programme are the diesel fuel oil storage tanks, piping, and other metal components subject to ageing management review that are exposed to an environment of diesel fuel oil. The programme is focused on managing loss of material due to general, pitting and crevice corrosion, and microbiologically induced corrosion (MIC).

1. ***Preventive actions to minimize and control ageing degradation:***

All delivered new fuel oil is checked before filling in the storage tanks.

Some EPRI references could be useful, such as Nuclear Maintenance Applications Center: Guide for the Storage and Handling of Fuel Oil for Standby Diesel Generator Systems, Revision 3: Diesel Fuel Oil Guide. EPRI, Palo Alto, CA: 2007. 1015061 [32], Storage and Use of Low-Concentration (5%) Biodiesel Blends in Nuclear Plant Emergency Diesel Generators. EPRI, Palo Alto, CA: 2017. 3002010609 [33] and Winterizing Diesel Fuel; EPRI, Palo Alto, CA: 1994; TR-104843 [34].

The programme reduces the potential for (a) exposure of the storage tanks internal surface to fuel oil contaminated with water and microbiological organisms, also reduces the potential for age-related degradation in other components exposed to diesel fuel oil; and (b) transport of corrosion products, sludge, or particulates to components serviced by the fuel oil storage tanks. Biocides or corrosion inhibitors may be added as a preventive measure or if periodic testing indicates biological activity or evidence of corrosion.

The presence of copper alloy and chromium plating is carefully considered because the presence of these materials in catalytic doses leads to accelerate ageing of the fuel oil. As a result of this accelerated ageing acids can be produced and this can lead to corrosion of the storage tanks internal surfaces and piping to the engines as well. The ignitibility of the fuel oil can be reduced too. It is recommended to exclude the using of these materials in the tanks and the tank vehicles as well.

1. ***Detection of ageing effects:***

Loss of material due to corrosion of the diesel fuel oil tank or other components exposed to diesel fuel oil cannot occur without exposure of the tank’s internal surfaces to contaminants in the fuel oil, such as water and microbiological organisms. Periodic (e.g. every 6 months) multilevel sampling provides assurance that fuel oil contaminants are below unacceptable levels. If tank design features do not allow for multilevel sampling, a sampling methodology that includes a representative sample from the lowest point in the tank is to be used. If the sampling results approach the limiting value of ageing products, the period of sampling is reduced. In case the sampling results exceed the limiting values, the storage tanks are drained, cleaned and filled up with new fuel oil.

At least once during a 5 to 10-year period (depending on the results of sampling), each diesel fuel tank is to be drained and cleaned, the internal surfaces are visually inspected (if is physically possible) and volumetrically-inspected if evidence of degradation is observed during visual inspection, or if visual inspection is not possible.

Other alternative inspection and monitoring methodologies can also be considered in recognition of accessibility and operational constraints.

1. ***Monitoring and trending of ageing effects:***

Water, biological activity, and particulate contamination concentrations are monitored and trended in accordance with the pertinent governing requirements or guidance documents for the plant.

1. ***Mitigating ageing effects:***

Periodic cleaning of a tank allows removal of sediments, and periodic draining of water collected at the bottom of a tank minimizes the amount of water and the length of contact time. Accordingly, these measures are effective in mitigating corrosion inside diesel fuel oil tanks. Coatings, if used, prevent or mitigate corrosion by protecting the internal surfaces of the tank from contact with water and microbiological organisms. If coatings are used the AMP 157 is to be taken into account.

1. ***Acceptance criteria:***

Acceptance criteria for fuel oil quality parameters are as invoked or referenced in a plant’s technical specifications. Additional acceptance criteria may be implemented using guidance from industry standards and equipment manufacturer or fuel oil supplier recommendations. Other appropriate national or international industry standards may be used to develop fuel oil quality acceptance criteria. Suspended water concentrations are in accordance with the applicable fuel oil quality specifications. Corrective actions are to be taken if microbiological activity is detected.

1. ***Corrective actions:***

Specific corrective actions are implemented in accordance with the plant quality assurance (QA) programme. For example, corrective actions are taken to prevent recurrence when the specified limits for fuel oil standards are exceeded or when water is drained during periodic surveillance. If accumulated water is found in a fuel oil storage tank, it is to be immediately removed. In addition, when the presence of biological activity is confirmed, a biocide is added to fuel oil or an appropriate action is taken in consultation with the plant chemistry.

1. ***Operating experience feedback and feedback of research and development results:***

This AMP addresses the industry-wide generic experience. Relevant plant-specific operating experience is considered in the development of the plant AMP to ensure the AMP is adequate for the plant. The plant implements a feedback process to periodically evaluate plant and industry-wide operating experience and research and development (R&D) results, and, as necessary, either modifies the plant AMP or takes additional actions (e.g. develop a new plant-specific AMP) to ensure the continued effectiveness of the ageing management.

The operating experience at some plants has included identification of water in the fuel, particulate contamination, and biological fouling. The programme reviews the operating experience throughout the industry to ensure they are taken into account in this programme. (e.g. NRC Regulatory Guide 1.137 [8] or KTA 1403 [35]).

Research and development efforts and an effective experience exchange are important elements for implementing continuous improvement in this programme and in defining adequate corrective actions.

At the time when this AMP was produced, no relevant R&D was identified.

1. ***Quality management:***

Site quality assurance procedures, review and approval processes, and administrative controls are implemented in accordance with international guides (e.g., 10 CFR Part 50, Appendix B [9] or KTA 3702 [36]).

### References

[1] ASTM International, ASTM D 0975-04, Standard Specification for Diesel Fuel Oils, ASTM, 2004.

[2] ASTM International, ASTM D 1796-97, Standard Test Method for Water and Sediment in Fuel Oils by the Centrifuge Method, ASTM, 1997.

[3] ASTM International, ASTM D 2276-00, Standard Test Method for Particulate Contaminant in Aviation Fuel by Line Sampling, ASTM, 2000.

[4] ASTM International, ASTM D 2709-96, Standard Test Method for Water and Sediment in Middle Distillate Fuels by Centrifuge, ASTM, 1996.

[5] ASTM International, ASTM D 6217-98, Standard Test Method for Particulate Contamination in Middle Distillate Fuels by Laboratory Filtration, ASTM, 1998.

[6] ASTM International, ASTM D 4057-95, Standard Practice for Manual Sampling of Petroleum and Petroleum Products, ASTM, 2000.

[7] AMERICAN PETROLEUM INSTITUTE, API 653, Tank Inspection, Repair, Alteration, and Reconstruction, API, April 23, 2009.

[8] UNITED STATES NUCLEAR REGULATORY COMMISSION, Regulatory Guide 1.137, Rev. 2, Fuel Oil Systems for Emergency Power Supplies, USNRC, June 2013.

[9] UNITED STATES NUCLEAR REGULATORY COMMISSION, 10 CFR Part 50, Appendix B, Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants, USNRC, December 2019.

[10] EN 590, Automotive fuels, Diesel, Requirements and test methods.

[11] EN ISO 12185, Crude petroleum products, Determination of density, Oscillating U-tube method.

[12] EN ISO 3104, Petroleum products, Transparent and opaque liquids, Determination of kinematic viscosity and calculation of dynamic viscosity.

[13] EN ISO 3405, Petroleum products, Determination of distillation characteristics at atmospheric pressure.

[14] DIN EN 116, Diesel and domestic heating fuels, Determination of cold filter plugging point, Stepwise cooling bath method.

[15] EN ISO 14596, Petroleum products, Determination of sulfur content, Wavelength-dispersive X-ray fluorescence spectrometry.

[16] EN ISO 10370, Petroleum products, Determination of carbon residue, Micro method.

[17] EN ISO 4264, Petroleum products, Calculation of Cetan index of middle-distillate fuels by the four-variable equation.

[18] EN ISO 6245, Petroleum products, Determination of ash.

[19] EN 12662, Liquid petroleum products, Determination of total contamination in middle distillates, diesel fuels and fatty acid methyl esters.

[20] EN ISO 12205, Petroleum products, Determination of the oxidation stability of middle-distillate fuels.

[21] ASTM D56 - 16a, Standard Test Method for Flash Point by Tag Closed Cup Tester.

[22] ASTM D482 – 19, Standard Test Method for Ash from Petroleum Products.

[23] ASTM D1744-13, Standard Test Method for Determination of Water in Liquid Petroleum Products by Karl Fischer Reagent (Withdrawn 2016).

[24] ASTM D2274 - 14(2019), Standard Test Method for Oxidation Stability of Distillate Fuel Oil (Accelerated Method).

[25] ASTM D5453 - 19a, Standard Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence.

[26] ASTM D4737 - 10(2016), Standard Test Method for Calculated Cetane Index by Four Variable Equation.

[27] ASTM D4052 - 18a, Standard Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter.

[28] DIN 51365, Testing of lubricants; determination of total dirt in used engine oils; separation by centrifuging.

[29] ISO 3771:2011, Petroleum products — Determination of base number — Perchloric acid potentiometric titration method.

[30] ISO 2592:2017, Petroleum and related products — Determination of flash and fire points — Cleveland open cup method.

[31] ISO 3733:1999, Petroleum products and bituminous materials — Determination of water — Distillation method.

[32] Nuclear Maintenance Applications Center: Guide for the Storage and Handling of Fuel Oil for Standby Diesel Generator Systems, Revision 3: Diesel Fuel Oil Guide. EPRI, Palo Alto, CA: 2007. 1015061.

[33] Storage and Use of Low-Concentration (5%) Biodiesel Blends in Nuclear Plant Emergency Diesel Generators. EPRI, Palo Alto, CA: 2017. 3002010609.

[34] Winterizing Diesel Fuel; EPRI, Palo Alto, CA: 1994; TR-104843.

[35] KTA 1403, Ageing Management in Nuclear Power Plants, Bundesanzeiger BAnz No. 199a, December 30th, 2010.

[36] KTA 3702, Emergency Power Generating Facilities with Diesel-Generator Units in Nuclear Power Plants, Bundesanzeiger BAnz, January 15th, 2015.