Annex A

Wightlink Ltd - Lymington Harbour Safe Operating Procedure

ANNEX A TO SECTION 5: LYMINGTON HARBOUR – SAFE OPERATING PROCEDURE

A5.1 SAFE OPERATING PROCEDURE

The agreed Safe Operating Procedure is as follows:

1. Except as shown under (2) below, the aft thruster must only be used on the 'slow' (Yellow) setting in the river unless mean wind speeds exceed 25 knots gusting 30 knots.

2. The 'medium' (Blue/Blue) thruster setting on both f'wd and aft thruster units may be used at mean wind speeds below 25 knots between the North end of HM Pontoon and Wightlink fresh water berth to facilitate low speed berthing manoeuvres. This setting may only be used in the following circumstances:

    a. In mean wind speeds of up to 25 knots when absolutely necessary due to prevailing conditions, when approaching or departing the Linkspan/Emergency Berthing Barge.

    b. In all conditions when moving from stand-by berths or vice versa, but with the following provisions:

        (1) Vessels leaving the lay-by berth to make a sound signal prior to departing if other vessels are approaching.

        (2) Vessels not to leave the lay-by berths until the Linkspan is clear.

3. In mean wind speeds above 25 knots, the 'medium' (Blue) aft thruster can be used throughout the river. This represents the maximum thruster power configuration assessed as safe for routine use in the river in wind speeds above 25 knots.

4. The upper wind speed limit for operating within harbour limits is 40 knots mean gusting 47 knots, as measured at the Royal Lymington Yacht Club Starting Platform.

5. The full power (Green) setting must not be used on the aft thruster unit when in the river except in very exceptional circumstances when failure to use this setting would endanger the ferry or other users. If a Master has knowledge from his/her previous trip (because of prevailing weather conditions) that full power is likely to be required when transiting the river, then the vessel should not depart.

Cylinder Liner Cavitation Erosion On Diesel Engines

Cylinder Liner Cavitation Erosion On Diesel Engines

The AERA Technical Committee offers the following information on cylinder liner cavitation erosion on diesel engines. This information should be considered anytime maintenance is being performed on a diesel engine.

The cavitation erosion that is found in diesel engines on the exterior side of the cylinder liners (wet) has been a theme of investigation by engine and corresponding component manufacturers, even though no definite manner of eliminating the problem has been found. See Figure 1.

Figure 1. Severely Eroded liner

The degree and size of erosion or decay as well as its form and distribution on the affected zones can vary from engine to engine and inclusively from cylinder to cylinder within the same engine.

The affected areas form vertical strips or patches sometimes in alignment with the thrust face of the piston within the cylinder, or also formed immediately over the top sealing ring of the liner. The erosion can penetrate the wall of the cylinder and permit the flow of antifreeze/coolant to the oil or vice-versa.

The cavitation erosion is caused by excess in harmonic vibrations of the engine and in some cases by loose fitting liners that result in a fast formation and implosion of small vapor bubbles within the coolant which attack the cylinders' liner wall. The vibration in combination with collapsing bubbles produces an erosive effect over the surface of the liner's exterior face. This occurs as the piston moves up and down within the cylinder causing vibration especially over the area of thrust in the cylinder liner.

We can say that the wall of the sleeve, which comes in contact with the coolant, quickly moves inwards and outwards striking these vapor formations. During this process, tiny bubbles are formed that implode or collapse violently producing shock waves against the liner's wall. The results of these implosions at the impact area of the liner's wall have been calculated to reach over 10,000º F with pressures of over 10,000 psi.

A specific material, which would prevent cavitation erosion within reasonable cost, has not yet been found. Nevertheless, some coatings can be applied to delay cavitation erosion until it is time for major engine repairs.

In order to reduce or prevent cavitation, manufacturer recommendations should be followed.

In many cases, cavitation can be avoided by reducing harmonic vibrations. For example, by making sure the injection complies with the manufacturer's specifications, the engine's speed is governed according to the manufacturer's data and that the control functions. Also, do not underestimate the importance of correct clearances between liner and cylinder blocks; incorrect liner fit is a serious contributor to liner vibration resulting in cavitation erosion.

Engine manufacturers have specific additives for the coolant called SCA (supplementary cooling additive). These additives will form a protective coating over the cylinder liner, which is exposed to the coolant, therefore reducing cavitation damage. With time, additive concentration reduces in the system, consequently making it necessary to follow system maintenance recommendations in order to keep the adequate levels.
The following points will be supplied:

1. pH control to avoid corrosion
2. Water hardness control to avoid mineral deposit formation
3. Cavitation protection

In all cases, it is required that all manufacturer's recommendations regarding coolants, base additives, additives, coolant filters as well as maintenance schedules should be strictly adhered to or followed at all times.

Event 1: number 6 connecting rod debris analysis

Exponent International Limited

Exponent is an international consultancy with offices located in UK, Germany, Switzerland, USA, China and Hong Kong SAR

[redacted]

26th February, 2019

[redacted],
Volvo Penta UK
[redacted]

Subject: Volvo Penta – Wightlink Ferry
Exponent Project No.: 1808759.UK0-0870

Dear [redacted],

At your request, Exponent International Limited (Exponent) has carried out an analyses of the material located within the lubricating oil channel of connecting rod no.6, during the stripdown of a Volvo Penta D16 engine, serial number 1016027578. This stripdown was carried out in Warwick on the 29th January, 2019, by Volvo Penta staff in the presecence of representatives from the Marine Accident Investigation Branch, Lloyd's Register, Wightlink and RK Marine as part of ongoing investigations into various engine failures which have occured onboard Wightlink ferries since August 2017.

At an inspection on the 19th February, 2019 at an Exponent Labortory within The Natural History Museum, London, a connecting rod from the subject engine was visually inspected and samples collected from the lubrication channel by Dr. [redacted], an Exponent Materials Engineer. The lubrication channel openings and particles after collection are shown in **FIGURE 1**, **FIGURE 2** and

FIGURE 3, respectively. These particles were cleaned in an organic solvent (acetone) and prepared for scanning electron microscopy (SEM) and qualitative chemical analysis via energy dispersive x-ray spectroscopy (EDS). No analysis of the connecting rod material was performed.

SEM is an analysis technique whereby high magnification images of a sample can be created by interrogating the surface with an electron beam. When the electron beam from an SEM interrogates a material surface, x-rays are released by the sample.[1] These x-rays have a characteristic energy that depends on the element being interrogated. As a result, it is possible to determine what elements are present in a material through EDS.

In certain cases, it may be possible to estimate the relative amounts of each element present through a semi-quantitative analysis, but the sample must be specially prepared (i.e., flat and polished) to successfully perform this analysis;[1] the size and morphology of the particles precluded such semi-quantitative analysis, thus the presence of particular elements in the particles is noted without specific information regarding the concentration of each element in the particles.

Additionally, EDS does not provide information regarding the electronic state of the elements (i.e., what elements are bonded together), so specific information regarding the composition of the particles is not provided.

Two particles, both approximately 1 mm^3, were collected from the subject connecting rod and arbitrarily named "Particle 1" and "Particle 2." Both particles were examined via SEM/EDS. Representative SEM images of the Particles 1 and 2 are shown in **FIGURE 4** and **FIGURE 5**, respectively. The contrast in **FIGURE 4** and **FIGURE 5** represents compositional differences: brighter areas represent heavier elements (e.g., iron, Fe) while darker areas represent lighter elements (e.g., carbon, C). Note, the contrast is not uniform across all of the images, thus a particular shade of grey does not represent the same element image-to-image. Smaller, micron-scale particles were observed decorating the larger 1 mm^3 particles. The larger 1 mm^3 particles appear to consist mainly of carbon (C), while the smaller particles consist of a mix of aluminium (**FIGURE 6**), iron (**FIGURE 7**), nickel (**FIGURE 7**), copper (**FIGURE 7**) and lead (**FIGURE 8**). Traces of other elements, including but not limited to, phosphorus (P), calcium (Ca), sulphur (S) and silicon (Si) were also detected in various small particles decorating Particles 1 and 2.

[1] ASM Handbook Volume 10 Materials Characterization, ASM International, Metals Park, OH USA, 1986, pp. 518 – 535.

FIGURE 1. Representative photograph of the subject connecting rod.

FIGURE 2. Representative photographs of the lubrication channel openings in the subject connecting rod. Particles were visible in both openings.

FIGURE 3. Representative photograph of the two particles collected from the subject connecting rod.

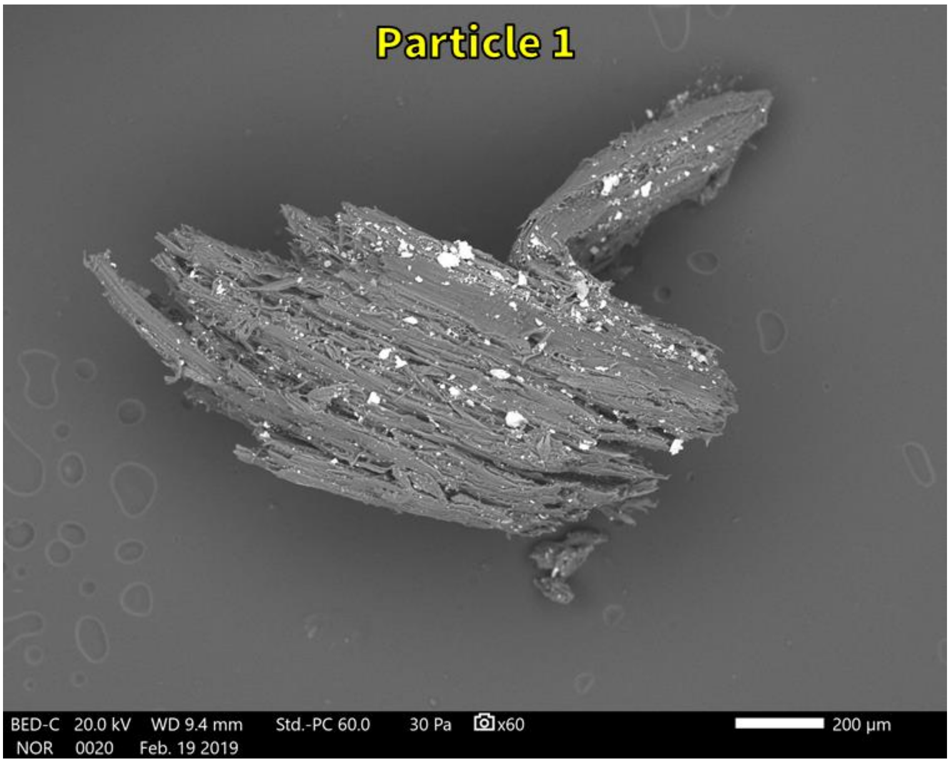

FIGURE 4. Representative SEM image of Particle 1.

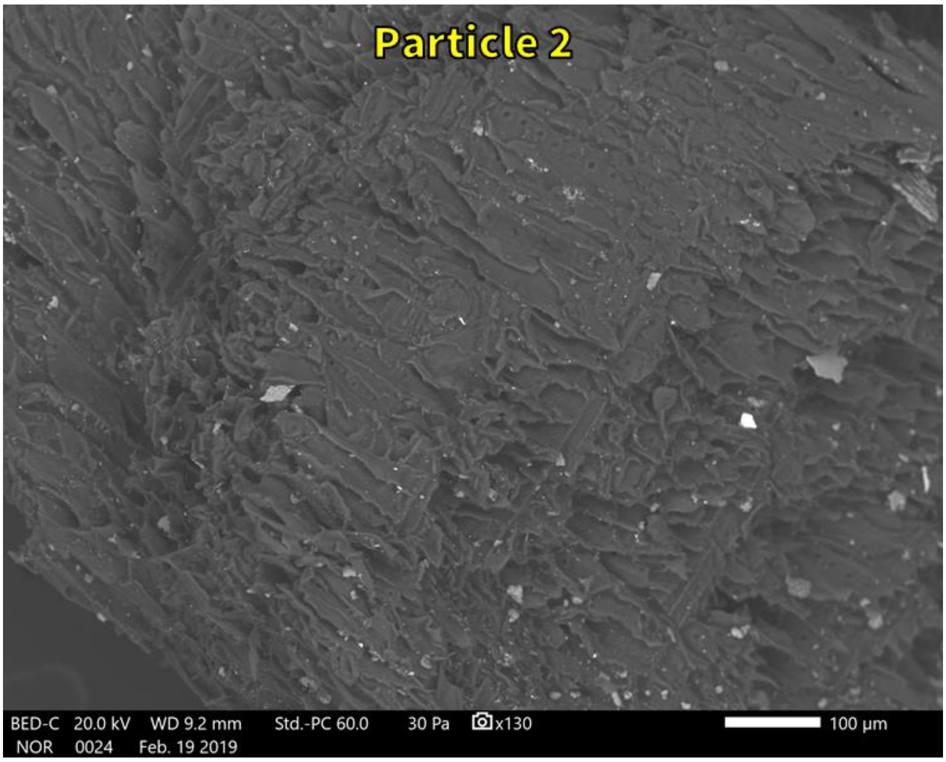

FIGURE 5. Representative SEM image of Particle 2.

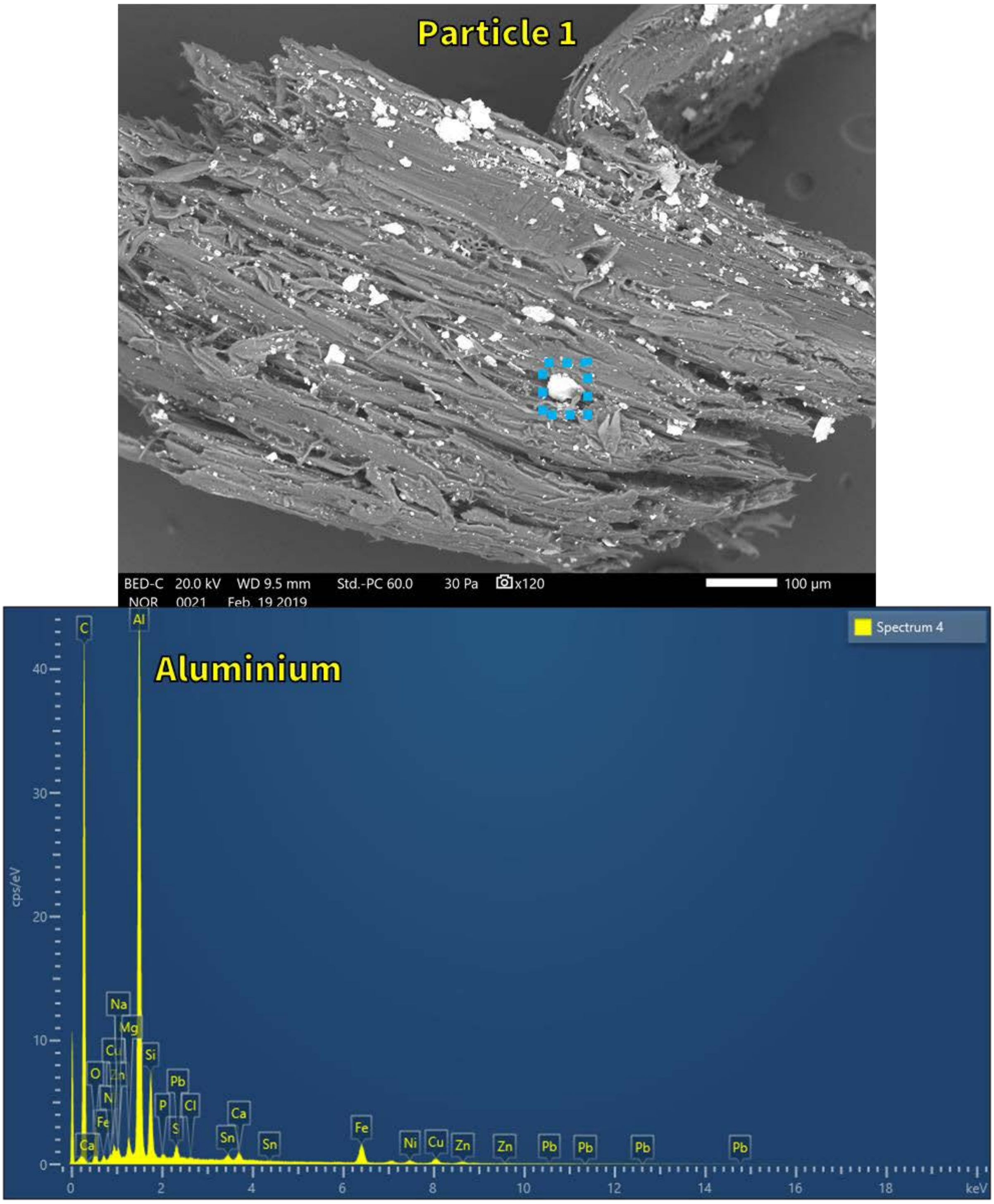

FIGURE 6. Representative EDS spectrum of a small particle decorating Particle 1. Aluminium (Al) was detected in this smaller particle.

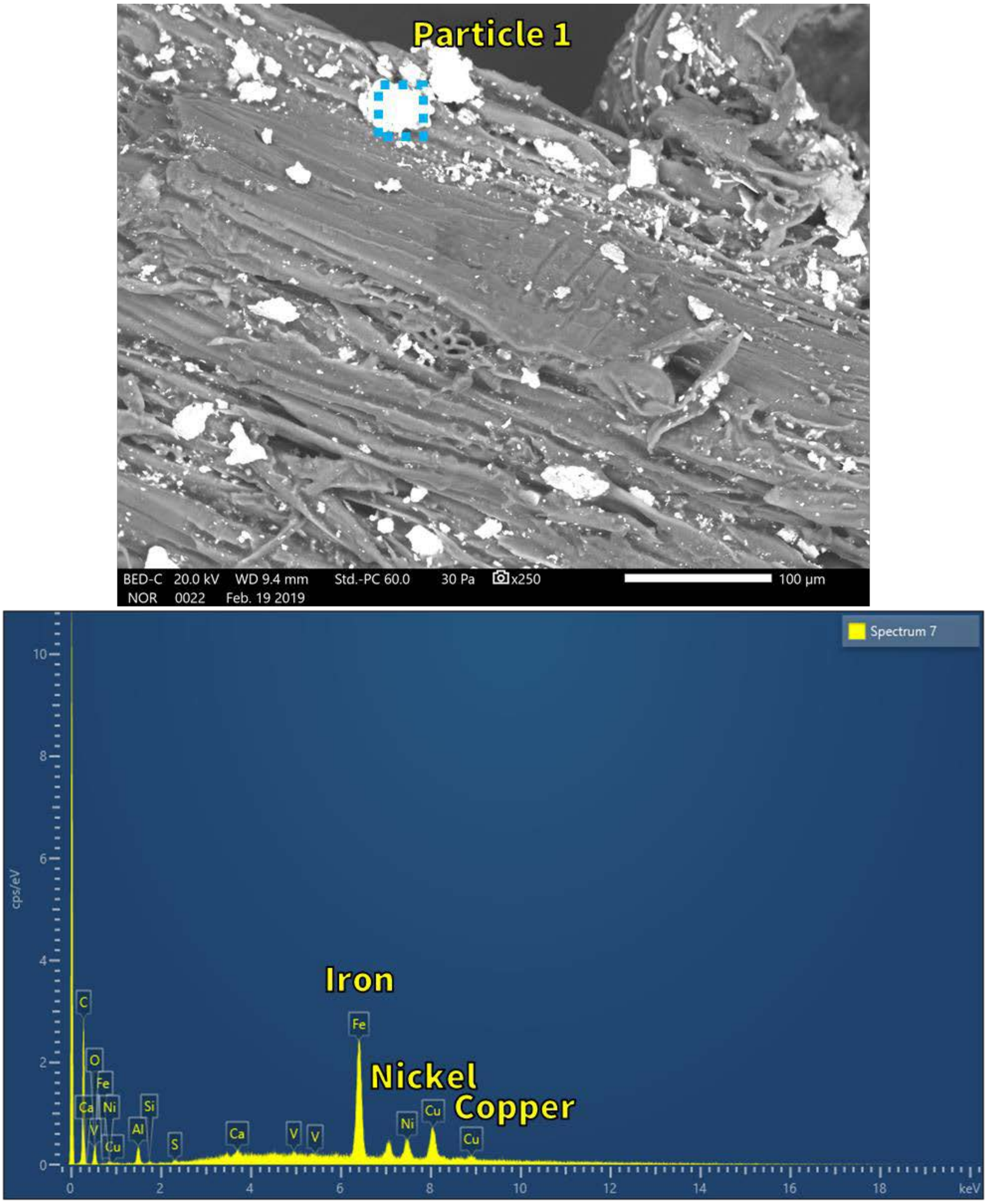

FIGURE 7. Representative EDS spectrum of a small particle decorating Particle 1. Iron (Fe), nickel (Ni) and copper (Cu) were detected in this smaller particle.

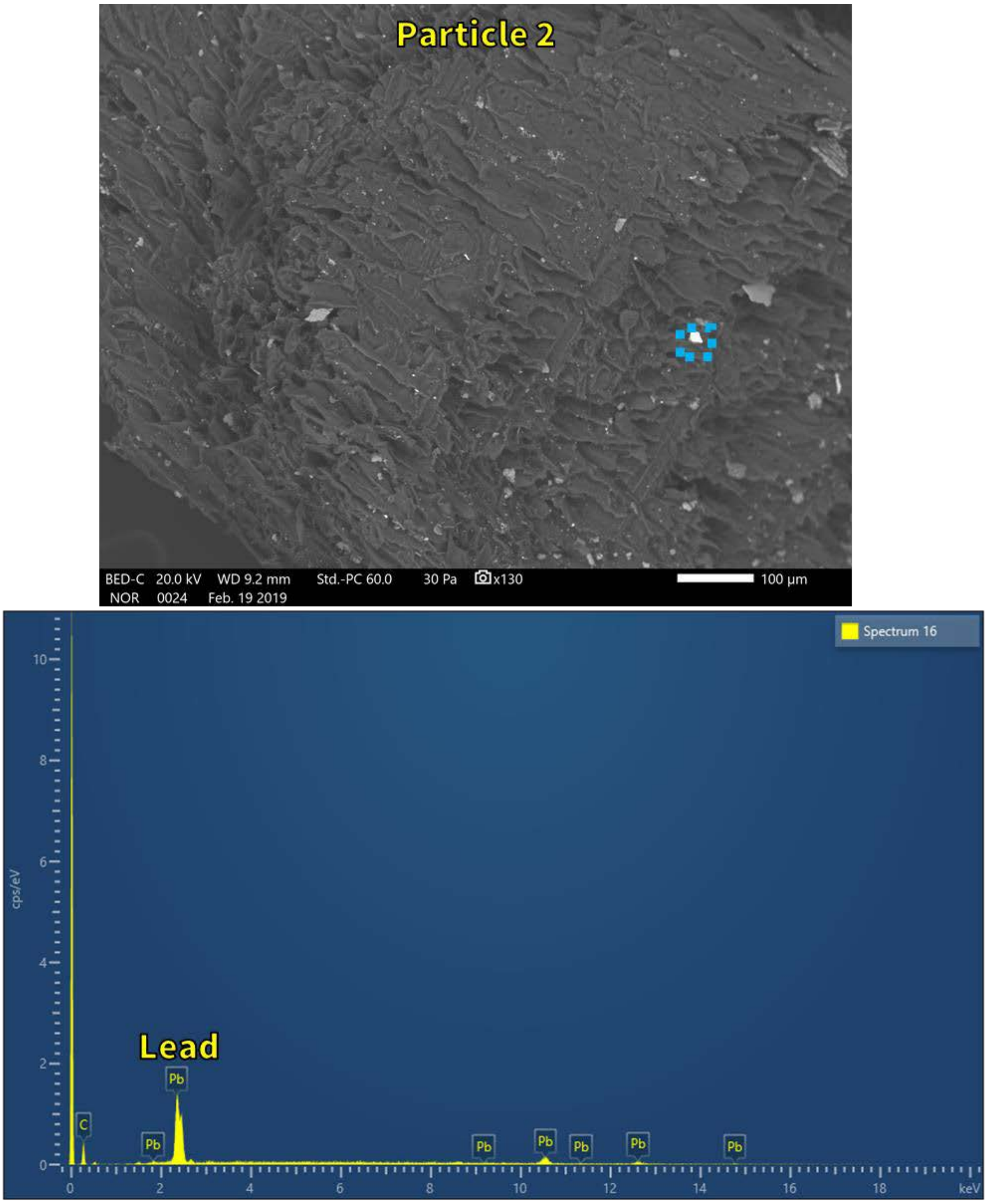

FIGURE 8. Representative EDS spectrum of a small particle decorating Particle 2. Lead (Pb) was detected in this smaller particle.

To summarise, during the analyses of No.6 connecting rod lubricating oil channel taken from a Volvo Penta D16 engine, serial number 1016027578, carbon particles were detected surrounded by wear metal material.

If we can be of further assistance in this matter, pelase do not hesistate to contact us.

Your sincerely,

[redacted]

Exponent International.