ECO FLEXO INDUSTRIAL

THE SOLID ADDITIVE FOR FUELS

FLEX-O ™

www.flexoeco.com

What are asphaltenes?

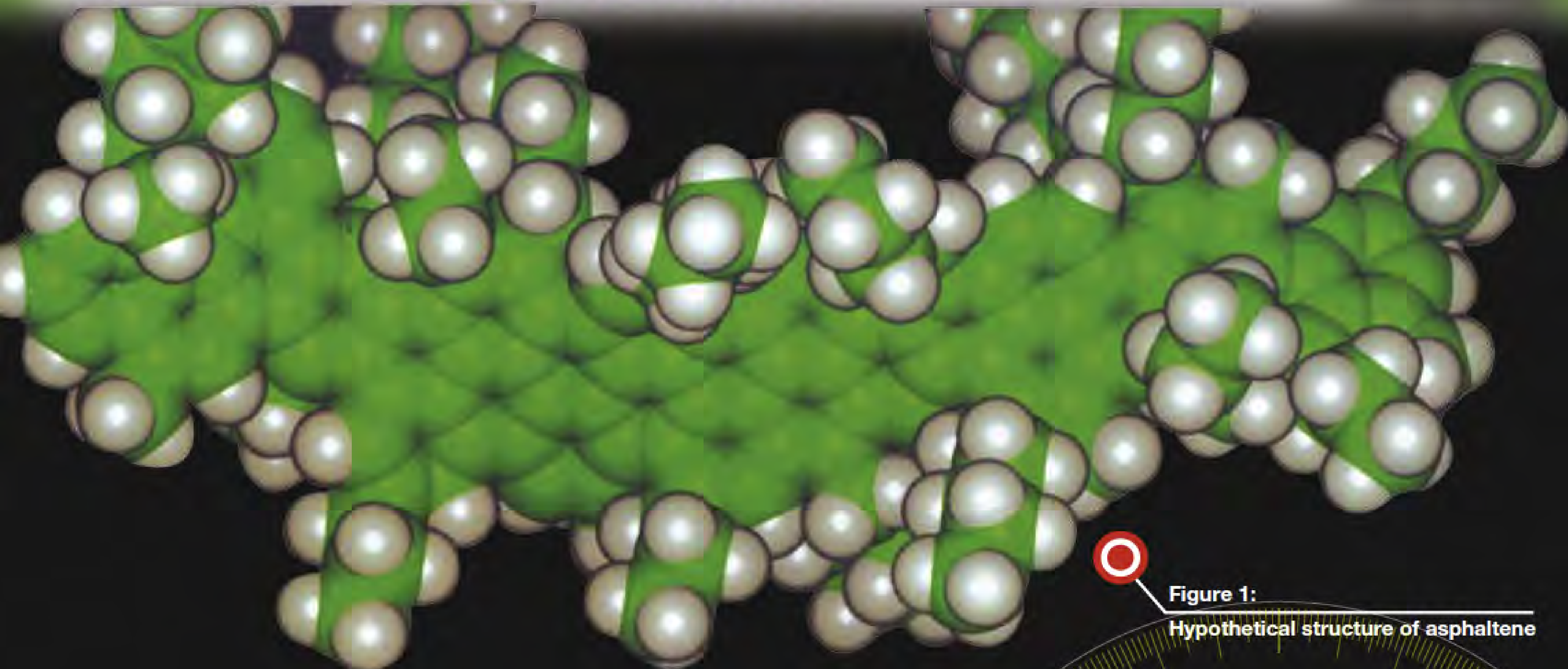


Figure 1:
Hypothetical structure of asphaltene

The current trend in the oil industry is a growing demand for light products. To meet market demands, refineries convert some of their residue into lighter compounds. Such a conversion results in the creation of modern heavy fuels that contain higher concentrations of sulfur, vanadium, and asphaltene.

Asphaltenes are considered part of the “bottom of the barrel” because they make up the part of the oil that does not evaporate, having high molecular mass. In addition, they are defined in terms of melting properties as non-melting compounds in heptanes using standard methods (ASTM D3279 or IP 143). Therefore, they also retain their solid state in fuel. However, their exact molecular structure is difficult to determine. According to one hypothesis, the structure would consist of condensed polynuclear aromatic rings bearing alkyl side chains (see Figure 1).

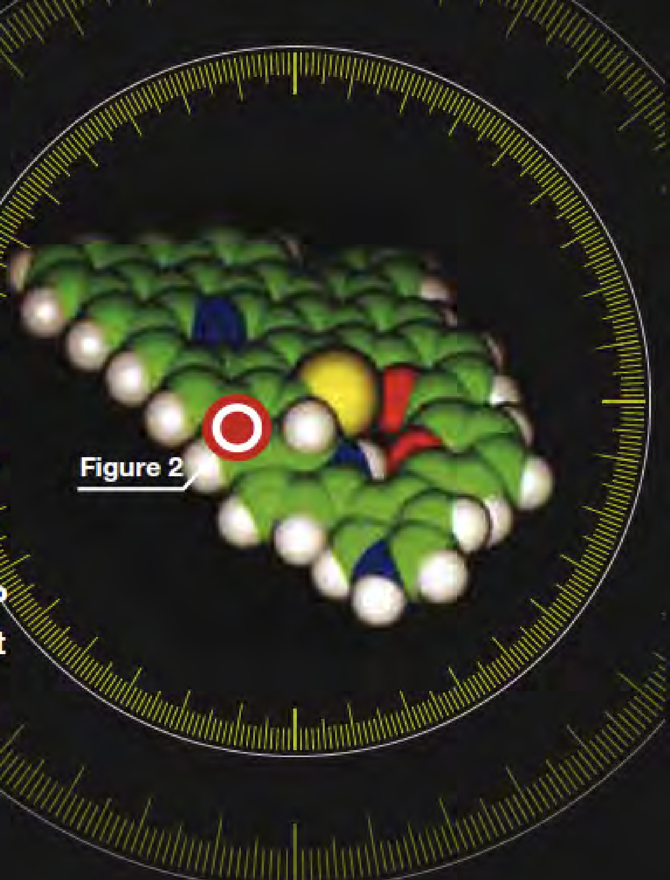


Figure 2

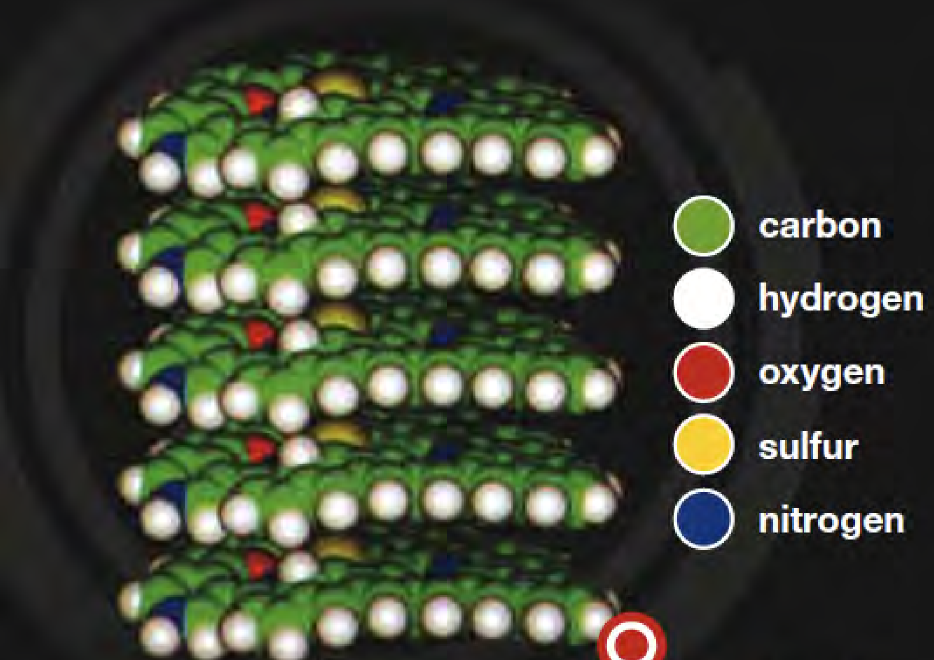


Figure 3

The condensed aromatic rings exist as flat non-homogeneous sheets (see Figure 2). In the fuel, the sheets remain as dispersed asphaltene. However, without the presence of liquid, they tend to attract each other, leading to the development of clusters. The structure of the clusters is similar to that of a book: a compact group of thin sheets (see Figure 3).

Why do asphaltenes present a problem in furnaces?

Asphaltenes exist in a dispersed state within the fuel and are kept in this state by the resins.

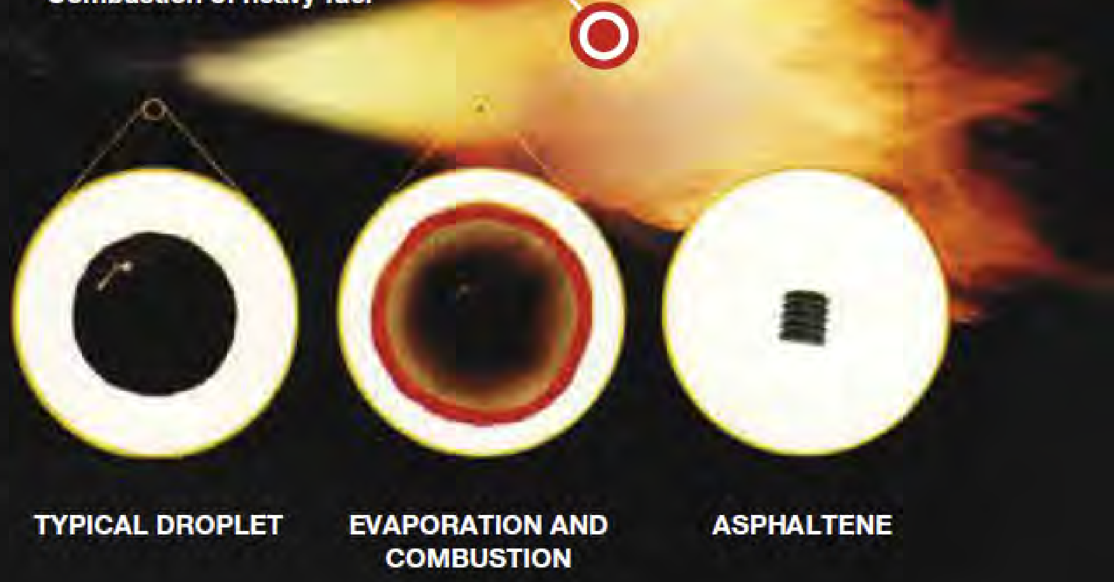
They have three (3) characteristics that make them problematic for the combustion system:

1) They make up the greatest aromatic portion within the oil and are also the compounds with the highest molecular mass,
2) They have no determined melting point and retain their solid state, thus contributing to the composition of carbon residue in gas emissions,
3) They clump together to form a structure that looks like many sheets within a book.

The liquid fuel does not burn in its liquid state, but burns in its gaseous state.
For the liquid fuel to burn, the fuel must first transform to a mist of fine droplets. As the droplets get closer to the front of the flame, the temperature rises rapidly, causing the light parts of the droplets to vaporize. The solid asphaltenes, which form the heavy parts, pile into compact structures resembling a book after the combustion of the evaporated compounds (see Figures 3 and 4).

These large solid hydrocarbons in the form of books do not burn well because their combustion must occur in the solid state. The mechanism by which the combustion of the solids occurs involves the distribution of oxygen through the pores of the solids. That distribution inside the solids is generally a slow process, which limits the rate of combustion. In addition, the combustion time of the solid being proportional to the square of its corresponding diameter makes the combustion of clusters of asphaltene solids more difficult because the combustion time increases significantly. The time spent in the flame area - 0.1 seconds – is not enough to complete the combustion.

Figure 4:
Combustion of heavy fuel



Residues of unburned carbons are formed, contributing 40% to 80% of the total emission of particles. The resulting problems, as in the furnace example (shown below), are as follows:

1) LESS EFFICIENCY IN THE TRANSMISSION OF HEAT

Some of these residues are deposited inside the furnace, forming a layer of insulation on conduits, which reduces their effectiveness in transferring heat. The result will be a less productive operation (see Figure 5), since the temperature of the emitted gases will increase gradually.

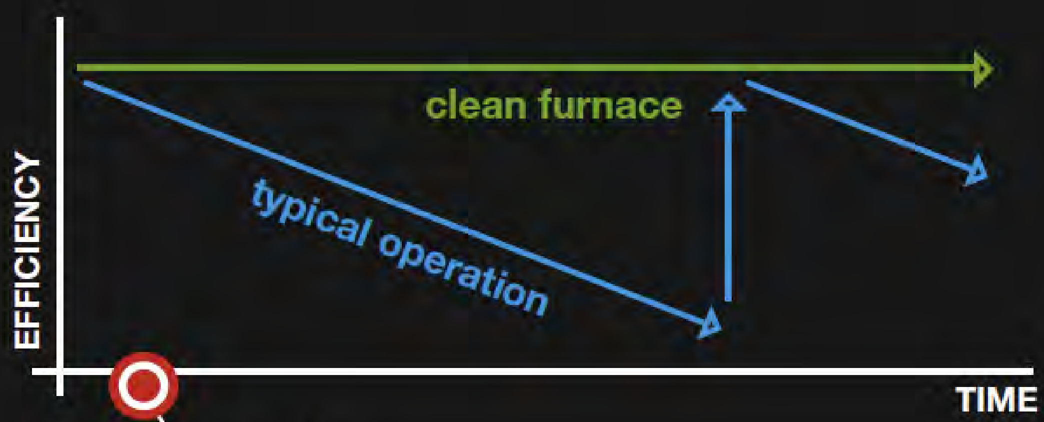


Figure 5:
Efficiency in heat transfer with respect to time

2) CORROSION AT HIGH TEMPERATURES

The unburned carbon residue also acts as a carrier of incombustible compounds such as vanadium. Carried through gas emissions, some of the residue is deposited on the high-resistance conduits. The environment of these conduits is particularly subject to oxidation, this is due to high temperatures and the presence of remaining oxygen. In this environment, the hydrocarbon content of the residue deposited will slowly oxidize up to its to gaseous CO_2 and H_20 state and then be evacuated with the gas emissions. However, vanadium will also oxidize into vanadium trioxide (V_2O_3), which is solid ash at 1970°C. Gradually, the vanadium trioxide is then oxidized into vanadium tetraoxide (V_2O4) at 1967°C, and into vanadium pentoxide (V_2O_5) at a temperature between 550°C and 700°C in the presence of sodium oxides (see Figure 6).

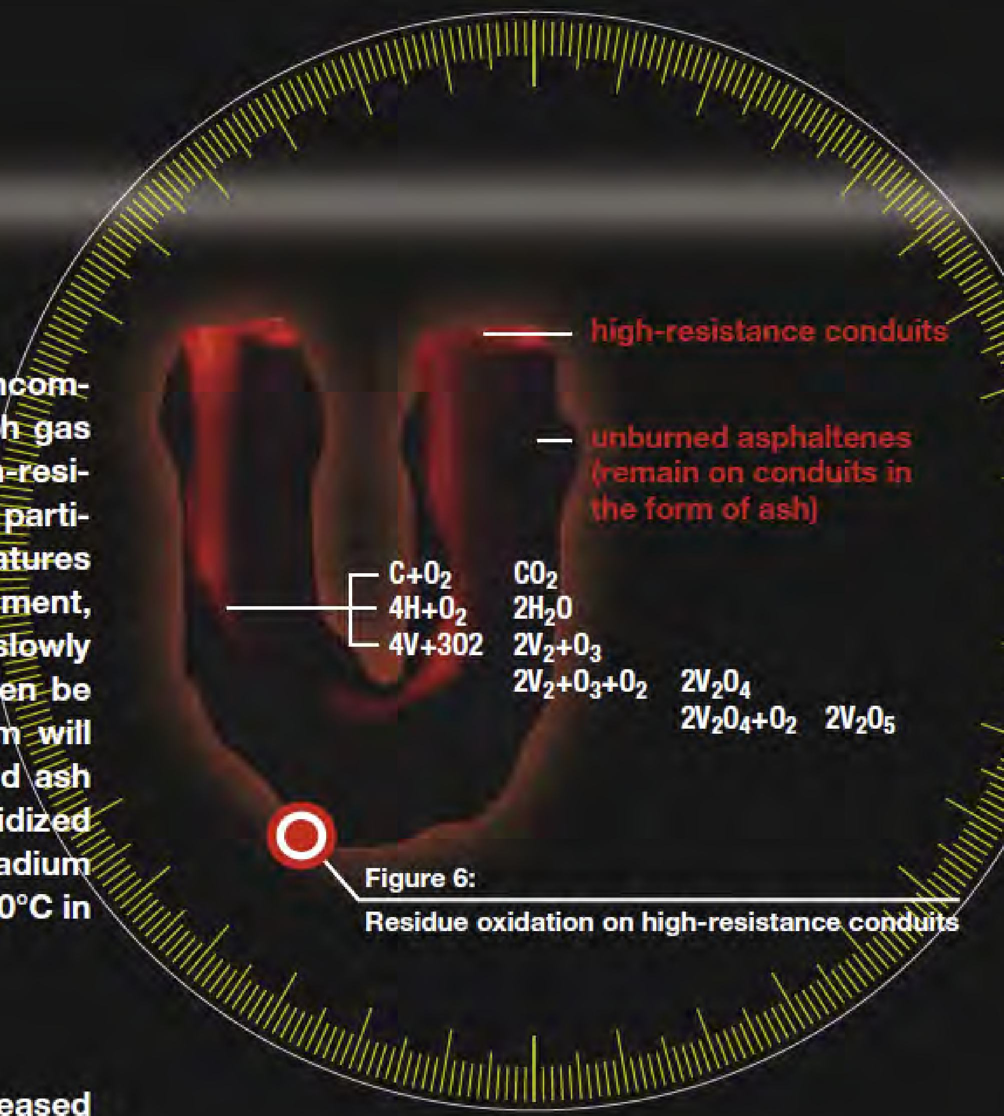


Figure 6:
Residue oxidation on high-resistance conduits

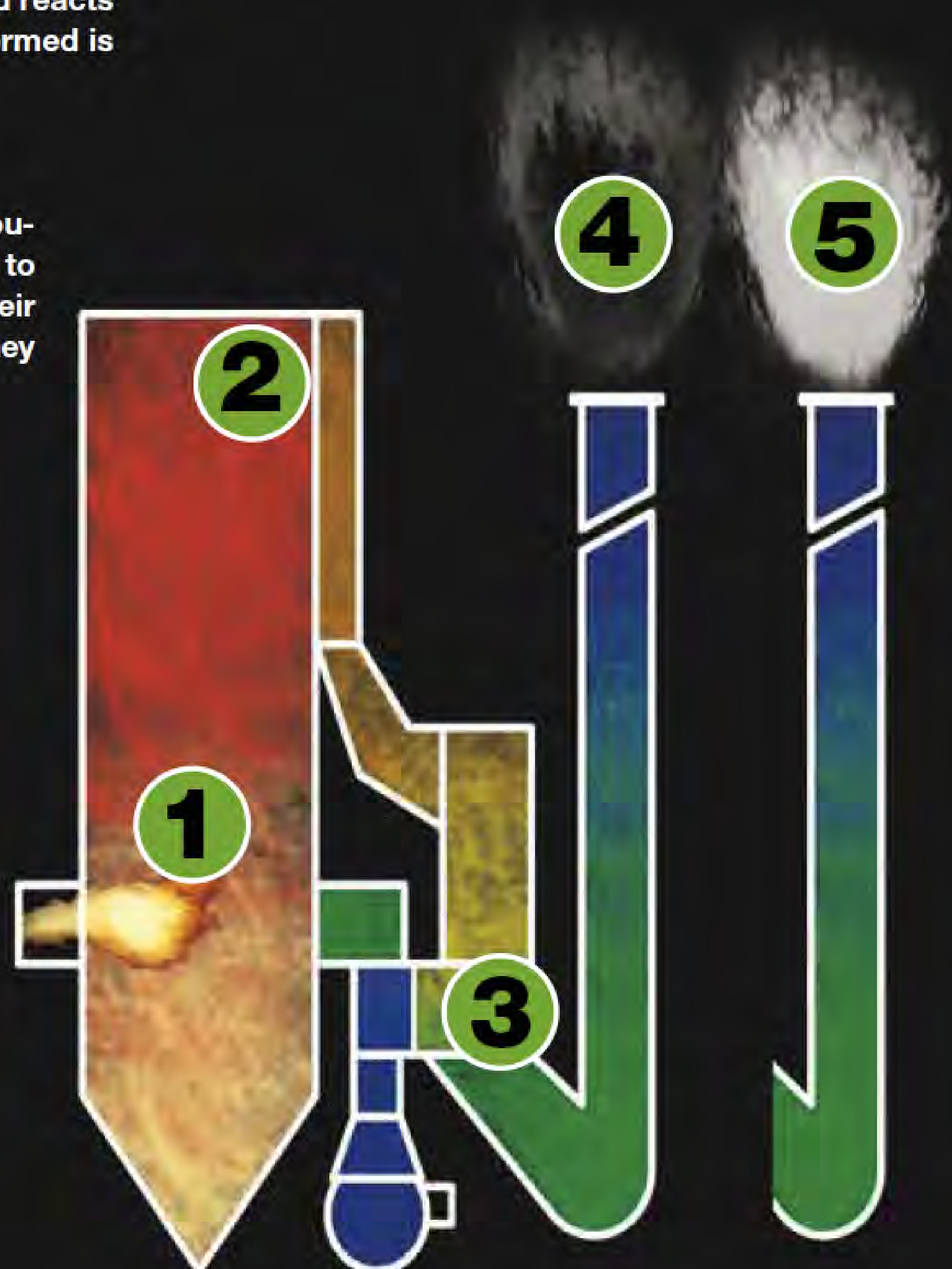
3) CORROSION AT LOW TEMPERATURES

Aside from the limited transmission of heat and the increased frequency of maintenance, the unburned residue that settles on the pre-heater drum will act as a filter/emitter of carbon from the absorption of sulfur oxides in the gas emissions. When the surface temperature of the pre-heater drum drops below the dew point, water vapor (H_2O) condenses and reacts with SO_3 remaining in the deposit. The sulfuric acid formed is at the root of the cold-end corrosion.

4) CHIMNEY OPACITY

Lastly, the unburned carbon residue is evacuated through the chimney, forming black visible ash. According to observation, the unburned carbon particles, due to their high coefficient of light absorption, can increase chimney opacity by up to 75%.

5) EFFICIENCY AND ECOLOGY



SOLUTION:

ECO FXO INDUSTRIAL

What is the ECO FXO INDUSTRIAL formula?

The ECO FXO INDUSTRIAL formula additives are highly-concentrated active surface agents, 100% organic, and therefore without metals. They are specifically synthesized to overcome the problems tied to high concentrations of asphaltenes in today's fuels.

How does the ECO FXO INDUSTRIAL formula work?

As we have seen in Figure 3, asphaltene sheets pile up in layers to form a structure resembling a book.
ECO FXO INDUSTRIAL is an active surface agent that attacks the cluster by decomposing the cluster into individual asphaltene sheets as shown on Figure 7, thus preventing them from clustering together again.
The ECO FXO INDUSTRIAL formula does not change the molecular structure of asphaltenes through chemical reactions. Instead, it separates the clusters of asphaltenes sheets into smaller individual asphaltene sheets. As shown in Figures 8 and 9, the effectiveness of the ECO FXO INDUSTRIAL formula is shown through microscopic analysis.

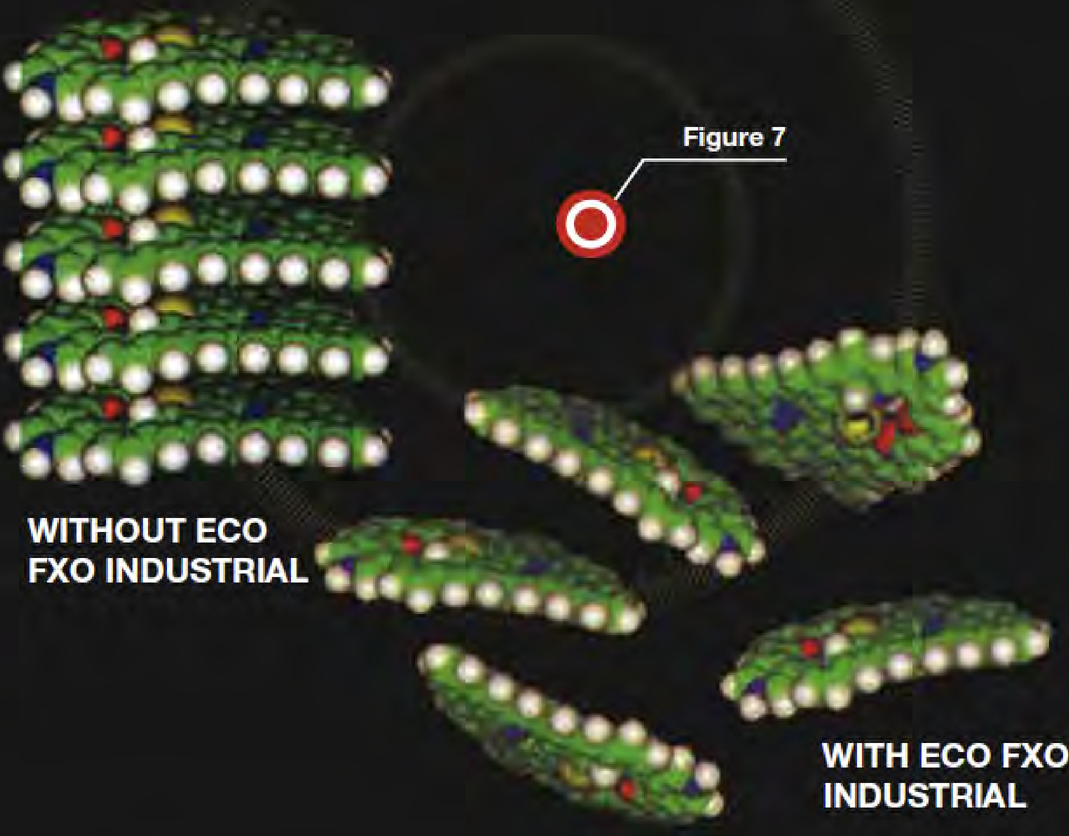


Figure 7


Figure 8

Figure 8: 4140x enlarged electron microscope with scan. Without the ECO FXO INDUSTRIAL formula, the asphaltene clumps uniformly, whereas with the ECO FXO INDUSTRIAL formula, asphaltene separates/decomposes into smaller fragments.

Figure 9: Asphaltene in a benzene solution. Magnified 290x using an optical microscope. Without the ECO FXO INDUSTRIAL formula, many large clusters of suspended asphaltene are present. With the ECO FXO INDUSTRIAL formula, asphaltene decomposes into smaller fragments that ultimately become barely visible.

From the above illustrations, it is obvious that the ECO FXO INDUSTRIAL formula breaks down large asphaltenes clusters into smaller units that burn more easily in the flame area, which in turn reduces the amount of unburned residual carbons in the emitted gases (see Figure 10). You can compare this to the burning of logs in a fireplace. A large log needs more time to completely burn, incomplete combustion is therefore inevitable. However, if the log is cut into smaller pieces, combustion is more rapid and complete.


Figure 9

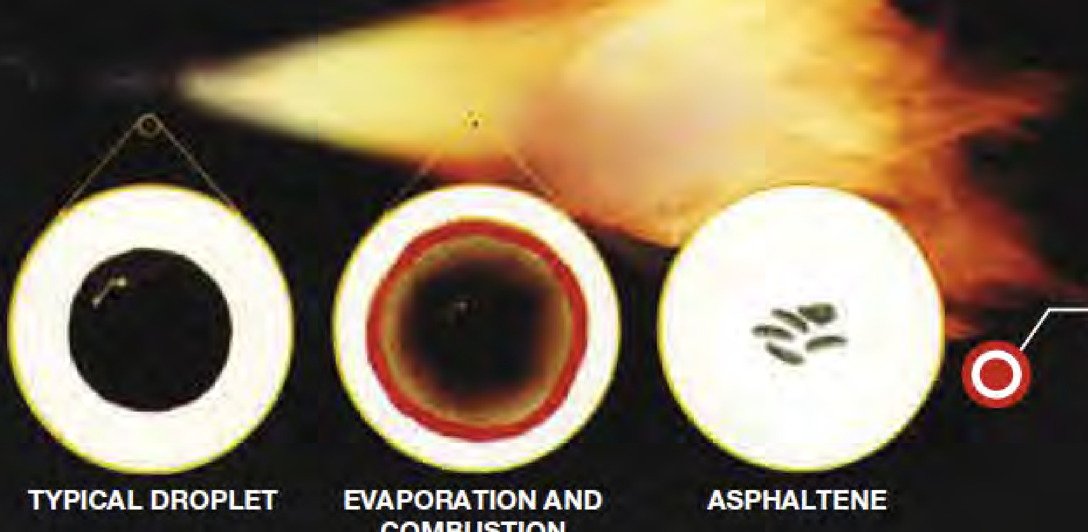


Figure 10:
Combustion of heavy fuels with ECO FXO INDUSTRIAL

Advantages in using the ECO FXO INDUSTRIAL formula

1) MORE EFFICIENT IN THE TRANSMISSION OF HEAT

Combustion is more complete, much less carbon residue is deposited on the heat transfer structures of the furnace. A more efficient operation is then achieved resulting in fuel savings (as shown in Figure 11).

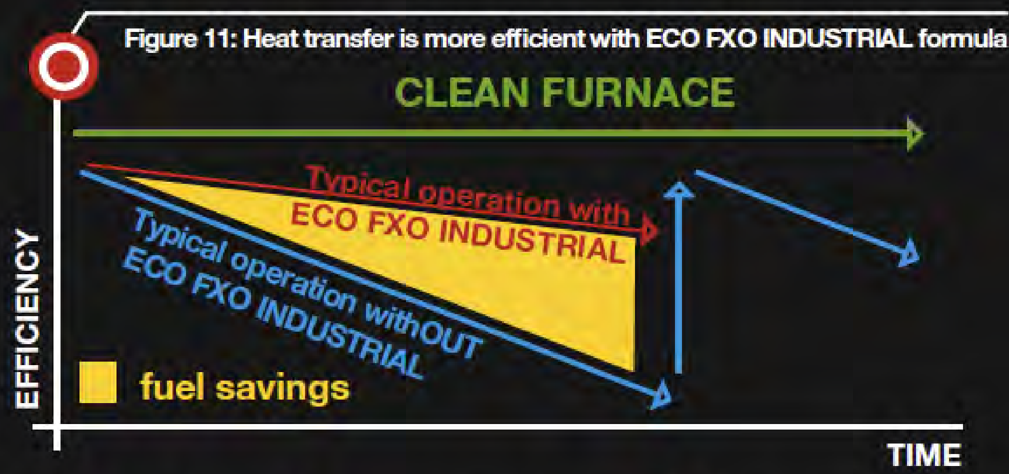


Figure 11: Heat transfer is more efficient with ECO FXO INDUSTRIAL formula

2) MINIMAL CORROSION AT HIGH TEMPERATURES

If the asphaltene is consumed entirely within the flame area where the presence of oxygen is higher, and the exposure time of the oxidant becomes short, vanadium deposits with high melting points will occur as trioxide or tetraoxide. These will remain in the solid state and will not stick to heat transfer surfaces. Even with few deposits of vanadium pentoxide, these will result in particles of molecular size with very little inertia and be ejected with the emitted gases. Consequently, there will remain negligible amounts of vanadium oxide that could cause corrosion inside the furnace (see Figure 12).

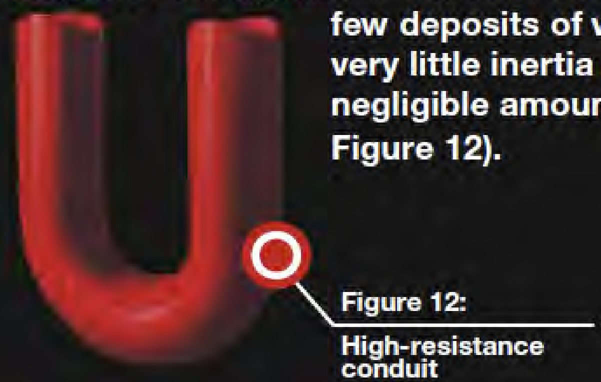


Figure 12: High-resistance conduit

3) MINIMAL CORROSION AT LOW TEMPERATURES

The absence of dirt on the conduits brings about a decreased absorption of sulfur oxides in the carbon residue. Therefore less sulfuric acid is produced (H2SO4), which is normally at the root of conduit corrosion.

4) DECREASE IN CHIMNEY OPACITY

Lastly, if less soot occurs, the chimney opacity decreases. The operator has the following options: 1. Maintain the same oxygen (O_2) surplus and benefit from a cleaner chimney, or 2. Reduce the oxygen (O_2) surplus to revert to the initial chimney opacity and gain higher efficiency, with less SO_3, and less V_2O_5 ... (as Figure 13 shows).

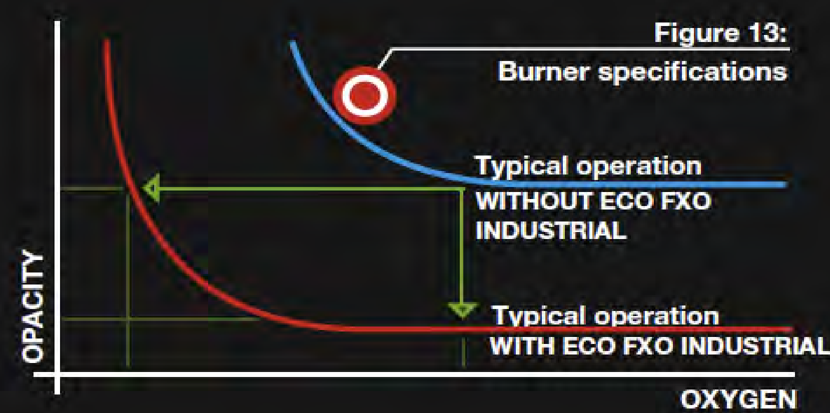


Figure 13: Burner specifications

ECO FXO INDUSTRIAL Additives, 100% organic.

THE ONLY TREATMENT TO SOLVE ALL PROBLEMS THAT ARISE FROM THE USAGE OF TODAY'S HEAVY OILS

ECO FXO INDUSTRIAL will:

- Eliminate deposits in tanks
- Improve pre-heating and the operation of filters
- Prevent coke deposits on top of burners
- Improve combustion through better dispersion
- Minimize the corrosion of conduits
- Minimize the cold end corrosion tied to fuels
- Reduce emissions of particles and potentially condensing sulfur oxides

The ECO FXO INDUSTRIAL formula is proud to have fully and exclusively met its obligations of fuel additive production since 1980.

We would like to thank Dr. Normand Brais, engineer, combustion scientist, for his aid in certifying the authenticity of the technical elements shown in this brochure

PRODUCT OF:
FLEX-O CANADA Inc.
www.flexocanada.com

DISTRIBUTED BY:
Orbis Calculus d.o.o.
Crvenog križa 31
10000 Zagreb, Croatia
t: +385.1.606.1863
t2: +385.1.606.1864
em@il: info@flexoeco.com

www.flexoeco.com