MAGNESIUM AS A SOLUTION AGAINST THE CORROSION PROBLEMS DERIVED FROM THE COMBUSTION OF THE HEAVY FUEL OIL OR CRUDE OIL

Vanadium and Sodium corrosion inhibitor

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Technical document: RB-12

Regarding to the heavy fuel oil or crude oil combustion, the following facts are generally accepted worldwide:

1- Heavy fuel oil contains several metallic impurities, mainly Vanadium and Sodium, that promote the formation of corrosive compounds during the combustion because all of them are in liquid state at temperatures below 650ºC :
   - Vanadium pentoxide (melts at 600-650ºC)
   - Sodium vanadate (melts at 340-650ºC depending on molar ratio V/Na)

   If these kinds of compounds are not neutralized, during the combustion a lot of corrosion will appear on the valves and turbos of Diesel engines, gas turbines blades and also on the surface of the boilers heat exchangers (besides solid encrustations)

2- Heavy fuel oil also contains Sulphur as impurity, which causes the formation of SO_2 and some SO_3 during combustion, and the possible formation of sulfuric acid when exhaust gases temperature go below 160ºC, or even sulfurous acid at temperature below 50ºC.

Regarding the use of ADDITIVES CONTAINING MAGNESIUM as a solution for the heavy fuel oil and crude oil corrosion problems during its combustion, and depending on the specific needs and requirements, the "rb bertomeu" additives are supplied with up to 30% wt/wt of Magnesium and varying percentages of other components.

Next we develop some concepts that we consider essential as well as some proven facts:

COMBUSTION OF HEAVY FUEL OIL OR CRUDE OIL IN LARGE DIESEL ENGINES AND GAS TURBINES

In order to avoid corrosion in ENGINES and GAS TURBINES when using additives containing Magnesium, inhibitor of Vanadium and Sodium corrosion, and **not making any damage due to incrustation or impact of in-suspension solid micrometric Magnesium particles** in pumps, fuel injection nozzles, blades, rotors and turbines, it is only possible when Magnesium is in form of Organic salts of Fatty acids (molecules - trade secret) SOLUBLE in HYDROCARBONS, like the **"rb bertomeu"** additives.

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The chemical synthesis process by "rb bertomeu" produces the before-mentioned Magnesium Organic salts of fatty acids completely soluble in hydrocarbons where the Magnesium particles are Mg^{2+} ions, with a radius of 72 picometers (1 picometer is 1,000 times smaller than a nanometer).

The surface reactivity of these Magnesium ions over conventional materials (oxides and hydroxides of Magnesium) is about 10 times higher if the particles are nanometric and 100 times higher if the particles are micrometric.

The "rb bertomeu" additives with soluble Magnesium are the most reactive agents known to neutralize corrosion by Vanadium pentoxide and Sodium vanadates and cannot make any damage by hitting or corroding the gas turbine's blades because the Magnesium particles are molecules. Being the additive in molecular form, it provides an active area (~ 1,800 m^2 / g of Mg) between 10 and 100 times higher than the one in nanometer-sized or micrometer-sized particles, and thereby increasing by a proportional factor the chemical reactivity.

During the combustion, the SOLUBLE Magnesium of the additives produced by **"rb bertomeu"** reacts with the Vanadium oxide and forms Magnesium Vanadate of high melting point (more than 1,200ºC), which is solid and non-corrosive at the internal temperature of the engine or gas turbine exhaust.

The action of fixing heavy metals (Vanadium), is also translated into a decrease in the oxidation of SO_2 to SO_3 (formed from the fuel oil's Sulphur) by minimizing its catalytic action on the reaction; as a consequence, the formation of Sodium sulfate is reduced (Na_2SO_2) that melts at 888 ºC and also diminishes the appearance of Sulfuric acid condensation when the combustion gases cool down and, along with it, cold corrosion.

The Magnesium (Mg) molecule, becomes integrated in the Vanadate molecule, which leaves the engine or gas turbine together with the rest of solid residues formed in the combustion (for example, MgV_2O_6 o $Mg_3V_2O_8$). The rest of the organic components of the **"rb bertomeu" beco F1/ASF** additive, including the organic anion which has supported the atom of Magnesium in soluble form, are burned during the combustion in the engine or gas turbine, generating residual gases as CO_2 y H_2O, like the fuel oil itself, and not generating solid residues.

The Magnesium salts formed during the combustion are inert (non-corrosive), unlike the Calcium salts also formed from Calcium contained in the fuel and from Calcium contained in the engine oil burned by the engine.

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The theoretical damage[1] that the Magnesium oxide or hydroxide nanometric particles in suspension could make in the gas turbine's blades by hitting them (as it might happen in some fuel additives for boilers as discussed in the next section), cannot be given in the case of the additives "rb bertomeu", because there is no Magnesium oxide or hydroxide present, neither solid nor liquid and neither before nor after the combustion. In the "rb bertomeu", additives Magnesium is in form of Organic salts of Fatty acids (molecules - trade secret) SOLUBLE in HYDROCARBONS.

COMBUSTION OF HEAVY FUEL OIL OR CRUDE OIL IN STEAM BOILERS AND GAS TURBINES.

Additives with a suspension of solid Magnesium oxide or hydroxide in form of solid micrometric particles have been used, and are still used, in kerosene or another liquid agent, which is injected into the fuel oil just before the combustion.

These kind of additives, with solid Magnesium (suspension of Magnesium oxide or hydroxide), can only be used when the combustion equipment is a burner or gas turbine, NEVER WHEN USING A DIESEL ENGINE because the presence of micrometric solid particles of Magnesium oxide or hydroxide in suspension in the engine, can cause damages by scratching the metallic parts of pumps and jet nozzles.

CONCLUSIONS REGARDING THE USE OF ADDITIVES CONTAINING MAGNESIUM :

1- Additives containing Magnesium oxide or hydroxide with micrometric, non-soluble particles CAN NOT BE USED IN ENGINES THAT BURN HEAVY FUEL OIL OR CRUDE OIL because the Magnesium solid micro particles in suspension can cause damages.

   The additives with solid, non-soluble micrometric particles in suspension CAN be used in gas turbines, boilers, furnaces or similar combustion equipment.

2- Additives with Magnesium ORGANIC SALTS OF FATTY ACID (molecules - trade secret) COMPLETELY SOLUBLE in HYDROCARBONS, CAN BE USED IN ENGINES THAT BURN HEAVY FUEL OIL OR CRUDE OIL like the additive **"rb bertomeu" beco F1/ASF** that is very effective in minimizing the corrosion in valves and turbos. Please read our Bulletin Num. 1 "Corrosion on exhaust valves and turbo-compressors in Diesel engines running on heavy fuel oil is preventable"

[1] The Magnesium Oxide and the Magnesium Hydroxide particles, which are solid minerals, can damage the fuel injection system. The injection pumps in engines fed with fuel oil have the piston adjusted approximately to 1 micron and work under a pressure of 400-500 bars.
The Magnesium Oxide and the Magnesium Hydroxide solid particles would cause the breakdown of the injection system.

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3- The kind of compound with Magnesium Organic salts of Fatty acids (molecules - trade secret) SOLUBLES in HYDROCARBONS present in the **"rb bertomeu"** additives is innocuous and since 1995 it is amply demonstrated that it does not produce any damage to the engines. Please read our technical document RB-13 "Extension of the useful life of exhaust valves up to doubling de TBO (Time Between Overhauls)"

As you can read in the above-mentioned link, in 2002 we collaborated with a customer, EnergyWorks-Carballo, who wanted to make a thorough test to verify the effectiveness of our additive **"rb bertomeu" beco F1/ASF**. Such test showed that continued use of the additive managed to double the TBO of the valves, resulting in cost savings in parts and downtime.
Ever since, year 2002, EnergyWorks-Carballo has been using and still uses with very satisfactory results the **"rb bertomeu"** products, allowing them to extend the initial TBO period from 3,000 up to 7,200 hours in June 2015

More information at RB-7 "Fuel oil and its corrosive effects in the industrial combustion".

As a proof of the excellent results obtained when our additive is used, following you can find several letters of reference (from 1996 until 2015) from some of our customers, showing their satisfaction and ratifying the effectiveness of the additive **"rb bertomeu" beco F1/ASF**:

- Letter UFEFYS 26/06/2015
- Letter EnergyWorks-Carballo (16/06/2015)
- Letter MYTA 17/06/2015
- Letter Paquito 02/02/2012
- Letter Unión Fenosa 26/09/2005
- Letter EnergyWorks-Carballo (24/11/2002)
- Letter Coosur 15/09/2005
- Letter Coosur 21/05/2002
- Letter Olcesa 15/05/2002
- Letter DDR 04/04/2002
- Letter Artabra 15/02/2001
- Letter UFEFYS 30/01/2001
- Letter Calvo 26/01/2001
- Letter Intasa 20/01/2001
- Letter Cogeneración Bañeres 15/01/2001
- Letter Paquito 15/01/2001
- Letter Boinersa 10/01/2001
- Letter Cogemansa 10/01/2001
- Letter Calvo 01/02/1999
- Letter MYTA 25/01/1999
- Letter Cogeneración Bañeres 18/01/1999
- Letter Minera Santa Marta 01/08/1998
- Letter UFEFYS 24/10/1996
- Letter Cogeneración Electrica Ribera d'Ebre (CERE) 10/10/1996
- Letter Minera Santa Marta 18/09/1996
- Letter MASA Madrid 17/09/1996

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