HISTORICAL STUDY ON THE MAINTENANCE OF THE EXHAUST VALVES IN THE DEUTZ ENGINES INSTALLED AT THE *MINERA DE SANTA MARTA S.A.* POWER PLANT

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VOLUME 3

1 - INTRODUCTION

This historical study has been carried out by **rb bertomeu SL**, with the aim of compiling its experience in power plants equipped with Diesel engines, mainly by reviewing the improvements achieved in the maintenance and conservation of engine exhaust valves, with the use of the **"rb bertomeu"** fuel oil additives, which are dosed to the fuel storage tank.

For this purpose, a power plant has been chosen, located in Spain, which has used **"rb bertomeu"** additives for a long period of time. The selected plant, belonging to the company "MINERA DE SANTA MARTA S.A.", is equipped with Diesel engines and uses No. 1 BIA fuel oil as fuel.

The realization of this study has been possible thanks to the compilation of technical data carried out since the commissioning, which has been provided by the owner company itself, and to the photographic reports made by us during the engine reviews that have been periodically carried out.

We are convinced that through the content of this study, it is easy to conclude that the use of **"rb bertomeu"** additives provides significant improvements in engine maintenance costs, as well as increased energy production by reduction of time lost in maintenance shutdowns.

2 – POWER PLANT
BELORADO - BURGOS

QUANTITY OF ENGINES: 3

ENGINE TYPE: Deutz BV 16 M - 640

START-UP DATE:

Engine 1: March - 1995
Engine 2: March - 1995
Engine 3: March - 1995

BRIEF SUMMARY OF OPERATION FROM START UP:

All three engines were started on the dates indicated above, using Fuel Oil No. 1 BIA without any additive.

After operating for 3,000 hours, many corrosion problems appeared, both in the exhaust valves and in the valve bodies, and many of them had to be mechanically changed or rectified (August-95) during the engines overhaul.

Due to this, M.S.M. considered the possibility of using fuel oil additives as a way to solve their problems, and, for this purpose, contacted our company, RB BERTOMEU S.L.
Approximately in early August-95 M.S.M. started, using the fuel oil **"rb bertomeu"** additives.

In October 1995, after 4,500 hours of running (1,500 hours with **"rb bertomeu"** additives), a general inspection of the exhaust valves of the engines was carried out to verify their state of conservation. No signs of corrosion were found on this inspection.

After the aforementioned inspection (October-95), M.S.M. decided to interrupt the fuel oil treatment in order to test a new running period without additive, to ensure that the lack of corrosion achieved was actually due to the effects of the additive

"rb bertomeu". In this way, the plant was operating without additives for another 1,500 hours, until it reached the inspection of the 6,000 hours of engine work.

During this inspection, many exhaust valves and valve bodies were found again with corrosion, which had to be changed or mechanically rectified again.

After putting the engines into service again, on 08-01-96, M.S.M. resumed the fuel oil treatment with **"rb bertomeu"** additives, which has been maintained uninterrupted to date.

All the engine reviews carried out are detailed below:

GENERAL INSPECTION OF ENGINES AT **3,000** HOURS

Inspection date ..... Engine num. 1: August-95
Engine num. 2: August-95
Engine num. 3: August-95

Service hours..... Engine num. 1: 3,000 (TBO = 3,000 H)
Engine num. 2: 3,000 (TBO = 3,000 H)
Engine num. 3: 3,000 (TBO = 3,000 H)

Fuel oil treatment: No
Additive: None

Scale detected at the exhaust valves: Not available

Corrosion detected at the exhaust valves:

Engine num. 1: Many (Exact number not available)
Engine num. 2: Many (Exact number not available)
Engine num. 3: Many (Exact number not available)

Note: During this inspection no valve pictures were taken.

EXHAUST VALVE INSPECTION AT **4,500** H

Inspection date ..... Engine num. 1: 05-10-95
Engine num. 2: 05-10-95
Engine num. 3: 05-10-95

Service hours ..... Engine num. 1: 4,500 (TBO = 1,500 H)
Engine num. 2: 4,500 (TBO = 1,500 H)
Engine num. 3: 4,500 (TBO = 1,500 H)

Fuel oil treatment: All the period
Additive: **"rb bertomeu" beco F1/ASF**

Scale detected at the exhaust valves: 3.15 g/valv. (average)

Corrosion detected at the exhaust valves:

Engine num. 1: None
Engine num. 2: None
Engine num. 3: None

Note: See photo report number 1 at the chapter 3.

GENERAL INSPECTION OF ENGINES AT **6,000** HOURS

Inspection date ..... Engine num. 1: 13-12-95
Engine num. 2: 11-12-95
Engine num. 3: 14-12-95

Service hours ..... Engine num. 1: 6,000 (TBO = 1,500 H)
Engine num. 2: 6,000 (TBO = 1,500 H)
Engine num. 3: 6,000 (TBO = 1,500 H)

Fuel oil treatment: No
Additive: None

Scale detected at the exhaust valves: 7.00 g/valv. (average)

Corrosion detected at the exhaust valves:

Engine num. 1: 3 valves
Engine num. 2: 4 valves
Engine num. 3: 12 valves

Notes: See photo report number 2 at the chapter 4.

Many crushing deformations were found in the valve seats due to large amounts of debris.

GENERAL INSPECTION OF ENGINES AT **9,000** HOURS

Inspection date ..... Engine num. 1: 19-04-96
Engine num. 2: 24-04-96
Engine num. 3: Not available

Service hours ..... Engine num. 1: 9,000 (TBO = 3,000 H)
Engine num. 2: 9,000 (TBO = 3,000 H)
Engine num. 3: 9,000 (TBO = 3,000 H)

Fuel oil treatment: From 6,575 hours
Additive: **"rb bertomeu" beco F1/ASF**

Scale detected at the exhaust valves: 4.60 g/vlv. (average)

Corrosion detected at the exhaust valves:

Engine num. 1: None
Engine num. 2: None
Engine num. 3: None

Note: See photo report number 3 at the chapter 5.

GENERAL INSPECTION OF ENGINES AT **12,000** HOURS

Inspection date ..... Engine num. 1: Not available
Engine num. 2: Not available
Engine num. 3: Not available

Service hours ..... Engine num. 1: 12,000 (TBO = 3,000 H)
Engine num. 2: 12,000 (TBO = 3,000 H)
Engine num. 3: 12,000 (TBO = 3,000 H)

Fuel oil treatment: All the period
Additive: **"rb bertomeu" beco F1/ASF**

Scale detected at the exhaust valves: Not registered

Corrosion detected at the exhaust valves:

Engine num. 1: Not registered
Engine num. 2: Not registered
Engine num. 3: Not registered

Note: This engine inspection was not supervised by RB Bertomeu S.L.

GENERAL INSPECTION OF ENGINES AT **15,000** HOURS

Inspection date ..... Engine num. 1: 23-01-97
Engine num. 2: Engine out of service
Engine num. 3: 11-02-97

Service hours..... Engine num. 1: 15,282 (TBO = 3,282 H)
Engine num. 2: Engine out of service
Engine num. 3: 15,943 (TBO = 3,942 H)

Fuel oil treatment: All the period
Additive: **"rb bertomeu" beco F1/ASF**

Scale detected at the exhaust valves: 3.12 g/valv. (average)

Corrosion detected at the exhaust valves:

Engine num. 1: None
Engine num. 2: Engine out of service
Engine num. 3: None

Note: See photo report number 4 at the chapter 6.

GENERAL INSPECTION OF ENGINES AT **18,000** HOURS

Inspection date ..... Engine num. 1: 27-05-97
Engine num. 2: Not inspected
Engine num. 3: 05-06-97

Service hours..... Engine num. 1: 18,029 (TBO = 2,747 H)
Engine num. 2:
Engine num. 3: 18,409 (TBO = 2,466 H)

Fuel oil treatment: All the period
Additive: **"rb bertomeu" beco F1/ASF**

Scale detected at the exhaust valves: 2.62 g/valv. (average)

Corrosion detected at the exhaust valves:

Engine num. 1: None. Thermal fatigue of metal in 2 valves
Engine num. 2:
Engine num. 3: None. Thermal fatigue of metal in 3 valves

Notes: See photo report number 5 at the chapter 7.
It should be noted that the thermal fatigue of the metal has appeared in the exhaust valves, after more than 18,000 hours of engine service.

GENERAL INSPECTION OF ENGINES AT **20,000** HOURS

Inspection date ..... Engine num. 1: Not inspected
Engine num. 2: 04-09-97
Engine num. 3: 04-08-97

Service hours ..... Engine num. 1:
Engine num. 2: 19,220
Engine num. 3: 19,730 (TBO = 1,321 H)

Fuel oil treatment: All the period
Additive: **"rb bertomeu" beco F1/ASF**

Scale detected at the exhaust valves: 2.17 g/valv. (average)

Corrosion detected at the exhaust valves:

Engine num. 1:
Engine num. 2: 2 valves. Thermal fatigue of metal in 11 valves
Engine num. 3: None. Thermal fatigue of metal in 6 valves

Notes: See photo report number 6 at the chapter 8.
It should be noted that the thermal fatigue of the metal has appeared in the exhaust valves, after more than 19,000 hours of engine service.

GENERAL INSPECTION OF ENGINES AT **22,000** HOURS

Inspection date ..... Engine num. 1: 11-11-97
Engine num. 2: Not inspected
Engine num. 3: 07-11-97

Service hours ..... Engine num. 1: 21,610 (TBO = 3,581 H)
Engine num. 2:
Engine num. 3: 21,498 (TBO = 1,768 H)

Fuel oil treatment: All the period
Additive: **"rb bertomeu" beco F1/ASF**

Scale detected at the exhaust valves: 1.04 g/valv. (average)

Corrosion detected at the exhaust valves:

Engine num. 1: None. Thermal fatigue of metal in 2 valves
Engine num. 2:
Engine num. 3: None.

Notes: See photo report number 7 at the chapter 9.

GENERAL INSPECTION OF ENGINES AT **24,000** HOURS

Inspection date ..... Engine num. 1: Not inspected
Engine num. 2: 09-03-98
Engine num. 3: Not inspected

Service hours ..... Engine num. 1:
Engine num. 2: 23.529 (TBO = 4.309 H)
Engine num. 3:

Fuel oil treatment: All the period
Additive: **"rb bertomeu" beco F1/ASF**

Scale detected at the exhaust valves: 2.70 g/valv. (average)

Corrosion detected at the exhaust valves:

Engine num. 1:
Engine num. 2: 10 valves . Thermal fatigue of metal in 2 val.
Engine num. 3:

Notes: See photo report number 8 at the chapter 10.

GENERAL INSPECTION OF ENGINES AT **25,000 / 26,000** HOURS

Inspection date ..... Engine num. 1: 04-05-98
Engine num. 2: 15-05-98
Engine num. 3: 28-05-98

Service hours ..... Engine num. 1: 25,512 (TBO = 3,902 H)
Engine num. 2: 25,012 (TBO = 1,483 H)
Engine num. 3: 26,074 (TBO = 4,576 H)

Fuel oil treatment: All the period
Additive: **"rb bertomeu" beco F1/ASF**

Scale detected at the exhaust valves: 3.53 g/valv. (average)

Corrosion detected at the exhaust valves:

Engine num. 1: None. Changed 10 spindles and 3 baskets per measurements.
Engine num. 2: 3 valves. Changed 3 spindles for thermal fatigue and 4 baskets for measurements.
Engine num. 3: None. Changed 11 spindles for thermal fatigue at the valve head.

Notes: See photo report number 9 at the chapter 11.

GENERAL INSPECTION OF ENGINES AT **28,000 / 29,000** HOURS

Inspection date ..... Engine num. 1: 29-09-98
Engine num. 2: 05-10-98
Engine num. 3: 13-10-98

Service hours..... Engine num. 1: 28,713 (TBO = 3.201 H)
Engine num. 2: 28,059 (TBO = 3.047 H)
Engine num. 3: 28,902 (TBO = 2.828 H)

Fuel oil treatment: All the period
Additive: **"rb bertomeu" beco F1/ASF**

Scale detected at the exhaust valves: 2.27 g/valv. (average)

Corrosion detected at the exhaust valves:

Engine num. 1: In 6 spindles and 4 baskets. Changed 6 spindles and 3 baskets
Engine num. 2: In 3 spindles and 5 baskets. Changed 5 spindles and 6 baskets
Engine num. 3: In 4 spindles. Changed 4 spindles.

Notes: See photo report number 10 at the chapter 12.

GENERAL INSPECTION OF ENGINES AT **31,000 / 32,000** HOURS

Inspection date ..... Engine num. 1: 16-03-99
Engine num. 2: 22-03-99
Engine num. 3: 26-03-99

Service hours..... Engine num. 1: 31,716 (TBO = 3.003 H)
Engine num. 2: 31,103 (TBO = 3.044 H)
Engine num. 3: 32,038 (TBO = 3.136 H)

Fuel oil treatment: All the period
Additive: **"rb bertomeu" beco F1/ASF**

Scale detected at the exhaust valves: 2.53 g/valv. (average)

Corrosion detected at the exhaust valves:
Engine num. 1: In 2 spindles (started in another 4 spindles and 5 baskets)
Engine num. 2: In 4 spindles and 5 baskets (started in another 2 spindles)
Engine num. 3: In 4 spindles

Blown valves between inspections:
Engine num. 1: 5
Engine num. 2: 3
Engine num. 3: 1

Notes: See photo report number 11 at the chapter 13.

GENERAL INSPECTION OF ENGINES AT **36,000** HOURS

Inspection date ..... Engine num. 1: 04-08-99
Engine num. 2: Not inspected
Engine num. 3: 16-08-99

Service hours ..... Engine num. 1: 36,000 (TBO = 4,284 H)
Engine num. 2: Not inspected
Engine num. 3: 36,000 (TBO = 3,962 H)

Fuel oil treatment: All the period
Additive: **"rb bertomeu" beco F1/ASF**

Scale detected at the exhaust valves: Not registered

Corrosion detected at the exhaust valves:
Engine num. 1:
Engine num. 2: Not inspected
Engine num. 3:

Blown valves between inspections:
Engine num. 1: Not available
Engine num. 2: Not available
Engine num. 3: Not available

Notes: See photo report number 12 at the chapter 14.

MAIN OPERATING DATA FROM START TO DEC-97

A) Fuel oil consumption..... 215.6 g / kWh

B) Engine oil consumption..... 2.1 g / kWh

C) Fuel oil sludge (dry base):
Using additive ..... 3.3 k / MT of fuel oil
Without additive ..... 6.9 k / MT of fuel oil

D) Operating temperature (exhaust gases)..... 354/349/353 ºC (E-1/E-2/E-3)

E) Combustion air excess index..... 2.0/2.05/2.0 (E-1/E-2/E-3)

F) Exhaust gases analysis (up to Sep-97)

	Engine 1	Engine 2	Engine 3
O_2 (%)	13.5	13.7	13.8
CO_2 (%)	5.7	5.6	5.55
CO (mg/Nm^3)	91	86	91
NO (mg/Nm^3)	1490	1540	1320
NO_2 (mg/Nm^3)	135	145	110
SO_2 (mg/Nm^3)	155	160	170
Bacharach index	3.5	3.8	4.2

CONCLUSIONS:

1 - The corrosion problems in the engine exhaust valves, detected during the first 3,000 hours after start-up, were solved using **“rb bertomeu”** fuel oil additives.

2 - The effectiveness of the additives **"rb bertomeu"** was verified by M.S.M. suspending fuel oil additive for a period of 1,500 hours, after confirming the excellent results obtained with the treatment.

3 - For more than 12,000 hours of service (since the 6,000-hour engine overhaul) the need for exhaust valve changes due to corrosion problems has been practically non-existent.

4 - The replacement of the exhaust valves has started after more than 18,000 hours of engine work, due to the thermal fatigue of the metal, but not due to problems or signs of corrosion.

5 - In this case, it is very difficult for us to calculate other important benefits or advantages obtained with the use of our fuel oil additives (fuel oil consumption, motor oil consumption, savings in maintenance and cleaning, etc.), mainly because it would be It is necessary to compare the current data with those obtained in hypothetical, very long periods, without using our products, which is not at all advisable in the current situation, especially taking into account past experience.

3 - PHOTO REPORT Number 1

M.S.M. - POWER PLANT

Inspection of exhaust valves at 4,500 hours

	Inspection date	Service hours	T.B.O. (hours)
Engine 1	05/10/95	4,500	1,500
Engine 2	05/10/95	4,500	1,500
Engine 3	05/10/95	4,500	1,500

Fuel oil treatment: From 3,000 hours
First 3,000 hours without additives

4 - PHOTO REPORT Number 2

M.S.M. - POWER PLANT

Engine inspection at 6,000 hours

	Inspection date	Service hours	T.B.O. (hours)
Engine 1	13/12/95	6,000	1,500
Engine 2	11/12/95	6,000	1,500
Engine 3	14/12/95	6,000	1,500

Fuel oil treatment: No (customer tries without additive)

5 - PHOTO REPORT Number 3

M.S.M. - POWER PLANT

Engine inspection at 9,000 hours

	Inspection date	Service hours	T.B.O. (hours)
Engine 1	19/04/96	9,000	3,000
Engine 2	24/04/96	9,000	3,000
Engine 3	--	9,000	3,000

Fuel oil treatment: All the period, except the first 575 hours

6 - PHOTO REPORT Number 4

M.S.M. - POWER PLANT

Engine inspection at 15,000 hours

	Inspection date	Service hours	T.B.O. (hours)
Engine 1	23/01/97	15,282	3,282
Engine 2	Stopped	--	--
Engine 3	11/02/97	15,943	3,942

Fuel oil treatment: All the period

7 - PHOTO REPORT Number 5

M.S.M. - POWER PLANT

Engine inspection at 18,000 hours

	Inspection date	Service hours	T.B.O. (hours)
Engine 1	27/05/97	18,029	2,747
Engine 2	Not inspected	--	--
Engine 3	05/06/97	18,409	2,466

Fuel oil treatment: All the period

8 - PHOTO REPORT Number 6

M.S.M. - POWER PLANT

Engine inspection at 20,000 hours

	Inspection date	Service hours	T.B.O. (hours)
Engine 1	Not inspected	--	--
Engine 2	04/09/97	19,220	--
Engine 3	04/08/97	19,730	1,321

Fuel oil treatment: All the period

9 - PHOTO REPORT Number 7

M.S.M. - POWER PLANT

Engine inspection at 22,000 hours

	Inspection date	Service hours	T.B.O. (hours)
Engine 1	11/11/97	21,610	3,581
Engine 2	Not inspected	--	--
Engine 3	07/11/97	21,498	1,768

Fuel oil treatment: All the period

10 - PHOTO REPORT Number 8

M.S.M. - POWER PLANT

Engine inspection at 24,000 hours

	Inspection date	Service hours	T.B.O. (hours)
Engine 1	Not inspected	--	--
Engine 2	09/03/98	23,529	4,309
Engine 3	Not inspected	--	--

Fuel oil treatment: All the period

11 - PHOTO REPORT Number 9

M.S.M. - POWER PLANT

Engine inspection at 25,000 / 26,000 hours

	Inspection date	Service hours	T.B.O. (hours)
Engine 1	04/05/98	25,512	3,902
Engine 2	15/05/98	25,012	1,483
Engine 3	28/05/98	26,074	4,576

Fuel oil treatment: All the period , with **“rb bertomeu” beco F1/ASF**

NOTE: This was a special review of all engines, scheduled taking into account the high number of hours in operation. Therefore, the TBO of the No. 2 engine is lower than usual and that of the other engines higher than usual.

12 - PHOTO REPORT Number 10

M.S.M. - POWER PLANT

Engine inspection at 28,000 / 29,000 hours

	Inspection date	Service hours	T.B.O. (hours)
Engine 1	29/09/98	28,713	3,201
Engine 2	05/10/98	28,052	3,047
Engine 3	13/10/98	28,902	2,828

Fuel oil treatment: All the period, with **"rb bertomeu" beco F1/ASF**

Changes made:

Engine 1: 2 spindles due to corrosion
2 spindles due to thermal fatigue
2 spindles due to out-of-range measurements
1 basket due to corrosion
2 baskets due to out-of-range measurements

Engine 2: 3 spindles due to thermal fatigue
2 spindles due to out-of-range measurements
1 basket due to corrosion
5 baskets due to out-of-range measurements

Engine 3: 1 spindle due to corrosion
2 spindles due to thermal fatigue
1 spindle due to out-of-range measurements

13 - PHOTO REPORT Number 11

M.S.M. - POWER PLANT

Engine inspection at 31,000 / 32,000 hours

	Inspection date	Service hours	T.B.O. (hours)
Engine 1	16/03/99	31,716	3,003
Engine 2	22/03/99	31,103	3,044
Engine 3	26/03/99	32,038	3,136

Fuel oil treatment: All the period, with **"rb bertomeu" beco F1/ASF**

Detected thermal fatigue of metal:

Engine 1: In 18 spindles
Engine 2: In 16 spindles
Engine 3: In 17 spindles

Changes made:

Engine 1: 5 spindles due to thermal fatigue
8 spindles due to out-of-range measurements
2 baskets due to out-of-range measurements

Engine 2: 15 spindles due to out-of-range measurements
7 baskets due to out-of-range measurements

Engine 3: 2 spindles due to out-of-range measurements

14 - PHOTO REPORT Number 12

M.S.M. - POWER PLANT

Engine inspection at 36,000 hours

	Inspection date	Service hours	T.B.O. (hours)
Engine 1	04/08/99	36,000	4,284
Engine 2	Not inspected	---	---
Engine 3	16/08/99	36,000	3,962

Fuel oil treatment: All the period, with **"rb bertomeu" beco F1/ASF**

Detected thermal fatigue of metal:

Engine 1: Not inspected spindles
Engine 2: Not inspected
Engine 3: Not inspected spindles

Changes made:

Engine 1: 10 spindles and 5 baskets
Engine 2: Not inspected
Engine 3: 18 spindles and 0 baskets