Arka Lube

Mobil Serv℠
Performance by ExxonMobil

Metagri

Optimum Drain Interval Study

Energy lives here™

Engineering Benefit Report

Mobil Pegasus 605 Ultra 40 doubled the oil drain interval on the MWM TCG 2020V12 at Metagri biogas plant

Potential Annual Savings: 8 Hours (Hour Exposure Reduction), 1,300 Liters (Environmental Improvement), € 3,840 (Revenue Improvement)

Highlights

ExxonMobil and Arka Lube have completed an Optimum Drain Interval Study. The investigation and this report were completed as part of our Field Engineering Service (FES) program. The objective of Metagri was to decrease the lubrication and maintenance costs associated with the operation of the MWM TCG 2020 V12 engine unit fueled with a biogas with an average methane content of 52% and an H2S level around 100 ppm. The engine was operated with a conventional gas engine oil reaching an oil drain interval of 2000 hours

The ExxonMobil recommendation provided the following potential annual saving:

Safety	Hour Exposure Reduction	**8 Hours**
Environmental Care	Environmental Improvement	**1,300 Liters**
Productivity	Cost Reduction	**€ 3,840 EUR**

The savings calculations are set out in the TCO Appendix.

Recommendation

The adoption of Mobil Pegasus 605 Ultra 40 in the MWM TCG 2020 V 12 engine doubled the oil drain interval while reducing the engine stops and the associated maintenance costs.

There are three reasons that support this outcome:

1. Superior TBN retention and TAN Control
2. Excellent thermal and oxidation stability
3. Long lasting wear protection

The factual findings that support this recommendation are listed in the following discussion.

ExxonMobil would like to thank and the Metagri team for their assistance in completing this inspection. ExxonMobil appreciates the opportunity to be of service to Metagri .

Respectfully,
ExxonMobil and Arka Lube

Visit mobilindustrial.com to learn how certain Mobil branded lubricant may provide benefits to help minimize environmental impact. Actual benefits will depend upon product selected, operating condition and applications.

Contents

Highlights 2
Recommendation 2
Discussion 4
The adoption of Mobil Pegasus 605 Ultra 40 in the Metagri MWM TCG 2020 V 12 engine 4
Superior TBN retention and TAN Control 4
Excellent thermal and oxidation stability 7
Long lasting wear protection 9
Conclusion 11
Appendices 12
Appendix 1 - Total Cost of Ownership
Appendix 2 - MWM used Oil analysis Limits

Visit mobilindustrial.com to learn how certain Mobil branded lubricant may provide benefits to help minimize environmental impact. Actual benefits will depend upon product selected, operating condition and applications.

Discussion

The discussion that follows includes factual findings that validate the achievement of the below result:

The adoption of Mobil Pegasus 605 Ultra 40 on the MWM TCG 2020V12 at Metagri site provided following savings

This recommendation provided the below potential annual savings:			
Safety	**8 Hours**	Long Lubricant Life	8 Hours
Environmental Care	**1,300 Liters**	Long Lubricant Life	1,300 Liters
Productivity	**€ 3,840**	Long Lubricant Life	€ 3,840

The savings calculations are set out in the TCO Appendix.

Recommendation

The adoption of Mobil Pegasus 605 Ultra 40 in the Metagri MWM TCG 2020 V 12 engine

doubled the oil drain interval while reducing the engine stops and the associated maintenance costs

There are three reasons that support this outcome:

1. Superior TBN retention and TAN Control
2. Excellent thermal and oxidation stability
3. Long lasting wear protection

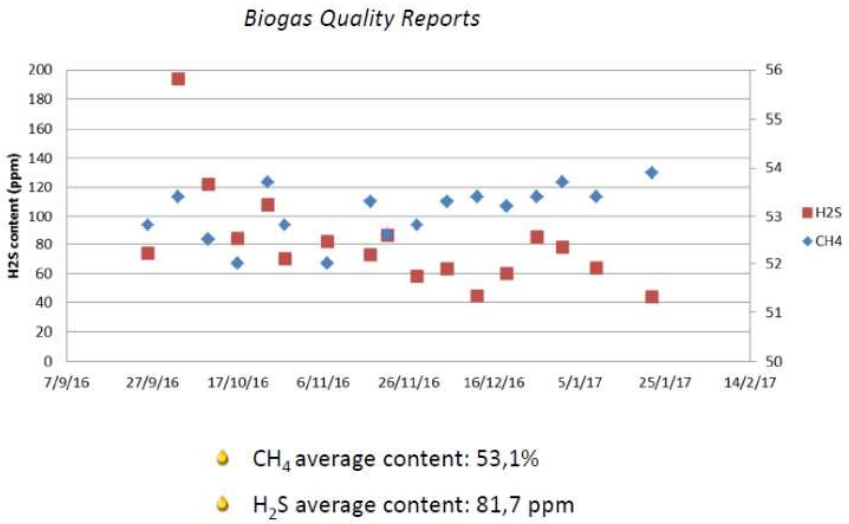
Superior TBN retention and TAN Control

Mobil Pegasus 605 ultra 40 has been proposed to Metagri in order to increase the 2000 hours oil drain interval achieved on MWM TCG 2002 V12 engine with a conventional gas engine oil. The engine was fueled with biogas with an average methane content of 52% and an H2S levelt varying between 70 to 200 ppm as reported here below by test measurement conducted on the field by on the gas stream by Arka Lube field engineers.

Visit mobilindustrial.com to learn how certain Mobil branded lubricant may provide benefits to help minimize environmental impact. Actual benefits will depend upon product selected, operating condition and applications.

Mobil Pegasus 605 Ultra 40

1. Agricultural biogas plant with MWM 2020 V12 (650 liters in oil sump)



- CH_4 average content: 53,1%
- H_2S average content: 81,7 ppm

2

FORESE GROUP

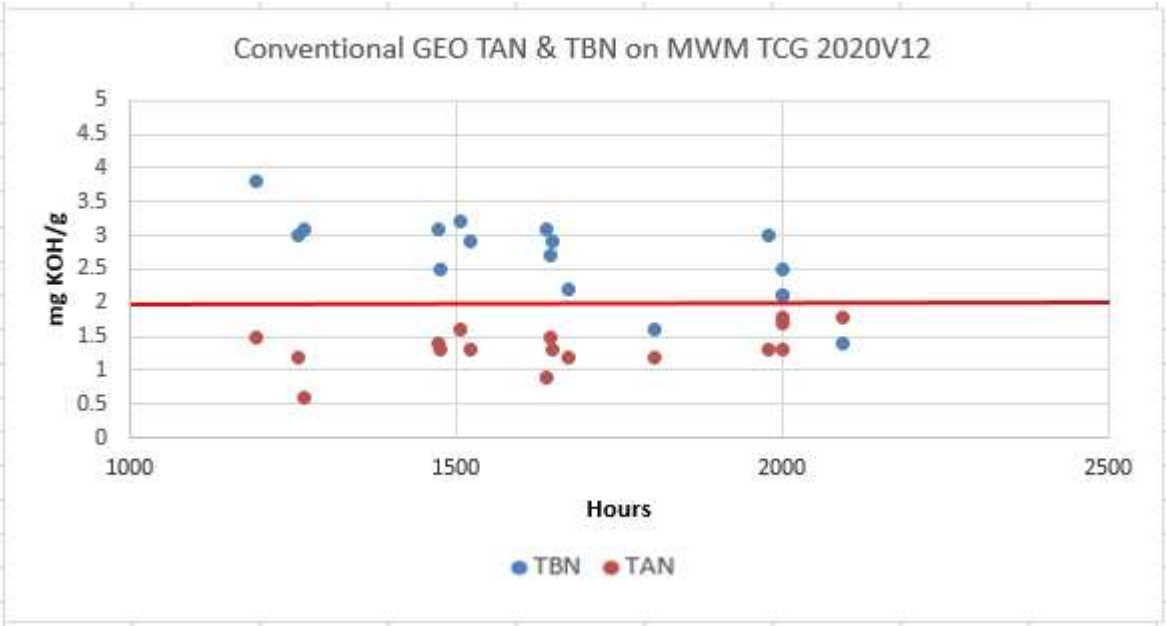
Mobil 605 Ultra 40 is a new generation gas engine oil based on high quality severely hydro treated base stocks and an innovative additive package that confers the product a superior TBN retention and TAN control while maintaining high detergency dispersant characteristics as well as corrosion protection against acidic combustion compounds.

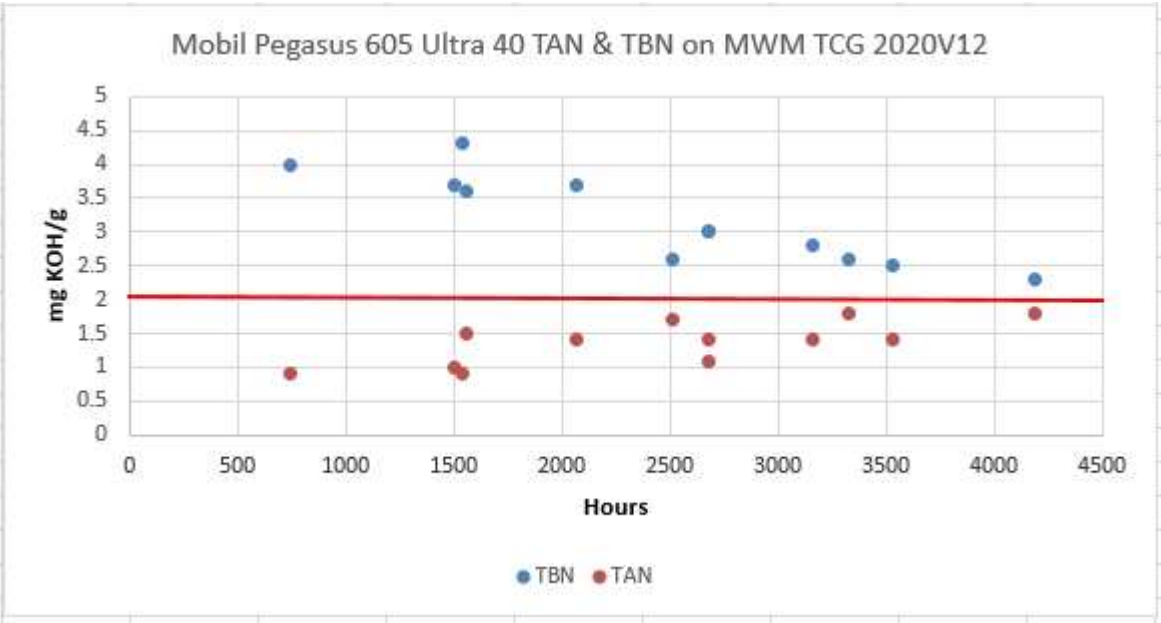
The main driver for the oil change with the conventional gas engine oil in use was TBN drop linked to TAN Increase achieving respectively the minimum and maximum level recommended by MWM for the used oil

Here below, to substantiate the results achieved with the use of the new product, we report TAN and TBN measurements up to 4000 hours compared with the value previously obtained with the conventional oil.

Mobil Pegasus 605 Ultra 40 at double oil service provide in average same results previously obtained with the conventional gas engine oil and meeting recommended used oil limits established by MWM for TBN and TAN

Visit mobilindustrial.com to learn how certain Mobil branded lubricant may provide benefits to help minimize environmental impact. Actual benefits will depend upon product selected, operating condition and applications.

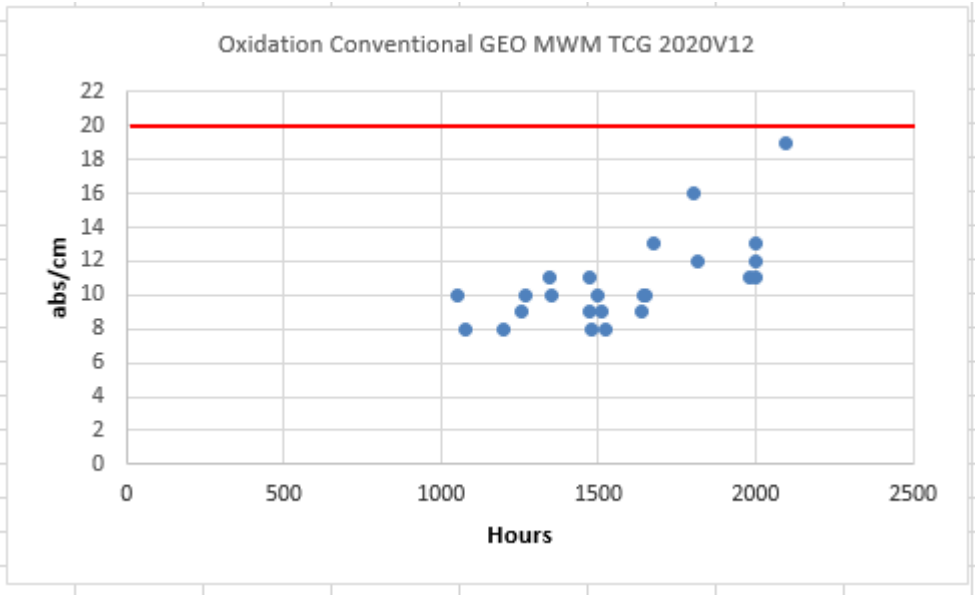


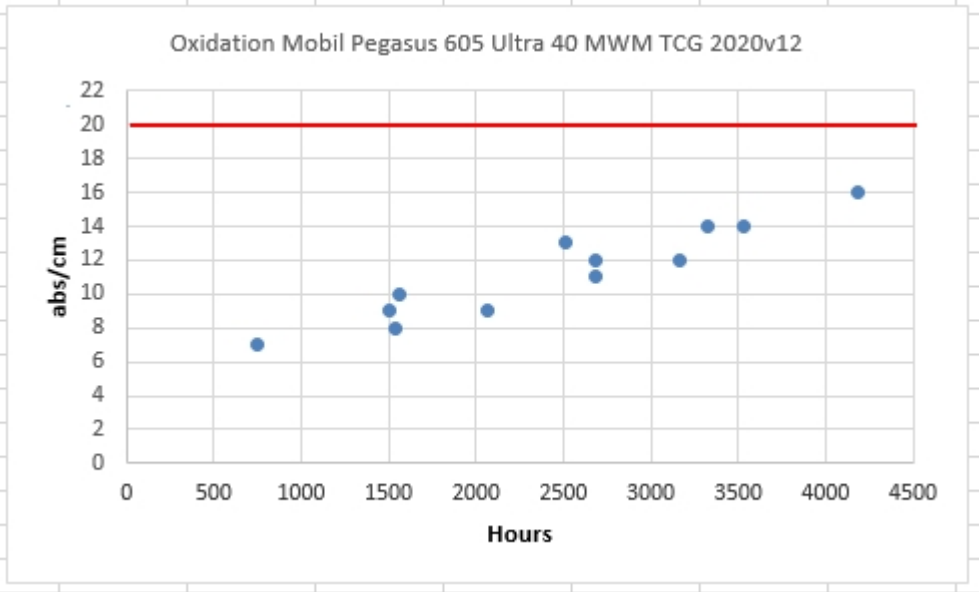


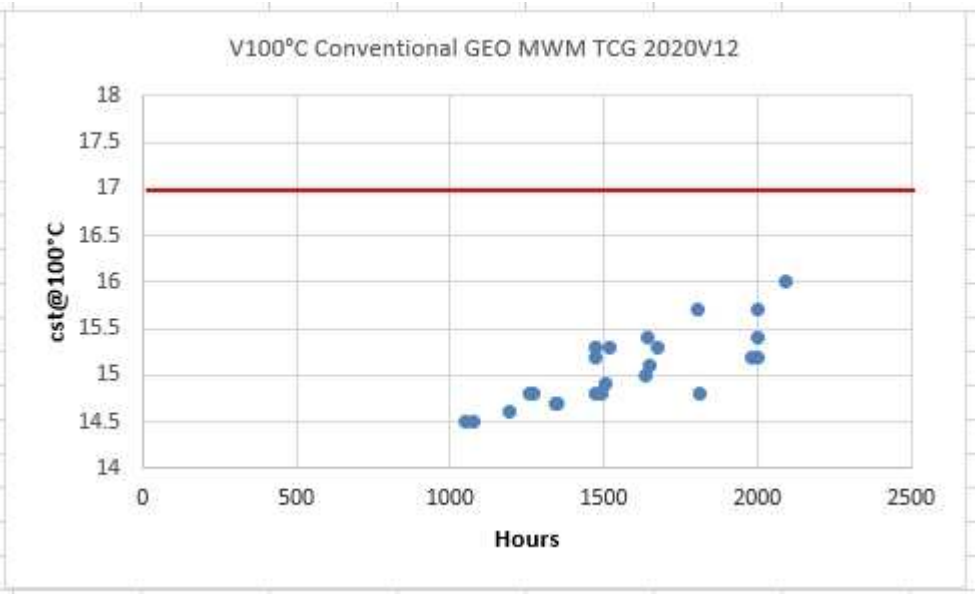
Visit mobilindustrial.com to learn how certain Mobil branded lubricant may provide benefits to help minimize environmental impact. Actual benefits will depend upon product selected, operating condition and applications.

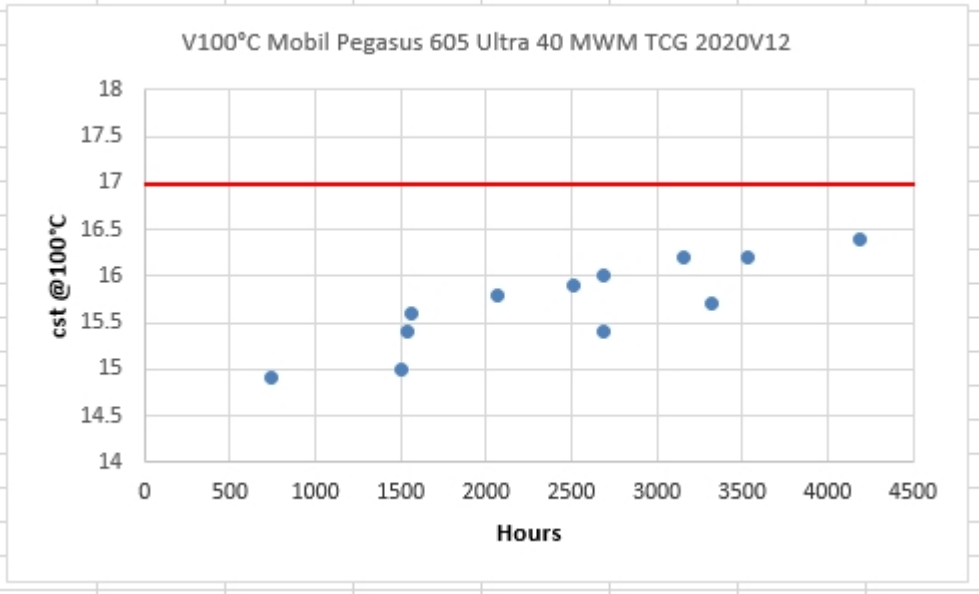
Excellent thermal and oxidation stability

While doubling the oil service, Mobil Pegasus 605 Ultra 40, thanks to his superior oxidation and thermal stability , shows lower or equal oxidation values and better viscosity control as shown here below by data collected over one year service .






V100°C Conventional GEO MWM TCG 2020V12
cst@100°C
18
17.5
17
16.5
16
15.5
15
14.5
14
0
500
1000
1500
2000
2500
Hours

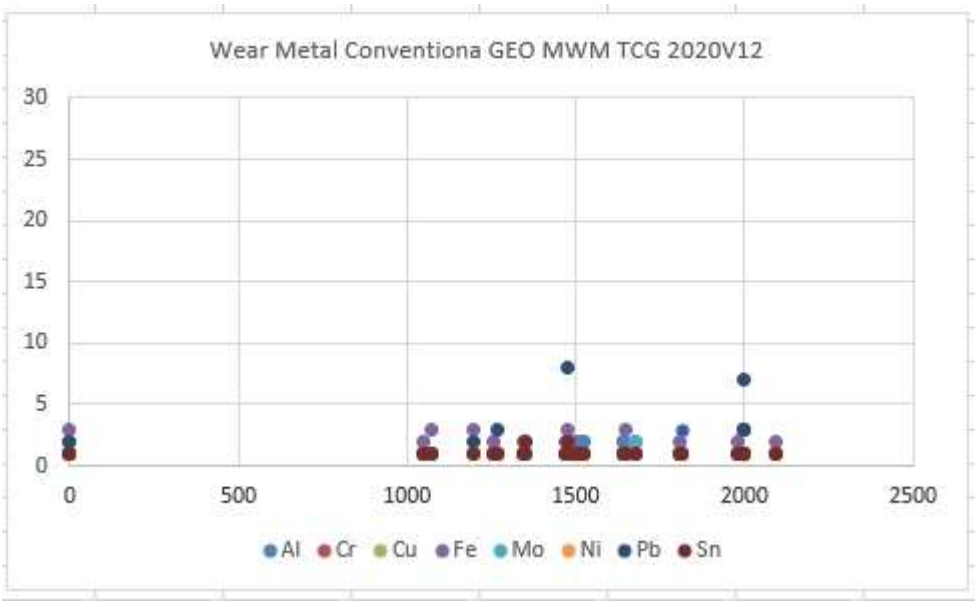

V100°C Mobil Pegasus 605 Ultra 40 MWM TCG 2020V12
cst @100°C
18
17.5
17
16.5
16
15.5
15
14.5
14
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Hours

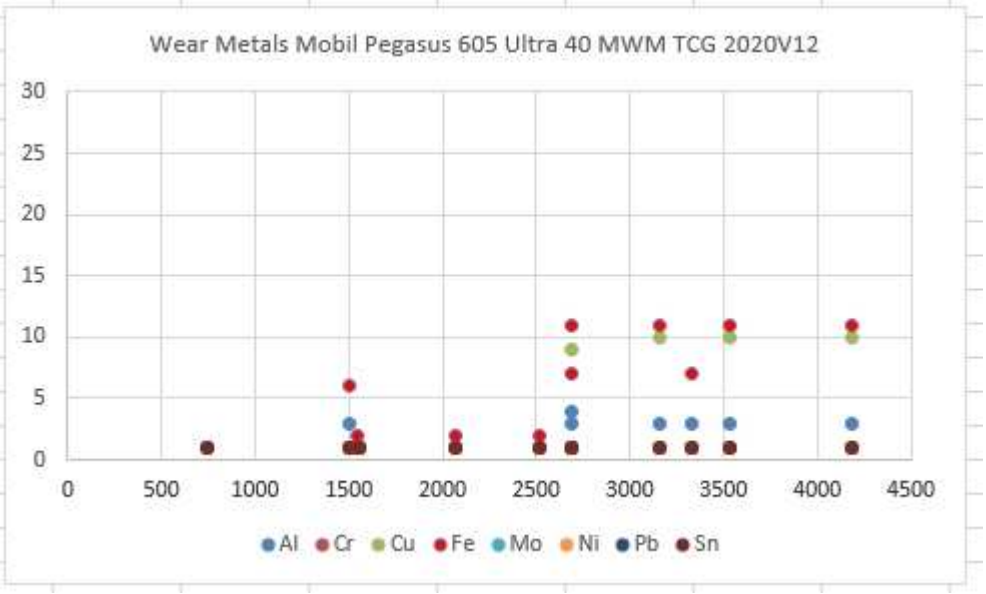
Long lasting wear protection

Mobil Pegasus 605 Ultra 40 have been developed to delivers in service superior protection against wear and scuffing also with highly polluted landfill gas where significant silicon level can be present.

Although the service hours of the Metagri MWM TCG 2020V12 have been doubled, the superior anti wear protection and the and specific anti scuffing capability allows to keep wear metals level well below the builder recommended limits for used oil

Visit mobilindustrial.com to learn how certain Mobil branded lubricant may provide benefits to help minimize environmental impact. Actual benefits will depend upon product selected, operating condition and applications.


Wear Metal Conventiona GEO MWM TCG 2020V12
30
25
20
15
10
5
0
0
500
1000
1500
2000
2500
Al Cr Cu Fe Mo Ni Pb Sn


Wear Metals Mobil Pegasus 605 Ultra 40 MWM TCG 2020V12
30
25
20
15
10
5
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Al Cr Cu Fe Mo Ni Pb Sn

Conclusion

Based on the investigation findings ExxonMobil recommended Metagri
The adoption of Mobil Pegasus 605 Ultra 40 in the Metagri MWM TCG 2020 V 12 engine doubled the oil drain interval while reducing the engine stops and the associated maintenance costs.

There are three reasons that support this outcome:

1. Superior TBN retention and TAN Control
2. Excellent thermal and oxidation stability
3. Long lasting wear protection

Next Actions

As step(s) to continue the benefits described in this report and achieve additional potential benefits, we recommend the following:

1. To continue the use of Mobil Pegasus 605 Ultra 40

Thank you for reviewing this report and for your assistance with our investigation.

Visit mobilindustrial.com to learn how certain Mobil branded lubricant may provide benefits to help minimize environmental impact. Actual benefits will depend upon product selected, operating condition and applications.

Appendices

Appendix 1 - Total Cost of Ownership

Benefit Calculation

Mobil Serv
Performance by ExxonMobil

Metagri Veneto

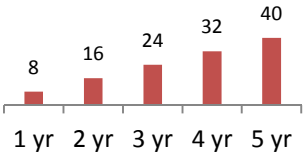
Mobil Pegasus 605 Ultra 40 in the Metagri MWM TCG 2020 V 12 engine

Customer Benefit Summary

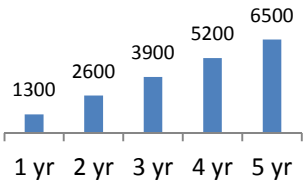
Potential Annual Savings

Safety	**8 Hours**
Environmental Care	**1,300 Liters**
Productivity	**€ 3,840 EUR**

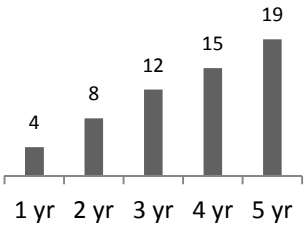
Potential Exposure Reduction



Potential Environment Improvement



Potential Annual Savings



Visit mobilindustrial.com to learn how certain Mobil branded lubricant may provide benefits to help minimize environmental impact. Actual benefits will depend upon product selected, operating condition and applications.

Baseline

Baseline

Input	Value	Measure
Conventional GEO lubricant ODI	2000	hours
Current Annual Cost of Lube Change Supplies	120	€
Current Annual Lube Change Events	4	Events
Current Lube Unit guess Cost	2.5	€
Mobil Pegasus 605 Ultra guess cost	3.0	€
Maintenance manpower cost	30	€/h
Maintenance people involved	2	
Manpower to change oil and filter set	2	Hours
Mobil Pegasus 605 Ultra 40 ODI	4000	Hours
Oil filter set cost	500	Hours
System Volume Per Lube Change	650	Liters
Yearly Engine Working Hours	8000	Hours

Metagri- Veneto

The adoption of Mobil Pegasus 605 Ultra 40 in the Metagri MWM TCG 2020 V 12 engine

Recommendation Annual Benefit Summary

Potential annual savings			
Safety	**8 Hours**	Long Lubricant Life	8 Hours
Environmental Care	**1300 Liters**	Long Lubricant Life	1,300 Liters
Productivity	**€ 3,840 EUR**	Long Lubricant Life	€ 3,840 EUR

Annual Savings Calculations

SAFETY

Long Lubricant Life : (OPEN CALCULATION - Enter Description Here)

	Current Annual Lube Change Events		Proposed Annual Lube Change Events		Maintenance people involved		Manpower to change oil and filterset		TOTAL
(	4	-	2	) *	2	*	2	=	**8 Hours**

ENVIRONMENTAL CARE

Long Lubricant Life : Reduced amount of waste lube generated for disposal due to increase ODI

	Current Annual Lube Change Events		Proposed Annual Lube Change Events		System Volume Per Lube Change		TOTAL
(	4	-	2	) *	650	=	**1,300 Liters**

EXPENDITURE REDUCTION

Long Lubricant Life : Reduced cost of lube purchased due to feed rate optimization

	Current Annual Lube Change Events		System Volume Per Lube Change		Current Lube Guess Unit Cost		Proposed Annual Lube Change Events		System Volume Per Lube Change		MP605U40 Guess Lube Unit Cost		TOTAL
((	4	*	650	)*	2.5	) - ((	2	*	650	)*	3.0	) =	**€2,600**

Long Lubricant Life : Reduced cost of oil change supplies

	Current Annual Lube Change Events		Proposed Annual Lube Change Events		Current Annual Cost of Lube Change Supplies		TOTAL
(	4	-	2	) *	120	=	**€240**

Annual cost of lube change=30 €/h * 2 hours*2 People involved in the oil and filter change

Long Lubricant Life : (OPEN CALCULATION - Enter Description Here)

Oil filter set cost			Current Annual Lube Change Events		Proposed Annual Lube Change Events			TOTAL
500	*	(	4	-	2	)	=	€1,000

Appendix 2 - MWM used Oil analysis Limits

Technical Bulletin

MWM

2105/12 EN

TR

Limit values

Risk of destruction of components

Due to failure to comply with the limit values

- If one of the following limit values is not complied with, the lubricating oil must be changed immediately.

During operation

Properties	Limit value	Test method
Viscosity at 100 °C	min. 12 mm^2/s (cSt) max. 18 mm^2/s (cSt)	DIN 51366, ASTM D 445, DIN EN ISO 3104
Increase in viscosity in comparison with the new condition at 100 °C	max. 3 mm^2/s (cSt)	
Water content	max. 0.2 %	DIN 51777, ASTM D 1744, DIN ISO 12937
Glycol content	max. 500 ppm	DIN 51375, ASTM D 4291
Total base number TBN	min. 2.0 mg KOH/g	ISO 3771, ASTM D 4739
AN	not greater than the TBN	DIN EN 12634, ASTM 664
SAN*	max. 0.2 mg KOH/g	ASTM 664
i pH value	min. 4.5	
Oxidation	max. 20 A/cm	DIN 51453
Nitration	max. 20 A/cm	DIN 51453
Silicon	max. 300 mg/kg	DIN 51396, ASTM D 5185

* The determination of the SAN is only necessary for combustion gases of the Low gas quality.

If a wear metal exceeds its permissible limit value, the limit value of silicon reduces to max. 15 mg/kg (DIN 51396, ASTM D 5185)