

# Eastman Optifilm™ Enhancer 400 for waterborne industrial maintenance coatings

## Introduction

Waterborne industrial maintenance coatings continue to present challenging formulation issues. Allowable volatile organic content (VOC) levels continue to be reduced in some regions of the U.S. In addition to the VOC limits, California's Office of Environmental Health and Hazard Assessment (OEHHA) recently added two of the most commonly used orthophthalate plasticizers, BBP (butyl benzyl phthalate) and DBP (dibutyl phthalate), to the Proposition 65 (Safe Drinking Water and Toxic Enforcement Act of 1986) list of chemicals, prompting some formulators to look for an alternative. Eastman Optifilm™ Enhancer 400 is an ideal solution for both of these formulating challenges.



Eastman Optifilm™ Enhancer 400 is an effective, near zero-VOC coalescent that reduces the minimum film formation temperature (MFFT) of a latex. Reducing the MFFT facilitates good film formation of the paint while improving film integrity at room temperature and allowing good film formation under adverse conditions such as low temperature or high humidity. Because it remains in the paint film, Optifilm™ Enhancer 400 will also help maintain film flexibility. Optifilm™ Enhancer 400 is a non-HAP, non-phthalate, low odor, non-yellowing alternative to orthophthalate products typically used for film flexibility. Table 1 shows that Optifilm™ 400 is safe to use under a variety of regulatory criteria.

Table 1 Regulatory information

	Eastman Optifilm™ Enhancer 400	BBP	DBP
SARA 313	No	No	Yes
HAP list CAAA title III	No	Yes	Yes
Prop 65	No	Yes	Yes
VOC	0.7%	2.3% <sup>1</sup>	~16%
EPA reportable quantity [CERCLA Section 102(a) hazardous substances]	Not listed	100 lbs	10 lbs
Acute aquatic effects, 96h LC-50 (fathead minnow) <sup>1</sup>	>96.7 mg/l	1.5 mg/l	0.92 mg/l
DOT classification <sup>1</sup>	Class not regulated	Environmentally hazardous substance (meets definition of a marine pollutant)	Environmentally hazardous substance (meets definition of a marine pollutant)
Use allowed in Green Seal certified paints	Yes	No	No

<sup>1</sup>Information from MSDS for Santicizer 160 (BBP), Ferro Corporation, Polymer Additives Division

## Latex direct-to-metal formulation

The following work on a latex direct-to-metal (DTM) formulation demonstrates how Eastman Optifilm™ Enhancer 400 can be easily incorporated into a waterborne industrial maintenance topcoat.

One formulation focused on reducing the VOC of standard latex DTM formulation from approximately 180 g/L to less than 100 g/L. To reduce the VOC, Eastman Optifilm™ Enhancer 400 replaced a portion of the higher VOC solvents. The orthophthalate plasticizer was also eliminated from the formulation.

Additional formulations, which maintained the higher VOC level, were tested with Eastman Optifilm™ Enhancer 400 as an alternative to orthophthalate plasticizers. In this portion of the testing, Optifilm™ Enhancer 400 was substituted for butyl benzyl phthalate (BBP) or dibutyl phthalate (DBP) on an equal wet-pounds basis. Like BBP and DBP, Optifilm™ 400 is easy to incorporate, has a high boiling point, and is compatible with a broad range of

waterborne resins. The performance results in this DTM formulation indicate that Optifilm™ Enhancer 400 can help maintain paint performance as a coalescent in a lower VOC formulation or as a replacement for common orthophthalate plasticizers.

## Testing and results

These paints were subjected to four different weathering tests: QUV-A (ASTM D4587, G53 and G154), Prohesion (ASTM G85), Salt spray (ASTM D1654 & B117), and Cleveland humidity (ASTM D4585 & D714). Table 2 summarizes the QUV-A results on cold rolled steel (CRS) panels, initially and after weathering for 250 and 500 hours. The initial gloss results were the same when Eastman Optifilm™ Enhancer 400 replaced the orthophthalate plasticizers, but the lower VOC formulation had much higher initial gloss. All of the formulations had a significant decrease in gloss after only 250 hours weathering, with no differences related to VOC reduction or alternatives for film flexibility. There was no significant yellowing in any of the formulations.

Table 2 QUV-A results

Initial	Gloss			Color			
	20°C	60°C	85°C	L	a	b	YI
180 g/l OE 400 <sup>a</sup>	17.9	61.9	93.6	95.0	-1.0	0.4	0.4
98 g/l OE 400 <sup>a</sup>	30.5	70.7	94.2	95.1	-1.1	0.5	0.6
180 g/l BBP	17.8	62.2	94.8	94.9	-1.1	0.4	0.4
180 g/l DBP	19.1	62.7	93.3	95.3	-1.0	0.5	0.6

250 hours	60° Gloss			YI			Delta E
	Initial	Rate interval	% retention	Initial	Rate interval	Delta	
180 g/l OE 400 <sup>a</sup>	61.9	11.9	19.2	0.4	0.0	-0.5	0.3
98 g/l OE 400 <sup>a</sup>	70.7	14.9	21.1	0.6	0.0	-0.6	0.5
180 g/l BBP	62.2	9.1	14.6	0.4	0.0	-0.5	0.4
180 g/l DBP	62.7	10.1	16.1	0.6	0.1	-0.5	0.4

500 hours	60° Gloss			YI			Delta E
	Initial	Rate interval	% retention	Initial	Rate interval	Delta	
180 g/l OE 400 <sup>a</sup>	61.9	9.6	15.6	0.4	0.4	0.0	0.1
98 g/l OE 400 <sup>a</sup>	70.7	12.4	17.6	0.6	0.3	-0.3	0.3
180 g/l BBP	62.2	8.0	12.9	0.4	0.5	0.1	0.3
180 g/l DBP	62.7	9.9	15.8	0.6	0.7	0.1	0.2

<sup>a</sup>Optifilm™ Enhancer 400

Like the QUV-A testing, Prohesion results showed very little difference between formulations after 500 hours. The formulations with Eastman Optifilm™ Enhancer 400 had slightly better corrosion resistance in the unscribed areas at 500 hours of testing as seen in Table 3.

**Table 3 Prohesion results**

	Substrate	Unscribed				Scribed	
		Blister size D714 <sup>1</sup>	Blister density D714 <sup>1</sup>	%Area rust D610	%Area rust D1654	Rust creepage D1654	Scribe blister size
<b>250 hours</b>							
180 g/l OE 400 <sup>a</sup>	CRS	8	Few	9.0	9.0	0.5–1.0 mm	8
98 g/l OE 400 <sup>a</sup>	CRS	8	Few	9.0	9.0	0.5–1.0 mm	8
180 g/l BBP	CRS	8	Few	8.3	9.0	0.5–1.0 mm	8
180 g/l DBP	CRS	8	Few	8.7	9.0	0.5–1.0 mm	8
<hr/>							
180 g/l OE 400 <sup>a</sup>	Galvanized	8	Few	10.0	10.0	None	None
98 g/l OE 400 <sup>a</sup>	Galvanized	8	Few	10.0	10.0	None	None
180 g/l BBP	Galvanized	8	Few	10.0	10.0	None	None
180 g/l DBP	Galvanized	8	Few	10.0	10.0	None	None
<hr/>							
180 g/l OE 400 <sup>a</sup>	Aluminum	10	None	10.0	10.0	None	None
98 g/l OE 400 <sup>a</sup>	Aluminum	10	None	10.0	10.0	None	None
180 g/l BBP	Aluminum	10	None	10.0	10.0	None	None
180 g/l DBP	Aluminum	10	None	10.0	10.0	None	None
<hr/>							
<b>500 hours</b>							
180 g/l OE 400 <sup>a</sup>	CRS	8	Few	9.0	9.0	0.5–1.0 mm	8
98 g/l OE 400 <sup>a</sup>	CRS	8	Few	8.5	9.0	0.5–1.0 mm	8
180 g/l BBP	CRS	8	Few	7.7	8.7	0.5–1.0 mm	8
180 g/l DBP	CRS	6 & 8	Few	8.0	8.7	0.5–1.0 mm	8
<hr/>							
180 g/l OE 400 <sup>a</sup>	Galvanized	6 & 8	Few	10.0	10.0	None	None
98 g/l OE 400 <sup>a</sup>	Galvanized	6	Medium	10.0	10.0	None	None
180 g/l BBP	Galvanized	4 & 6	Medium	10.0	10.0	None	None
180 g/l DBP	Galvanized	6	Medium	10.0	10.0	None	None
<hr/>							
180 g/l OE 400 <sup>a</sup>	Aluminum	10	None	10.0	10.0	None	None
98 g/l OE 400 <sup>a</sup>	Aluminum	10	None	10.0	10.0	None	None
180 g/l BBP	Aluminum	10	None	10.0	10.0	None	None
180 g/l DBP	Aluminum	10	None	10.0	10.0	None	None

<sup>1</sup>The blister rating is in accordance to ASTM D714.

<sup>a</sup>Optifilm™ Enhancer 400

Each formulation was also exposed for Cleveland humidity testing. Table 4 shows no differences in blistering or face rust after 500 hours.

**Table 4 Cleveland testing**

Initial	Color			
	L	a	b	YI
180 g/l OE 400 <sup>a</sup>	95.1	-1.0	0.4	0.4
98 g/l OE 400 <sup>a</sup>	94.8	-1.1	0.3	0.3
180 g/l BBP	95.2	-1.1	0.5	0.7
180 g/l DBP	94.9	-1.0	0.3	0.3

  

250 hours	YI			Delta E	Face blister		Face rust
	Initial	Rate interval	Delta		Size	Density	
180 g/l OE 400 <sup>a</sup>	0.4	1.8	1.3	1.4	None	None	None
98 g/l OE 400 <sup>a</sup>	0.3	2.0	1.7	1.8	None	None	None
180 g/l BBP	0.7	1.6	0.9	1.6	None	None	None
180 g/l DBP	0.3	1.9	1.6	1.8	None	None	None

  

500 hours							
180 g/l OE 400 <sup>a</sup>	0.4	1.8	1.4	1.9	None	None	None
98 g/l OE 400 <sup>a</sup>	0.3	1.7	1.4	1.0	None	None	None
180 g/l BBP	0.7	0.5	-0.1	1.3	None	None	None
180 g/l DBP	0.3	3.2	2.9	2.8	None	None	None

<sup>a</sup>Optifilm™ Enhancer 400



After 250 hours of salt fog testing, as shown in Table 5, the steel panels failed based on blister density and creepage. There was no significant difference between the formulations. The low VOC formulation did have slightly larger blisters, but slightly less face rusting.

**Table 5 Salt fog testing**

	Substrate	Unscribed				Scribed	
		Blister size D714 <sup>1</sup>	Blister density D714 <sup>1</sup>	% Area rust D610	% Area rust D1654	Rust creepage D1654	Scribe blister size
<b>250 hours</b>							
180 g/l OE 400 <sup>a</sup>	CRS	8	Dense	1	1	2.0-3.0 mm	8
98 g/l OE 400 <sup>a</sup>	CRS	6	Dense	2	2	2.0-3.0 mm	6
180 g/l BBP	CRS	8	Dense	1	1	2.0-3.0 mm	8
180 g/l DBP	CRS	8	Dense	1	1	2.0-3.0 mm	8
180 g/l OE 400 <sup>a</sup>	Galvanized	6	Dense	None	None	None	6
98 g/l OE 400 <sup>a</sup>	Galvanized	4 & 6	Dense	None	None	None	2
180 g/l BBP	Galvanized	6	Dense	None	None	None	4
180 g/l DBP	Galvanized	6 & 8	Dense	None	None	None	4 & 6
180 g/l OE 400 <sup>a</sup>	Aluminum	None	None	NA	NA	NA	None
98 g/l OE 400 <sup>a</sup>	Aluminum	None	None	NA	NA	NA	None
180 g/l BBP	Aluminum	None	None	NA	NA	NA	None
180 g/l DBP	Aluminum	None	None	NA	NA	NA	None

<sup>1</sup>The blister rating is in accordance to ASTM D714.

<sup>a</sup>Optifilm™ Enhancer 400

For early water resistance, the paints were cast on CRS panels and allowed to dry for four hours. Then the panels were placed into deionized water for five days. The paints which contained Eastman Optifilm™ Enhancer 400 had significantly less blistering than the paint containing BBP. The paint with DBP was similar to those with Optifilm™ Enhancer 400. This data is summarized in Table 6.

**Table 6 Early water resistance**

Formula	Average of three panels	
	Surface rust	Blisters <sup>1</sup>
180 g/l Waterborne DTM with OE 400 <sup>a</sup>	No surface rust	#6 few
98 g/l Waterborne DTM with OE 400 <sup>a</sup>	No surface rust	#8 few
180 g/l Waterborne DTM with BBP	No surface rust	#4 medium
180 g/l Waterborne DTM with DBP	No surface rust	#6 few

<sup>1</sup>The blister rating is in accordance to ASTM D714.

<sup>a</sup>Optifilm™ Enhancer 400

These paints were also tested for hardness and flexibility by pendulum hardness (ASTM D4366), T-bends (ASTM D4145), impact resistance (ASTM D2794) and thermal shock.

When tested by pendulum hardness, the surface hardness of the paint with Eastman Optifilm™ Enhancer 400 was slightly lower than those with DBP or BBP. Because Optifilm™ Enhancer 400 more effectively coalesces latexes, this may be an indication that the level needs to be reduced. Typically Optifilm™ Enhancer 400 can be reduced 10–20% to maintain the same hardness with no detrimental effect on the coating flexibility. Surface hardness is the property most affected by the VOC reduction, with a fairly significant reduction in surface hardness being evident (see Table 7).

**Table 7 Pendulum hardness**

Formula	Average of three oscillation readings
180 g/l Waterborne DTM with OE 400 <sup>a</sup>	43
98 g/l Waterborne DTM with OE 400 <sup>a</sup>	30
180 g/l Waterborne DTM with BBP	50
180 g/l Waterborne DTM with DBP	47

<sup>a</sup>Optifilm™ Enhancer 400

All of the paints had very good flexibility as is shown in the tables below. T-bend testing is a very severe test of coating flexibility. Good flexibility is critical to the coating’s ability to protect the substrate in the field. Improved flexibility reduces cracking of the coating surface and reduces the moisture penetration that may reduce the life of the substrate. The flexibility data are summarized in Table 8.

**Table 8 T-bends**

Formula	Average of three test readings
180 g/l Waterborne DTM with OE 400 <sup>a</sup>	0T
98 g/l Waterborne DTM with OE 400 <sup>a</sup>	0T
180 g/l Waterborne DTM with BBP	0T
180 g/l Waterborne DTM with DBP	0T

<sup>a</sup>Optifilm™ Enhancer 400

Impact resistance is a test that indicates both flexibility and adhesion. All four formulas exhibited excellent impact resistance. This is a very important test for structures that are repeatedly hit with flying debris. Bridges are a good example of a structure needing impact resistance because they are constantly hit with gravel flying off the tires of passing cargo trucks. The following table shows the results of the impact resistance test.

**Table 9 Impact resistance**

Formula	Average of three panels	
	Forward	Reverse
180 g/l Waterborne DTM with OE 400 <sup>a</sup>	160	160
98 g/l Waterborne DTM with OE 400 <sup>a</sup>	160	160
180 g/l Waterborne DTM with BBP	160	160
180 g/l Waterborne DTM with DBP	160	160

<sup>a</sup>Optifilm™ Enhancer 400

Thermal shock testing also helps to determine how a coating will resist cracking under extreme temperature changes. The films were cast on cold rolled steel (CRS) panels and an inside and an outside 90° bend were made on the ends of the panels to create stress points for the films to fail. This is a modified version of ASTM D 6944-03 method B. The films were cycled between -5°C for 16 hrs and 50°C for 8 hrs over a two week period. All of the films passed this test as seen in Table 10.

**Table 10 Thermal shock**

Formula	Two weeks average of three panels	
	90° inside bend	90° outside bend
180 g/l Waterborne DTM with OE 400 <sup>a</sup>	Pass	Pass
98 g/l Waterborne DTM with OE 400 <sup>a</sup>	Pass	Pass
180 g/l Waterborne DTM with BBP	Pass	Pass
180 g/l Waterborne DTM with DBP	Pass	Pass

<sup>a</sup>Optifilm™ Enhancer 400



### Summary

Eastman Optifilm™ Enhancer 400 will allow formulators to reduce the VOC of a waterborne DTM formulation with minimum performance compromise. Optifilm™ Enhancer 400 is also an excellent non-phthalate replacement for orthophthalate plasticizers, maintaining the performance of the formulation. For formulators who need to reduce the VOC of their waterborne DTM or prefer to replace their orthophthalate plasticizers, Optifilm™ Enhancer 400 is an excellent choice.

## Appendix

### Water-based direct to metal (DTM) spray formulas based on Rohm & Haas formula G-56-1

<b>Formula 1</b>	
<b>Components</b>	<b>Pounds</b>
<b>180 g/l VOC mid-gloss white DTM topcoat with OE 400<sup>a</sup></b>	
<b>Grind</b>	
Solvent DM	18
Water	35
Tamol 165	9.5
Ammonia	1
Triton CF-10	1.5
Tego 1488	1.5
TiPure 706	195
<b>Grind above then add:</b>	
Water	5
<b>Letdown</b>	
Maincote HG-56	523
Ammonia	4
Water	85
EEH	27.5
Solvent DM	27.5
<b>OE 400<sup>a</sup></b>	
Tego 1488	2.5
Sodium Nitrate (15% in water)	9
Acrysol RM 8W	3
<b>Total</b>	<b>962</b>

<sup>a</sup>Optifilm™ Enhancer 400

<b>Formula 2</b>	
<b>Components</b>	<b>Pounds</b>
<b>98 g/l VOC DTM white with OE 400<sup>a</sup></b>	
<b>Grind</b>	
Solvent DM	15
Water	35
Tamol 165	9.5
Ammonia	1
Triton CF-10	1.5
Tego 1488	1.5
TiPure 706	195
<b>Grind above then add:</b>	
Water	5
<b>Letdown</b>	
Maincote HG-56	523
Ammonia	4
Water	85
EEH	11
Solvent DM	10.5
<b>OE 400<sup>a</sup></b>	
Tego 1488	2.5
Sodium Nitrate (15% in water)	9
Acrysol RM 8W	3
<b>Total</b>	<b>931.5</b>

<sup>a</sup>Optifilm™ Enhancer 400

# EASTMAN

## **Eastman Chemical Company Corporate Headquarters**

P.O. Box 431  
Kingsport, TN 37662-5280 U.S.A.  
Telephone:  
U.S.A. and Canada, 800-EASTMAN  
(800-327-8626)  
Other Locations, (1) 423-229-2000  
Fax: (1) 423-229-1193

## **Eastman Chemical Latin America**

9155 South Dadeland Blvd.  
Suite 1116  
Miami, FL 33156 U.S.A.  
Telephone: (1) 305-671-2800  
Fax: (1) 305-671-2805

## **Eastman Chemical B.V.**

Fascinatio Boulevard 602-614  
2909 VA Capelle aan den IJssel  
The Netherlands  
Telephone: (31) 10 2402 111  
Fax: (31) 10 2402 100

## **Eastman (Shanghai) Chemical Commercial Company, Ltd. Jingan Branch**

1206, CITIC Square  
No. 1168 Nanjing Road (W)  
Shanghai 200041, P.R. China  
Telephone: (86) 21 6120-8700  
Fax: (86) 21 5213-5255

## **Eastman Chemical Japan, Ltd.**

AIG Aoyama Building 5F  
2-11-16 Minami Aoyama  
Minato-ku, Tokyo 107-0062 Japan  
Telephone: (81) 3-3475-9510  
Fax: (81) 3-3475-9515

## **Eastman Chemical Asia Pacific Pte. Ltd.**

#05-04 Winsland House  
3 Killiney Road  
Singapore 239519  
Telephone: (65) 6831-3100  
Fax: (65) 6732-4930

[www.eastman.com](http://www.eastman.com)

Material Safety Data Sheets providing safety precautions, that should be observed when handling and storing Eastman products, are available online or by request. You should obtain and review the available material safety information before handling any of these products. If any materials mentioned are not Eastman products, appropriate industrial hygiene and other safety precautions recommended by their manufacturers should be observed.

*Neither Eastman Chemical Company nor its marketing affiliates shall be responsible for the use of this information, or of any product, method or apparatus mentioned, and you must make your own determination of its suitability and completeness for your own use, for the protection of the environment and for the health and safety of your employees and purchasers of your products. NO WARRANTY IS MADE OF THE MERCHANTABILITY OR FITNESS OF ANY PRODUCT, AND NOTHING HEREIN WAIVES ANY OF THE SELLER'S CONDITIONS OF SALE.*

Eastman and Solus are trademarks of Eastman Chemical Company.

All other brands are the property of their respective owners.

© Eastman Chemical Company, 2009.