Report on the Introduction of Waterborne Paints to the Container Industry

Published by the COA’s New Materials Committee

Revision 6
May 2018
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1. Introduction

This Report published by the Container Owners Association was first published in 2010 when it became clear that the industry would have to move to the use of waterborne paint instead of solvent based paint. At that time, the timetable of the change was not clear but the report attempted to provide information to COA members on the challenges to the industry of making the change. As of April 1, 2017, all major container manufacturers had to make the switch so all buyers of dry boxes are now receiving their containers coated with waterborne paint. The aim of this report is to provide COA members with an easy-to-understand summary of the subject of waterborne paints as it potentially affects container owners. It has been revised and updated regularly since 2010, the last update being in May 2016.

The purpose of this report is to try to present the facts surrounding the introduction into the container industry of waterborne coating systems. It is left to the reader to decide what action, as a container owner, they should take on the basis of the information laid out in the report. It is not intended to be a technical report; just a simple explanation and summary of the changes that have been made and some of the problems that have been experienced arising from the change.

Thanks to the many people from within the industry who have supplied information for the report and comments on it, without which it would not have been possible to put this information pack together.

Nigel Stribley

About the COA

The Container Owners Association was established in November 2004 as an international organisation representing the common interests of all owners of freight containers. The principle aims of the COA are to provide global expertise, to promote common standards and to facilitate international lobbying.

www.containerownersassociation.org
2. Executive Summary

The switch to the use of waterborne paint in South China from July 2016 and in the rest of China from April 2017 has generally proceeded more smoothly than many predicted. Production volumes in 2017 were greater than was anticipated, driven by market demand encouraging buyers to overcome fears that they may have incidences of compromised quality during the initial period after the switch.

Most factories have converted to the use of waterborne paint, even older and small factories for which the rationale for investing in the cost of conversion might have been more questionable, so overall production capacity has been little affected. After years during which the industry hoped the problem would just go away and kept delaying investment decisions, factories have worked hard to get it right.

There was initial caution expressed about the use of waterborne paint in North China during the winter months when temperatures can be sub-zero for days at a time but factories did undertake production in these conditions over the winter of 2017/18 with the endorsement of some paint suppliers.

Despite the generally positive outlook, a number of problems have inevitably been experienced including sagging, cracking, bubbling and flash rusting amongst others. Given the extra complexity of the application and drying of waterborne paint compared to solvent borne paint, this is hardly surprising. Solvent borne paints were used for a reason; they are far easier to apply and more forgiving if there are shortcomings in the application process. Furthermore, container manufacturing is not a "high tech" business so the change to waterborne with more demanding application parameters has been a major challenge for the factories to accommodate.

It is to be hoped that as factories become more familiar with the application of waterborne paint, the problems will gradually diminish.

It should be noted that there is a substantial cost impact to the container factories of conversion to the use of waterborne paint. Aside from the investment in extending the line, adding heating, ventilation and dehumidification, power consumption to support these facilities during production is up to sixty per cent higher than with solvent borne and the line speed is potentially slower. Ironically, any additional cost in the paint is the least of their problems.

In the opinion of the COA, buyers should not be put off building new containers but should be aware that the successful application of waterborne paint is much more challenging than solvent borne and they should therefore monitor the application process very carefully.
3. Background

Led by the China Container Industry Association, composed of CIMC, Singamas, CXIC and Dong Fang International, the container industry voluntarily agreed with Chinese central and regional government to switch to the use of waterborne paint for container production in South China from July 1, 2016 and for production in the rest of China from April 1, 2017.

As partners in the Convention, the paint suppliers Hempel, Cosco Kansai, Chugoku, KCC, Valspar, Dowill, Jointas, Baojun and Mega agreed to support the container manufacturers in achieving this objective.

From these dates, the container manufacturers only offered waterborne paint as a coating to container buyers.

There are some exceptions:

- Zinc shop primers – container factories are still allowed to use solvent based zinc rich shop primers but the factory must comply with the local VOC emission levels set by the local government.
- Solvent borne touch up paint for minor corrections to a container in the storage yard during acceptance.
- Coatings for reefers and tank containers are also currently excluded from the Convention and there is no timetable under consideration for any future switch.

The Convention provided for a Special Environmental Committee of the Association to monitor the factories of CCIA members and non-members to verify that they are complying with the decision to use exclusively waterborne paints and that VOC emissions do not exceed the levels set by the regional government where the factories are situated. The reasons that some levels of VOC emissions will continue are the continuing use of some solvent based zinc rich primers, as mentioned above, and the fact that waterborne paints include some small levels of VOCs.

Maersk Container Industries are not members of the CCIA but they were the pioneers of the use of waterborne paint on volume production of containers in China, having converted their dry box factory in Dongguan to the use of waterborne paint at the end of 2013. MCI has only used waterborne products since then.
4. Suppliers of Waterborne Paint

The supply of solvent borne paint was dominated for many years by the “big four” of Chugoku, Cosco Kansai, Hempel and KCC with Mega and SKF being smaller suppliers.

However, the first paint supplier to make a waterborne paint available to the container industry was Valspar (excluding the experiments that were undertaken on a small scale in the 1990s), offering a two coat system for the exterior, using a resin based anti-corrosive primer instead of the zinc primer used by all the suppliers of solvent based paint. The Valspar system remains unique as on conversion to waterborne, all the other paint suppliers opted to keep a three coat system for the exterior with a zinc primer, an epoxy or acrylic mid-coat and an acrylic top coat. The enforced switch to waterborne has seen some newcomers from China enter the market. Dowill has been the primary new supplier and Baojun and Jointas have indicated an intention to do so as well.

Prior to the enforced conversion to waterborne paint, all the suppliers committed to provide full waterborne coating systems for containers but the pace of conversion of this into the support of volume production has varied significantly. By far the biggest supplier of waterborne paint in 2017 was newcomer Dowill, which achieved a market share of over fifty per cent in 2016 and remained the largest supplier in 2017, followed by KCC, Chugoku and Mega. Volumes for Kansai, Hempel have been much less and SKF hardly any. Valspar supply was limited to the ongoing production of containers for Maersk Line at MCI.
As indicated in the Executive Summary, solvent borne paints were used for a reason; they are far easier to apply and more forgiving if there are shortcomings in the application process and more tolerant of cold and variable ambients. The addition of various additives to a waterborne paint makes its application characteristics closer to those of solvent borne paints but they cannot replicate them, just as hearing aids can never fully restore the hearing of someone who is deaf. So the container factory has to make up for those shortcomings and as container manufacturing is not a “high tech” business, this is challenging for them to accommodate. Furthermore, there are greater variations in the characteristics of the waterborne paint of the paint suppliers than there were between their solvent borne products, which makes it more cumbersome for the factories to switch from one supplier to another. Container owners might consider consulting the factory and/or the paint supplier prior to appointing a specific provider.

The role of the representatives of the paint suppliers advising on and monitoring the application of the paint during production has therefore become even more important.
5. Waterborne Paint at Container Factories

Of the main parties involved in the switch to using waterborne paint – the container manufacturers, the paint suppliers and the container buyers - the challenge has been greatest for the container manufacturers.

There was some uncertainty whether all the factories would convert their production lines to the use of waterborne paint given the investment required, the extra space needed to allow for the additional drying / curing time required by waterborne paint and because recent profitability of some factories had been under pressure in the period leading up to when conversion had to take place. In the event, with a couple of exceptions, virtually every factory opted to convert. We believe that the decision to do so in some cases was driven by the unexpectedly high level of demand for containers in 2017.

The uncertainty about whether all factories would make the investment to convert arose from the fact that conversion is not a simple procedure as it requires extra stations on the line for the longer drying time required by waterborne paint and for the drying of each coat before application of the next, something not required with solvent borne paint. Heat must be available to warm the containers prior to painting, in cases when the ambient is below the application parameters of waterborne, heat is also required to dry the coatings, ventilation is required to circulate and exhaust the water laden air and a dehumidifier for occasions when background humidity is high and ventilation is insufficient to ensure humidity levels are maintained within the targets laid down by the paint suppliers.

The nature and extent of the work undertaken to achieve the conversion has varied from one container factory to another and some have undertaken additional work based on the experience of actual production. The newer factories generally have the luxury of greater space than the older ones, to add the extra stations to the production line and those with greater production volumes have potentially had a larger budget to do so.

What conversion work was required varied depending upon the location. The application of waterborne paint is much more sensitive to temperature and humidity than solvent borne. For example, low temperatures in North China during winter make the transport and the storage of paint above a minimum temperature and the warming of the containers crucial and high humidity, particularly combined with a cold ambient, will slow or even temporarily stop the curing of the paint. As weather conditions vary from day to day, or even during the day, adjustment of the heating, ventilation and dehumidification on the line have to be made.

A container production line applying waterborne paint is therefore substantially more complicated than one for solvent borne and requires regular “retuning” of the paint application to accommodate the whims of the weather and the product of the specific paint supplier.

An example of a lay out of the painting area of a container production line applying waterborne paint is shown below. Each factory will vary but the stations shown on this diagram will exist in all or most factories. COA buyers of containers are advised to seek details from their nominated container factory of the lay out of their particular production line and to understand the paint application process.
Shop primer - zinc rich primer – solvent - 10 microns applied during cutting and assembly before reaching the painting line

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre – heat containers prior to paint application</td>
</tr>
<tr>
<td>2</td>
<td>Pre coating zinc rich primer – waterborne</td>
</tr>
<tr>
<td>3</td>
<td>Auto spray zinc rich primer</td>
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<tr>
<td>4</td>
<td>Drying oven for curing</td>
</tr>
<tr>
<td>5</td>
<td>Auto spray mid coat exterior</td>
</tr>
<tr>
<td>6</td>
<td>Check and touch up mid coat exterior</td>
</tr>
<tr>
<td>7</td>
<td>Drying oven for curing</td>
</tr>
<tr>
<td>8</td>
<td>Auto spray interior coat</td>
</tr>
<tr>
<td>9</td>
<td>Check and touch up interior coat</td>
</tr>
<tr>
<td>10</td>
<td>Drying oven for curing</td>
</tr>
<tr>
<td>11</td>
<td>Pre-spray exterior top coat</td>
</tr>
<tr>
<td>12</td>
<td>Auto spray exterior top coat</td>
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<tr>
<td>13</td>
<td>Drying oven for curing</td>
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<tr>
<td>14</td>
<td>Under coating</td>
</tr>
<tr>
<td>15</td>
<td>Undercoating touch up</td>
</tr>
<tr>
<td>16</td>
<td>Drying oven for curing</td>
</tr>
</tbody>
</table>

Container Owners Association
The extra power required to provide the heat, ventilation and dehumidification at the painting stations is substantial and this falls on the container manufacturer. It will vary according to the season, the weather and the location of the factory but indications are that the power required to build a container utilising waterborne paint could have risen by as much as 60% compared to a container with solvent borne paint.

The additional stations on the production line and the necessity of adjusting the speed of the production line to match the drying time required for each coat of paint has meant the line speed for a waterborne production is likely to be slower than for solvent borne production. Line speed translates directly into the number of containers that can be built per shift and therefore into the profitability of the factory so is a crucial factor for container buyers, paint suppliers and the factories. Too great a speed may not allow enough drying time for the paint and lead to hurried and incomplete application. Too slow and production costs rise to a potentially unacceptable level for the container manufacturer. In the initial production runs following the switch to waterborne paint, production lines were typically running at approximately 70% of the line speed for solvent borne production. Since then, factories have sought to gradually increase the speed without compromising on application quality and a select few have or are coming close to achieving parity with a solvent borne paint line. However, it remains a matter that container buyers are advised to monitor carefully on their production as excess speed can severely compromise the quality of the paint application.
6. **Typical Problems**

The problems shown below are just some of those that might occur during or after container production. Some problems may be caused by more than one issue occurring together and are not included in this report, which is intended just to provide an overview for the non-technical reader.

**Surface Pin Holes**
These are very small / shallow holes on a single paint layer and are only detectable under microscope at 15X. This is perhaps the most common waterborne paint defect, due to poor airflow and insufficient setting and drying time.

![Surface Pin Holes](image1.jpg)

**Sponge Pin Holes**
This mostly affects interior/exterior topcoat and cannot be seen from the surface. Bubbles form within cured paint creating a sponge like appearance of the paint when cut. It is the result of excess heat/air flow creating unstable paint layer.

![Sponge Pin Holes](image2.jpg)
**Penetrable Pin Hole**
This continues through all paint layers and through the zinc rich primer so will result in immediate rusting.

![Penetrable Pin Hole Image]

**Paint Crack**
A common waterborne paint defect that usually occurs at high DFT areas.

![Paint Crack Image]
**Flash Rust**
A rust stain condition that usually occurs at the interior top coat. It may appear right away or after a few months, or even 1 or 2 years - usually in the interior of the container.

![Flash Rust Image]

**Water Blister**
This occurs in a high DFT area on horizontal surfaces where water accumulates. It is usually when the units are off line in the yard and exposed to rain.

![Water Blister Image]
Rust Bloom

Probably caused by “bubbling” - small air bubbles (possibly occurring because the nozzle of the spray gun was too close to the surface being painted) in the waterborne zinc primer and then bursting when the mid coat is applied before the waterborne zinc primer has dried. The bursting bubble breaches both coats exposing tiny areas of the steel underneath, which are then only protected by the top coat. With salt spray, this will be penetrated in time. This problem may only become obvious some weeks or even months after production.

Other problems reported or observed:

- **Sagging** – waterborne paint is more prone to this problem than solvent. It is caused by over application of paint.

- **Poor adhesion** – the adhesion of waterborne paint on corner castings has been unsatisfactory on some containers. The paint chips off in use, leading to the corner casting rusting, which then runs down the corner post creating stains.

- **Light colours** - more flash rusting and rust bloom problems have been noted on light colours than dark colours, although there is no reason technically why this would be so.

- **Streaking** – occurs when below spec DFT is overcoated / touched up with solvent paint in yard (waterborne paint cannot be used in the yard), which attacks the waterborne surface, which has not had time to fully cure. Paint suppliers recommend that water borne coatings are left at least three days to cure before touching up with a solvent borne paint.
7. Potential Implications of the Switch to COA Members

It may appear that the implications of the switch to waterborne paint are limited. The cost of containers has not risen noticeably as a result of it and no major problems have been reported with containers either in the factory or during operation later out in the field. However, it is too early to claim that the change has been completed satisfactorily.

Some production problems have been found and overcome in the factories whilst out in the field, some containers have exhibited problems of premature rusting. The numbers are small and it will hopefully only be a temporary phenomenon but it has highlighted that there are no facilities to rework boxes with paint problems out in the field. Depot facilities are mostly simple and unsophisticated and nowhere are there depots with the capability to blast and repaint complete containers. So in the event of serious problems emerging, containers would either have to be moved back to the factory in China for the work to be undertaken or sold off locally at a discount for other uses. Even if containers are moved back to China, factories are not actually equipped to blast and repaint containers without ceasing production of new containers, so it would be a solution of last resort.

In the long term, we simply do not know whether waterborne coatings will be as durable as solvent borne. Theoretically, water and solvent are just mediums to apply the paint to the surface of the steel so both coatings should have the same lifespan if applied well, but it will take another ten years to prove this conclusively to be the case. We had perhaps become blasé about just how effective the solvent borne paint coatings applied to container had become before the switch. Building on that, many shipping lines and leasing companies had gradually been extending the planned lifespan of their containers from ten to twelve to fifteen years and even beyond. This has financial benefits, so if it is found that waterborne painted containers are less durable and have to be retired earlier, it will have a significant financial impact on both shipping lines and leasing companies, depending on how long the lifespan is reduced. Only time will tell if this is going to be an issue or not.
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