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What Are the Differences between One-Sided and Enclosed Condensation?

By Sean Fowler, Bill Tobin, Gary Cornell, Andreas Giehl, Sunny Sun, Henry Zhang, Andy Francis, and Dave Duecker
Q-Lab Corporation, 800 Canterbury Road, Westlake OH 44145, USA

Introduction

Condensation is an excellent way to simulate the moisture attack that materials experience outdoors. High-humidity condensing environments can be generated in QCT, QUV, Q-SUN and Q-FOG testers. However, not all condensation testing is the same. There is a fundamental difference between **one-sided** condensation and **enclosed (also referred to as "two-sided")** condensation. In this Technical Article, we will look at the different mechanisms between these two types of test architectures. We will also look at some results between the two demonstrating that the one-sided style typically results in a more aggressive test.

One-sided Condensation

This term describes the dynamic, continuous condensation exposure that has been used for over 50 years, since the invention of the Cleveland Cabinet, now known as the QCT Condensation Tester. Both QCT and QUV testers use this technique today. The method and apparatus is well described in condensation test standards like ISO 6270-1 and ASTM D4585, as well as weathering tests like ISO 4892-3 and ASTM G154.

As illustrated in Figure. 1, the test specimens form the chamber walls. A water heater increases the water vapor content within the chamber. Cooling air on the specimens' back side forces the warm saturated air inside the chamber to continuously form condensation on the test specimens' exposed front surfaces.

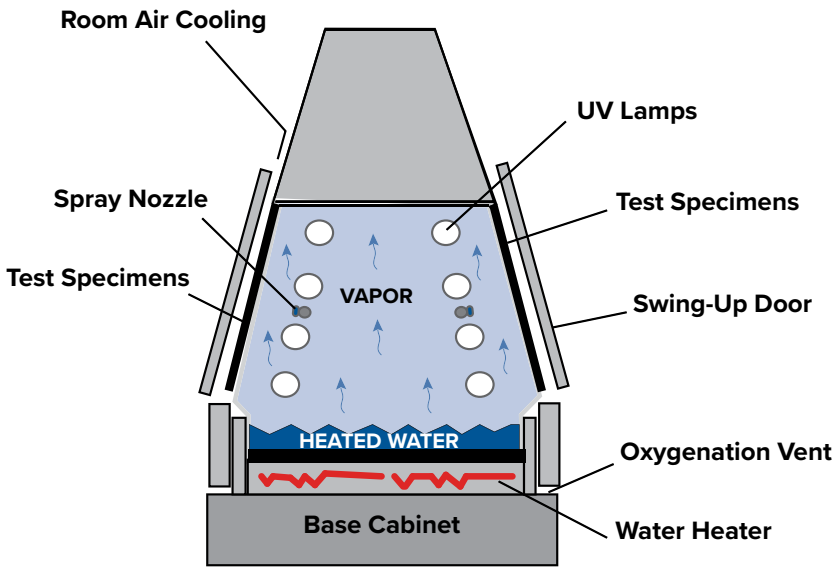

Figure 1. Cross-section of a QUV tester illustrating one-sided condensation

Enclosed Condensation

This term describes static, non-continuous condensation exposure where specimens are placed within a chamber that has an elevated air temperature and is highly saturated. This type of exposure is described in ISO 6270-2 and can be performed in a QCT with the humidity enclosure option (Figure 2). Q-FOG CCT and CRH models are also capable of generating saturating humidity in an enclosed area. Without the cooling on the back, as in the one-sided case, condensation forms on all surfaces of the specimen, until the temperature of the specimen reaches steady state. At this point, condensation then stops re-forming. The materials under test are thus simply exposed to a warm, saturated environment.

Figure 2. QCT tester with humidity enclosure attachment illustrating enclosed condensation

Differences between the two methods

The fundamental difference is that one-sided condensation maintains a front/back temperature differential throughout the exposure, whereas enclosed condensation does not maintain a significant temperature gradient. This is shown schematically in Figure 3

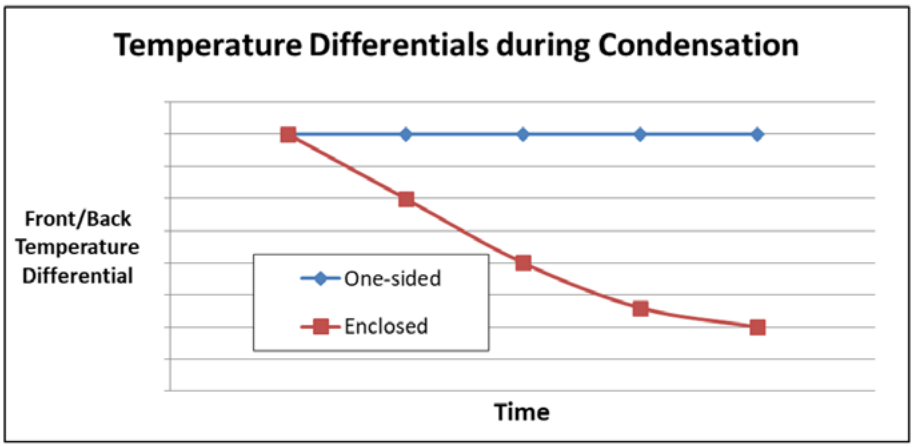

Figure 3. Schematic showing temperature differentials in one-sided and enclosed condensation

The one-sided condensation technique leads to continuous condensation formation where water drips off the specimens and droplets re-form. Water droplets begin to form ~25 mins into a test and the cycle repeats throughout condensation exposure. At any time 20 minutes or longer into the condensation cycle, specimens are covered in water. Condensation steps in QUV weathering testing are nearly always 2 hours or longer

Research Results

Q-Lab conducted a study to evaluate the differences between these methods. Three different exposures were evaluated:

- One-Sided Condensation
- Enclosed Condensation, specimens facing down
- Enclosed Condensation, specimens facing up

Painted steel panels of three different colors (Blue, White, and Black) were subjected to condensation testing at 50 °C. The QCT humidity enclosure was not developed at the time of this test, so a QUV was used (Figure 4).

Figure 4. Painted and unpainted specimens (left panel) and specimens mounted in a QUV with painted side facing down (right panel).

Evaluations were performed for adhesion using the crosshatch test, as well as gloss loss and color change. Gloss loss proved to be the largest observable degradation, with significant differences between the two types of testing (Figure 5). For the white specimens, all methods led to virtually no gloss loss. For black specimens, the enclosed method caused little degradation but the one-sided method let to a significant loss of glossiness. The effect is even more pronounced for blue panels, where the one-sided test has caused the panels to lose nearly all of their gloss while the enclosed test produced far less degradation.

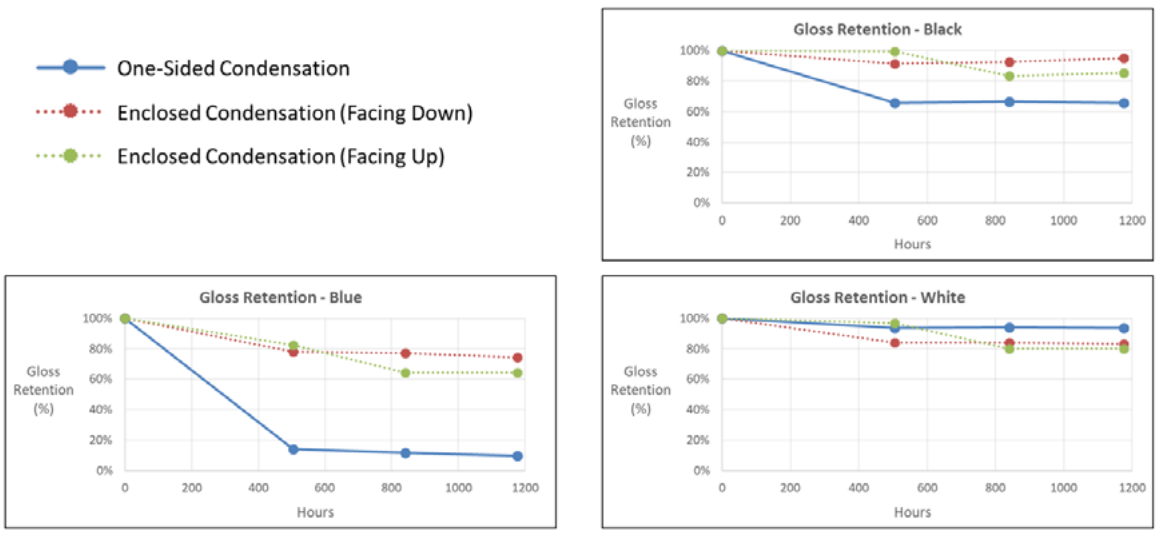

Figure 5. Gloss retention values for blue, white, and black painted panels. One-sided condensation is in blue with solid lines. Enclosed condensation has dashed lines for both specimens facing down (red) and facing up (green).

Adhesion testing was also performed (Figure 6). The one-sided condensation exposure led clearly to more degradation and worse performance in this test. Visible rust is observed on only the one-sided exposures, most notably the white panel.

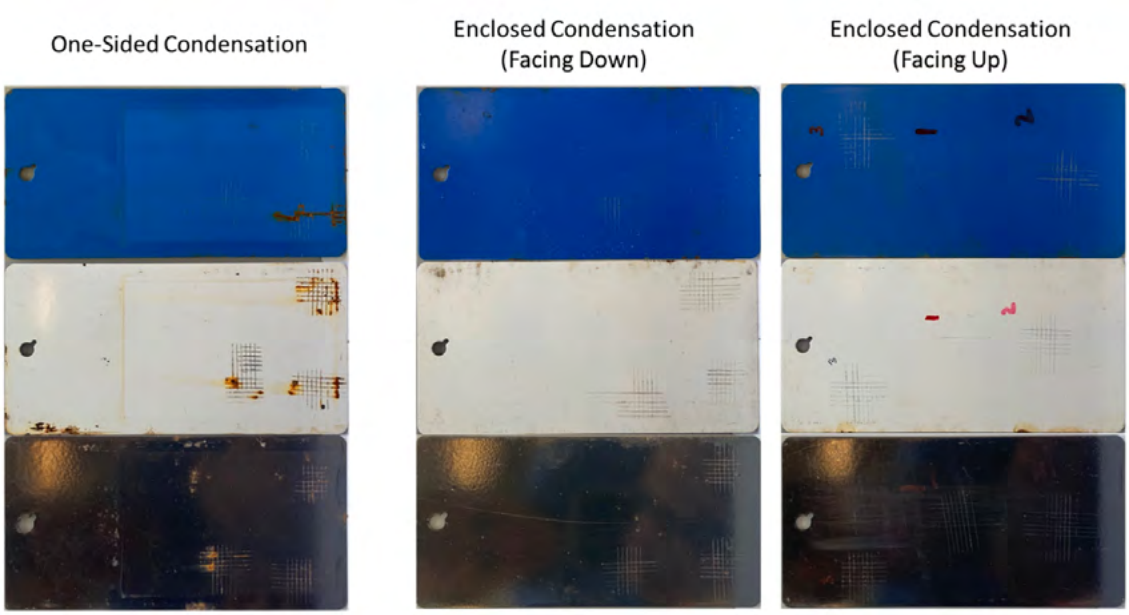

Figure 6. Crosshatch adhesion test results for the three condensation exposure types.

Conclusion

One-sided and enclosed condensation tests are fundamentally very different techniques to expose test specimens to outdoor water. One-sided condensation produces condensation that drips off the specimens and re-forms continually, while enclosed condensation is simply a warm, saturated environment. QCT testers can perform either method, although Q-Lab's research demonstrates that the one-sided test delivers more harsh results for adhesion and gloss retention of painted panels than an enclosed humidity test.

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