

SAE J2334

Automotive laboratory cyclic corrosion testing



[View Recorded Presentation](#)

Q-Lab's Corrosion Standards Webinar Series

- Today is the second of our four-part webinar series on automotive testing standards.
- Our upcoming and complete archive of past webinars, available on demand, are hosted at: q-lab.com/webinars

| Date | Topic |
|--------|-------------------|
| 23 Apr | CATCH |
| 30 Apr | SAE J2334 |
| 21 May | SAE J2412 / J2527 |
| 28 May | ASTM D7869 |

Presentation materials, Q&A

©Q-Lab

- You'll receive a follow-up email from info@email.q-lab.com with links to a survey, registration for future webinars, and to download the slides
- Use the Q&A feature in Zoom to ask us questions today! We'll stay on after the presentation is completed to answer all questions

 | We make testing simple.



Thank you for attending our webinar!

We hope you found our webinar on the **How to Run SAE J2334 Laboratory Cyclic Corrosion Test**, to be helpful and insightful. You can download [today's presentation](#) at any time - a link to the recording is included on the title slide. Subtitles can be accessed through YouTube for the video recording.

Our subject for today



SURFACE VEHICLE STANDARD

J2334™

APR2016

| | |
|------------|---------|
| Issued | 1998-06 |
| Revised | 2003-12 |
| Stabilized | 2016-04 |

Superseding J2334 DEC2003

Laboratory Cyclic Corrosion Test

Standard Summary

Foreword—This laboratory cyclic corrosion test procedure is based on a field-correlated Design of Experiment process conducted by the SAE Automotive Corrosion and Prevention Committee (SAE/ACAP) and the Auto/Steel Partnership (A/SP) Corrosion Task Force. Results from this test will provide excellent correlation to severe corrosive field environments with respect to cosmetic corrosion performance ...

A typical automotive paint system was used to develop this test ... If a different type of coating system is used, field correlation must be determined.

1. Scope—The SAE J2334 lab test procedure should be used when determining corrosion performance for a particular coating system, substrate, process, or design. Since it is a field-correlated test, it can be used as a validation tool as well as a development tool. If corrosion mechanisms other than cosmetic or general corrosion are to be examined using this test, field correlation must be established.

Environmental conditions

Humid

$50 \pm 2 \text{ }^\circ\text{C}$

100% Relative Humidity (RH)

Three methods are permitted for producing saturating humidity:

1. Wet-bottom
2. Water fog
3. Steam (vapor) generator

Dry

$60 \pm 2 \text{ }^\circ\text{C}$

50% RH $\pm 5\%$

- "Additional equipment will be required to maintain the 50% relative humidity condition."
- Air circulation is required to avoid stagnation and to encourage drying

Environmental conditions - commentary

- “100% RH” is a casual way of stating that the chamber must produce condensing humidity
 - Note that it has no tolerance, and thus isn’t an actual measurement
 - The standard clearly states the *intent*: “Whichever method is employed, test samples and controls are required to be visibly moist/wet.”
 - RH values above 90-95% meet this goal; 100% is nearly impossible to measure precisely and is not a realistic target
- Q-FOG CRH testers use the “water fog” method, though the standard says the method was developed using steam generation. We offer a wet bottom kit, but it is not needed
- Dry conditions require the use of “additional equipment” – a controlled RH tester like the **Q-FOG CRH**

Electrolyte (Salt) Solution

Composition

0.5% NaCl

0.1% CaCl₂

0.075% NaHCO₃

Similar to solution used in GMW14872,
which uses 0.9% NaCl

Application

Three methods are allowed:

1. Immersion
2. Spray
3. Fog

All are for 15 min, even though Spray
wets specimens much faster than Fog

Fog collection of 2-4 mL/hr
(2× of ASTM B117) is required

Salt Solution - details

©Q-Lab

©Q-Lab

| Chemical Component | % by Mass | Notes |
|--|-----------|--|
| Sodium Chloride ¹ (NaCl) | 0.9% | Reagent grade or 999 food grade |
| Calcium Chloride ² (CaCl ₂) | 0.1% | Reagent grade |
| Sodium bicarbonate (NaHCO ₃) | 0.075% | Reagent grade (but commercial-grade also accepted) |
| Water | 98.925% | ASTM D1193 Type IV |

©Q-Lab

©Q-Lab

©Q-Lab

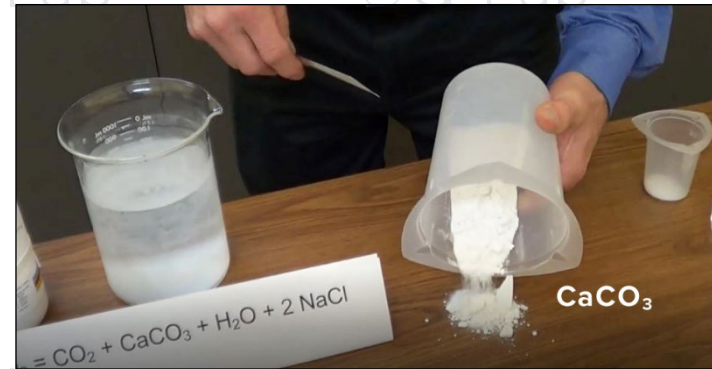
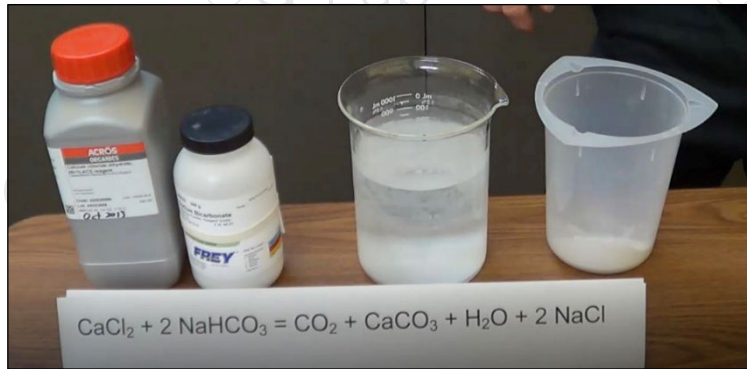
©Q-Lab

Electrolyte (Salt) Solution - commentary

- Guidance is provided for how to properly mix the solution
- Spray nozzles may get clogged by precipitate
- pH of the salt solution must be measured and recorded prior to the start of test and on a weekly basis thereafter. No pH buffering allowed.
- Test development was performed using the Immersion method; Spray is more modern and common and recommended for the Q-FOG CRH
- Conductivity should be 10-12 mS at $25\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$. It must be measured and recorded after mixing, and periodically as needed
- Spray shall not be so intense as to remove corrosion products

Mixing the Solution

Precipitation warning! (*No, not rain, snow, or hail*)



- Precipitate of Calcium Carbonate (CaCO_3) will form if solution isn't made properly
- Calcium Carbonate (CaCO_3) is insoluble in water and can cause problems

How NOT to Mix

Prepare two solutions individually

Calcium Chloride $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$



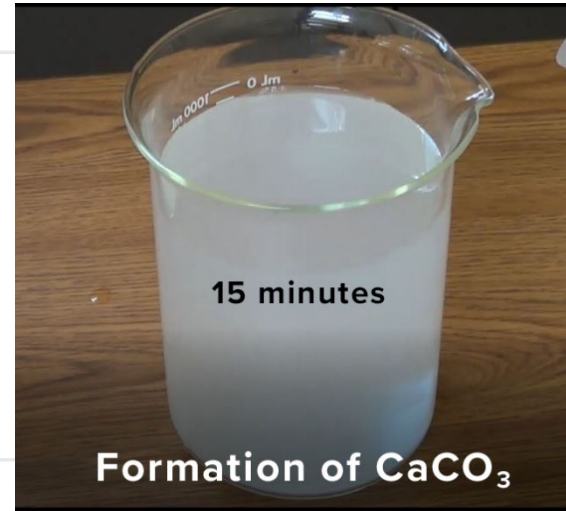
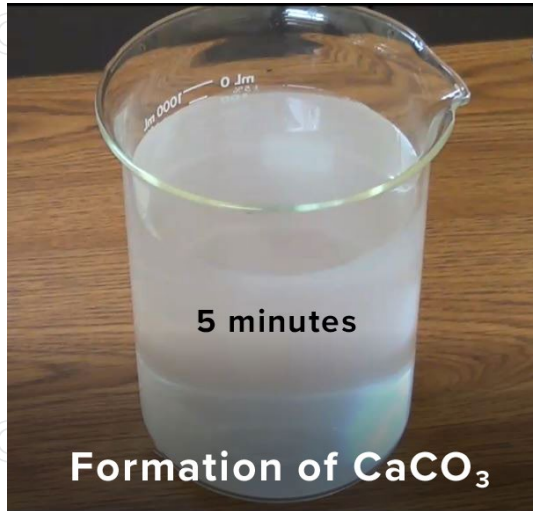
Sodium Bicarbonate NaHCO_3



Mix the two solutions together
Stir both solutions until all chemicals are dissolved



Just watch...



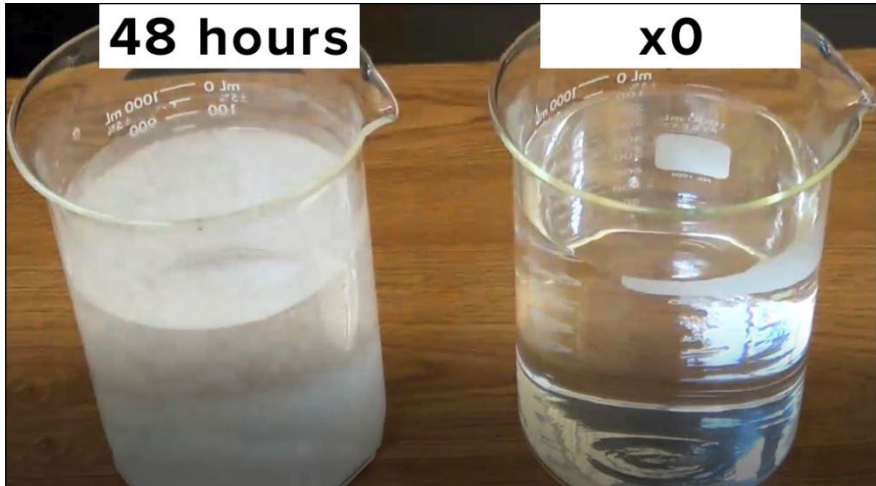
“Chalk it up” to Chemistry

©Q-Lab

©Q-Lab

©Q-Lab

©Q-Lab



©Q-Lab

©Q-Lab

©Q-Lab

©Q-Lab

How to Mix Solution

Initial step is to determine quantity of each chemical and water needed



- 1) Fill your reservoir with the full amount of water and siphon some into two containers, approximately 10% in each one

How to Mix Solution

2. Dissolve NaCl in the remaining reservoir water
3. Dissolve sodium bicarbonate in container 1 and calcium chloride in container 2



Container 1



Container 2

How to Mix Solution

4. Pour the NaHCO_3 solution into the main NaCl reservoir and mix
5. Pour the CaCl_2 solution into the main reservoir and mix



Spray Nozzles



- After spray, low-pressure water flow clears out any remaining solution to prevent/minimize precipitation
- Shower flow rate normalization detects low flow from clogged filters

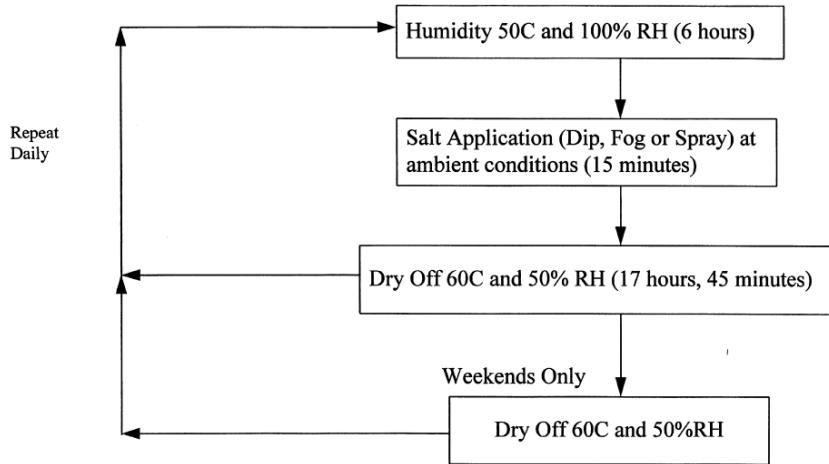
Test Cycles

©Q-Lab

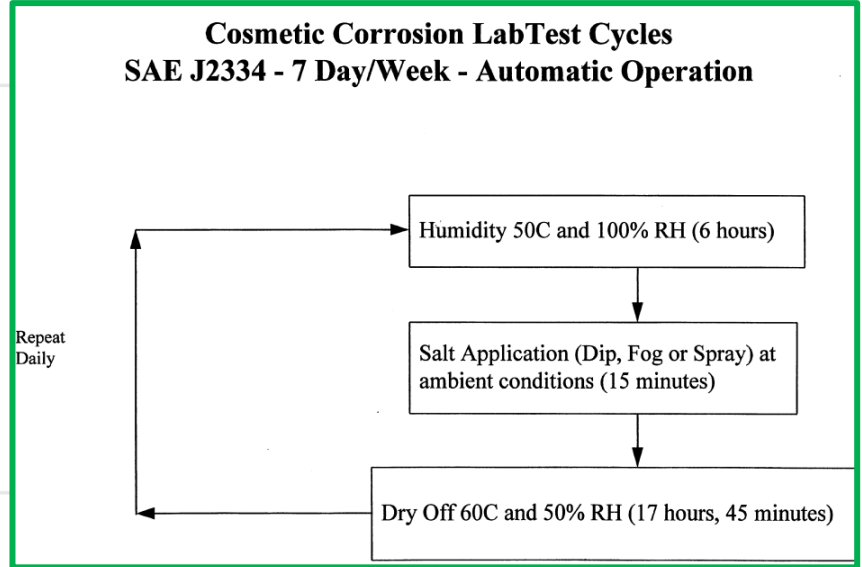
©Q-Lab

©Q-Lab

Cosmetic Corrosion LabTest Cycles SAE J2334 - 5 Day/Week - Manual Operation



Cosmetic Corrosion LabTest Cycles SAE J2334 - 7 Day/Week - Automatic Operation



©Q-Lab

©Q-Lab

©Q-Lab

©Q-Lab

Test Programming and Setup

| SAE J2334, SAE J2721 | | | | | | |
|----------------------|---------------------------|-----------------------|--------|-------------------|--------|-------------------|
| STEP | FUNCTION | Chamber Air Temp (°C) | RH (%) | Step Time (hh:mm) | Ramp | Ramp Time (hh:mm) |
| 1 | RH | 50 | 100 | 6:00 | Auto | |
| 2 | Shower | 25 | | 0:15 | | |
| 3 | RH | 60 | 50 | 17:45 | Linear | 2:00 |
| 4 | Final Step – Go To Step 1 | | | | | |

| | |
|------------------------------|---|
| Shower Pulse Rate: | Spray ON / OFF is set in Machine Configuration . CRH600: 25 seconds ON, 35 seconds OFF. CRH1100: 20 seconds ON, 40 seconds OFF. |
| Shower Pump Pressure: | CRH600: 40 psi CRH1100: 80 psi |

Test Cycles - commentary

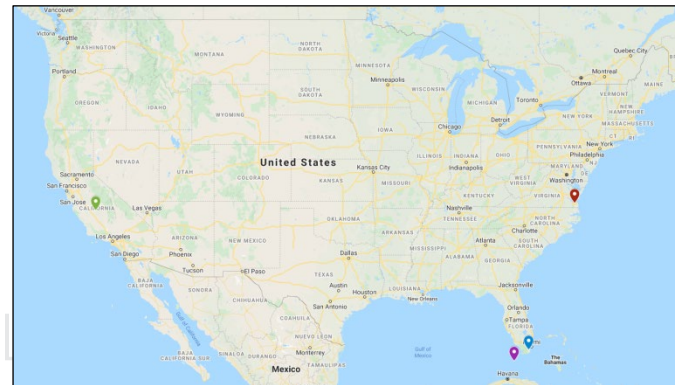
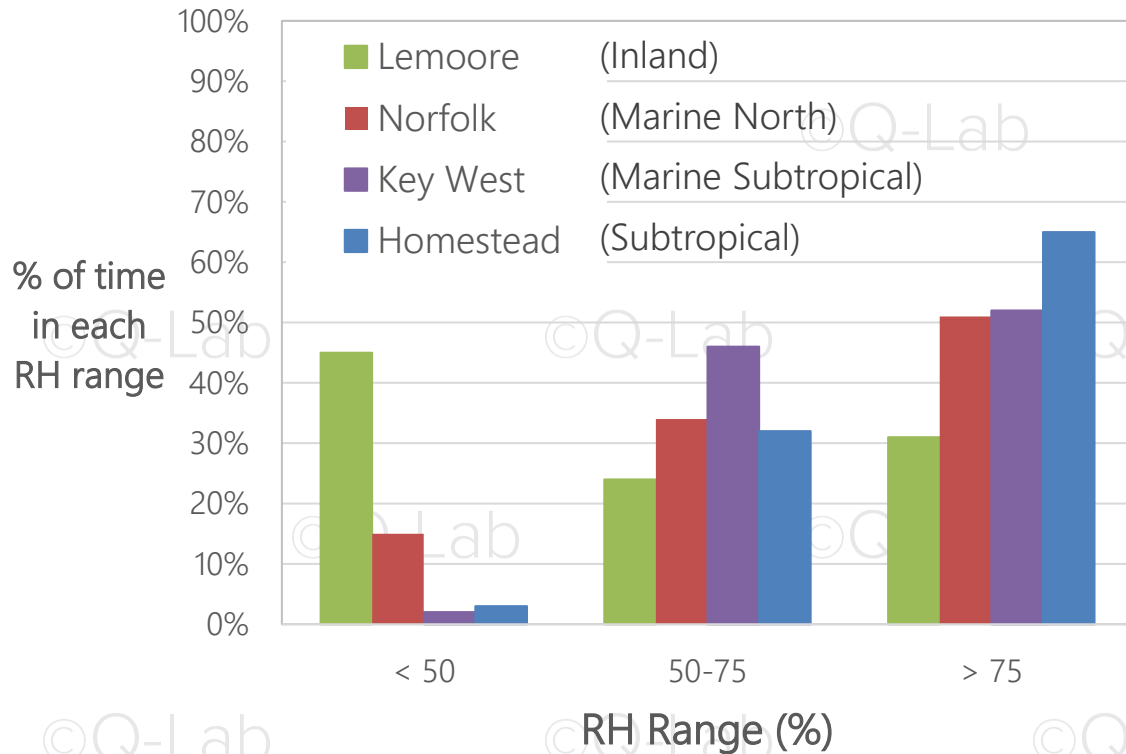
- Each cycle is a 24-hour repeat
- Dry-off is 73% of the total test time – that's quite a lot!
- Transition times are not defined
 - This can lead to variability in testing
- Ramp times count as part of step
- Minimum of 60 cycles recommended, but this is specimen-dependent

Corrosion Science and SAE J2334

Relative Humidity Control

Deliquescence

Intermediate RH Conditions are Important



Relative Humidity and Corrosion

©Q-Lab

| Condition | RH Range | Result |
|---|-------------|--|
| Dry | $\leq 50\%$ | Very little corrosion from NaCl |
| Electrolytic cells around salt crystals; film formation as RH increases | 50-76% | <ul style="list-style-type: none">• Corrosion of steel (maximum corroded area ~70% RH) and aluminum• AL-Steel galvanic couple broken |
| Uniform Electrolytic Film formation | $\geq 76\%$ | <ul style="list-style-type: none">• Maximum cathode area for steel; deeper non-uniform corrosion• Al corrosion in galvanic couple with steel |

Relative Humidity and Corrosion Testing

- RH control between 50% and 90% is critical for test realism
 - Affects corrosion **rate** and **morphology**
 - Modern Corrosion standards account for this
- Wet / Dry Cyclic tests like SAE J2334 do not “control the middle”
 - RH transition times not controlled
 - Variable specimen dry-off rates

Salt and Time of Wetness

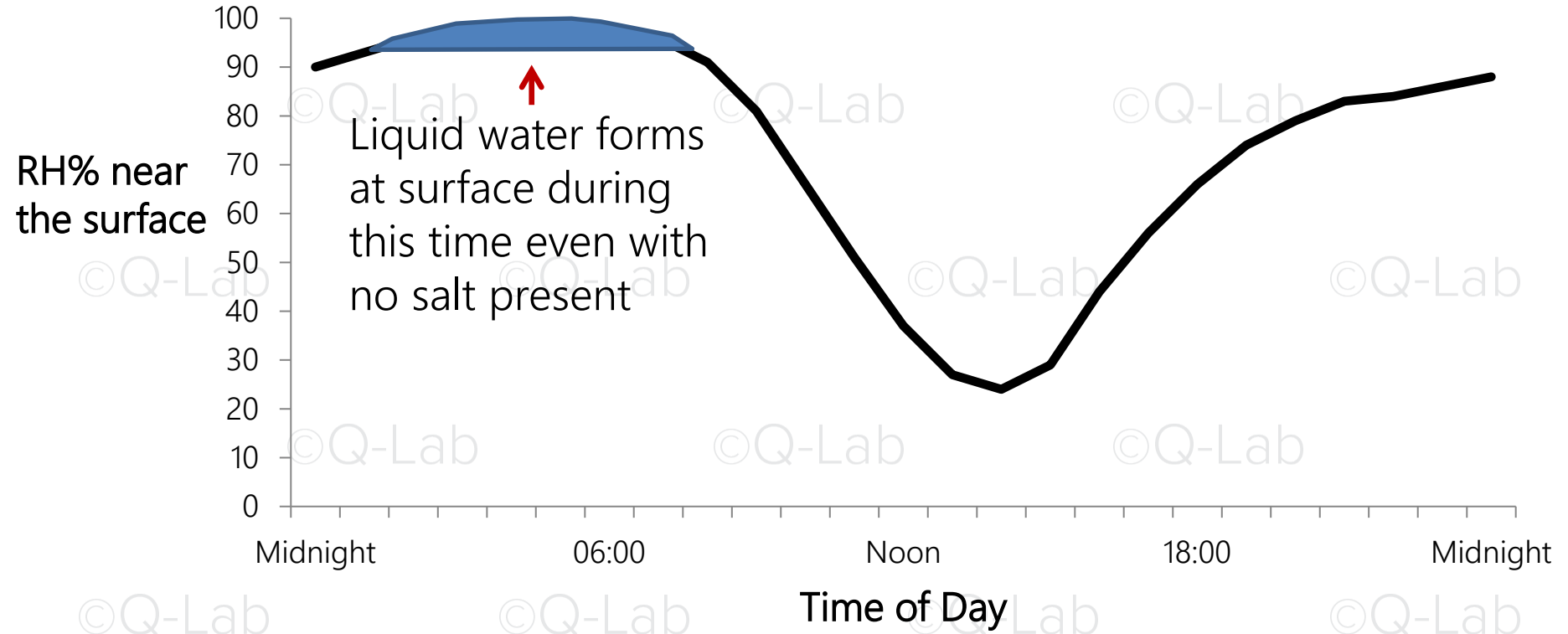
- Salts **deliquesce** - they absorb moisture from the atmosphere until they dissolve and form a solution.
- All soluble salts will liquefy for RH values $< 100\%$
- This leads to increased **time of wetness** and increased **corrosion**

Deliquescence Relative Humidity (DRH)

| Salt | DRH |
|--|------------|
| Potassium Chloride (KCl) | 85% |
| Ammonium Sulfate (NH ₄) ₂ SO ₄ | 81% |
| <i>Sodium Chloride (NaCl)</i> | <i>76%</i> |
| Sodium Nitrate (NaNO ₃) | 74% |
| Magnesium Chloride (MgCl ₂) | 33% |
| <i>Calcium Chloride (CaCl₂)</i> | <i>31%</i> |

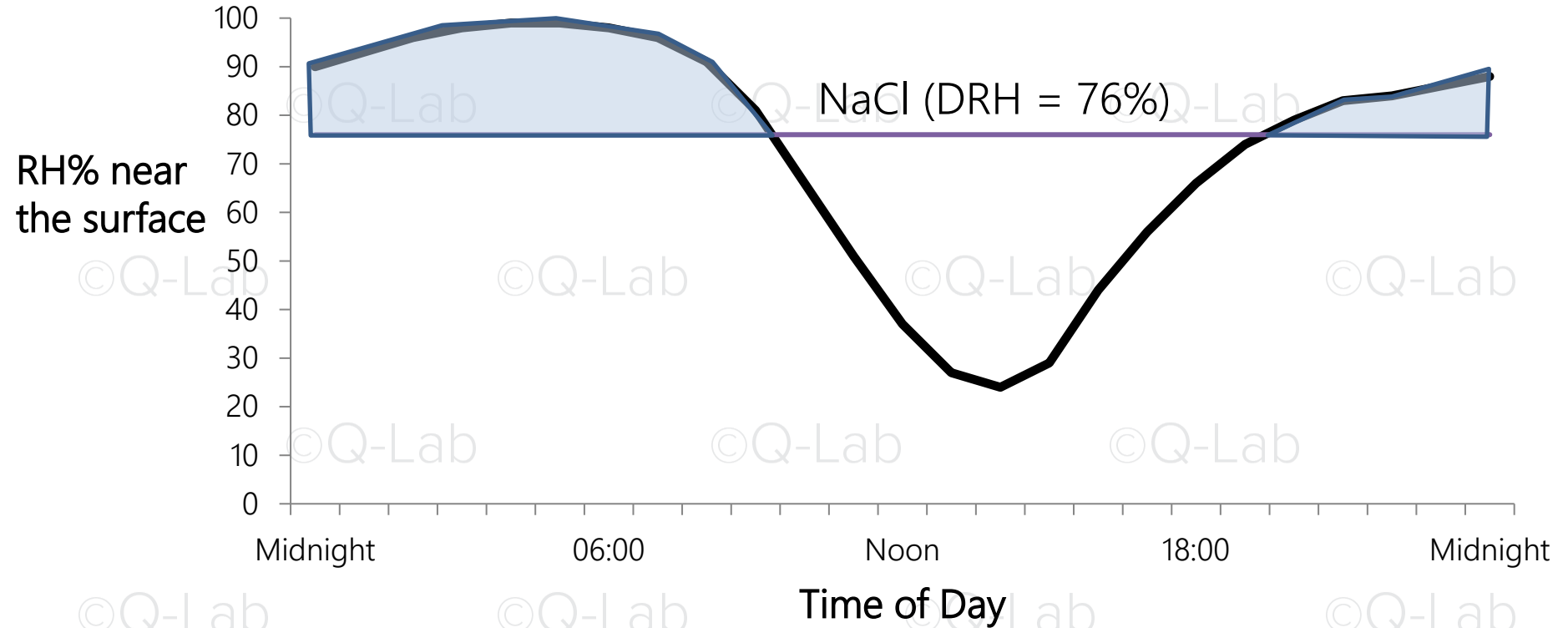
If the environment is above this RH, a liquid salt solution will form

RH and Time of Wetness

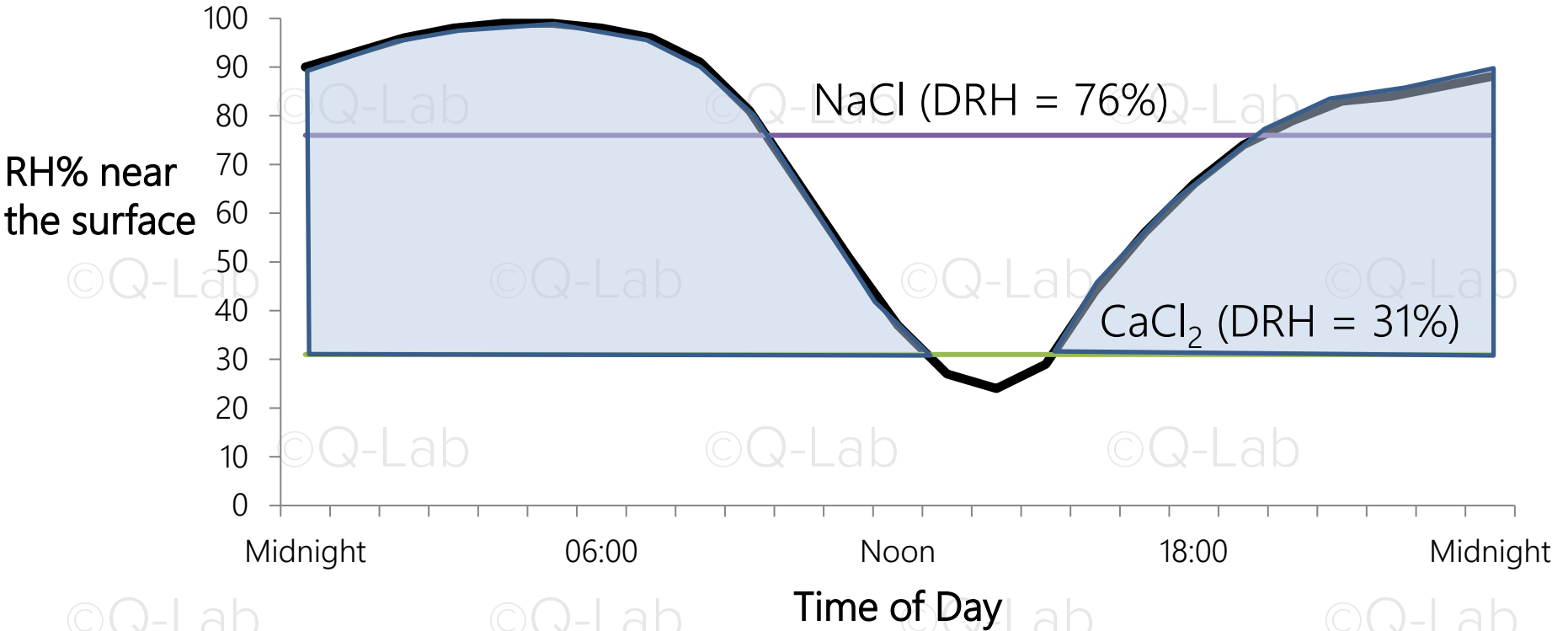


RH and Time of Wetness

©Q-Lab



RH and Time of Wetness



SAE J2334 Case Study

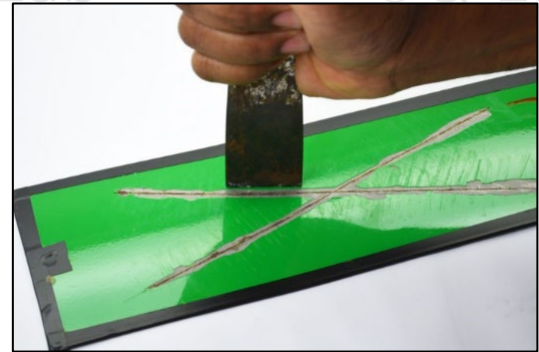
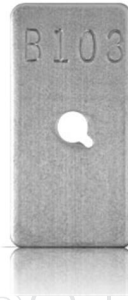
Corrosion Coupons in SAE J2334

- Corrosion coupons are required but there is no mass loss target`
 - Generally 25.4 × 50.8 mm (1.0 × 2.0 in) pieces of bare sheet metal
 - Always cold-rolled steel; may include zinc
 - Must be stamped with an ID
- Clean with degreaser and weigh before use.
- Affix to an aluminum or nonmetallic coupon rack and electrically isolate with plastic fasteners
- Allow min. 5 mm spacing between the coupons and the rack surface; mount max 15 ° from vertical.
- Place near test specimens so exposure is representative
- Remove and analyzed periodically to monitor corrosion. Before weighing, clean the coupons using a mild "sand blast" (preferably glass beads) to remove all corrosion by-products from the coupon surface. Chemical cleaning is permitted.



OEM Corrosion Coupon Spec

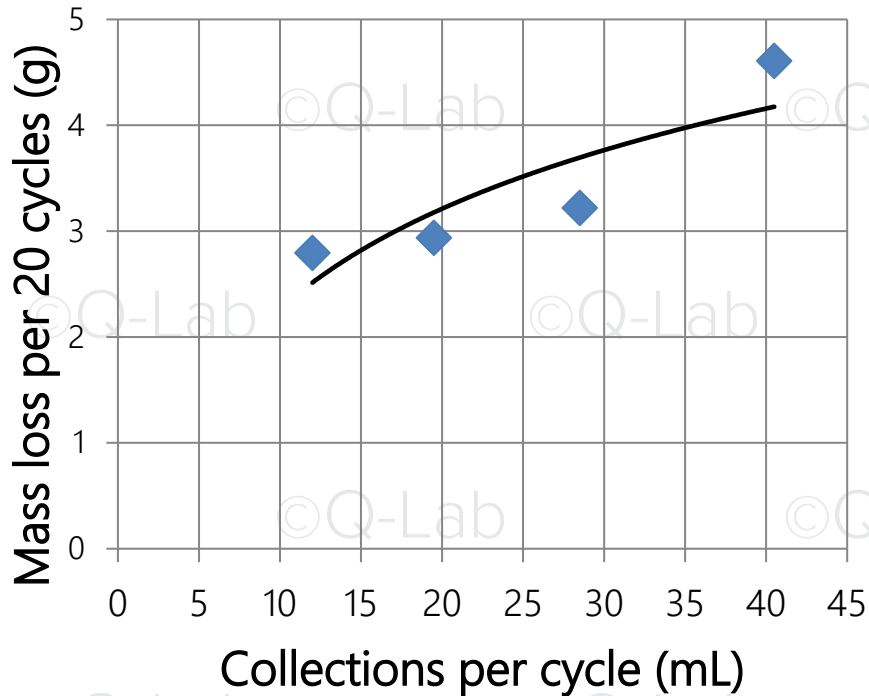
- Added mass loss requirement
 - 20 cycles
 - 1.3 – 3.0 g mass loss
- Includes topcoat rust specification
 - “Creepback Value Before Scraping”
 - Average: 4.0, maximum 6.5



The Problem

- U.S. lab “passed” a formulation (average CVBS < 3)
- European lab “failed” same formulation (average CVBS > 6)
- Formulation was a proven durable system (used as a test control; should pass)
- European lab coupon mass loss too high (~5 g after 20 cycles; 3 g is max allowed)

Experiment 1: Salt Shower Quantification



- Amount of collections correlated with mass loss (previously known from GMW 14872 testing)
- Adjusted spray on/off time to reduce spray (10 mL/cycle)
- **Mass loss remained high!**

Experiment 2: Dry-Off Times

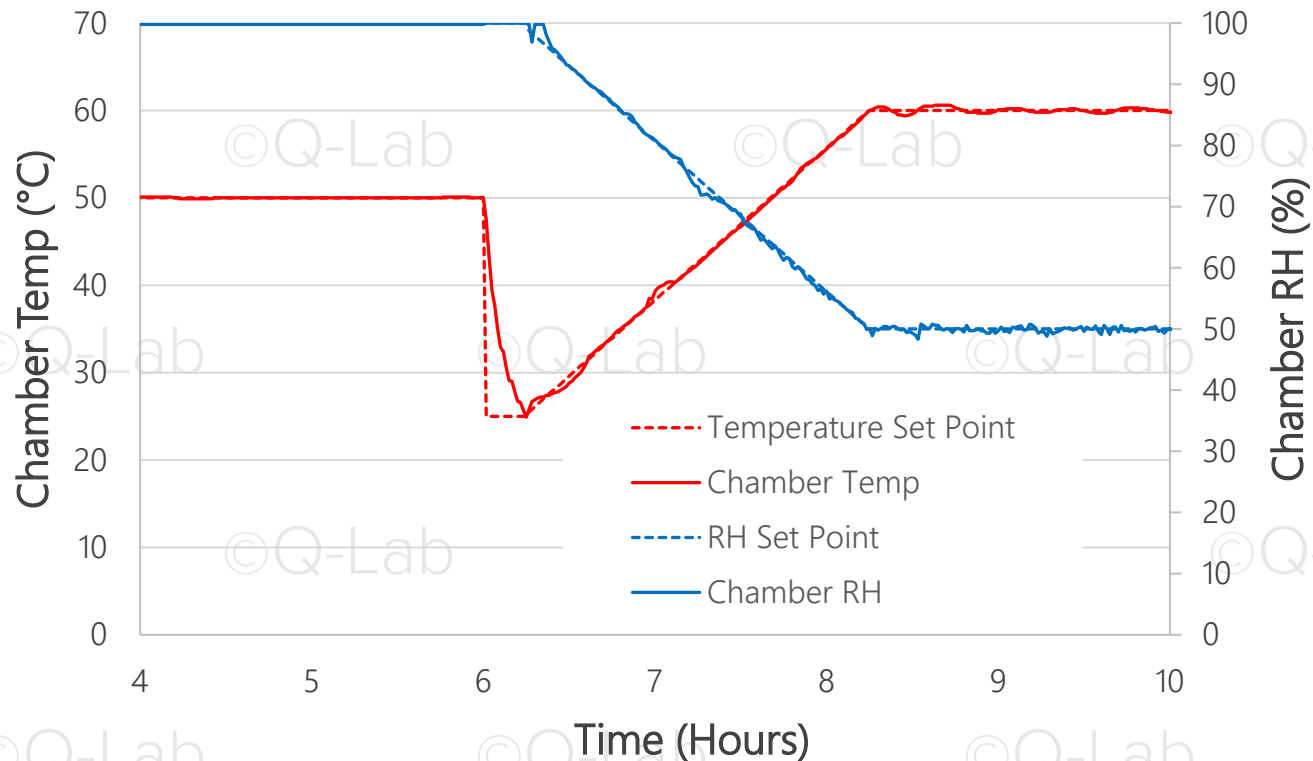
- Wet to dry transitions were programmed differently in U.S. lab (other chamber) and European lab (Q-FOG CRH)
 - 20 minute transition step added to U.S. chamber to speed up RH reduction (a common practice)
- **Approach:** Test original default SAE J2334 cycle in Q-FOG, compare to another cycle designed to achieve faster dry-off

Slow Dry-off

Programming Cycle

| Step | Function | Chamber Air Temp (°C) | RH (%) | Step Time (hh:mm) | Ramp |
|------|----------|-----------------------|--------|-------------------|---------------|
| 1 | RH | 50 | 100 | 6:00 | Auto |
| 2 | Shower | 25 | | 0:15 | |
| 3 | RH | 60 | 50 | 17:45 | Linear (2:00) |

Slow Dry-off

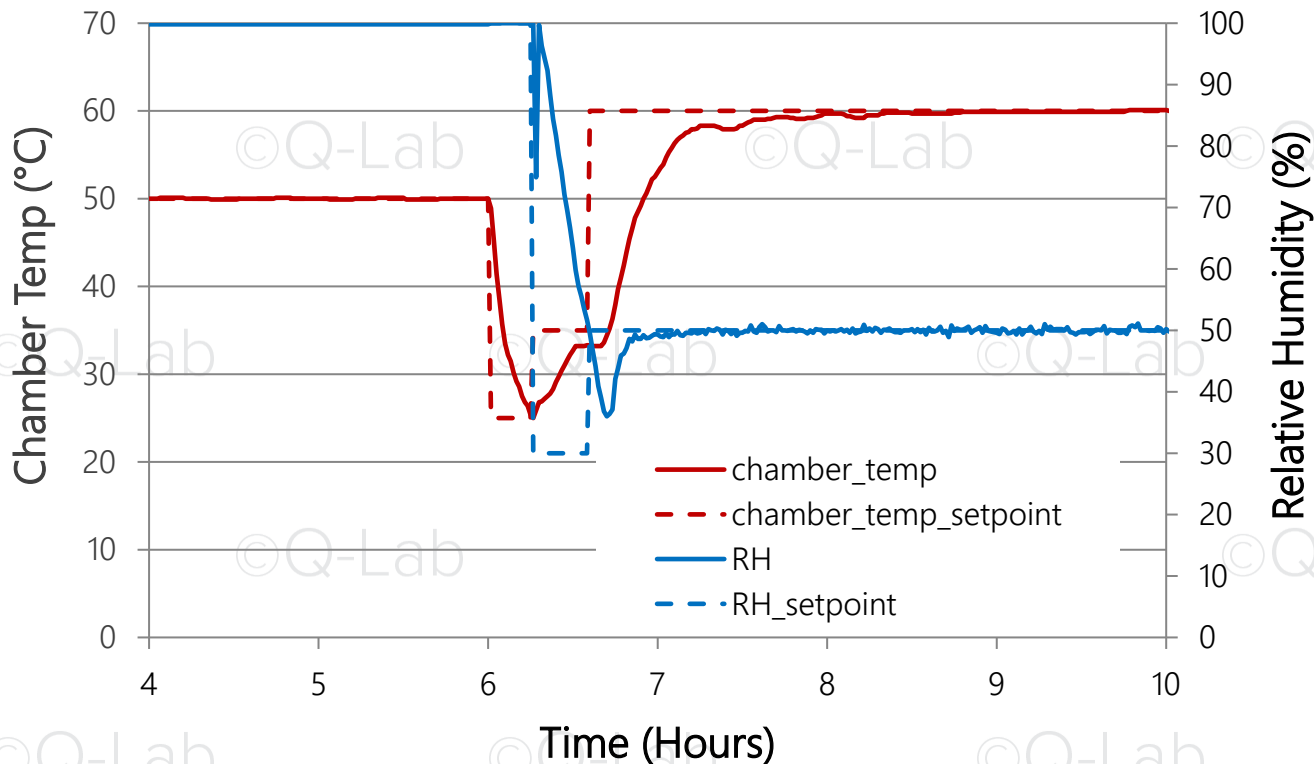


During the transition, the time above the Deliquescence RH of NaCl is about **1 hour**

Rapid Dry-off Programming Cycle

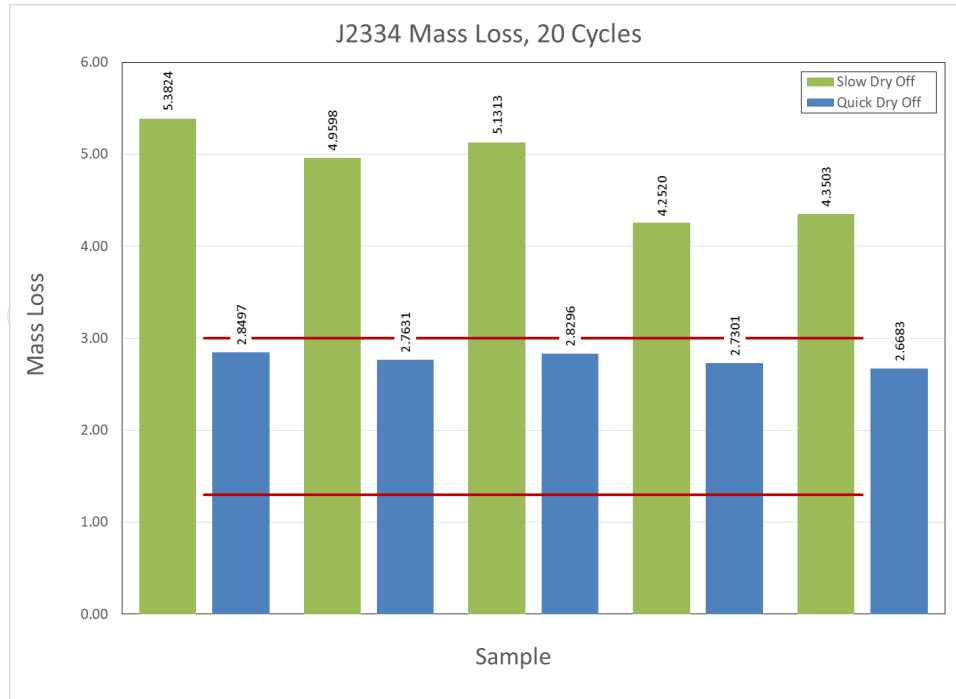
| Step | Function | Chamber Air Temp (°C) | RH (%) | Step Time (hh:mm) | Ramp |
|------|----------|-----------------------------|--------|-------------------------|------|
| 1 | RH | 50 | 100 | 6:00 | Auto |
| 2 | Shower | 25 | | 0:15 | |
| 3 | RH | 35 | 30 | 0:20 | |
| 3 | RH | 60 | 50 | 17:25 | Auto |

Rapid Dry-off



During the transition the time above the Deliquescence RH of NaCl is about **10 minutes**

SAE J2334 Results



- Red lines represent tolerance of OEM standard
- Green bars represent test under slow dry-off conditions: **panels fail**
- Blue bars represent test under quick dry-off conditions: **panels pass**

SAE J2334 Summary

- SAE J2334 is a first-generation cyclic automotive test, including humid, salt, and dry steps
- Test allows salt application by shower, fog, or immersion
- Salt solution is a less-concentrated version of GMW14872 – requires special attention when mixing
- Repeatability can be a challenge
 - Transition times are not controlled
 - Corrosion coupons are required, but no target is set

Thank you for your time.

Questions?
info@q-lab.com

We make testing simple. |

