How to Run the GMW14872 Cyclic Corrosion Laboratory Test

Q-Lab Corporation

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Topics

- Overview and Timeline of GMW 14872
- Environmental conditions & transitions
- Salt spray solution and procedure
- Corrosion coupons use and mass loss requirements
- Controlling the mass loss

Not covered: how to select specific exposure for the part being tested

GMW14872 Overview

- First published 2006
- Derived from GM9540P (1991)
- Designed around three workday “shifts” of 8 hours each
- GM times tests according to standard coupon mass loss
- Probably the world’s most popular cyclic corrosion test method

Major Changes from GM9540P to GMW 14872

- GM9540P included 4 different thicknesses of corrosion coupons; GMW 14872 includes only one: 1/8 inch (3.18 mm)
- Sodium bicarbonate ($NaHCO_3$) concentration reduced from 0.25% to 0.075%

GMW14872 Revisions

Publication Date	Major changes
November, 2006	Initial Publication
March, 2010	None to the technical parts of the test method
March, 2013	Corrosion coupon mass loss rate increased Longer duration Method E added
October, 2018	None to the technical parts of the test method

GMW14872 General Comments

- Standard is performance based; no specific hardware requirements
- GM times tests on specific mass loss of standard coupon (we'll explain a modification of the technique for non-GM approval testing)
- Lots of very useful information and tools within the document

Environmental Conditions: 8 hour stages (shifts)

Ambient Stage: 25°C, 45% RH, with intermittent spray

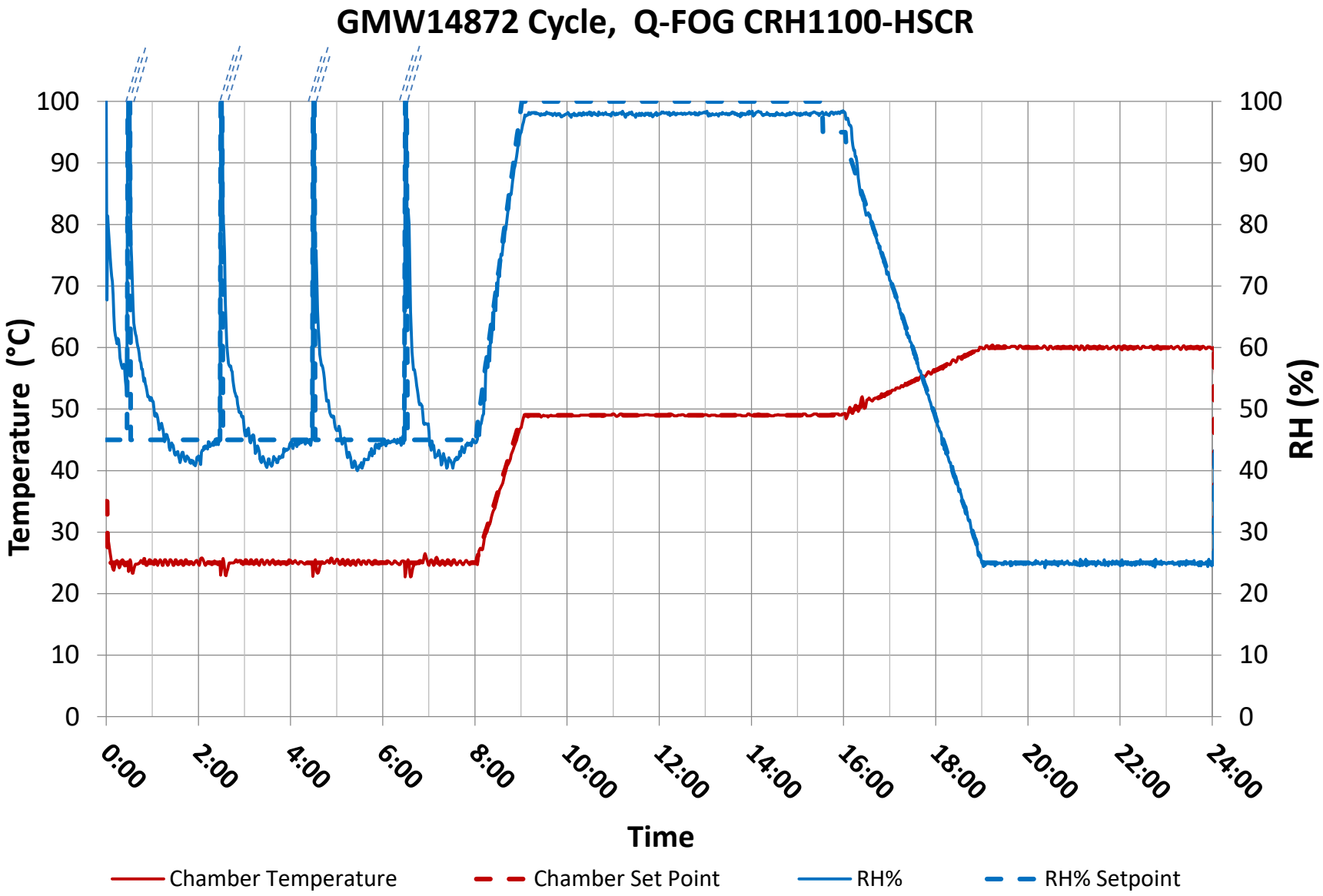
- Usually 4 spray applications, but sometimes only 1, sometimes once every 5 cycles
- Other stresses introduced in special cases (not discussed here, Appendices C-F)

Humid Stage: 100% RH, 49°C, ~1 hour ramp

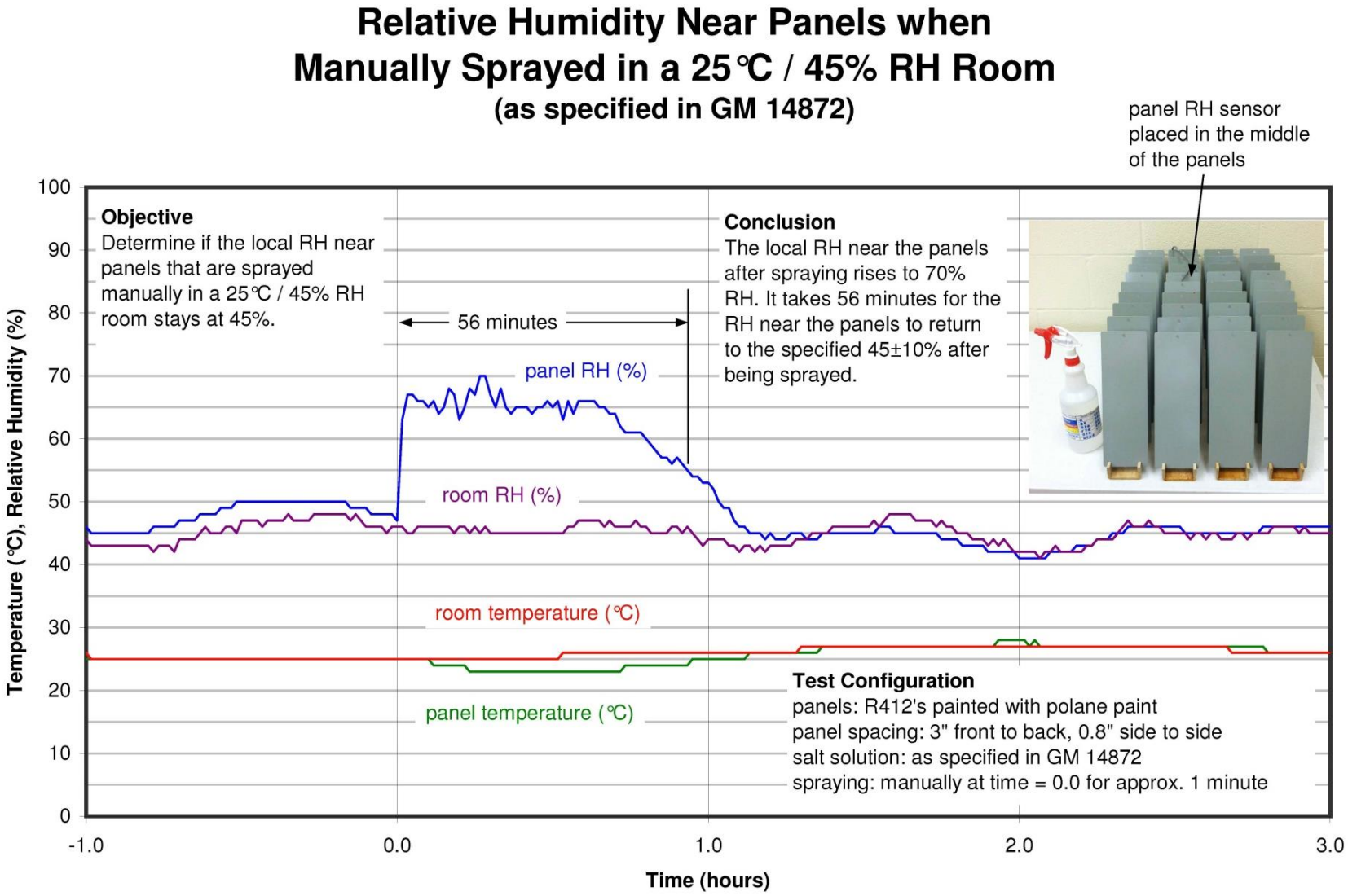
Dry Off Stage: ≤30% RH, 60°C, ~3 hour ramp

Q-FOG Program for GMW14872

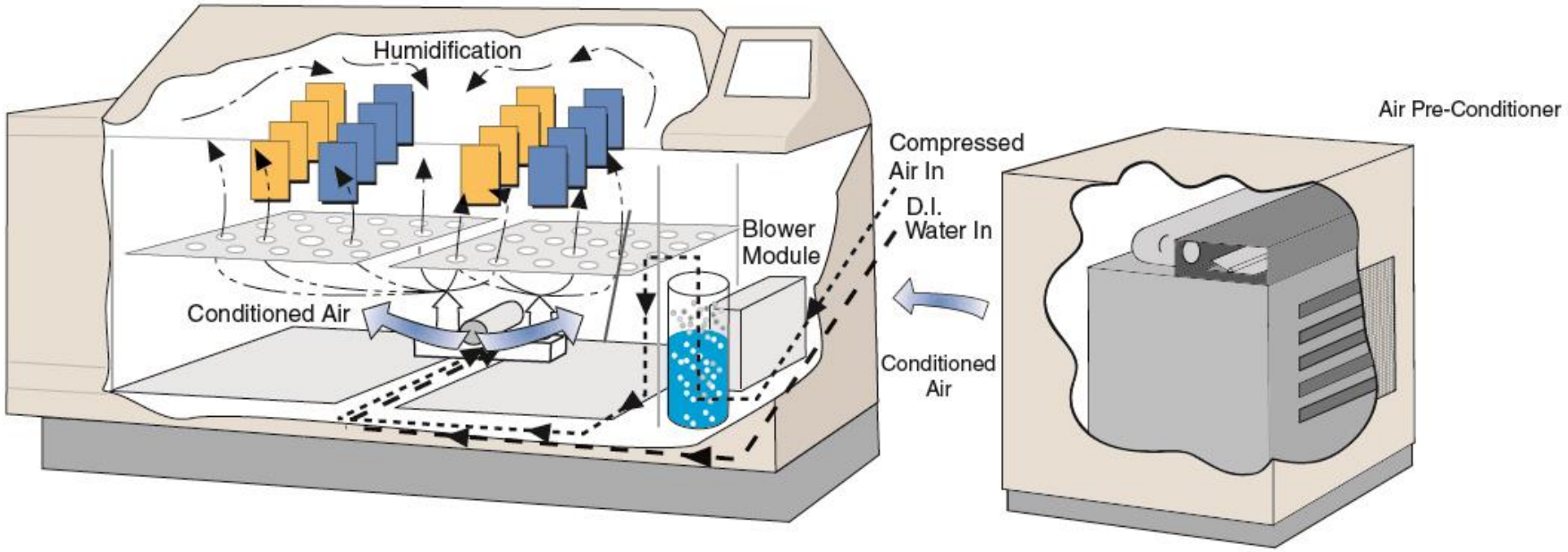
Step	Function	Chamber air temperature (°C)	RH (%)	Step time (hh:mm)	Ramp type	Ramp time (hh:mm)
1	Subcycle—Repeat steps 2-4 4x					
2	RH	25	45	0:27	Auto	
3	Shower	25		0:03		
4	RH	25	45	1:30	Auto	
5	RH	49	100	7:30	Linear	1:00
6	RH	49	95	0:30	Auto	
7	RH	60	25	8:00	Linear	3:00
8	Final Step – Go to 1					


GMW14872 Cycle, Q-FOG CRH1100-HSCR
Temperature (°C)
RH (%)
100
90
80
70
60
50
40
30
20
10
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
24:00
Time
Chamber Temperature
Chamber Set Point
RH%
RH% Setpoint

Salt Spray in Ambient Conditions

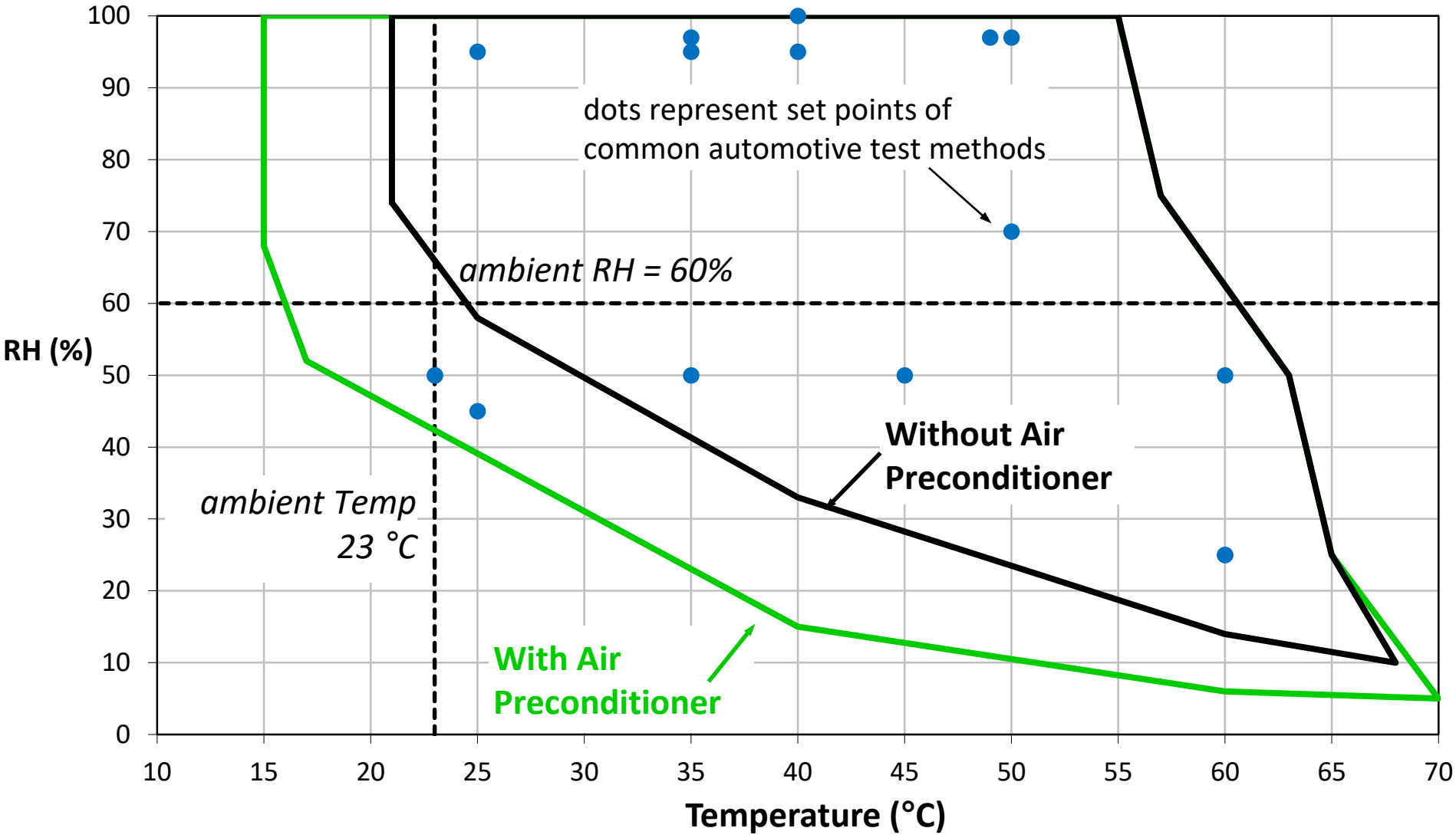


Corrosion Test Control
Air Pre-Conditioner



- Accurate control of “ambient” conditions
- Accurate Ramping of Temperature & Humidity

Corrosion Test Operational Range



Salt Spray Application

- Spray duration and volume not quantified
- “Approximately 1.5 h” between salt applications
- “mist the samples and coupons until all areas are thoroughly wet/dripping”
- “sufficient to rinse away any salt accumulation left from previous sprays”
- “Force/impingement” should not remove corrosion products or damage coatings

Spray Solution

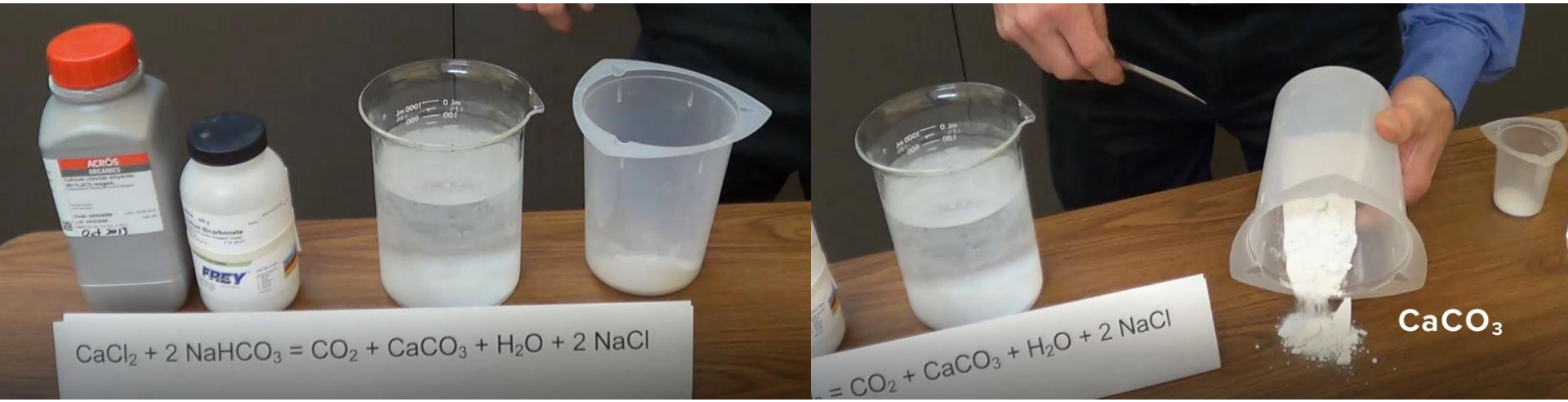
Chemical Component	Percent by Mass	Notes
Sodium Chloride[1] (NaCl)	0.9%	Reagent grade or Morton Culinox 999 food grade
Calcium Chloride[2] ($CaCl_2$)	0.1%	Reagent grade
Sodium bicarbonate ($NaHCO_3$)	0.075%	Reagent grade (but Arm & Hammer Baking Soda or comparable also accepted)
Water	98.925%	ASTM D1193 Type IV

1 SAE J2334 is the same recipe except 0.5% NaCl

2 $CaCl_2$ is often packaged in hydrated form; see Appendix B for correct recipes for anhydrous, one hydrate, and dihydrates

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 wreak havoc on your chamber (Q-FOG mitigates the problem)

Improper Mixing Example

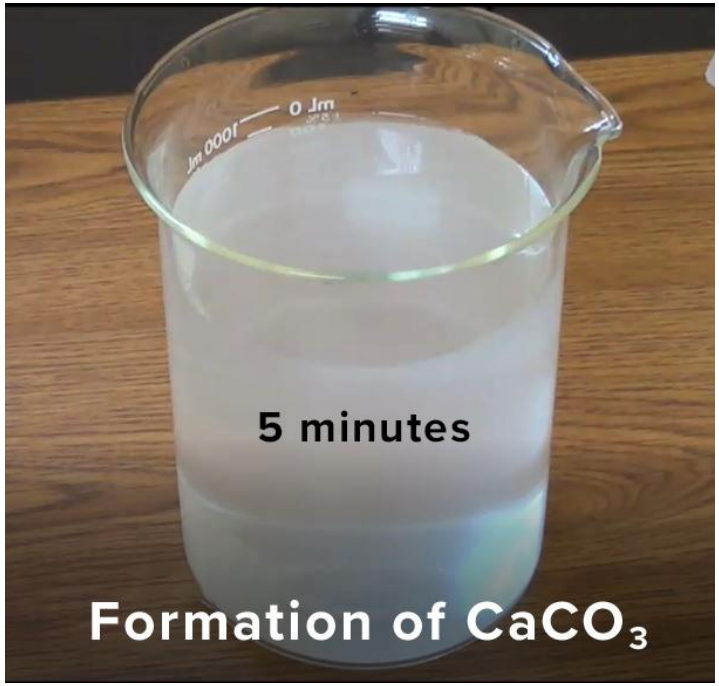
Calcium Chloride $CaCl_2 \cdot 2H_2O$

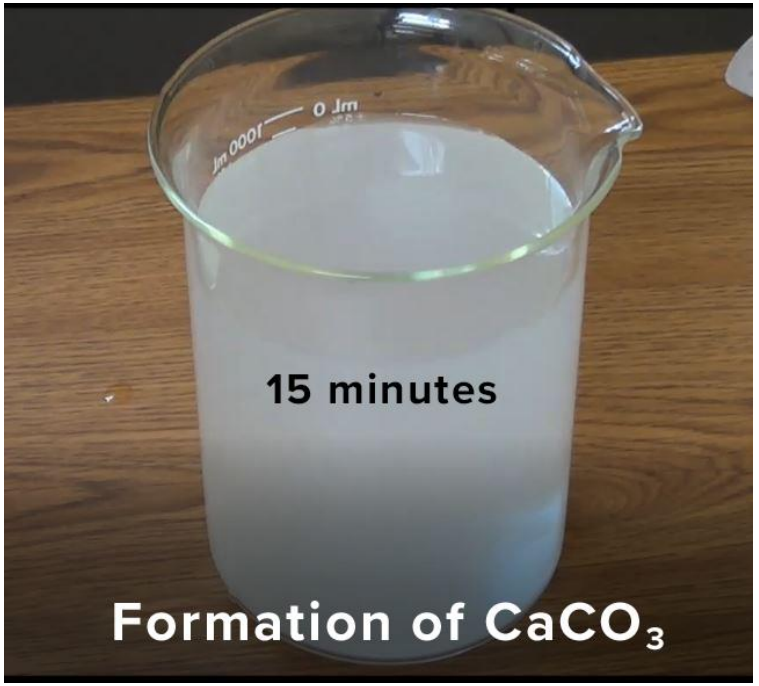
Sodium Bicarbonate $NaHCO_3$

Stir both solutions until all chemicals are dissolved.

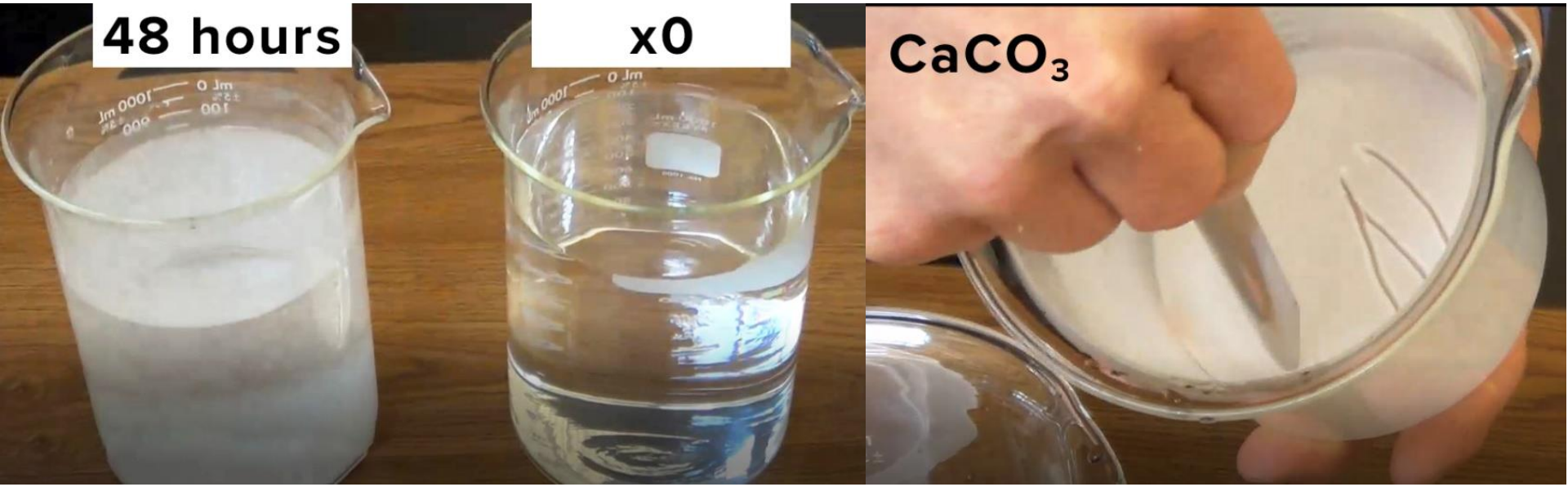
Mix the two solutions together

Just watch…





Chalk it up to Chemistry



How to Mix Solution

Refer to appendix B for recipes in gallons and liters for anhydrous, one hydrate, and dihydrate calcium chloride

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

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

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

Nozzle Flushing

After spray, low pressure water flow clears out any remaining solution to prevent/minimize precipitation

Corrosion Coupons

SAE 1008-1010, SAE J2329 CR1E

25.4 x 50.8 x 3.18 mm (1 x 2 x 1/8 inch)

Mounting hole in center and alphanumeric stamp included

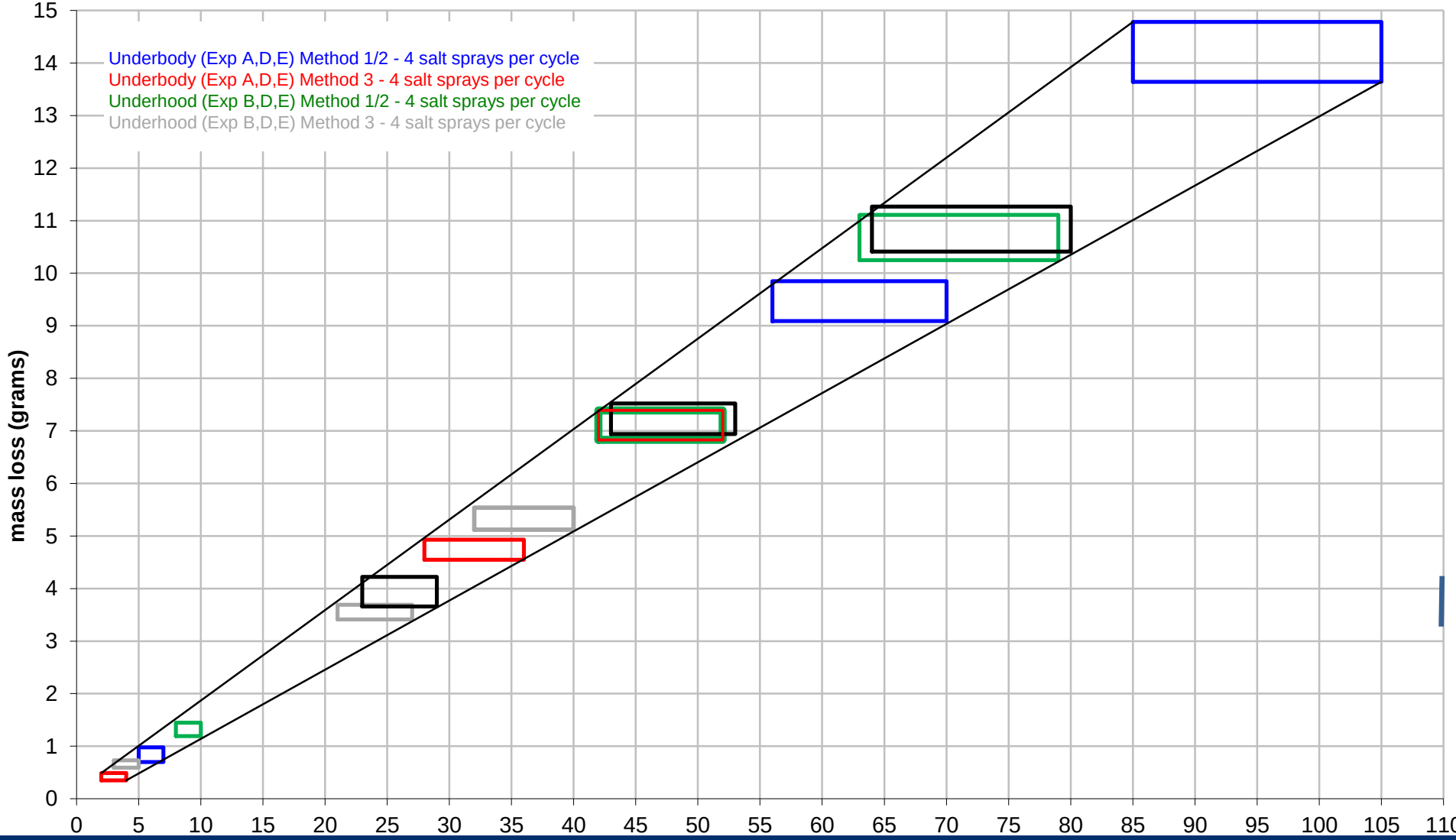
Tables A1, A2

Exposure D
9.47 g ± 0.38 g (430 µm ± 17 µm)
63 cycles ± 7 cycles

GM determines test duration by achievement of specified mass loss

Tolerance is on measured mass loss and number of cycles to achieve target

GMW14872 Mass Loss Targets for Exposures with 4 Sprays per Cycle (adapted from Appendix G)

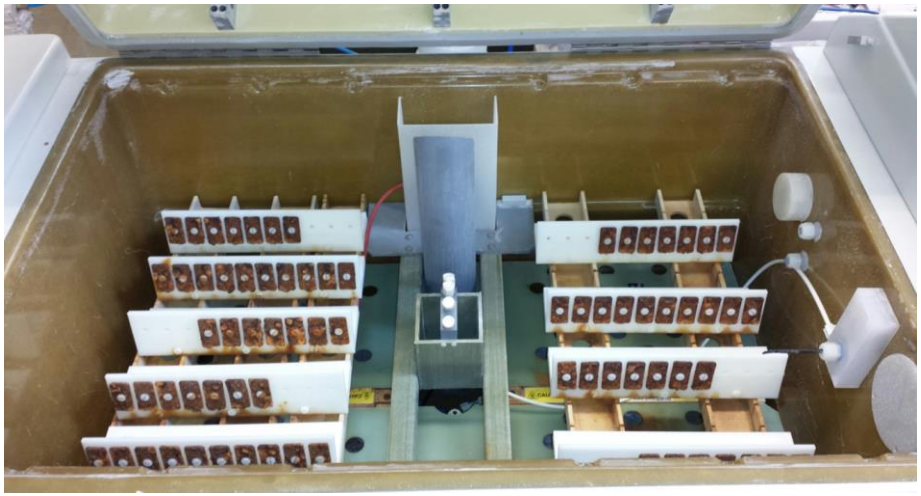


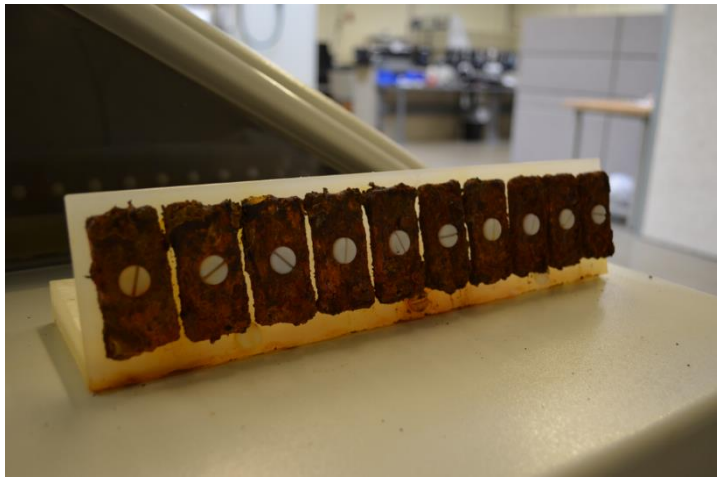
Mass Loss Rates

Spray Frequency	2006, 2010 Editions	2013, 2018 Editions
4 x per cycle	0.14 g/cycle	0.15 g/cycle
1 per cycle	0.08 g/cycle	0.11 g/cycle
1 per 5 cycles	0.06 g/cycle	0.06 g/cycle

- 2013 edition of GMW14872 kept the same mass loss targets but reduced the number of cycles to reach them
- Target mass loss rates are slightly lower for short duration tests

Using Corrosion Coupons





Coupons are mounted 15° from vertical

At least 5 mm spacing between coupon and bracket

Pre-exposure cleaning and removal of corrosion products are a common cause of low mass loss

Pre-Exposure Cleaning

Cleaning Process:

1. Parts cleaning degreaser
2. DI water and dish soap—coupons & soapy water poured between two containers
3. Rinse in DI water by pouring between two containers
4. Rinse in acetone (same technique)

Q-Panel coupons are pre-cleaned and ready to use

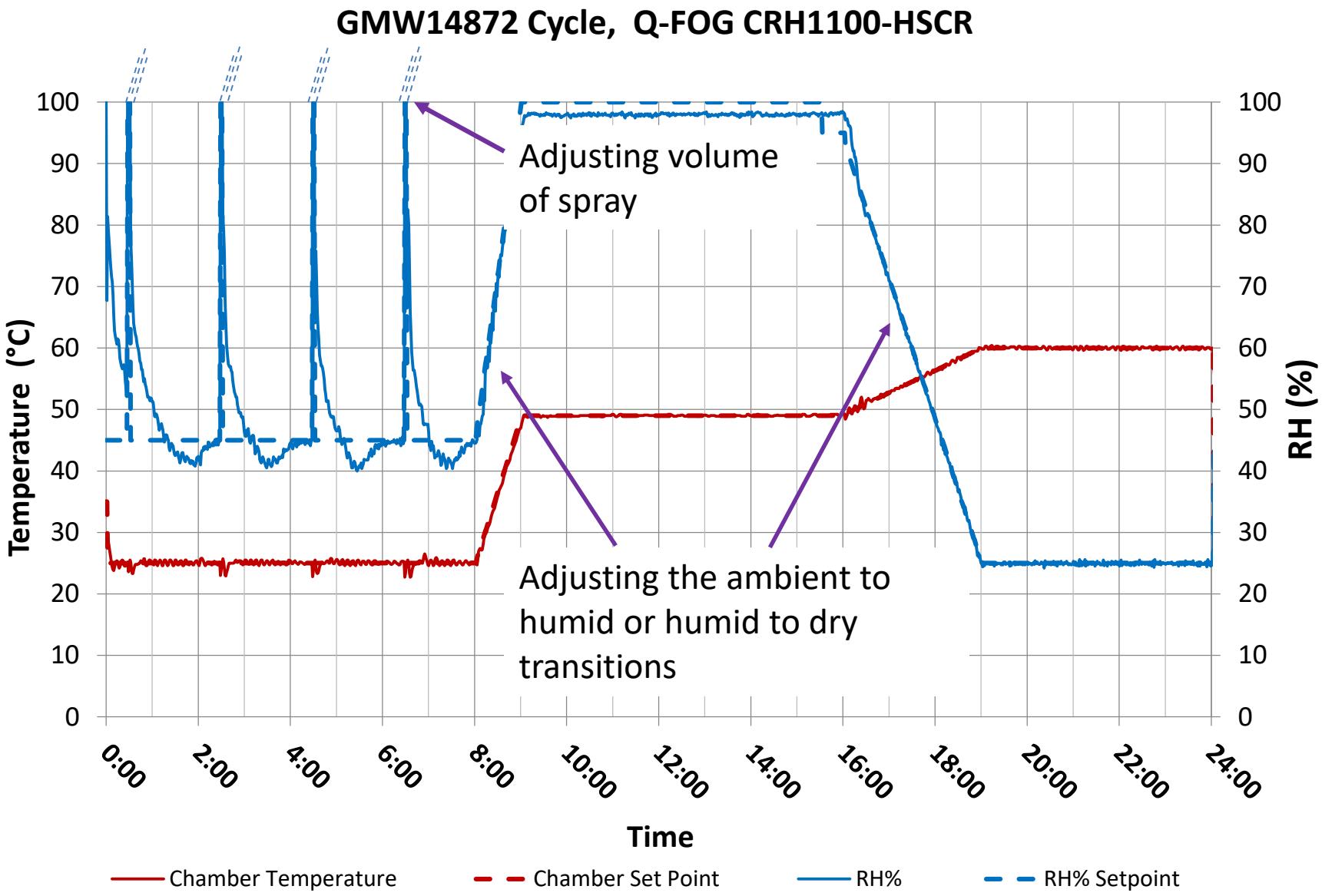
Corrosion Product Removal

- Chemical removal not recommended (too slow and inefficient)
- It is more likely you won't remove all rust than remove uncorroded metal
- Begin by tapping coupons with a hammer
- Bead blast with metal finishing glass beads
  - We use 60-80 psi (415-550 kPa) pressure
  - 100-200 µm nominal diameter beads
  - Clean all sides of panel (1-2 minutes)

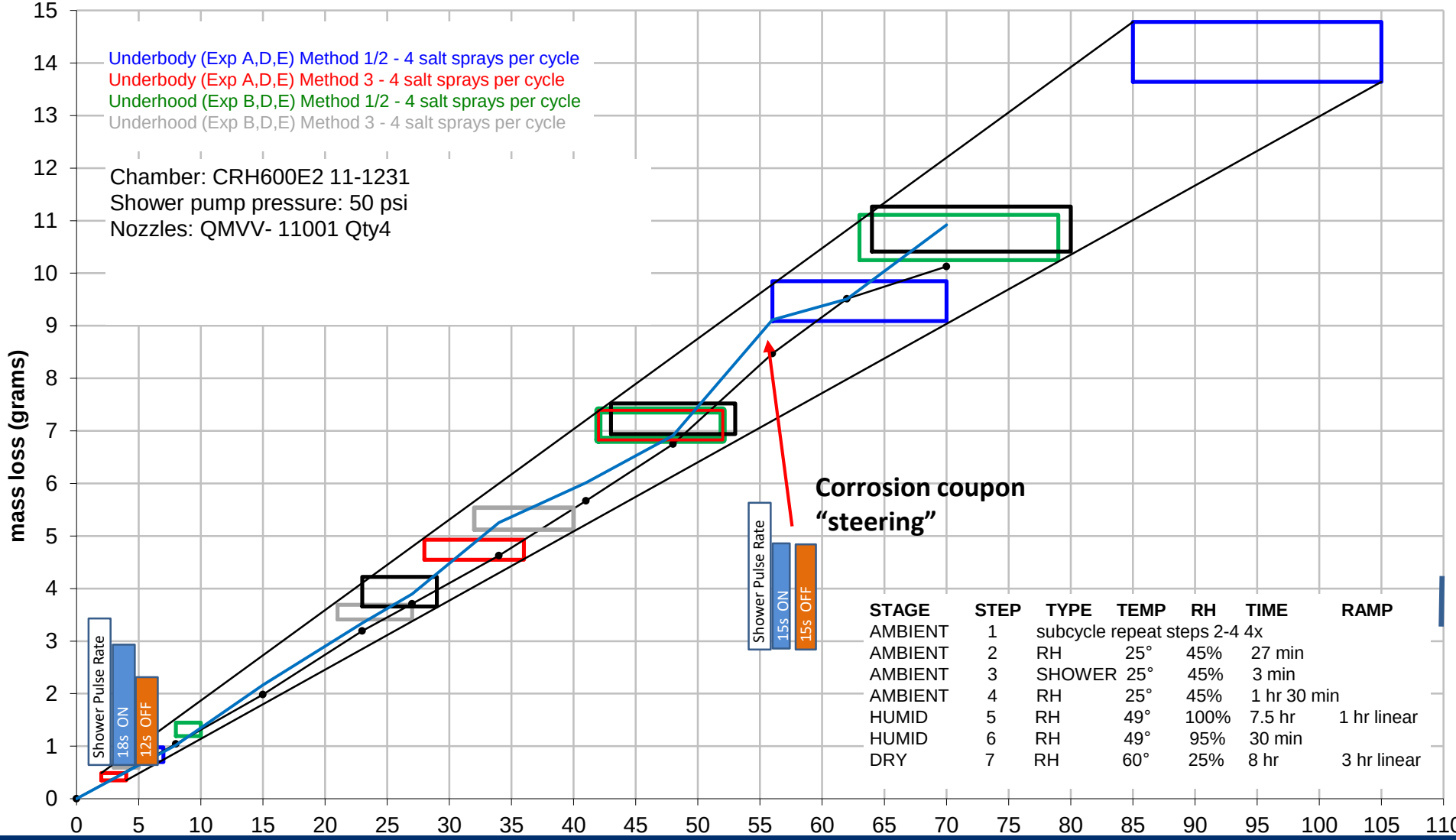
Controlling Mass Loss

Two techniques—one in the standard and another we recommend for Q-FOG users

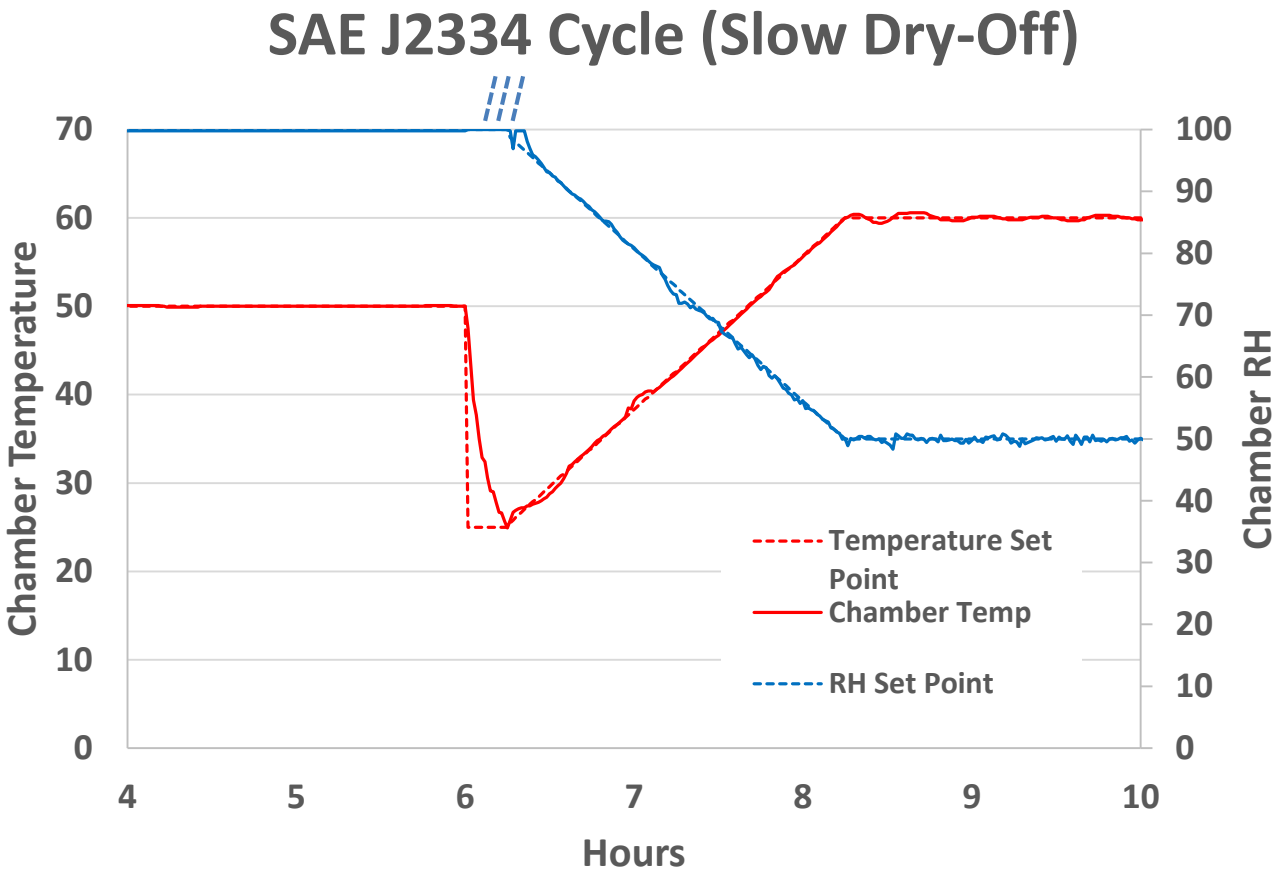
1. Adjusting climatic transitions
2. Adjusting volume of solution spray


GMW14872 Cycle, Q-FOG CRH1100-HSCR
Adjusting volume of spray
Adjusting the ambient to humid or humid to dry transitions
Temperature (°C)
RH (%)
Time
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
24:00
Chamber Temperature
Chamber Set Point
RH%
RH% Setpoint

GMW 14872 Mass Lost Test - Start Date 13 May 2015



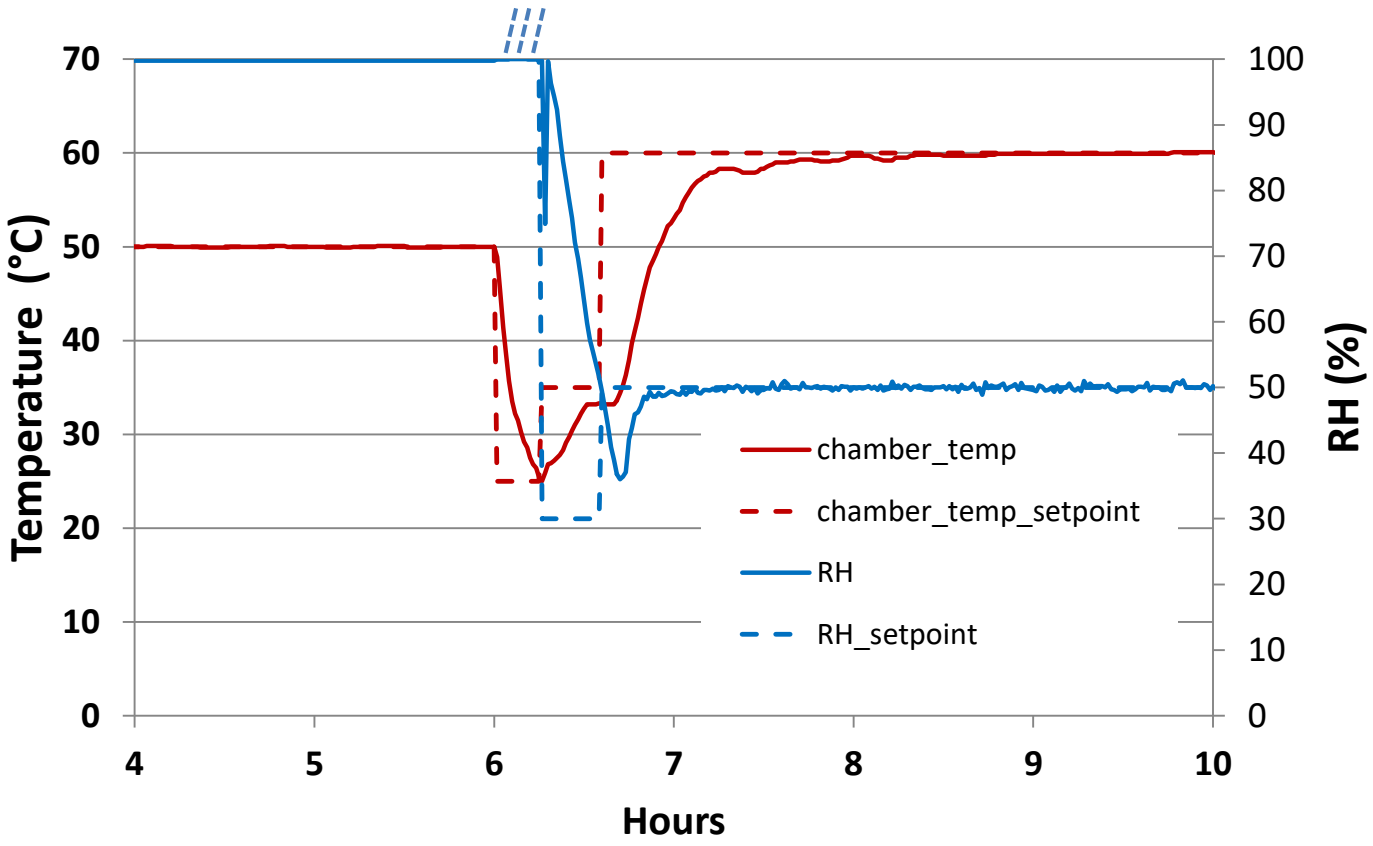
STAGE	STEP	TYPE	TEMP	RH	TIME	RAMP
AMBIENT	1	subcycle repeat steps 2-4 4x				
AMBIENT	2	RH	25°	45%	27 min	
AMBIENT	3	SHOWER	25°	45%	3 min	
AMBIENT	4	RH	25°	45%	1 hr 30 min	
HUMID	5	RH	49°	100%	7.5 hr	1 hr linear
HUMID	6	RH	49°	95%	30 min	
DRY	7	RH	60°	25%	8 hr	3 hr linear



Zoomed in view of the transition

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

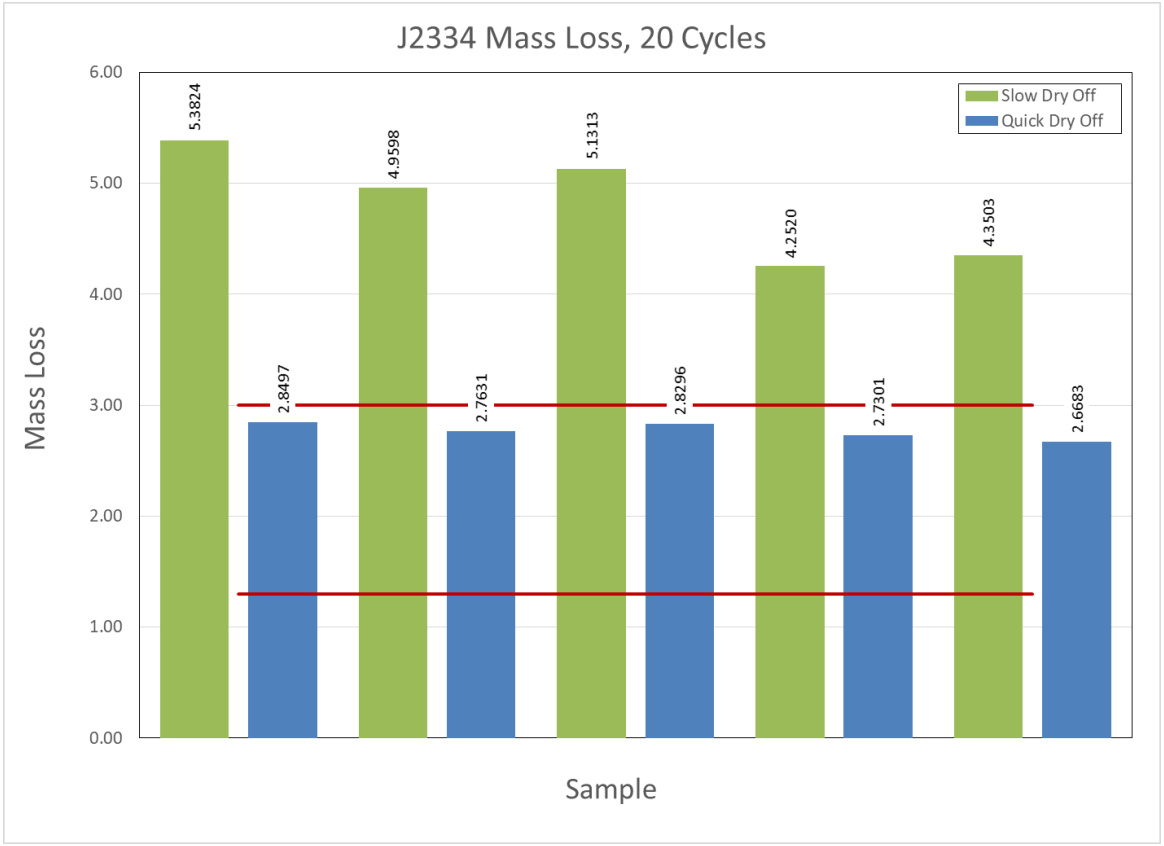
SAE J2334 Quick Dry-Off



Zoomed in view of the transition

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

SAE J2334 Results



Green bars represent test under slow dry-off conditions

Blue bars represent test under quick dry-off conditions

Red lines represent tolerance of OEM standard

Under the quick dry test, the coated panels once again passed the test

Controlling Mass Loss

- The Q-FOG allows on/off pulsing of spray nozzles and easy adjusting
- Controlling transition times could also work but is less practical

Summary

- GMW14872 overview and brief history
- Overcoming biggest challenges:
  - Maintaining ambient conditions
  - Preventing precipitate formation in solution and plugging of spray nozzles
  - Pre-exposure cleaning to remove oil
  - Removing all rust prior to mass loss measurement

Thank you for joining us today. We hope to see you again soon.

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