# Accelerated Corrosion Testing for Automotive Applications

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## Q-Lab Corporation



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**Thank you for attending our webinar!**

We hope you found our webinar on *Automotive Corrosion Testing* to be helpful and insightful.

# Topics

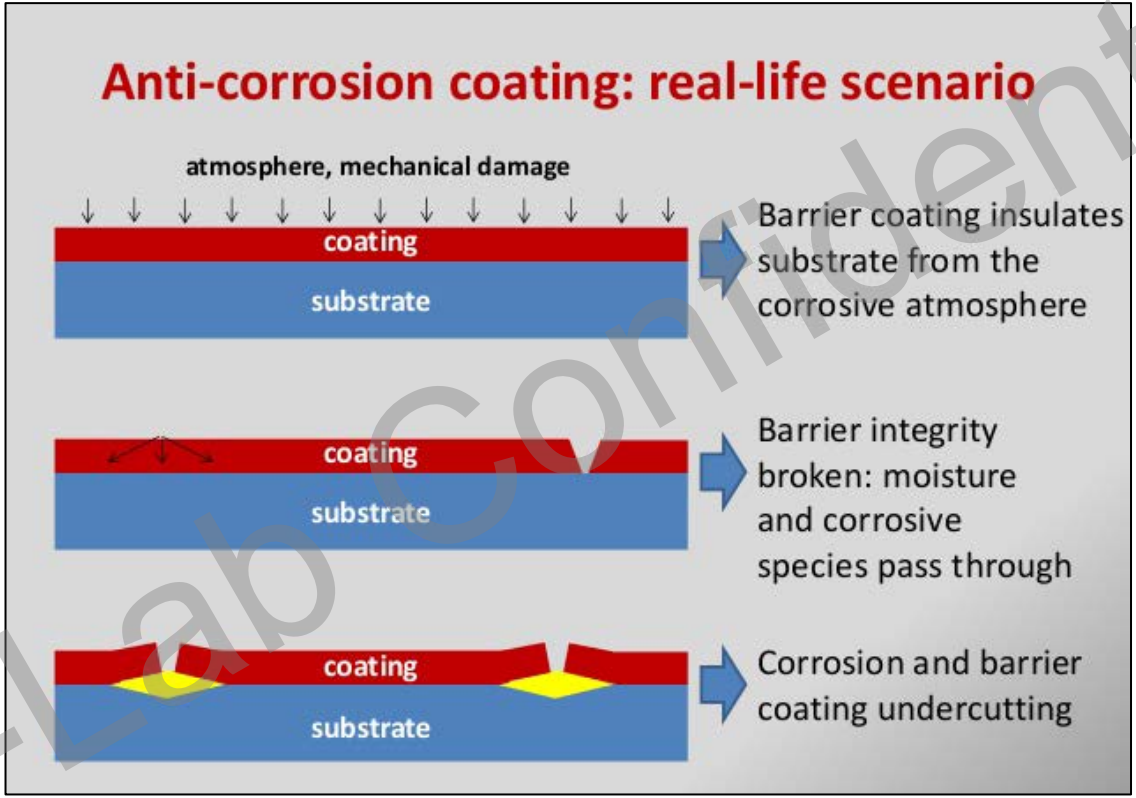
- Automotive Corrosion overview
- Recent developments in Cyclic Corrosion Testing
  - Relative humidity control
  - Electrolyte (salt) solutions
- Modern cyclic corrosion test methods and laboratory equipment

# Corrosion of Automotive Components

# What Causes Automotive Corrosion?

- Exposure to a corrosive climate
  - Wet and dry cycles
- Accelerated if chemicals present
  - Salt, Acid Rain
- Metal becomes exposed
  - Scratch, impact, chip
- Paint or coating may not protect after the initial damage

# Mechanics of Corrosion



# Corrosion Types

## Cosmetic corrosion

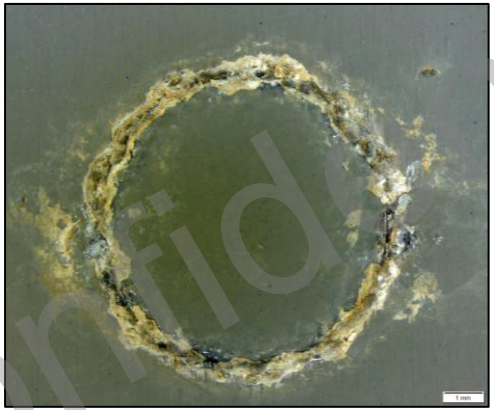
- Paint Protection
- High Moisture
- Road Splash Effect

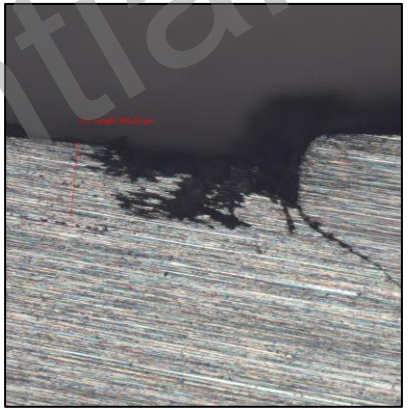
## Structural Corrosion

- No UV
- Parts are coated?

# Corrosive failure modes

***5xxx series Aluminium joined to Carbon Fiber***



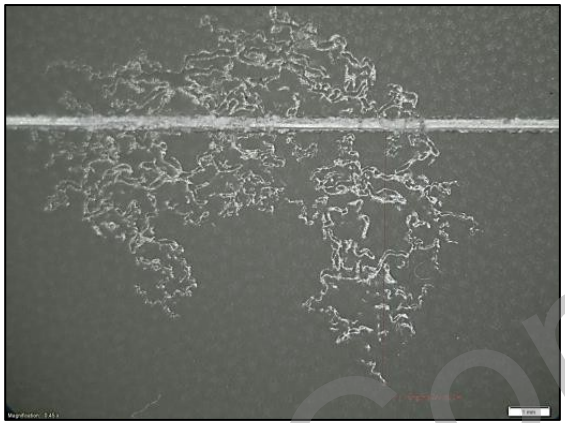


***Steel rivets into sheet aluminium***

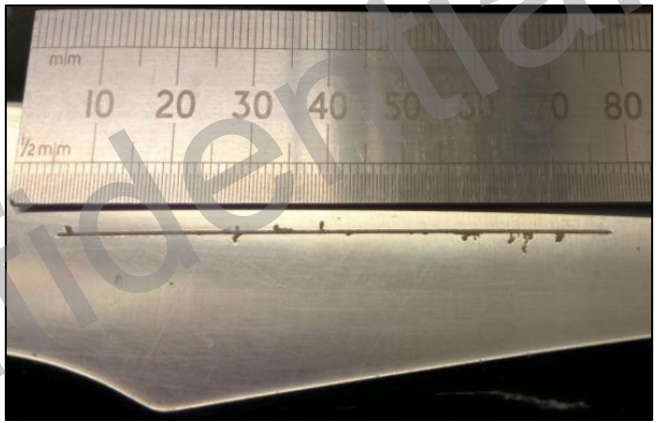
- Mixed material construction
  - Galvanic corrosion
  - Crevice corrosion
  - Filiform corrosion

- *Critical to correlate laboratory test methods to real world conditions*

# Corrosive failure modes



*Filiform corrosion on 6xxx series painted sheet aluminium.*




*Filiform corrosion on (lacquered) diamond cut road wheel surface, Al-Si, Mg*

Accelerated by galvanic & crevice conditions, cut edges, reworked surfaces

# Automotive Corrosion Testing

## Component level

### Test Method Types

- Neutral Salt Spray
- CCT
- CASS

### Test Specimen Types

- Flat panels/coupons: open, crevice, cosmetic
- Full components: e.g. fasteners, exhaust trim, badges, wheels



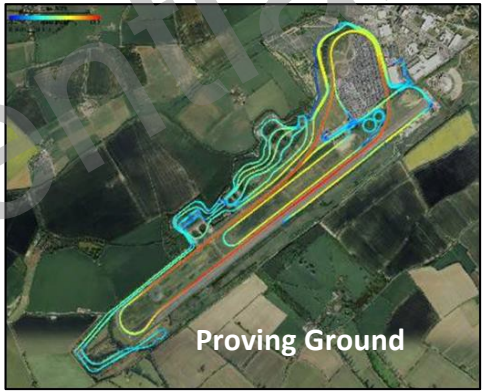


# Automotive Corrosion Testing

## Whole Vehicle

Vehicle Humidity Chamber


Durability Roads


Proving Ground


Teardown

- Humidity & temperature
- Salt spray
- Drive cycles (dust tracks, off road, durability roads)
- Teardown & evaluations

# Automotive Corrosion Testing Objectives

- **Objective 1**: Determine performance *before* and *after* damage
- **Objective 2**: Select and use realistic test methods
- **Objective 3**: Accelerate test and generate correlative results

***Recent advances in cyclic corrosion testing help us to reach these objectives***

# Laboratory Accelerated Corrosion Testing

## Cyclic Testing and Relative Humidity Control

# What is changing about cyclic corrosion testing, and why?

- Cyclic tests like PV1210 and JASO M609 more realistic than simple tests like ASTM B117 but not good enough for all applications
- Modern Corrosion tests control and maintain RH between 50-90%

# Key Aspects of Modern Corrosion Tests

- Specific relative humidity settings (not just ambient, wet, or dry)
- Controlled temp/RH and transitions to improve reproducibility
- Custom electrolyte (salt) solutions
- Salt “Fog” sometimes replaced by direct spray (“Shower”)

# Summary of Environmental Conditions in Modern Automotive Corrosion Standards

| Cycle | Solution | Spray Type | RH < 50% | 50%≤RH<76% | RH≥76% |
|---|---|---|---|---|---|
| Ford L-467/Volvo (ACT2) | NaCl 0.5%<br>pH uncontrolled | Shower | 0% | 66% | 34% |
| GMW 14872 | NaCl 0.9%<br>$CaCl_2$ 0.1%<br>$NaHCO_3$ 0.075%<br>pH uncontrolled | Shower | 46% (22% below RH30%) | 16% | 38% |
| Renault D17 2028 (ECC1) | NaCl 1.0%<br>pH =4.0 ($H_2SO_4$) | Fog | 8% | 62% | 30% |
| VDA 233-102 | NaCl 1.0%<br>pH neutral | Fog | 1%* | 39% | 60% |
| Volvo ACT1 | NaCl 1.0%<br>pH =4.2 ($H_2SO_4$) | Shower | 17% | 31% | 52% |

**Variety of electrolyte solutions and acidities**

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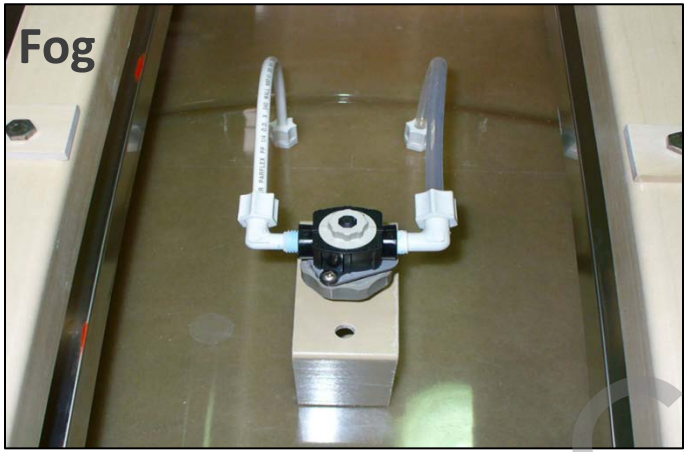
**Shower and Fog still both used widely**

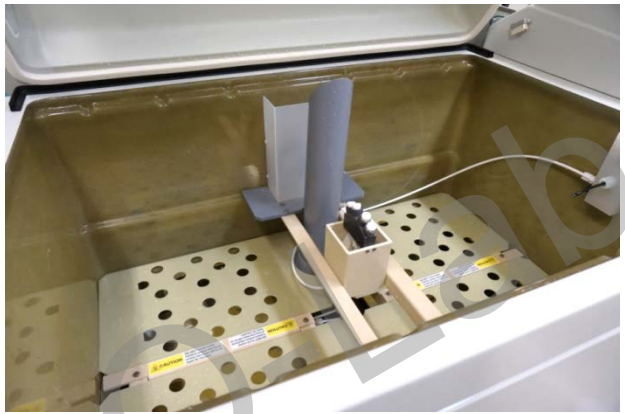
# Fog and Shower




- Atomizing nozzle
- Separate compressed air and liquid solution lines
- Controlled by pump speed and air pressure


- Non-compressed air nozzles installed over existing atomizing fog nozzle
- Controlled by adjustable pump pressure and spray on/off cycling

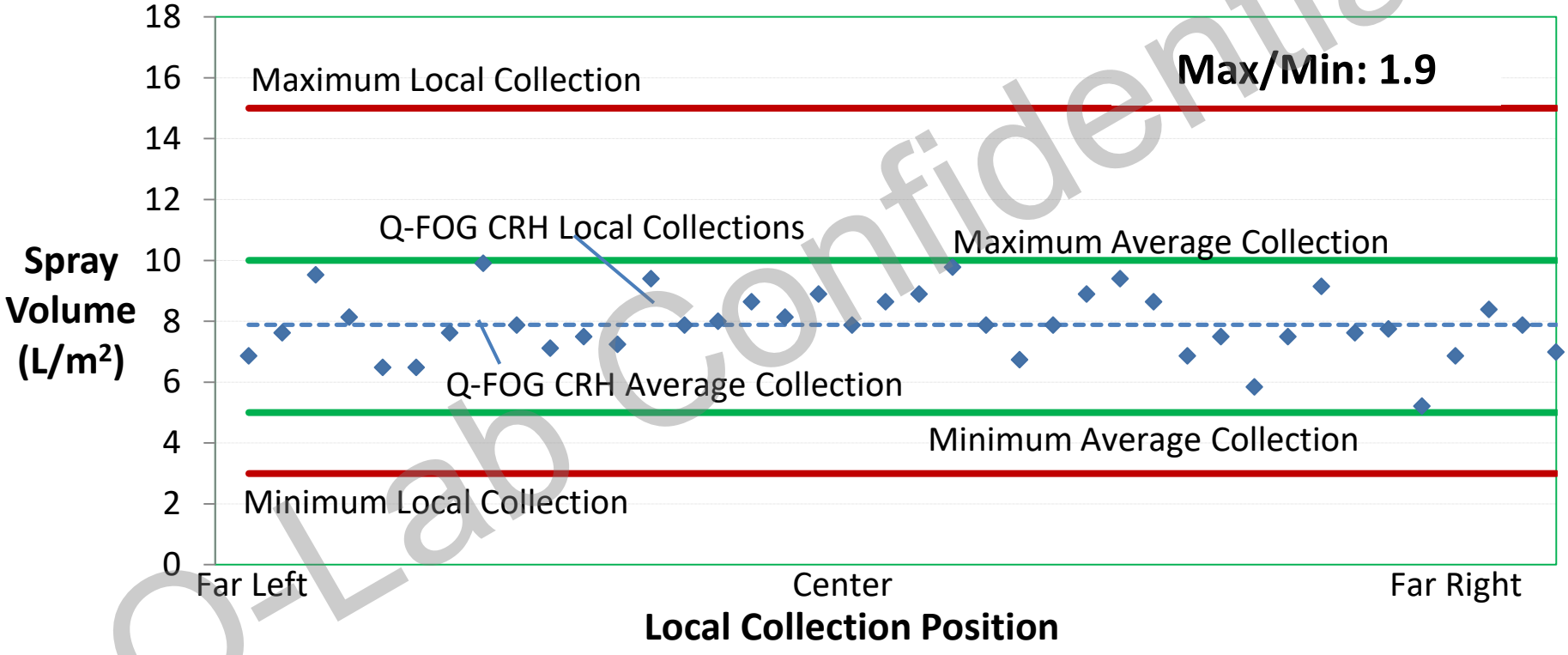
# Advantages of Shower (Spray)



- High volume spray wets specimens faster than traditional fog (~100× more volume)
- Spray volume can be controlled to adjust corrosion rates
- Fixed position with uniform coverage of chamber; no need for constant user adjustment
- Flow rate detection alerts user if a nozzle is plugged
- Self-cleaning with DI water

# Q-FOG CRH Shower Uniformity

## 40 positions (Ford L-467, Volvo ACT2)



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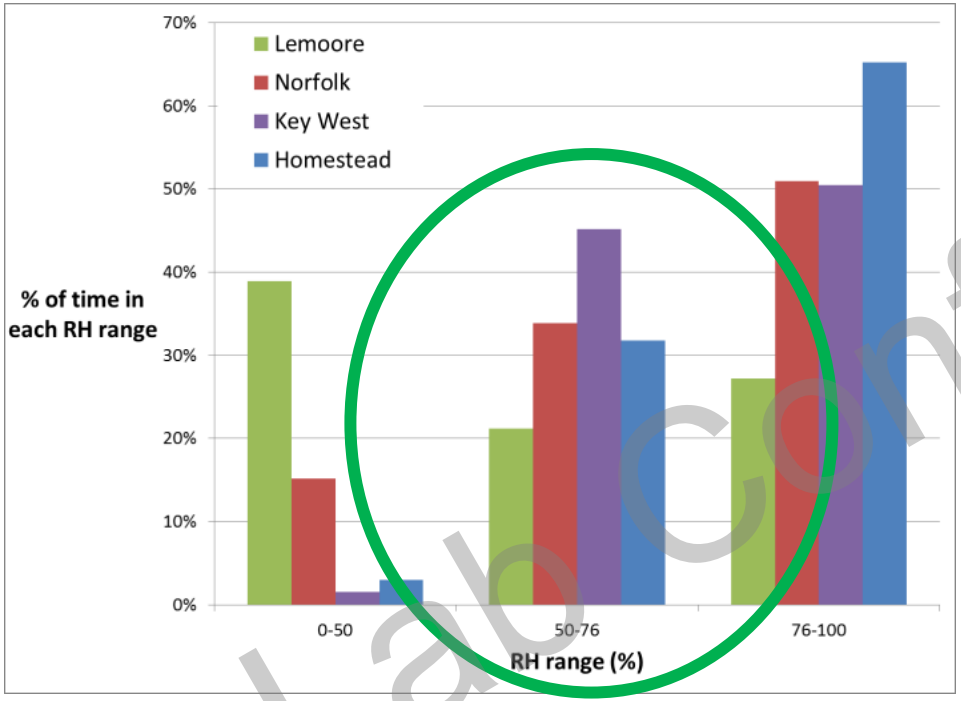
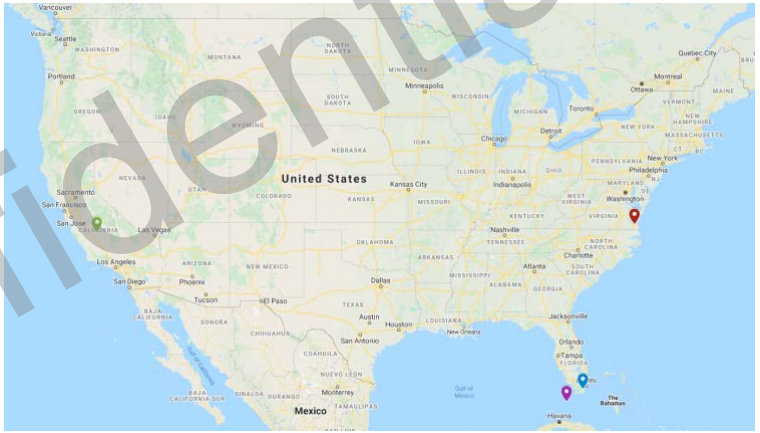
**All standards require control at intermediate values of Relative Humidity**

# RH Conditions in the Natural Environment



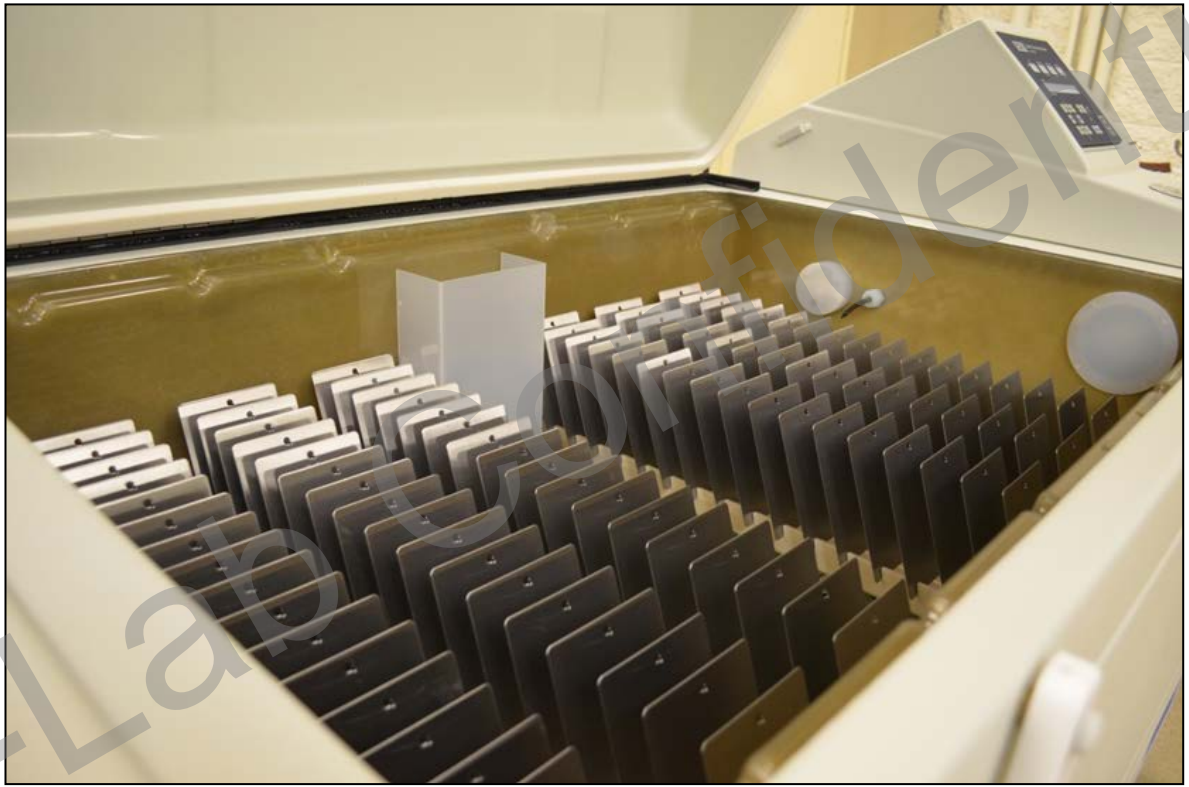




- All regions spend considerable time at intermediate RH (around 76%)
- **Modern test standards recognize this and control RH at these levels!**

# Relative Humidity
## "Controlling the Middle"

- RH control between 50% and 90% is critical
- Wet and Dry Cycling cannot do this
  - Can only do wet, dry, ambient
  - No control of RH transition times
  - Variable specimen dry-off rates

# Corrosion Chamber with Metal Panels



# Environmental Chamber

# Test Chamber Types

## Corrosion/Salt Spray

- More rectangular than square
- Single layer specimen mounting
- Stainless steels won't last in the environment
- Static air necessary during salt spray
- Liquid solutions & precipitated salts create microclimates
- Precise control is more difficult
- Dew point reduction is not common

## Environmental (Temp & RH)

- Cubic/cuboid in shape
- Multi-layer specimen mounting
- Interiors are usually stainless steel
- Constant air flow (low /high flow types)
- Rarely spray water
- Precise temperature & RH capabilities
- Dew point reduction is common

# Q-FOG CRH

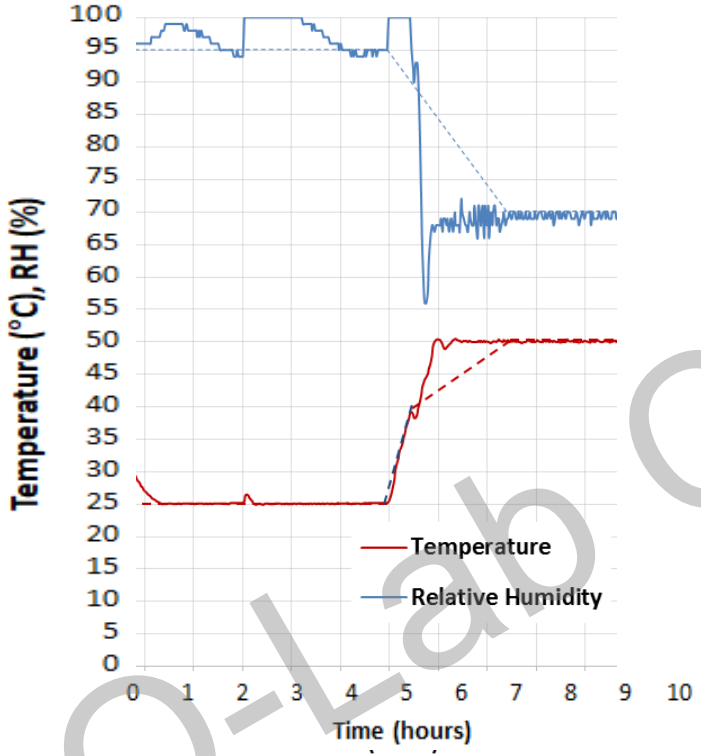

- Two types of salt spray delivery (Fog, Shower)
- Controlled linear transitions of temperature & RH
- Dehumidification via air preconditioner
- -HSCR model features Rapid Ramp Heater for fast transitions

# Q-FOG CRH Air Pre-Conditioner

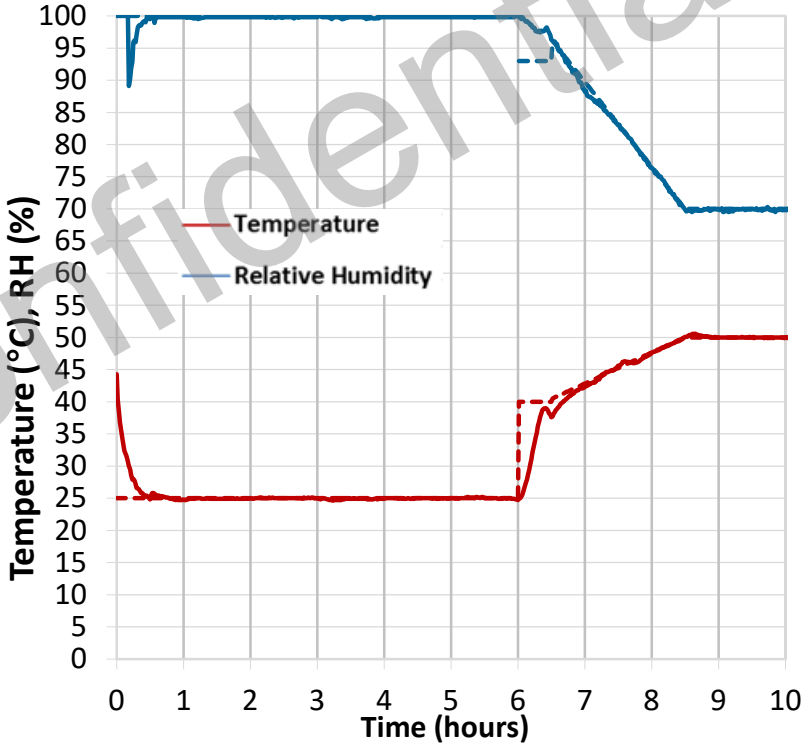
- Delivers consistently dry air to system
- Hot or cold
- Expands range of achievable conditions
- Allows precise control of temp and RH transitions

# Performance Improvement with Air Preconditioner

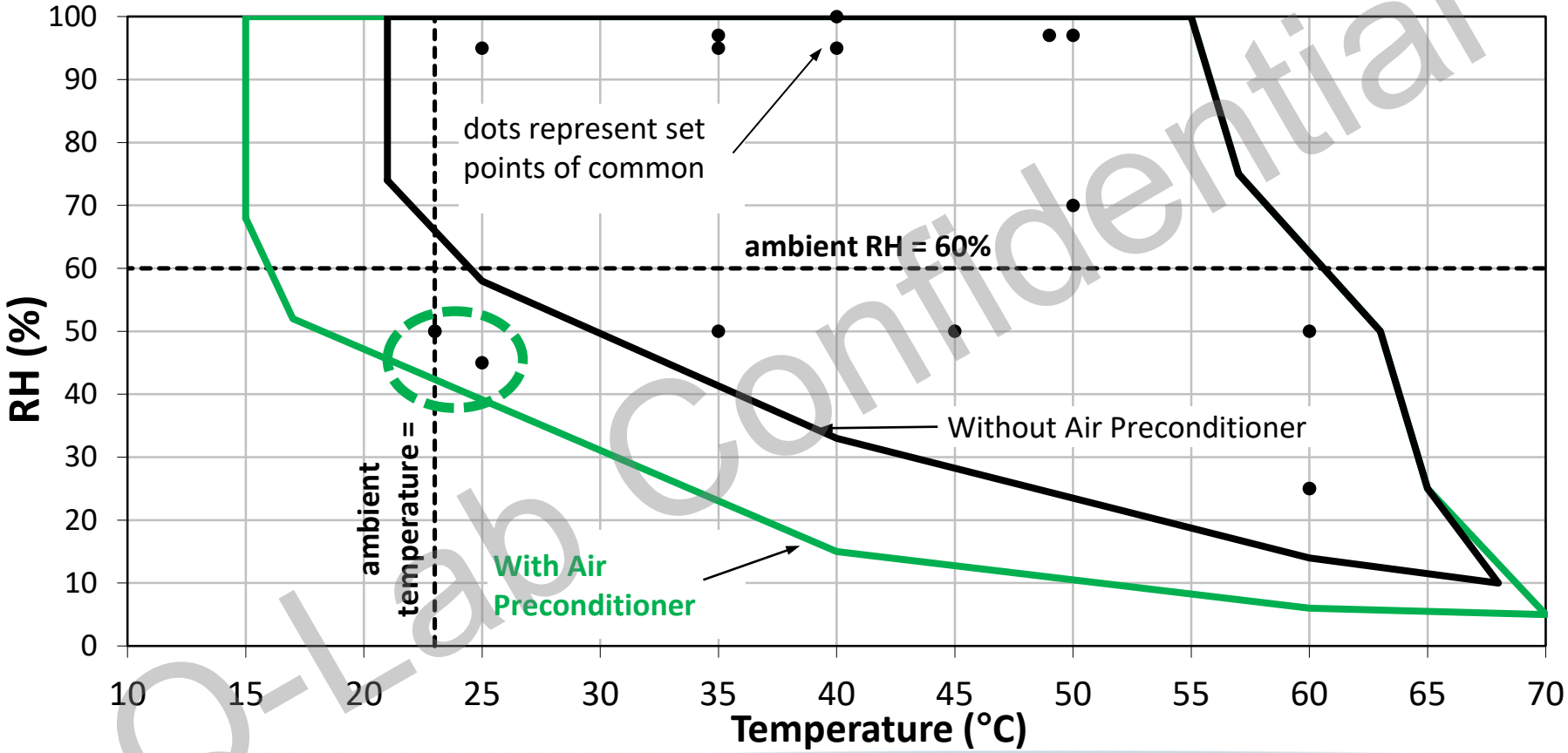
## No Air Preconditioner




## With Air Preconditioner



# Q-FOG CRH: Meets Test Conditions in All Major Automotive Standards



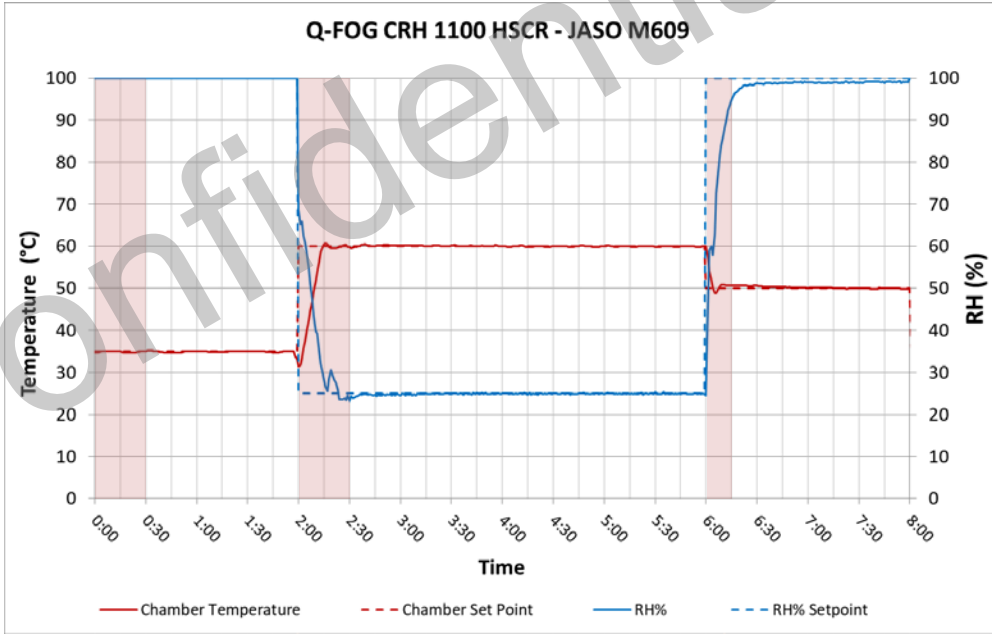
# Q-FOG CRH: Standards Met

| Test Standard | Standard Model | Rapid Ramp Heater |
|---|---|---|
| JASO M609 | | ✓ |
| CCT-C | | ✓ |
| CCT-I | | ✓ |
| CCT-IV | | ✓ |
| Renault D17-2028 (ECC1) | ✓ | ✓ |
| Volvo VCS 1027, 149 (ACT I) | ✓ | ✓ |
| Volvo VCS 1027, 1449 (ACT II) | ✓ | ✓ |
| GMW 14872 | ✓ | ✓ |

# JASO M609 (ISO 14993, 11997-1)

- Chamber Volume – 1100 L
- Chamber Load – 250 Steel Panels, 3” × 6”
- FOG Solution – 5% NaCl Solution
- Laboratory Room Temperature – 28-30 °C

| Step | Function | Chamber Air Temp (°C) | RH (%) | Step Time (hh:mm) | Ramp |
|---|---|---|---|---|---|
| 1 | FOG | 35 °C | | 2:00 | < 0:30 |
| 2 | RH | 60 °C | 25 % | 4:00 | < 0:30 |
| 3 | RH | 50 °C | 100 % | 2:00 | < 0:15 |
| 4 | Final Step – Go To Step 1 | | | | |



# JASO M609

Transition times for JASO M609 in full Q-FOG CRH 1100 HSCR Chamber.

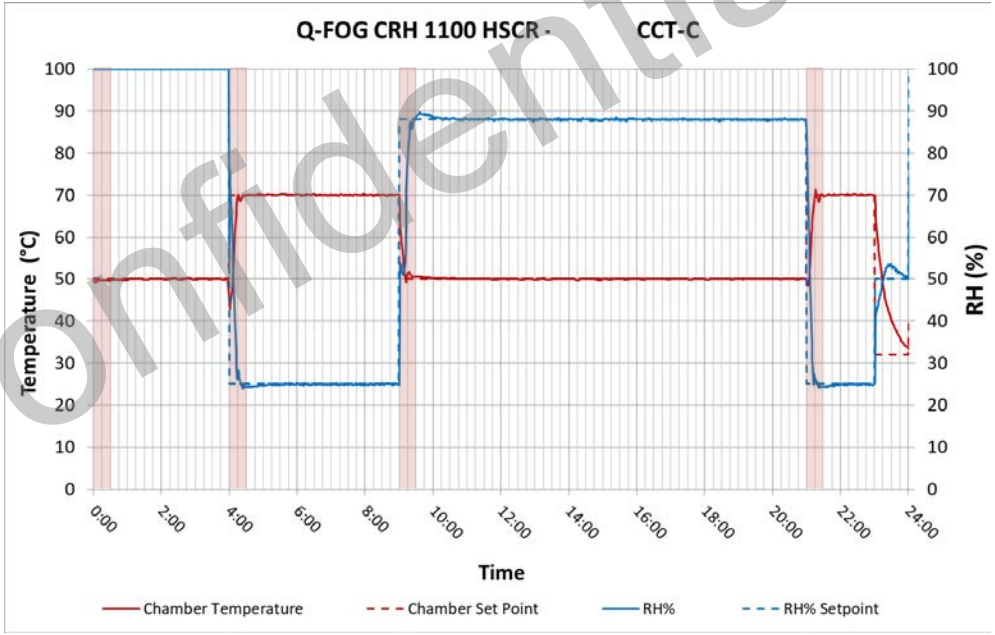
| | Function | Transition | Transition Time Requirement | Actual Temperature Transition Time | Actual RH Transition Time |
|---|---|---|---|---|---|
| JASO M609 | Fog to Dry | 35 °C → 60 ± 1 °C<br>FOG → < 30% RH | < 0:30 | 0:13 | 0:14 |
| | Dry to Wet | 60 ± 1 °C → 50 ± 1 °C<br>< 30% RH → > 95% RH | < 0:15 | 0:04 | 0:15 |
| | Wet to Fog | 50 ± 1 °C → 35 °C<br>> 95% RH → FOG | < 0:30 | 0:06 | |

# CCT-C

- Chamber Volume – 1100 L
- Chamber Load – 250 Steel Panels, 3” × 6”
- FOG Solution – 5% NaCl Solution
- Laboratory Room Temperature – 30-35 °C

| Step | Function | Chamber Air Temp (°C) | RH (%) | Step Time (hh:mm) | Ramp |
|---|---|---|---|---|---|
| 1 | FOG | 50 °C | | 4:00 | < 0:30 |
| 2 | RH | 70 °C | 25 % | 5:00 | < 0:30 |
| 3 | RH | 50 °C | 87 % | 12:00 | < 0:30 |
| 4 | RH | 70 °C | 25 % | 2:00 | < 0:30 |
| 5 | RH | 23 °C* | 60 %* | 1:00 | |
| 6 | Final Step – Go To Step 1 | | | | |

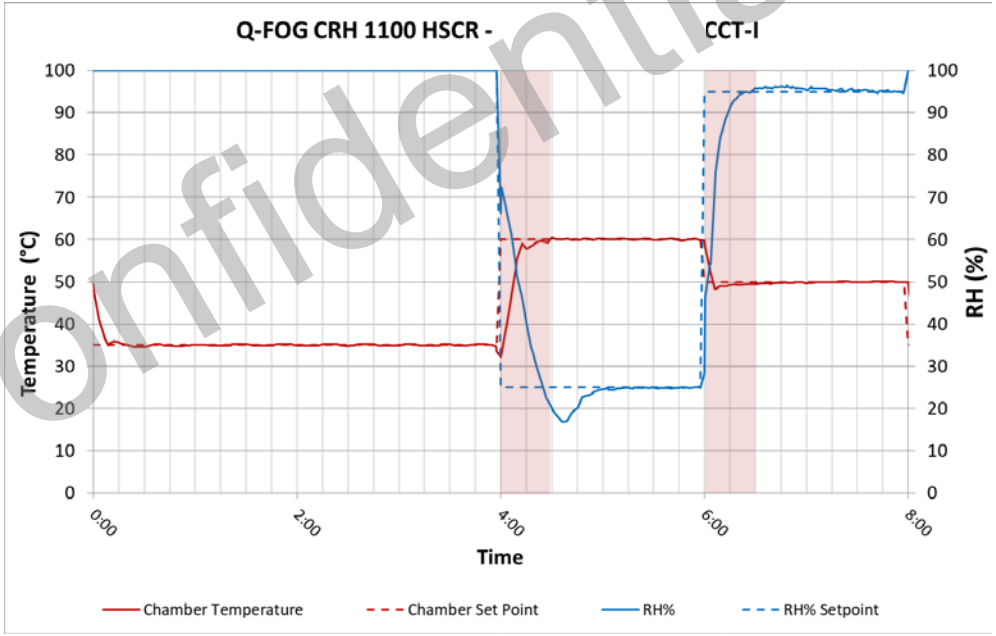
*Indicates no value specified in the test method but a value is programmed into the tester



# CCT-I

- Chamber Volume – 1100 L
- Chamber Load – 210 Aluminum & Steel Panels
- FOG Solution – 5% NaCl
- Laboratory Room Temperature – 26-28°C

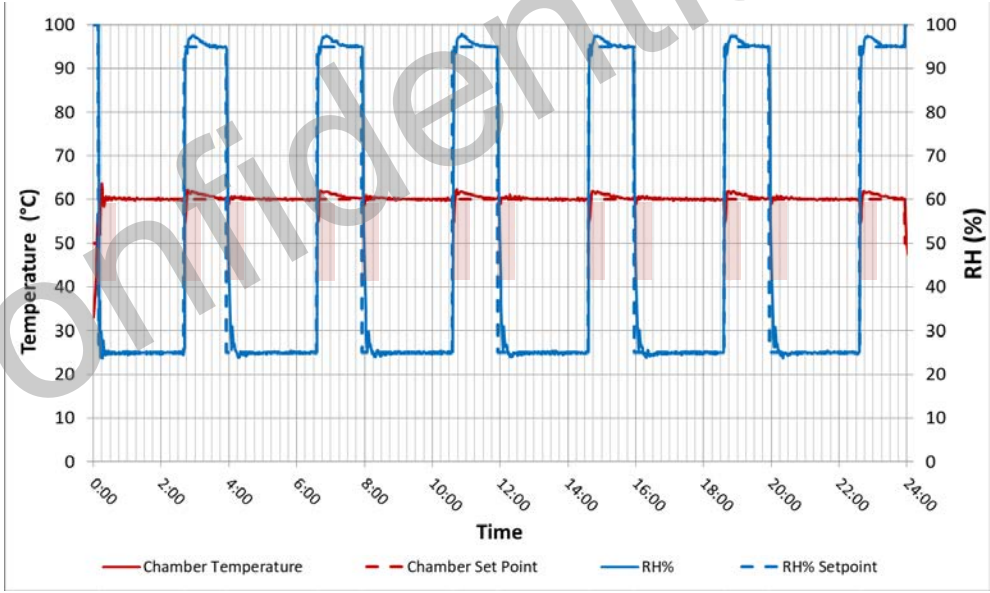
| Step | Function | Chamber Air Temp (°C) | RH (%) | Step Time (hh:mm) | Ramp |
|---|---|---|---|---|---|
| 1 | FOG | 35 °C | | 4:00 | |
| 2 | RH | 60 °C | 25 % | 2:00 | < 0:30 |
| 3 | RH | 50 °C | 95 % | 2:00 | < 0:30 |
| 4 | Final Step – Go To Step 1 | | | | |



# CCT-IV

- Chamber Volume – 1100 L
- Chamber Load – Empty
- FOG Solution – DI Water
- Laboratory Room Temperature – 22-25°C

| Step | Function | Chamber Air Temp (°C) | RH (%) | Step Time (hh:mm) | Ramp |
|---|---|---|---|---|---|
| 1 | FOG | 50 °C | | 0:15 | |
| 2 | RH | 60 °C | 25 % | 2:30 | < 0:30 |
| 3 | RH | 60 °C | 95 % | 1:15 | < 0:30 |
| 4 | Subcycle* | | Repeat steps 5-6 5x | | |
| 5 | RH | 60 °C | 25 % | 2:40 | < 0:30 |
| 6 | RH | 60 °C | 95 % | 1:20 | < 0:30 |
| 7 | Final Step – Go To Step 1 | | | | |



# Closing remarks

- Corrosion is a major problem that paint, galvanization, and anodization methods try to prevent
- Modern corrosion test methods are used to evaluate these techniques
  - Combine salt spray and environmental tests
  - Use linear temperature/RH transitions & accurate RH control
- A variety of tests are available, including both salt fog and shower
- Q-FOG CRH delivers stable test conditions, controlled transitions, and the –HSCR model can meet even demanding cyclic automotive tests like JASO M609

# Thank you for your attention!

Questions?

**info@q-lab.com**