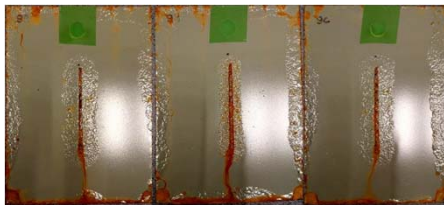
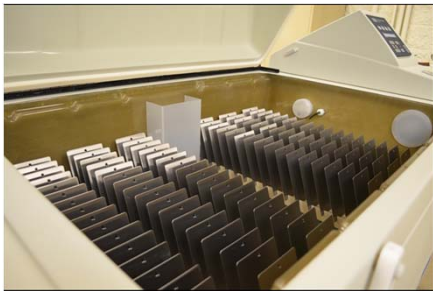


Controlled RH Corrosion Tests: Understanding Electrolyte Solution Application Methods and Correlating Delivered Volume with Corrosivity

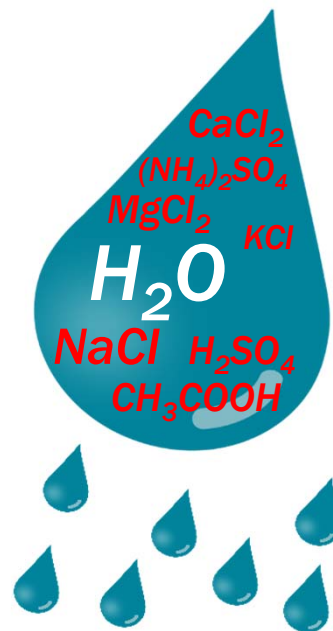
Sean Fowler
Q-Lab Corporation

Accelerated (Atmospheric) Corrosion Tests

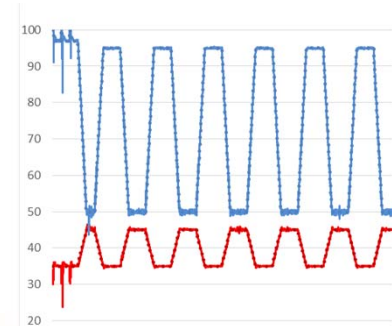
Corrosion chamber with specimens



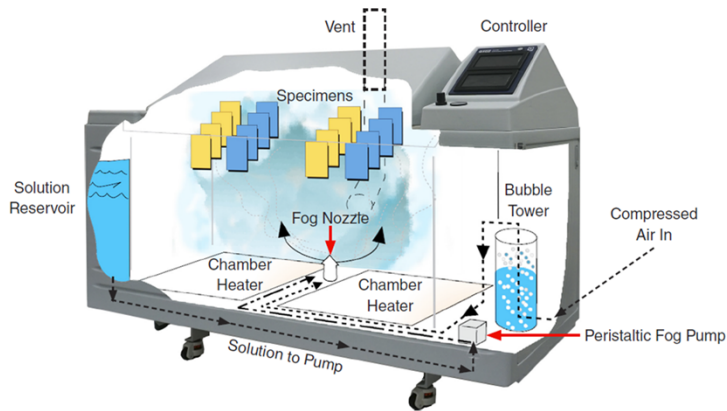
Electrolyte Spray



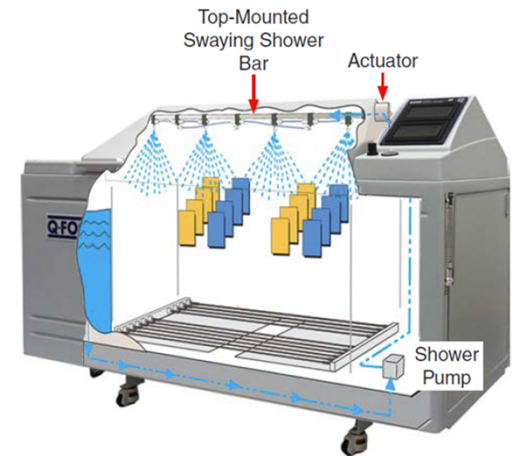
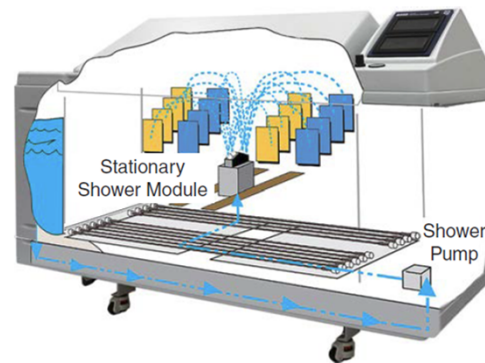
Climatic Control



Two Types of Salt Spray



Fog
(ASTM B117)



Shower

Fog vs Shower

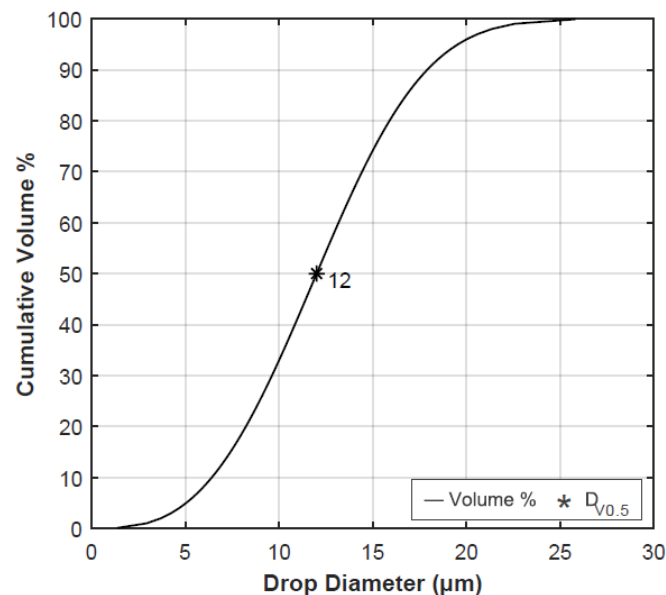
Can be defined in terms of...

- Droplet size
- Volumetric distribution or precipitation rate (preferred method for standardization)

Salt Spray Droplet Sizes

Drop Size Distribution according to ASTM E799

Volume Mean Diameter (VMD) also denoted as $D_{V0.5}$ is the drop size where 50% of total sprayed volume is comprised of larger drops and 50% of smaller drops



Spray Type	$D_{V0.5}$
Fog	$< 30 \mu M$
Shower	200-500 μM

- Approximate values which may not represent all chamber types
- This would be difficult to document in an ISO 17025 type quality system

Definitions

Fog (or Salt Fog)

A type of salt spray that uses a pneumatic powered (pressurized air) spray system, which delivers low volumes of solution as a very fine mist distributed throughout the chamber by the flow of air. Salt fog systems are capable of delivering solution at rates in the range of approximately 0.06 – 0.6 L/m²/h.

Shower (or Salt Shower)

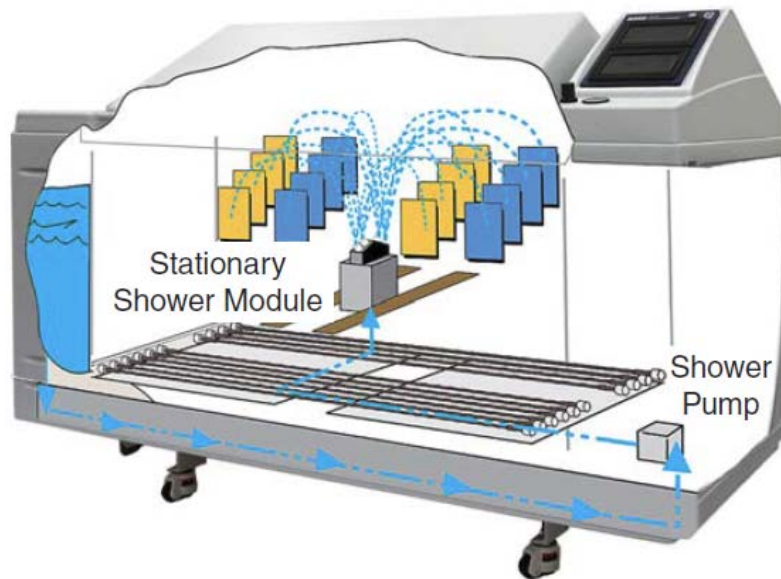
A coarse droplet salt spray which is delivered by means of pressurizing the liquid salt solution directly (hydraulic power). Shower systems deliver solution at comparatively much higher rates than fog, with rates ranging from approximately 40 to 100 L/m²/h. Note: Lower delivery rates can be achieved by cycling the shower system on and off.

Two Types of Spray

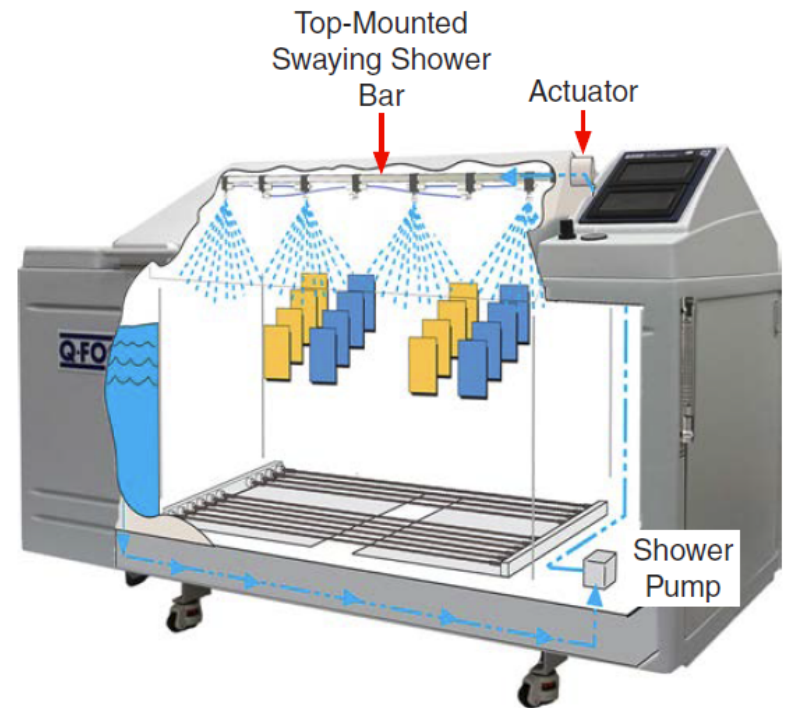
Standard	Term(s) used	Proposed new Term	Additional Notes
ISO 9227	spray	FOG	
ASTM B117	spray and fog, used interchangeably	FOG	Title is "Operating Salt Spray (Fog) Apparatus" and "fog" is in parenthesis in parts of the document, but not all
ASTM G85	spray and fog, used interchangeably	FOG	Title is "Modified Salt Spray (Fog) Testing" and "fog" is in parenthesis in parts of the document, but not all
Renault D17 2028 (ECC1)	spray	FOG	The term "fog" is used one time, but other references use the term "spray"
ISO 16701	spray	SHOWER	The document uses "spray" most often but also uses the term "mist"
Ford L-467	spray	SHOWER	A note in the document says "Continuous spraying with atomizing salt-fog type nozzles is not an option."
GMW 14872	spray, mist	SHOWER	The term "fog" is used in relation to a method for creating 100% RH condition, as in "water fog," which references ASTM D1735
SAE J2334	spray, fog	spray refers to SHOWER; fog refers to FOG	Spray is defined as "periodic or continuous direct impingement spray of the salt solution" and corresponds with "shower"; while fog is described as "Air Atomized Fog Method"
IEC 60068-2-11	spray, mist	FOG	spray and mist are used interchangeably and a note indicates they have the same meaning
Volvo VCS 1027.1449	spray	SHOWER	In a note, the term "salt mist" is used as follows: "continuous spraying with atomizing nozzles for salt mist is not an option"
Volvo STD 423-0014	spray	SHOWER	

Modern Corrosion Tests

Shower Function



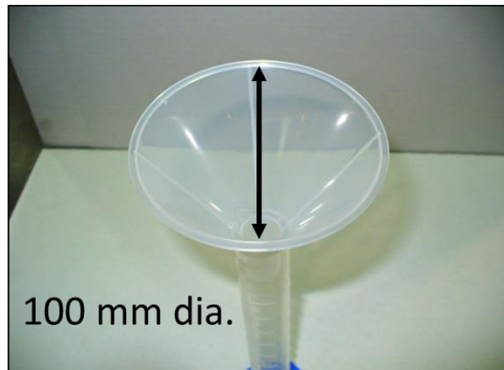
Stationary Shower Module (SSM)



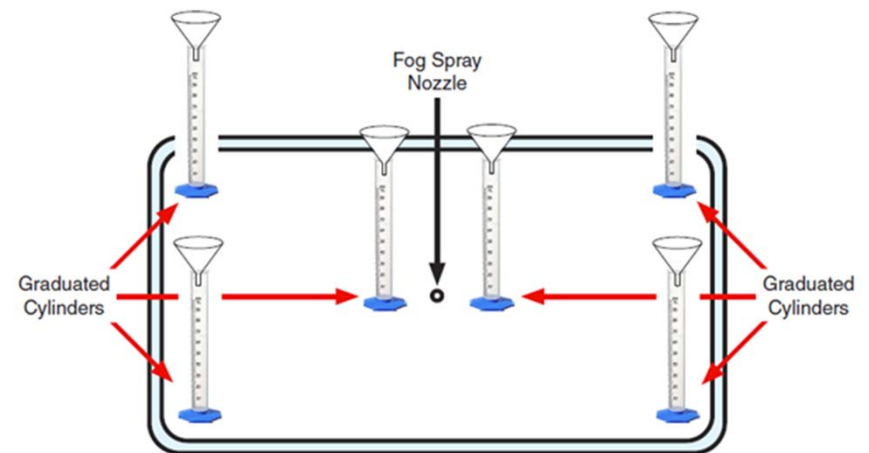
Top-Mounted Swaying Shower Bar (TSSB)

Faster application of salt solution than Fog

Quantifying Salt Fog



Per ASTM B117, use 10 cm diameter funnels to capture fog droplets and measure volume (1-2 ml per hour is the requirement)



Quantifying Salt Shower

GMW14872: “The test samples and coupons shall be thoroughly wet/dripping” and “should be sufficient to rinse away any salt accumulation left from previous sprays”

Ford L-467 (Volvo ACT2):
Average volume target is 5^* L/m^2
where 10 is an upper limit and 3-15 represent minimum and maximum in any one position; chamber set to pulse shower nozzles 10 seconds on, 35 seconds off



**Multiply by 7.85 to convert to collections in 10 cm funnel (39 ml/80cm² target)*

Experiment 1

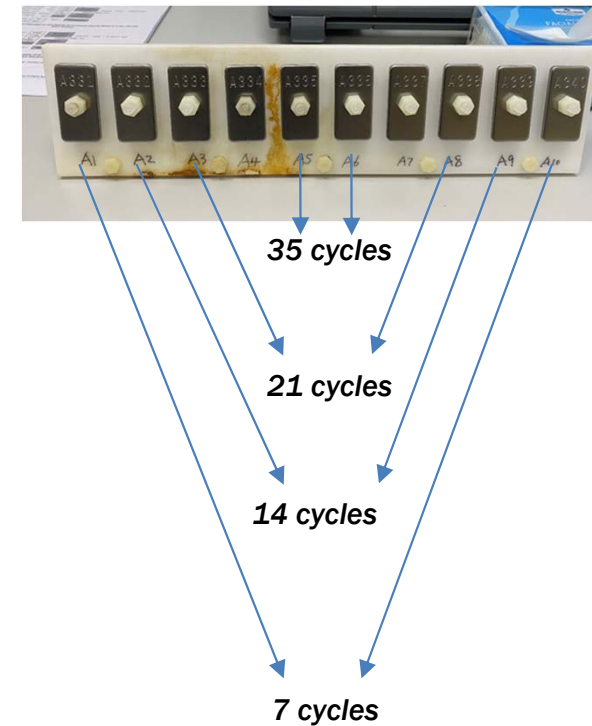
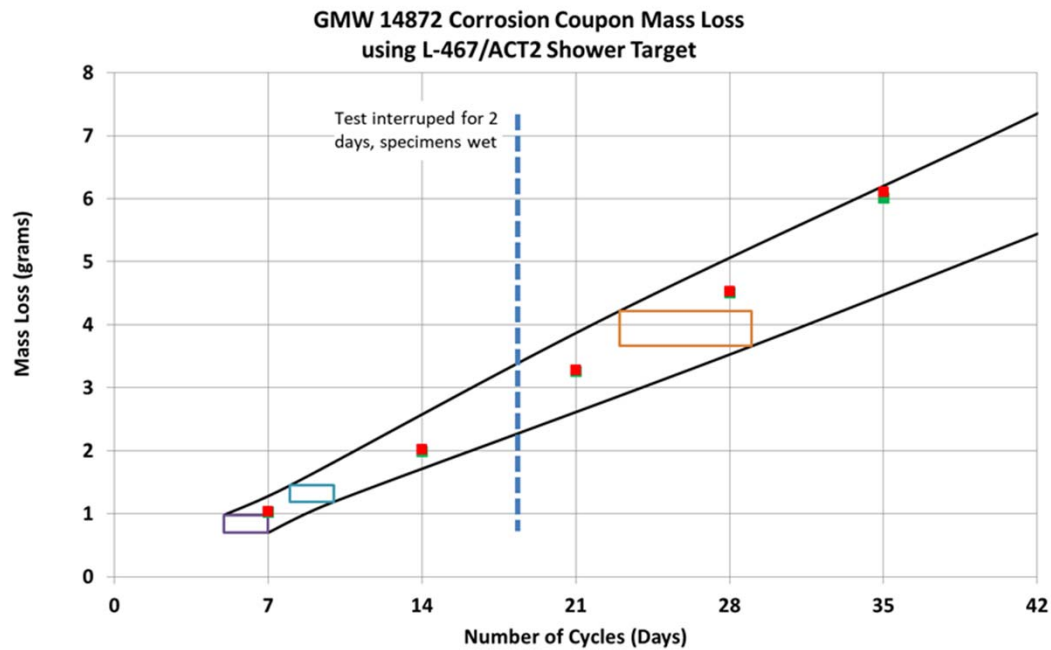
GMW14872 vs L-467/ACT2 Shower Requirements

- Run GMW14872 with shower (top-mounted swaying shower bar) set to L-467/ACT2 on/off cycling rate (10 seconds on/35 seconds off)
- 25 ml per 10 cm funnel
- Measure mass loss of standard corrosion coupons



- **SAE 1008-1010 carbon steel**
- **25 x 51 x 3 mm with center mounting hole**
- **Exposed at 15 ° from vertical with 5 cm spacer between coupon and rack**

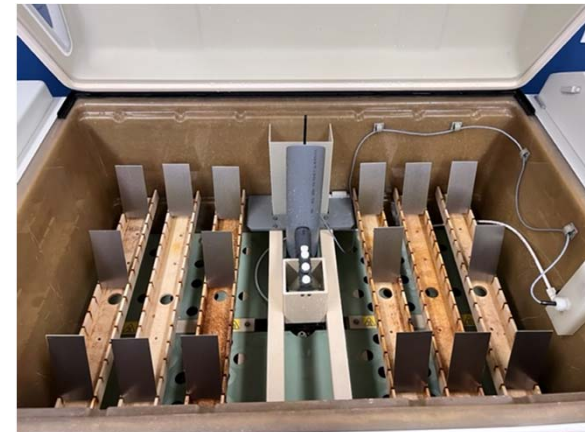
Experiment 1 Results



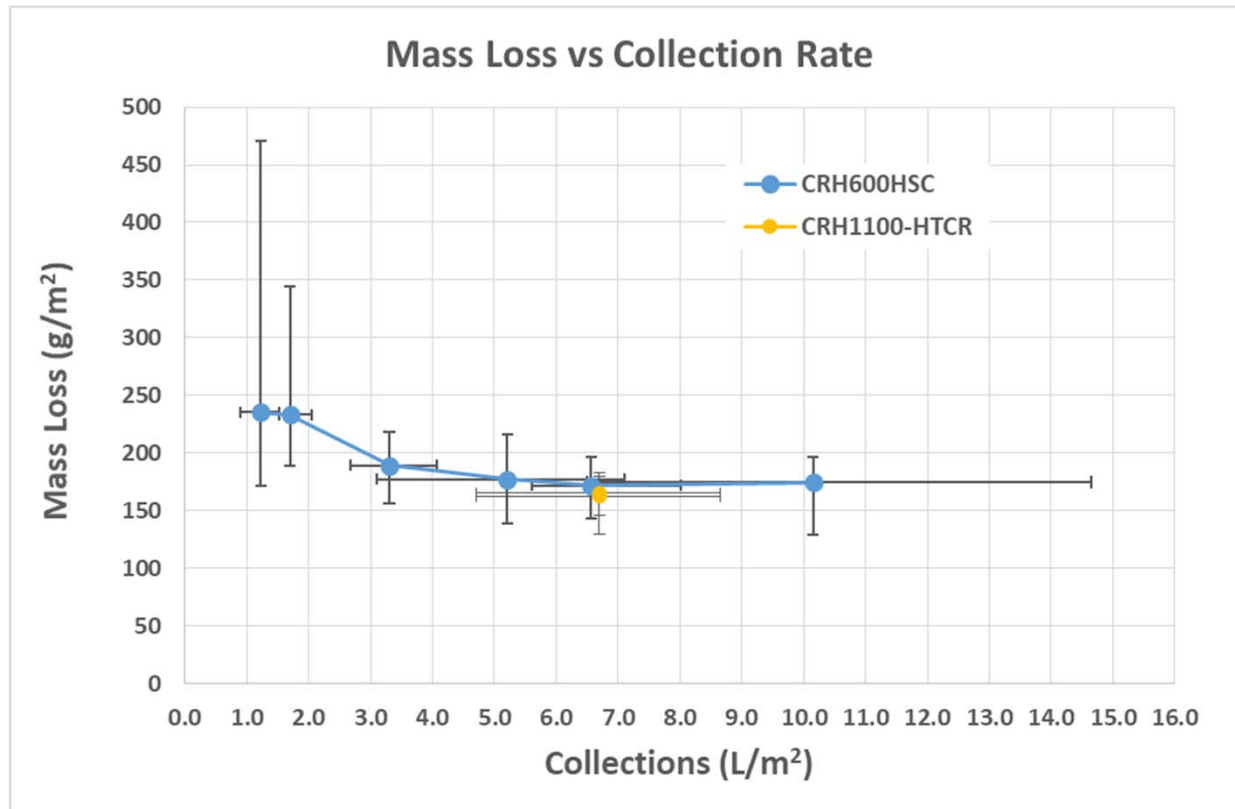
Experiment 2

Finding the optimal shower settings and corrosivity requirements for a new cycle

- Corrosion test panels according to ISO 9227:2022
 - SAE 1008 (newly permitted in 2022 edition of standard)
 - 150 x 70 mm, 1.0 mm thick
 - Taped on back side
- Exposures for 2 weeks
- 12 panels not repositioned; 4 panels repositioned during first two runs
- Cycle is quite different from GMW14872 and L-467



Summary of Completed Tests



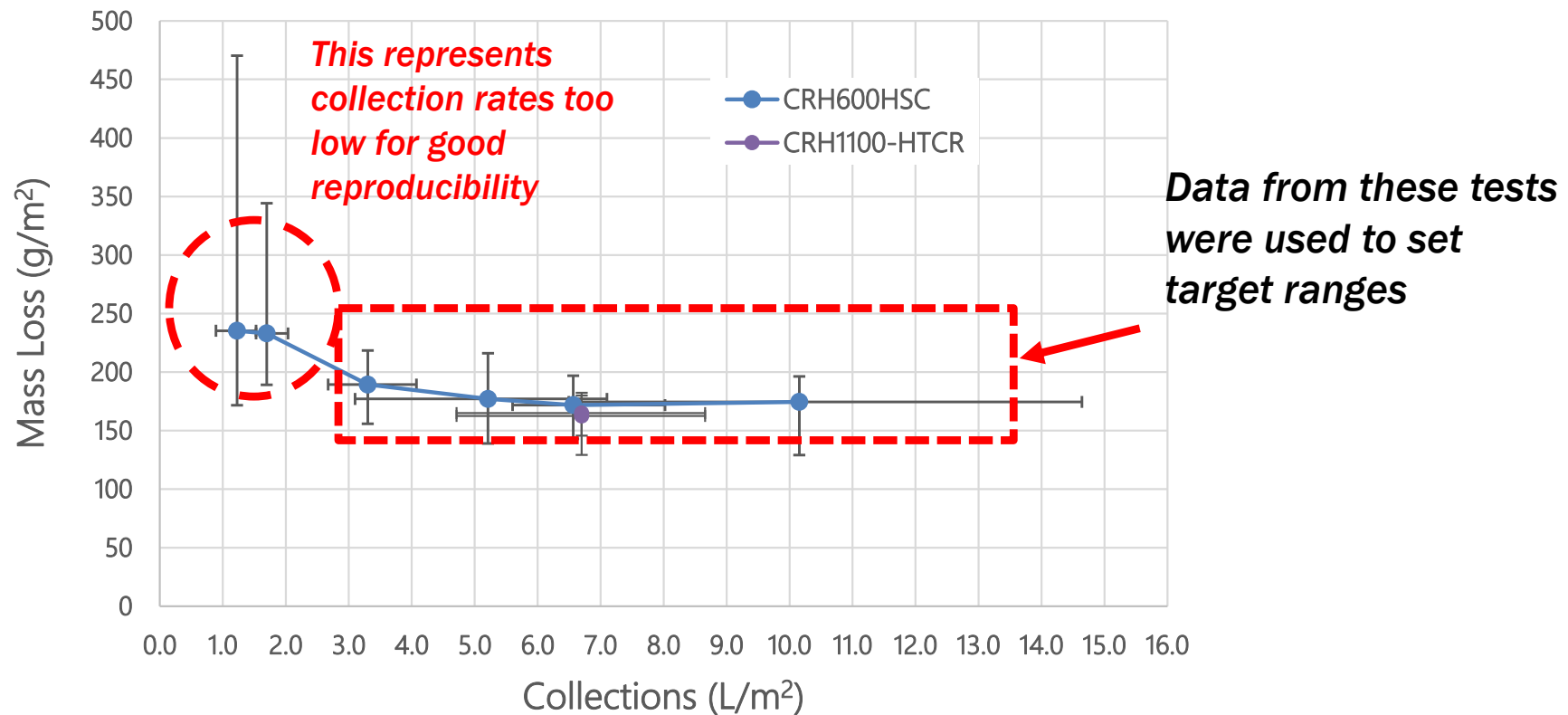
Note: There are two data points for the CRH1100; same on/off setting produced the same mass loss

Mass loss is ~equal once shower volume is $> 4 \text{ L/m}^2$

L-467/ACT2 target is 5-10 L/m^2

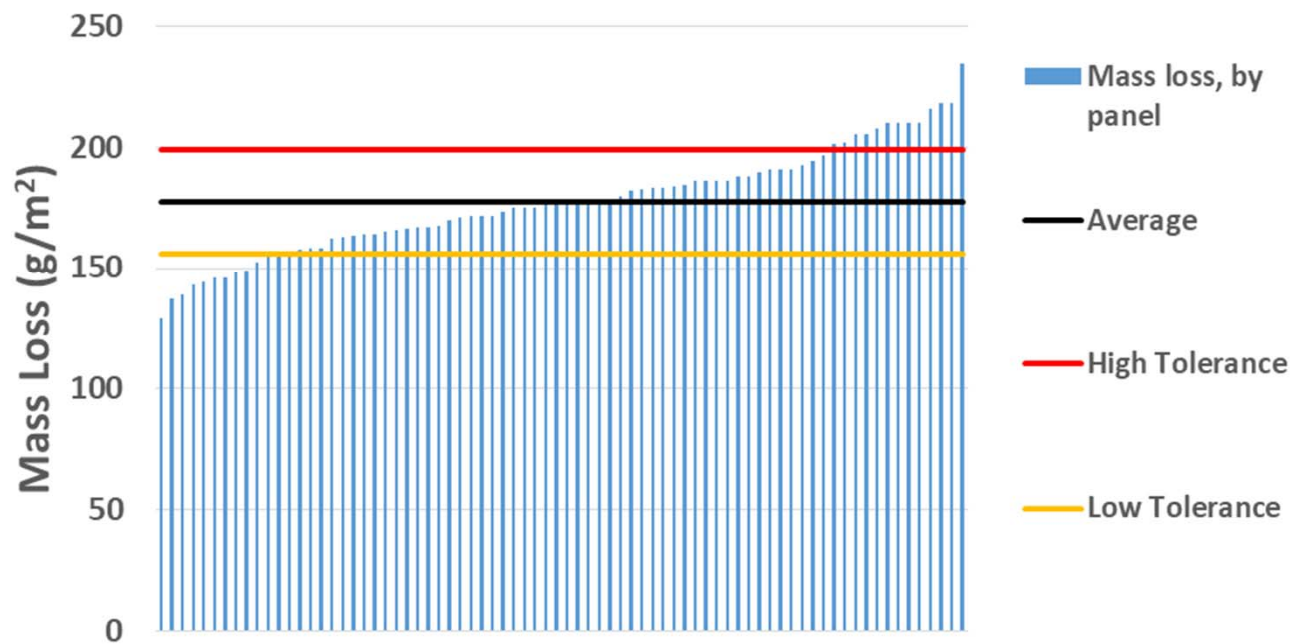
Summary of Completed Tests

Mass Loss vs Collection Rate



Determining Mass Loss Specification

Mass Loss of all panels in valid tests



How to set maximum and minimum mass loss criteria:

Average all panels from all valid tests, set tolerance to ± 1 standard deviation

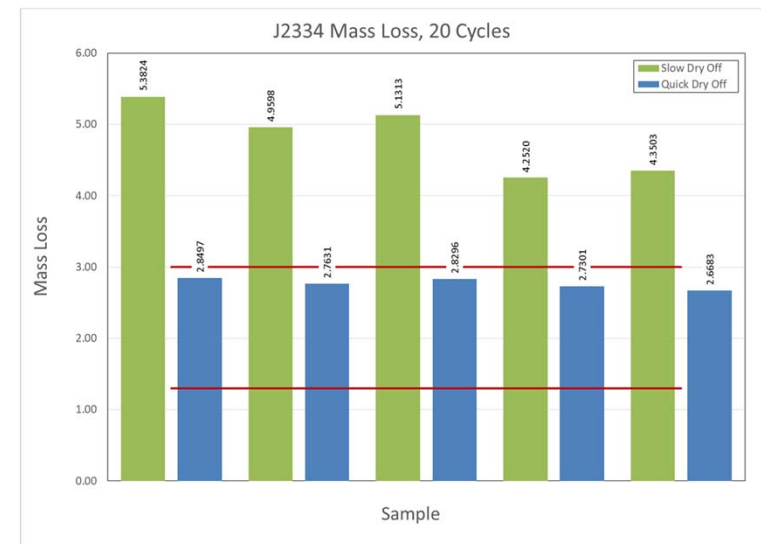
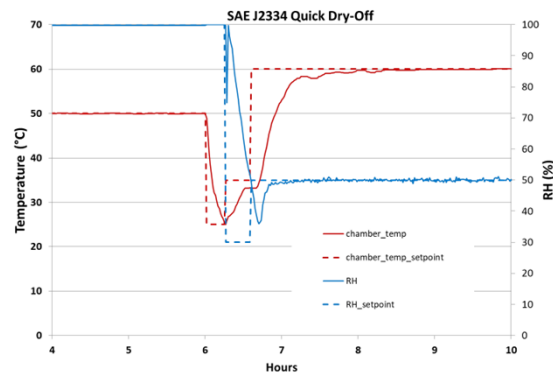
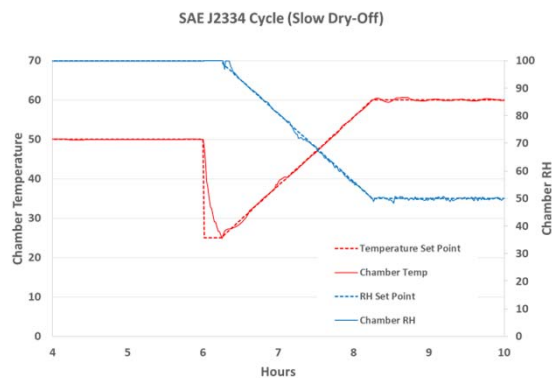
Average = 177 g/m²

High tolerance = 199 g/m²

Low tolerance = 156 g/m²

Current Work

- SAE J2334 with mass loss to an OEM specification
 - Revisit 2018/2019 study using top-mounted swaying shower bar



Conclusions

- Shower is another type of salt spray to consider for new accelerated atmospheric corrosion test methods
- Above a minimum volume of spray, corrosivity of steel panels is relatively constant over a wide volume range
- Shower requirements for any cycle may be very similar
- Standard metal coupons/panels are a useful test monitoring and development tool



Thank you for your time.

Sean Fowler
sfowler@q-lab.com



QUV



Q-FOG



Q-SUN