

# How to Run the GMW14872 Cyclic Corrosion Laboratory Test

## 如何运行实验室循环腐蚀测试GMW 14872

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# Topics

- Overview and Timeline of GMW 14872

GMW 14872 概述和发展

- Environmental conditions & transitions

环境条件和转换

- Salt spray solution and procedure

盐溶液配置

- Corrosion coupons use and mass loss requirements

标准腐蚀板和失重要求

- Controlling the mass loss

失重控制



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

# GMW14872 Overview

## GMW 14872 概述

- First published 2006

2006首次发布

- Derived from GM9540P (1991)

来自GM9540P

- Designed around three workday “shifts” of 8 hours each  
设计了3个工作日的轮班，每个轮班8小时

- GM times tests according to standard coupon mass loss  
根据标准片的失重设定测试时间

- Probably the world’s most popular cyclic corrosion test method

全球最广泛使用的循环盐雾测试



# Major Changes from GM9540P to GMW 14872

## 主要的变化从GM9540P到GMW 14872

- GM9540P included 4 different thicknesses of corrosion coupons; GMW 14872 includes only one: 1/8 inch (3.18 mm)

GM9540P包含4种不同的腐蚀板厚度；GMW14872只使用一种：1/8英寸

- Sodium bicarbonate ( $\text{NaHCO}_3$ ) concentration reduced from 0.25% to 0.075%

碳酸氢钠浓度从0.25%降低为0.075%



# GMW14872 Revisions

## GMW 14872不同历史版本

Publication Date 发布时间	Major changes 主要差异
November, 2006	Initial Publication 首次发布
March, 2010	None to the technical parts of the test method 技术部分没有差异
March, 2013	Corrosion coupon mass loss rate increased 腐蚀板失重速率变大 Longer duration Method E added 加入更长测试时间Method E
October, 2018	None to the technical parts of the test method 技术部分没有差异

# GMW14872 General Comments

- Standard is performance based; no specific hardware requirements

标准是基于性能的而非硬件要求的

- GM times tests on specific mass loss of standard coupon (we'll explain a modification of the technique for non-GM approval testing)

根据标准片的失重设定测试时间（我们之后会讨论一种调节失重的方法，虽然不在标准中提及）

- Lots of very useful information and tools within the document  
在该标准中有很多有用的信息和工具

# Environmental Conditions: 8 hour stages (shifts)

## 环境条件：8小时制的轮班

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

环境温湿度: 25°C, 45% RH, 间歇性的喷淋

- 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

潮湿阶段: 100% RH, 49°C, ~1小时过渡

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

干燥阶段: ≤30% RH, 60°C, ~3小时过渡

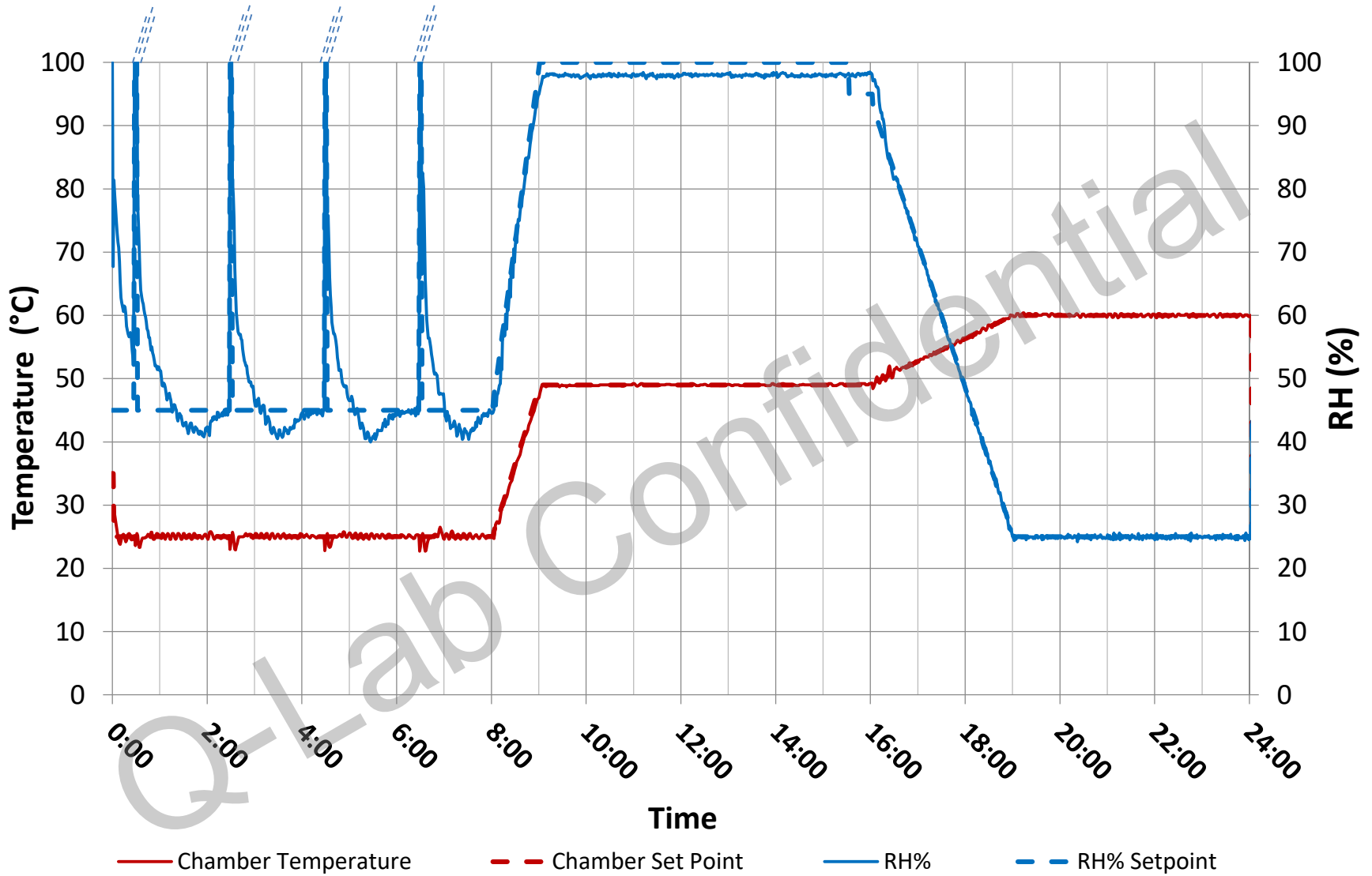
# Q-FOG Program for GMW14872

## Q-FOG设置GMW 14872程序

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					



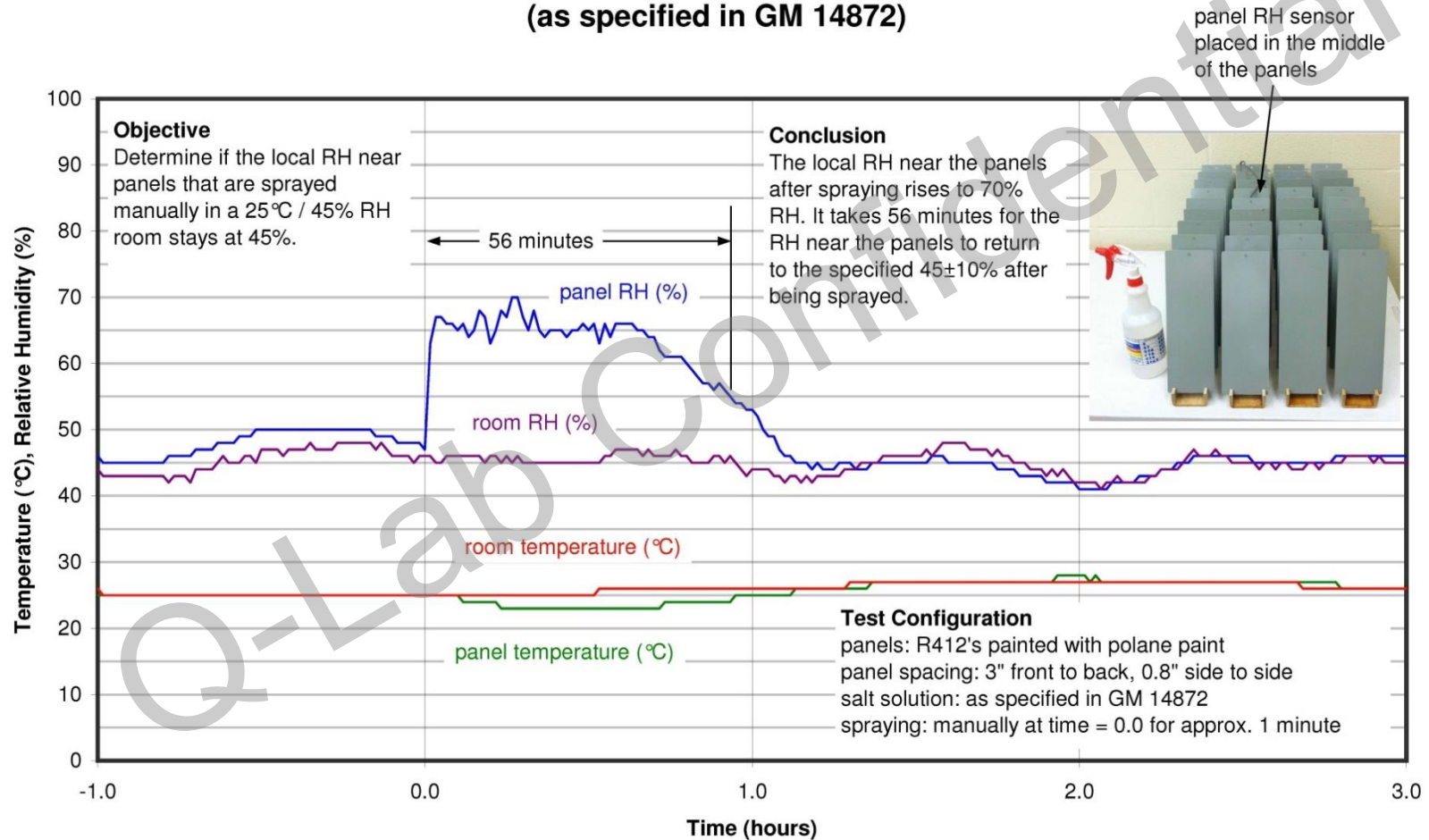
# GMW14872 Cycle, Q-FOG CRH1100-HSCR



# Salt Spray in Ambient Conditions

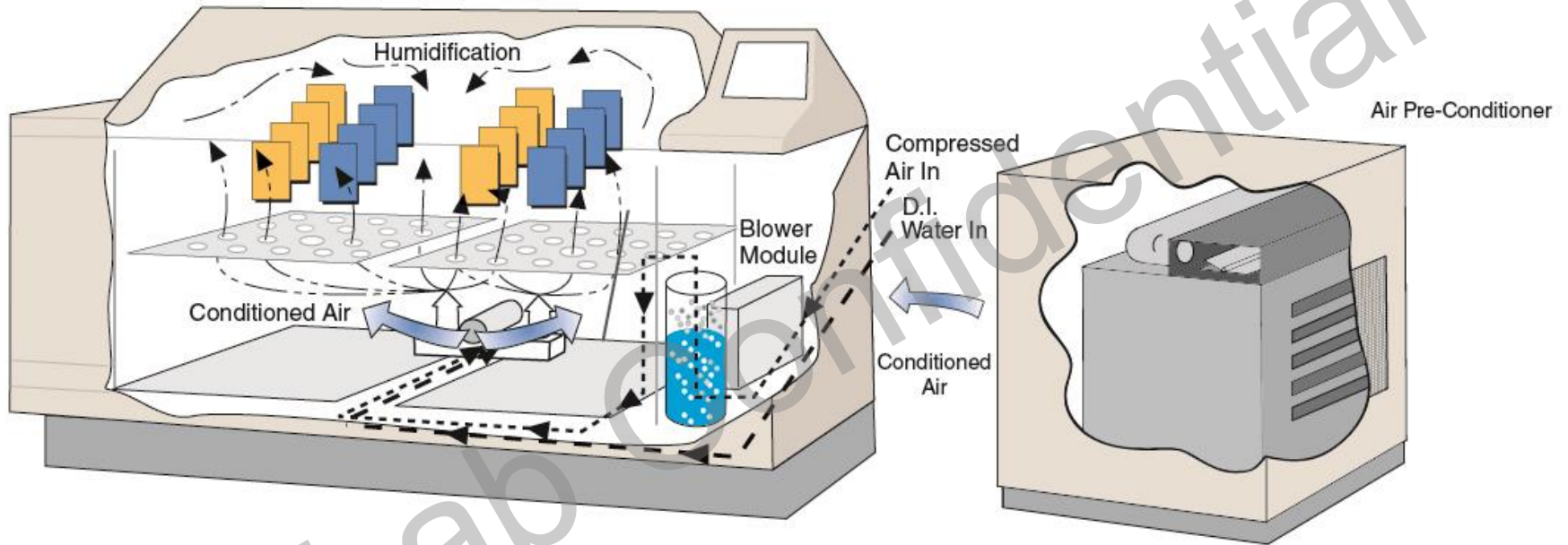
## 在环境温湿度的喷淋

### Relative Humidity Near Panels when Manually Sprayed in a 25°C / 45% RH Room (as specified in GM 14872)



# Corrosion Test Control: Air Pre-Conditioner

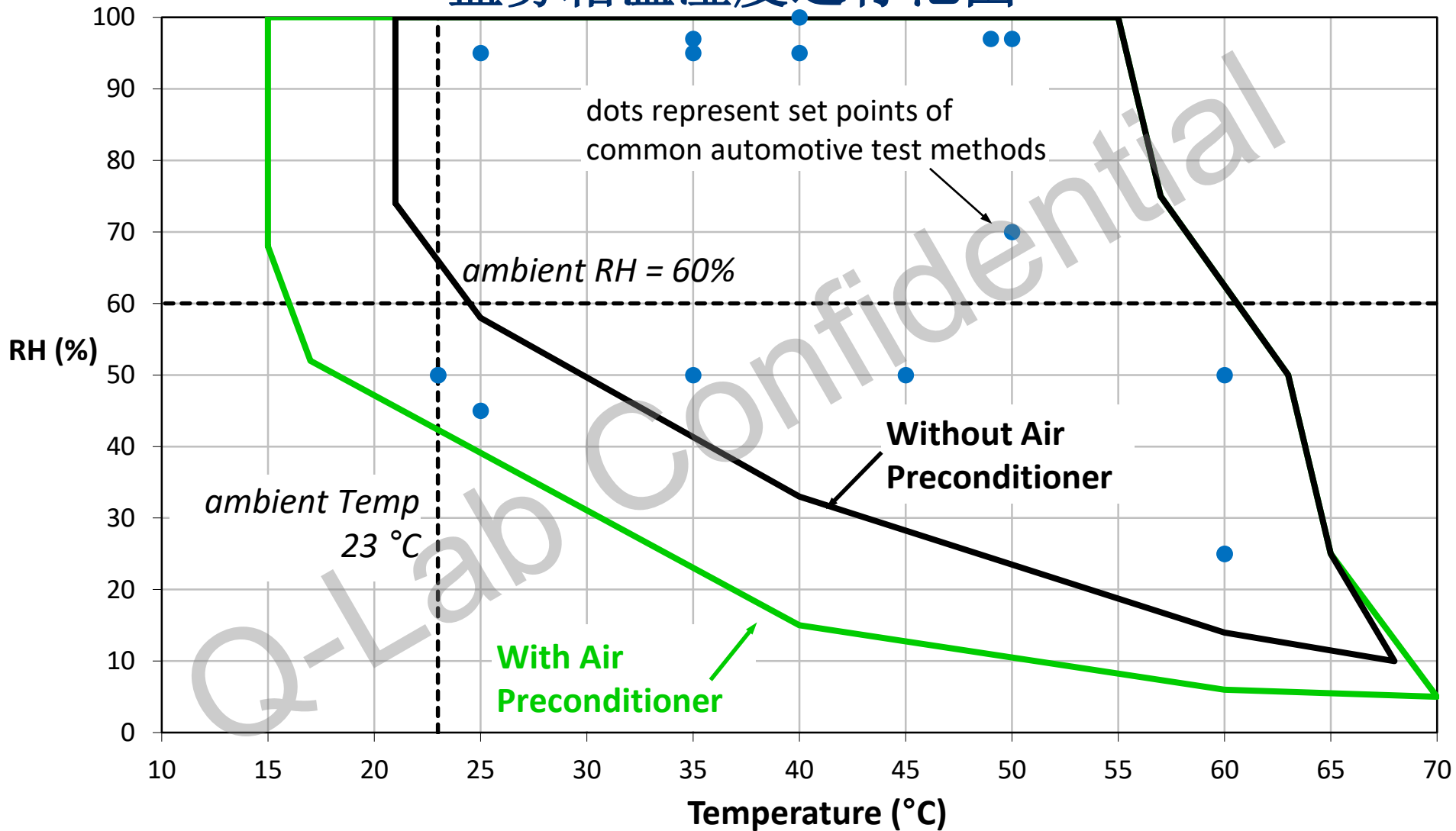
## 腐蚀测试的控制：空调



- Accurate control of “ambient” conditions 更精准的环境温湿度条件控制
- Accurate Ramping of Temperature & Humidity 更精准的温湿度转换控制

# Corrosion Test Operational Range

## 盐雾箱温湿度运行范围



# Salt Spray Application

## 喷淋的应用

- Spray duration and volume not quantified

喷淋时间和喷淋量没有规定

- “Approximately 1.5 h” between salt applications

每次喷淋大概间隔1.5小时

- “mist the samples and coupons until all areas are thoroughly wet/dripping”

润湿样品直到所有区域都潮湿

- “sufficient to rinse away any salt accumulation left from previous sprays”

喷淋要可以足够冲洗掉之前喷淋留下的盐

- “Force/impingement” should not remove corrosion products or damage coatings

喷淋不可以去除腐蚀产物或者破坏涂层

# Spray Solution

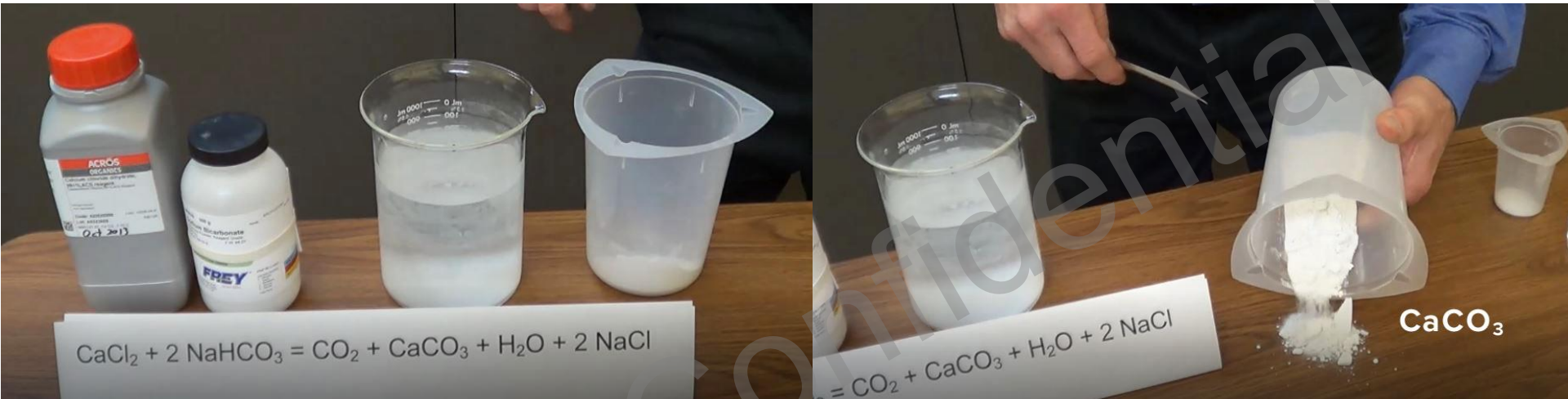
## 喷淋溶液

Chemical Component	Percent by Mass	Notes
Sodium Chloride <sup>1</sup> (NaCl)	0.9%	Reagent grade or Morton Culinox 999 food grade
Calcium Chloride <sup>2</sup> (CaCl <sub>2</sub> )	0.1%	Reagent grade
Sodium bicarbonate (NaHCO <sub>3</sub> )	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<sub>2</sub> is often packaged in hydrated form; see Appendix B for correct recipes for anhydrous, one hydrate, and dihydrates

# Mixing the Solution

## 溶液混合



- Precipitate of Calcium Carbonate ( $\text{CaCO}_3$ ) will form if solution isn't made properly

如果溶液配制不当，将形成碳酸钙( $\text{CaCO}_3$ )沉淀

- Calcium Carbonate ( $\text{CaCO}_3$ ) is insoluble in water and can wreak havoc on your chamber (Q-FOG mitigates the problem)

碳酸钙( $\text{CaCO}_3$ )不溶于水，会对你的试验箱造成严重破坏（Q-FOG可以缓解这个问题）



# Improper Mixing Example

## 不正确的混合

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



Sodium Bicarbonate  $\text{NaHCO}_3$



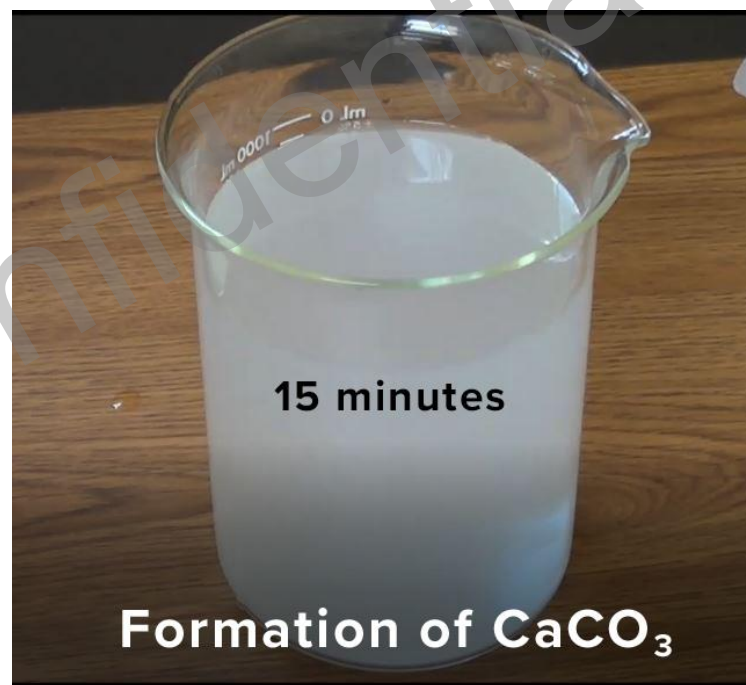
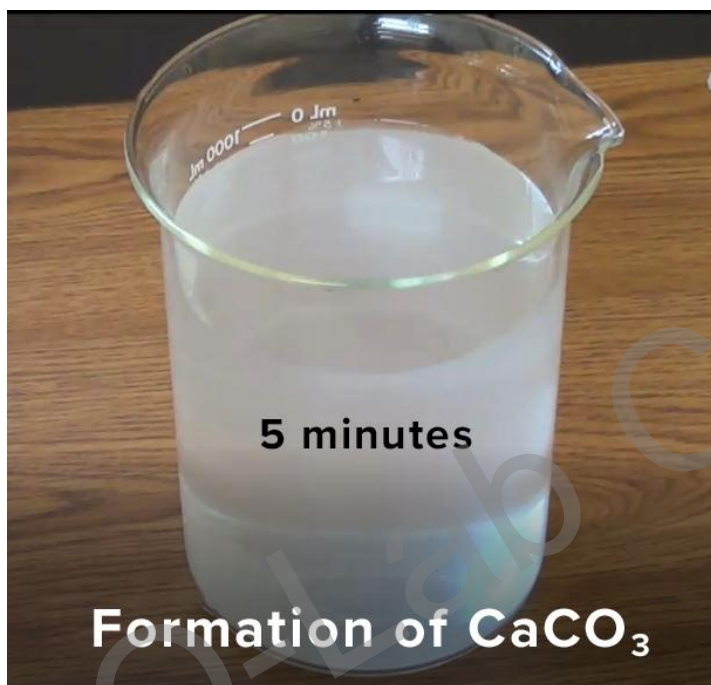
Stir both solutions until all chemicals are dissolved.

Mix the two solutions together

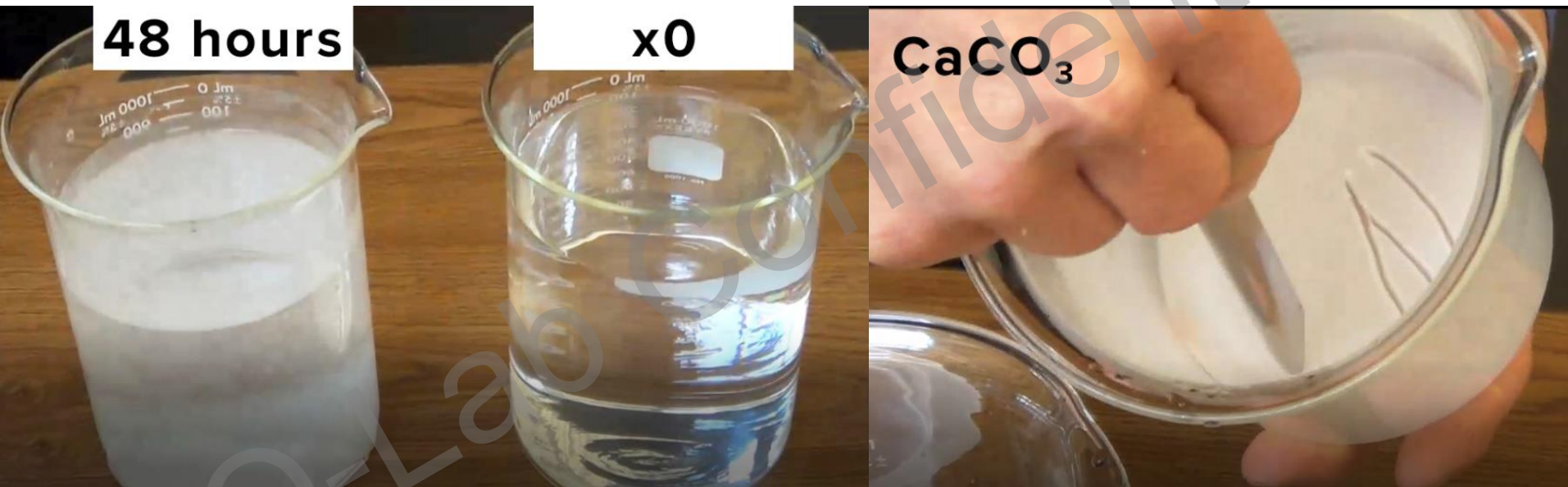




# Just watch...



# Chalk it up to Chemistry



# How to Mix Solution

## 如何配置溶液

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

请参考附录B的配方，使用加仑或者升单位，取适量无水氯化钙、一水合物氯化钙或二水合物氯化钙



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

在储液箱（大桶）中装满水，利用虹吸取出两小桶水，大概各10%

2. Dissolve NaCl in the remaining reservoir water

在储液桶（大桶）中溶解氯化钠

3. Dissolve sodium bicarbonate in container 1 and calcium chloride in container 2

在2个小桶中分别溶解碳酸氢钠和氯化钙



Container 1



Container 2

4. Pour the  $\text{NaHCO}_3$  solution into the main  $\text{NaCl}$  reservoir and mix  
将碳酸氢钠溶液倒入溶解有氯化钠的大桶中并搅拌

5. Pour the  $\text{CaCl}_2$  solution into the main reservoir and mix  
将氯化钙溶液倒入大桶中并且搅拌





# Nozzle Flushing

## 喷嘴自清洗



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

喷淋之后，低压纯水会从喷嘴微微冒出，起到冲洗的效果

# Corrosion Coupons

## 腐蚀标准片



SAE 1008-1010, SAE  
J2329 CR1E

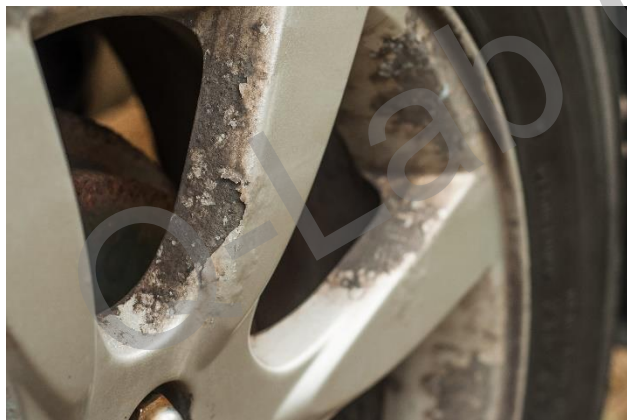
25.4 x 50.8 x 3.18 mm (1 x  
2 x 1/8 inch)

Mounting hole in center  
and alphanumeric stamp  
included

中间有安装孔且有字母  
和数字钢印

# Tables A1, A2

Exposure D  
9.47 g  $\pm$  0.38 g  
(430  $\mu$ m  $\pm$  17  $\mu$ m)  
63 cycles  $\pm$  7 cycles



- GM determines test duration by achievement of specified mass loss

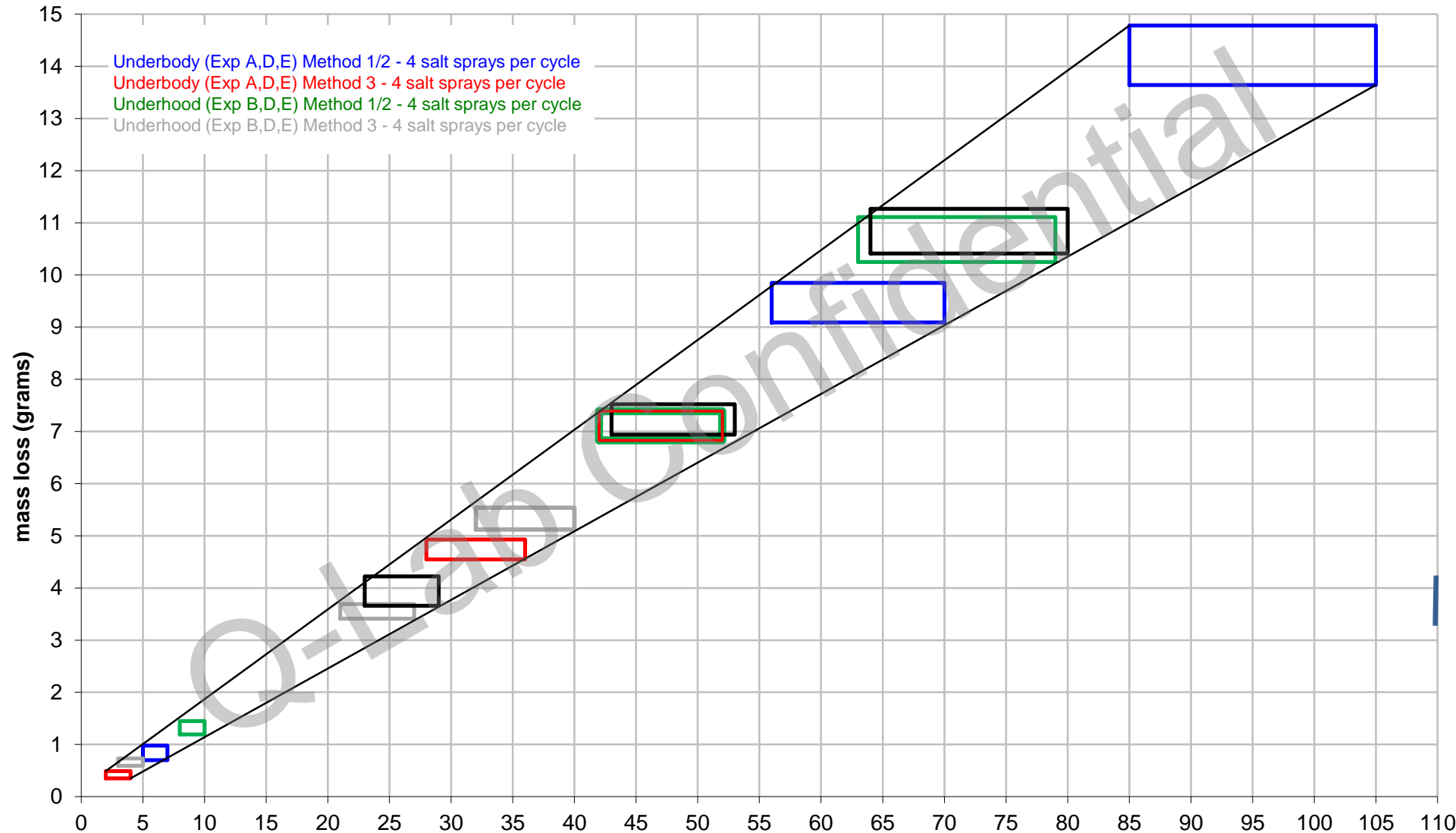
在规定的测试周期内达到失重的要求

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

失重和循环数组成了测试的容差



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



# Mass Loss Rates

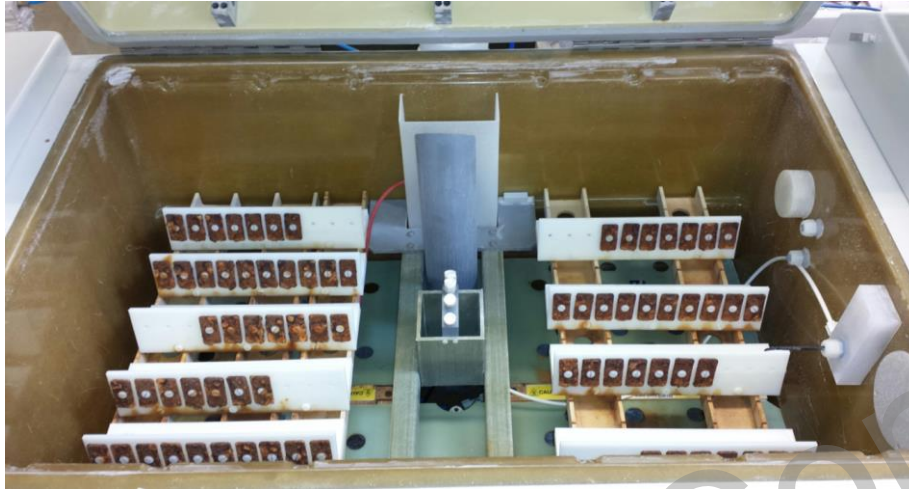
## 失重速率

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

2013版缩短了测试循环数来达到原来的失重目标

# Using Corrosion Coupons 使用标准腐蚀片



- Coupons are mounted 15° from vertical  
与垂直方向呈15度安装
- At least 5 mm spacing between coupon and bracket  
腐蚀片和托架之间的间隔大于5mm

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

***预清洗和去腐蚀产物可能导致失重值偏低***

# Pre-Exposure Cleaning

## 预清洗

Cleaning Process:

清洗过程:

1. Parts cleaning degreaser

脱脂剂

2. DI water and dish soap—coupons & soapy water poured between two containers

去离子水和清洗剂

3. Rinse in DI water by pouring between two containers

去离子水冲洗

4. Rinse in acetone (same technique)

丙酮冲洗

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

Q-Panel 腐蚀板预清洗，可拆包即用



# Corrosion Product Removal

## 腐蚀产物去除

- Chemical removal not recommended (too slow and inefficient)  
化学清洗不推荐（太慢且除不干净）
- It is more likely you won't remove all rust than remove uncorroded metal  
你应该担心没有除锈干净而不是担心会把未腐蚀的金属去除
- Begin by tapping coupons with a hammer  
先用锤子去除较厚的腐蚀产物
- Bead blast with metal finishing glass beads
  - We use 60-80 psi (415-550 kPa) pressure
  - 100-200  $\mu\text{m}$  nominal diameter beads
  - Clean all sides of panel (1-2 minutes)



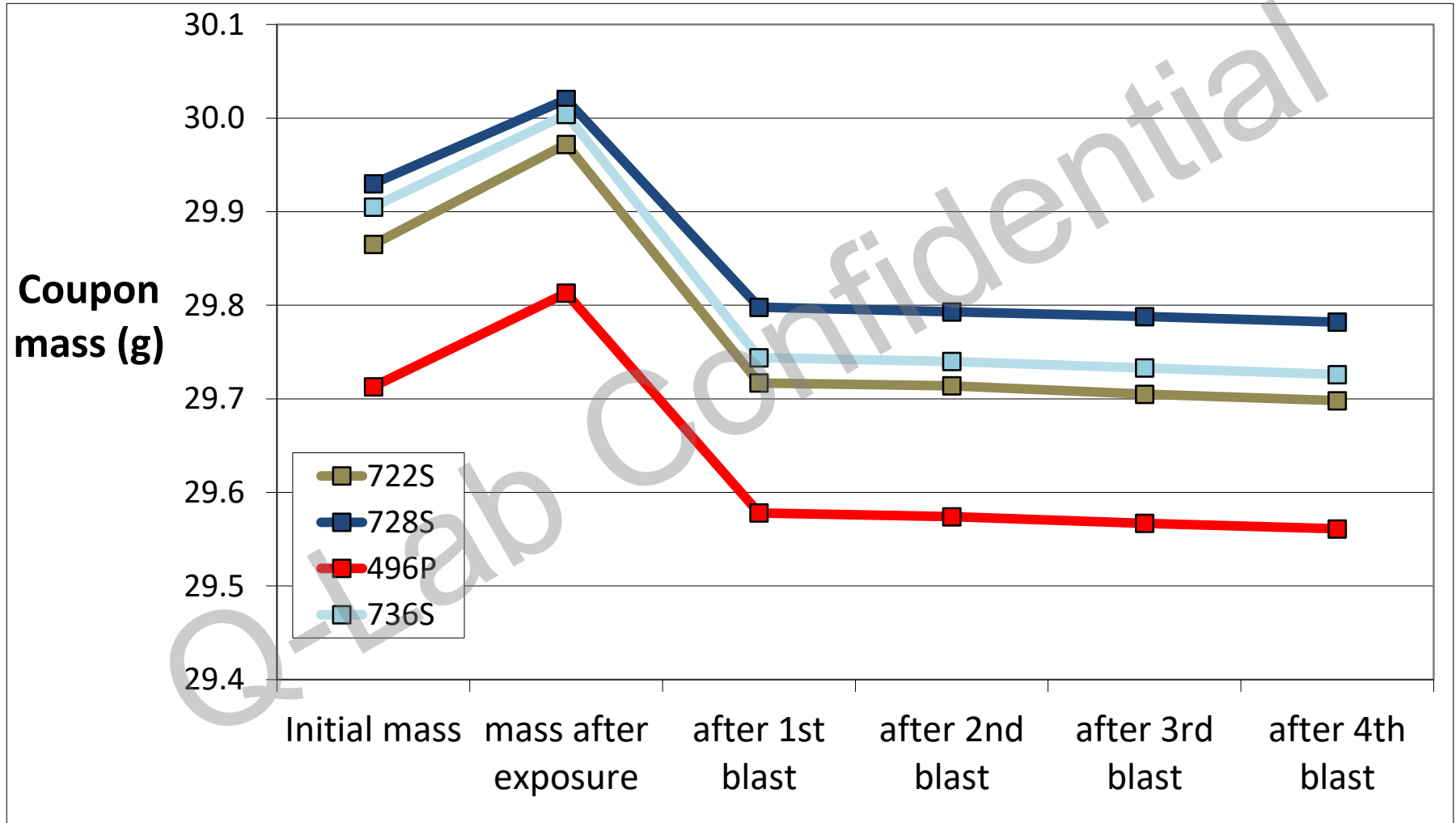
# Mass loss after one cycle of GMW 14872 and four sand blast operations

腐蚀板经过一个周期的测试，做了4个喷砂除锈

Coupon Identifier	Initial mass (g)	Mass Loss 1	Mass Loss 2	Mass Loss 3	Mass Loss 4
722S	29.865	0.148	0.003	0.009	0.007
728S	29.930	0.132	0.005	0.005	0.006
496P	29.713	0.135	0.004	0.007	0.006
736S	29.905	0.161	0.004	0.007	0.007
Average	29.853	0.144	0.004	0.007	0.0065
Percentage of initial mass		0.48%	0.01%	0.02%	0.02%

# Grit Blasting to Remove Post Exposure Rust

## 喷砂去除腐蚀后的产物



# Controlling Mass Loss

## 失重控制

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

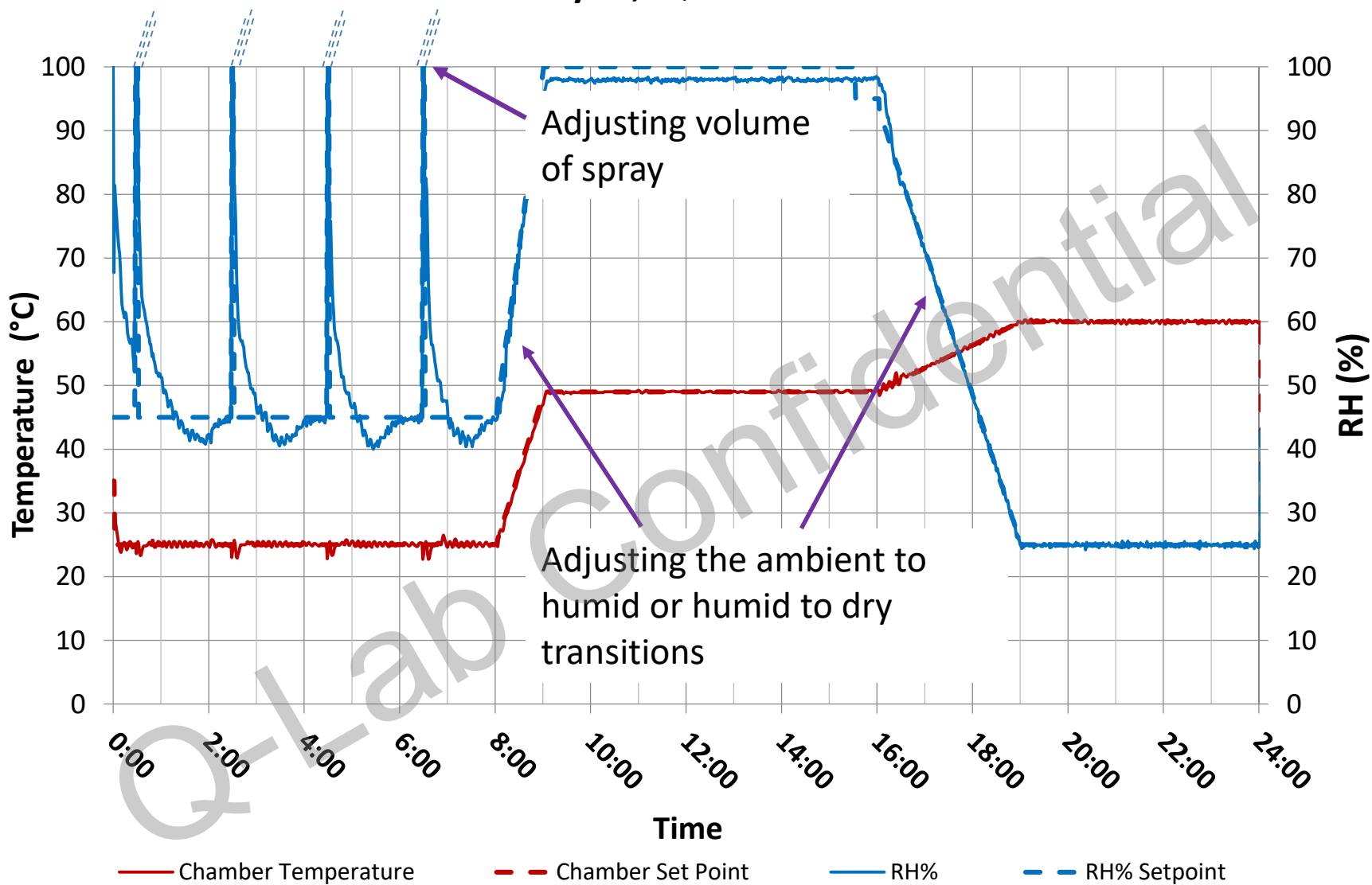
两种技术 – 标准中有提及一种，另一种推荐给Q-FOG的用户



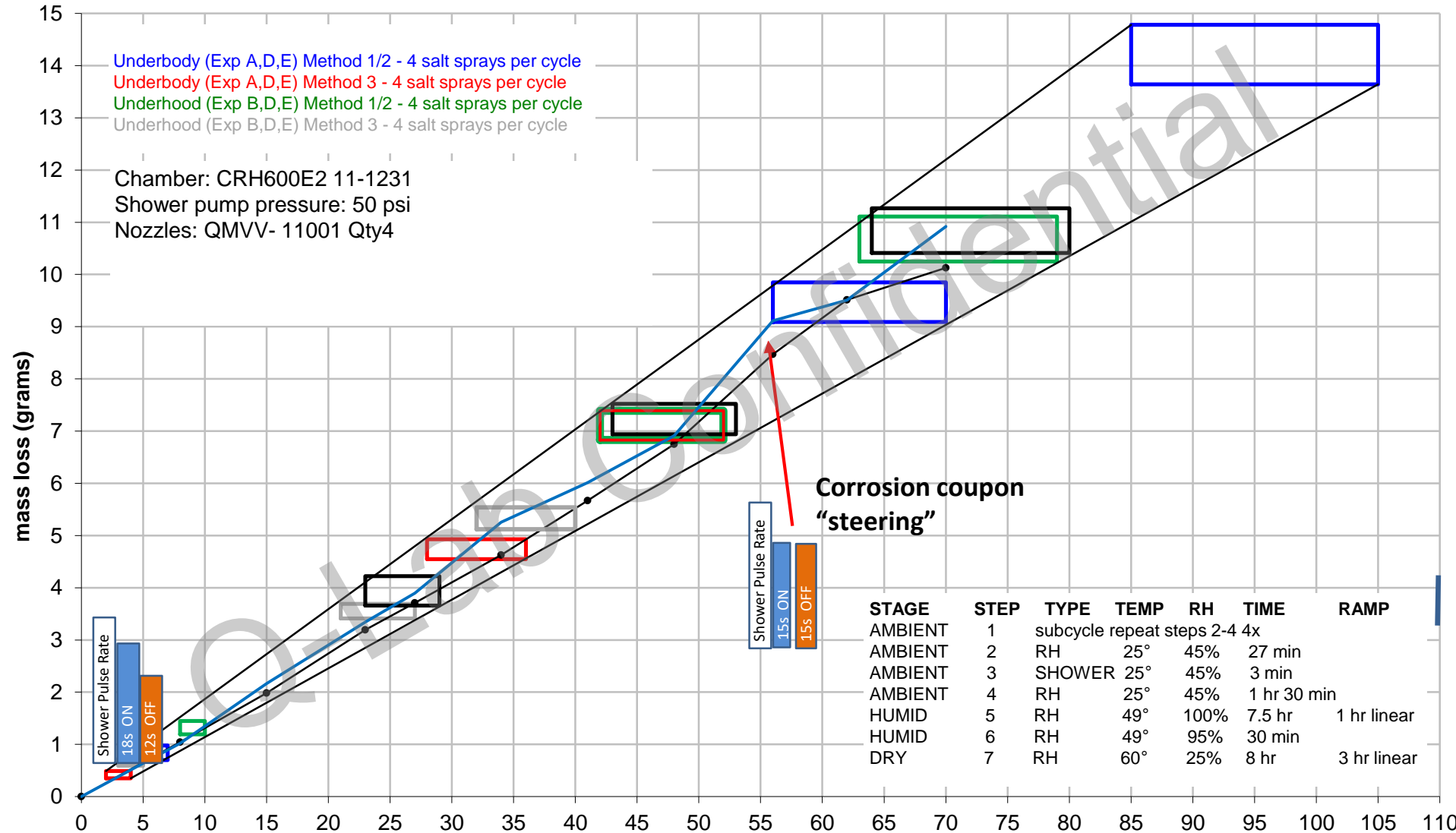
1. Adjusting climatic transitions 调节转换时间
2. Adjusting volume of solution spray 调节喷淋流量



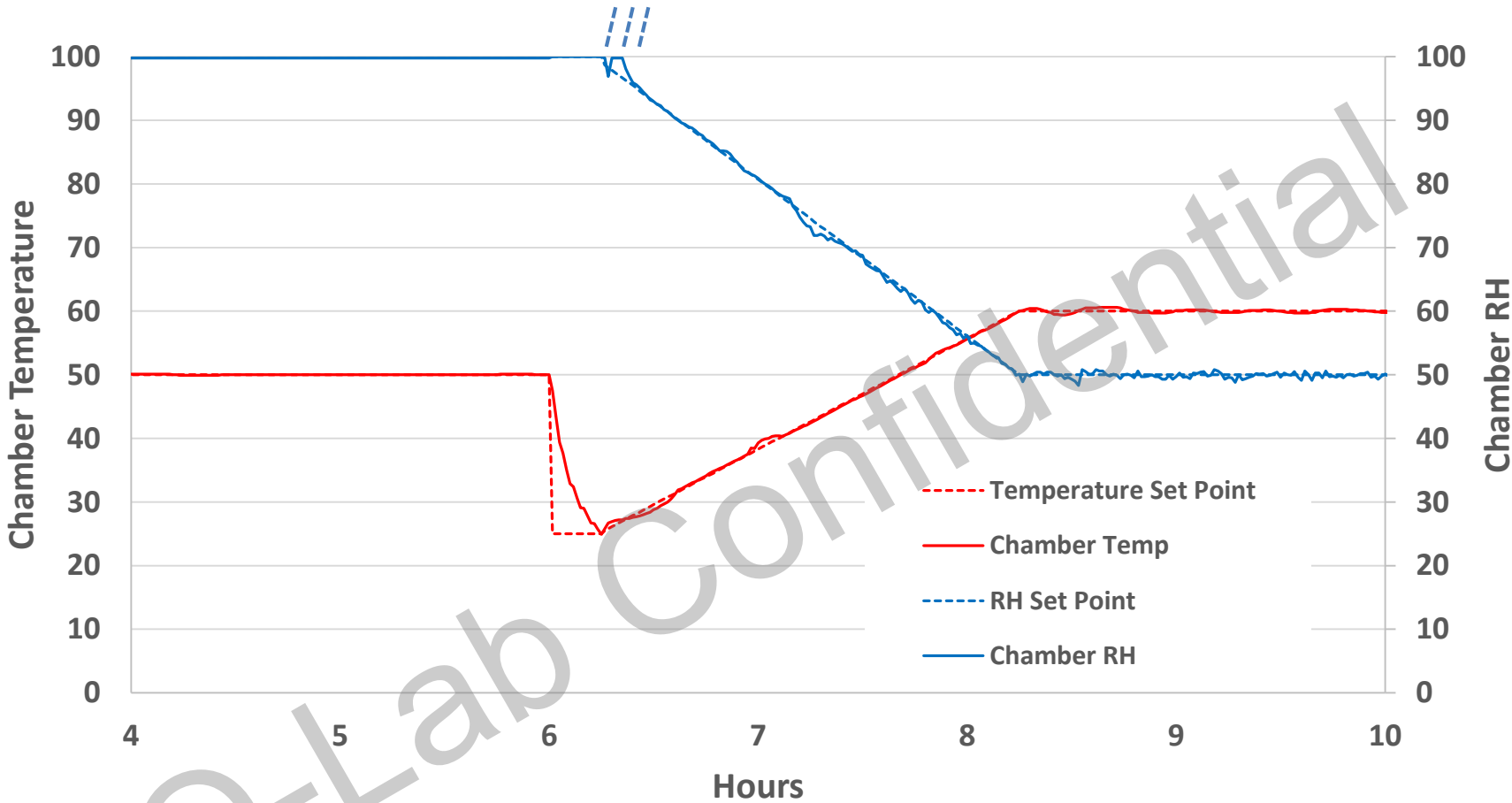
# GMW14872 Cycle, Q-FOG CRH1100-HSCR



# GMW 14872 Mass Lost Test - Start Date 13 May 2015



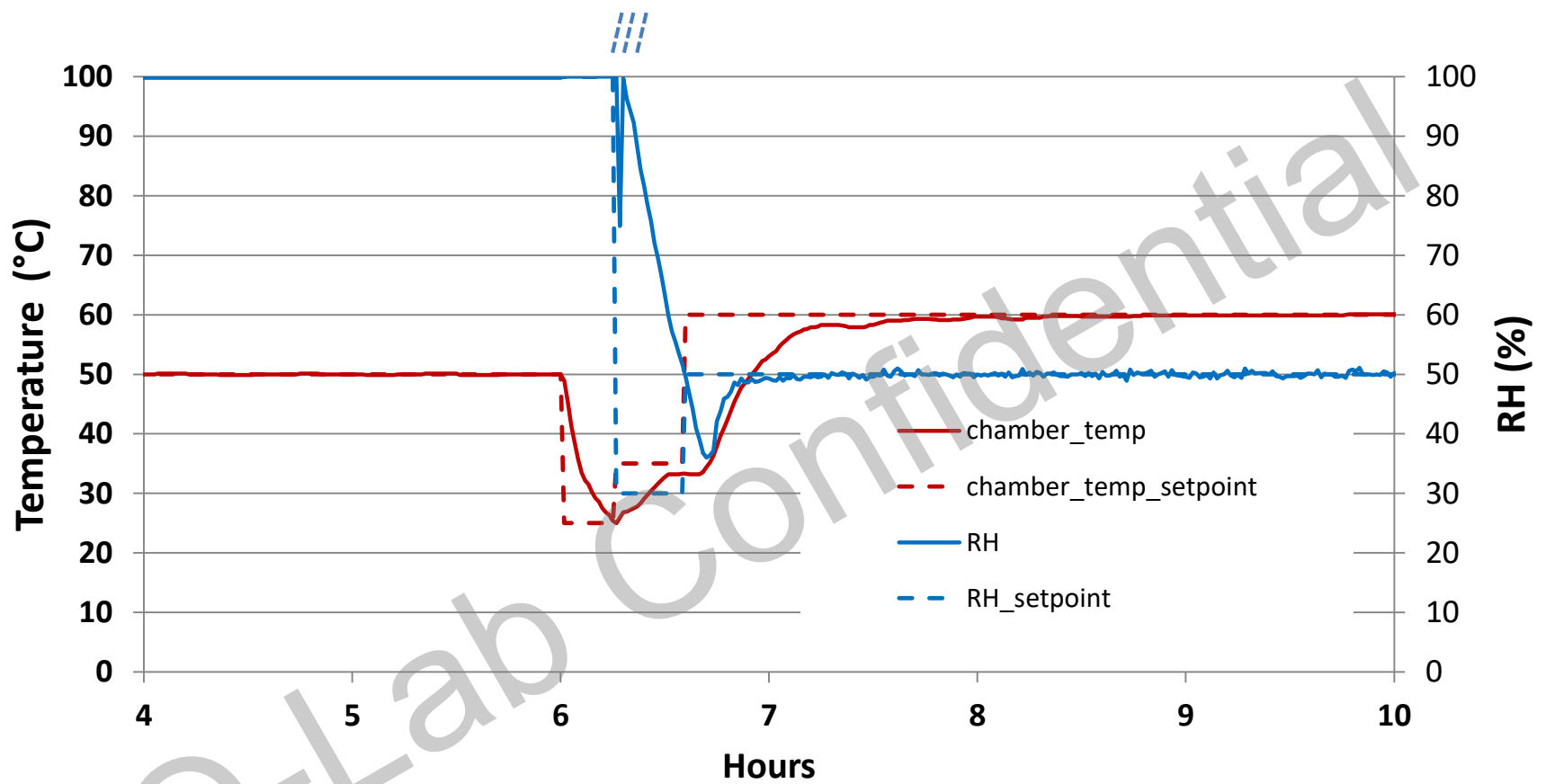
# SAE J2334 Cycle (Slow Dry-Off)



*Zoomed in view of the transition*

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

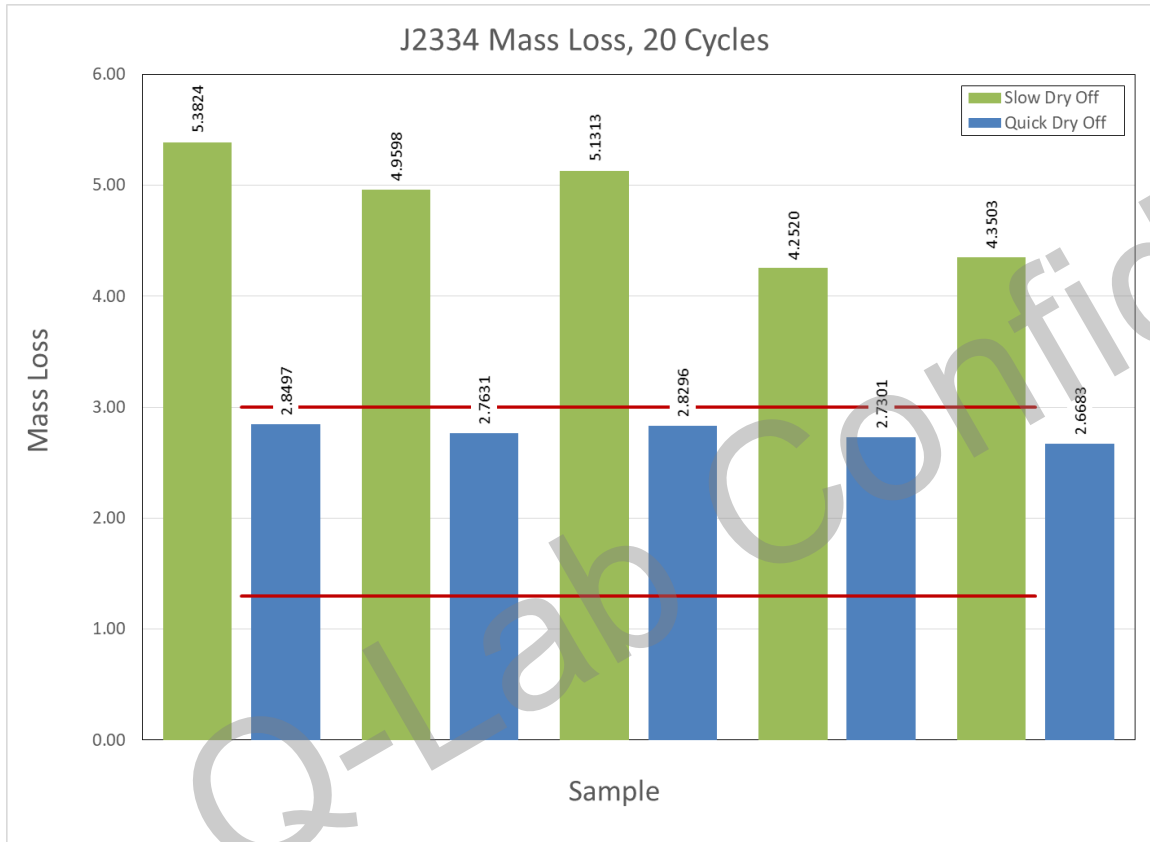
# SAE J2334 Quick Dry-Off



*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

## 失重的控制

- The Q-FOG allows on/off pulsing of spray nozzles and easy adjusting

Q-FOG 可以改变喷淋的脉冲时间on/off

- Controlling transition times could also work but is less practical

改变转换时间也起作用但是操作性不强

# Summary

- GMW14872 overview and brief history

## GMW 14872 概述和历史

- Overcoming biggest challenges:

### 测试的最大挑战:

- Maintaining ambient conditions

维持环境温湿度条件

- Preventing precipitate formation in solution and plugging of spray nozzles

避免沉淀生成和堵塞喷嘴

- Pre-exposure cleaning to remove oil

清洗标准腐蚀板

- Removing all rust prior to mass loss measurement

腐蚀产物的去除

# Question?



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