# Mixed Flowing Gas Test

## An Accelerated Corrosion Test

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# What is MFG test?

## brief introduction to MFG test

# What is MFG test?

- Electronic devices comprise a variety of materials that are highly corrosive. Without question, molecular gaseous pollutants such as $H_2S$, $NO_2$, $Cl_2$ and $SO_2$ are harmful to electronic equipment.

- With the specific analysis method like **MFG (mixed flowing gas) test**, we can understand the severity level of air quality in field or end-user environment.

# What does MFG test involve?

- MFG testing simulates the real-world corrosion from environmental exposure conditions and evaluates the risk of the premature corrosion.

- Temperature (°C), relative humidity (%), and concentration of gaseous pollutants and other essential variables, such as airflow and volume exchange rate, are carefully defined, monitored, and controlled.

# Classification of Reactive Environments

**[ANSI/ISA Standard 71.04]**

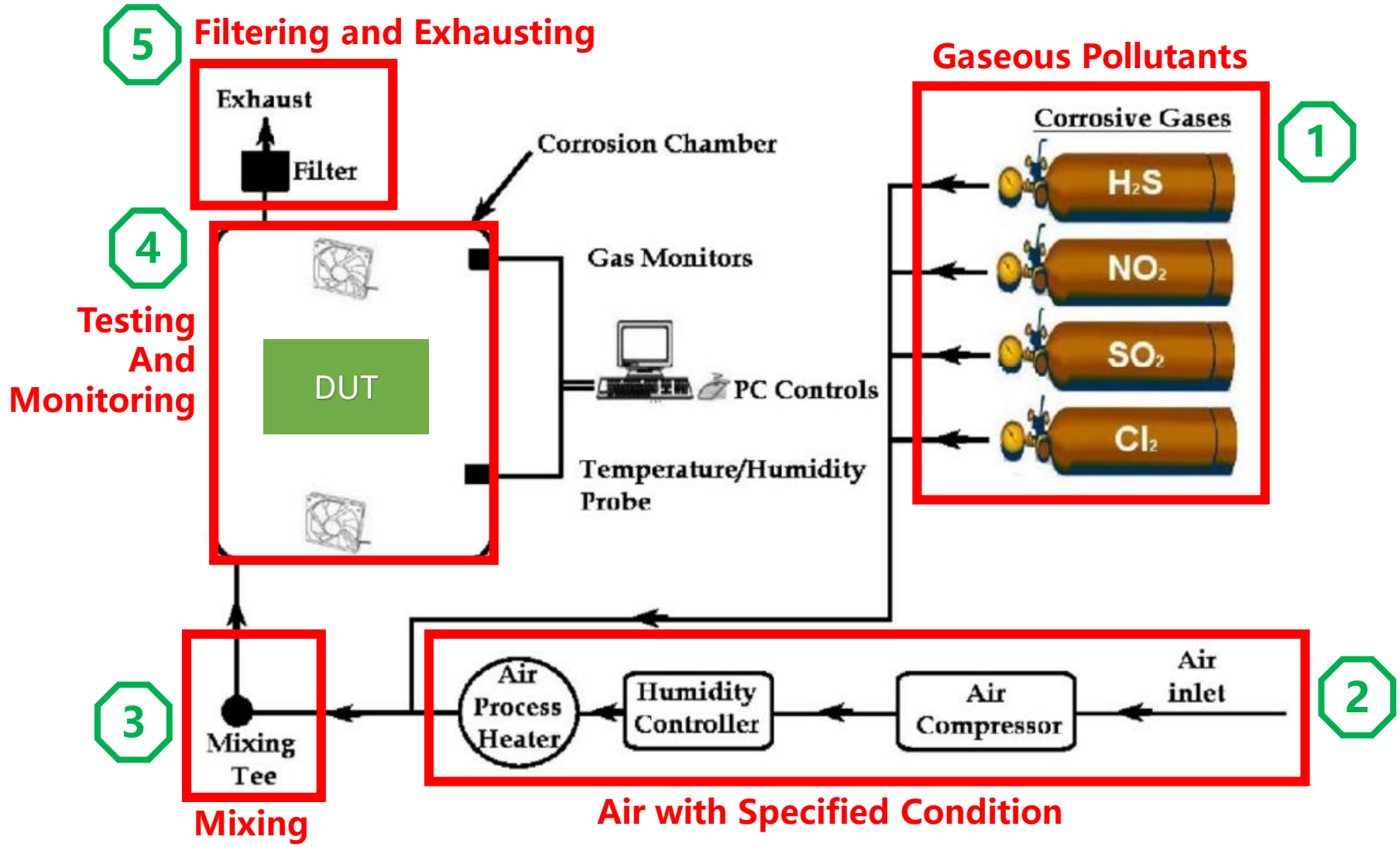
Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants

| Severity Level | Reactivity Level (Å/month) | | Description |
|---|---|---|---|
| | Silver | Copper | |
| G1 [Mild] | <200 | <300 | An environment sufficiently well controlled such that corrosion is not a factor in determining equipment reliability. |
| G2 [Moderate] | <1000 | <1000 | An environment in which the effects of corrosion are measurable and may be a factor in determining equipment reliability. |
| G3 [Harsh] | <2000 | <2000 | An environment in which there is a high probability that corrosive attack will occur. |
| GX [Severe] | ≥2000 | ≥2000 | An environment in which only specially designed and packaged equipment would be expected to survive. |

# Perform a MFG test

## preparation for MFG tests

# MFG Test Flow

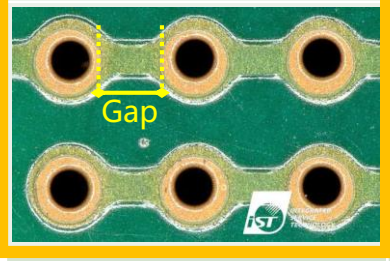
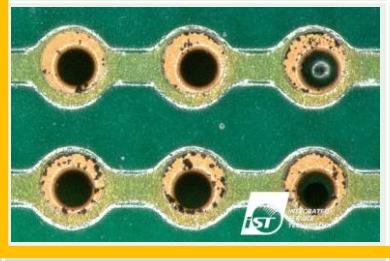
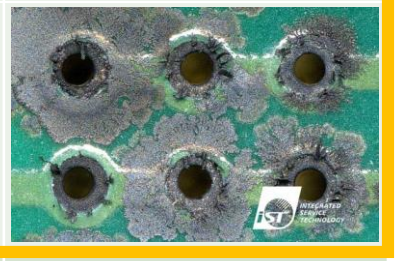


# Test Chamber and Corrosion Coupon

MFG Test Chamber

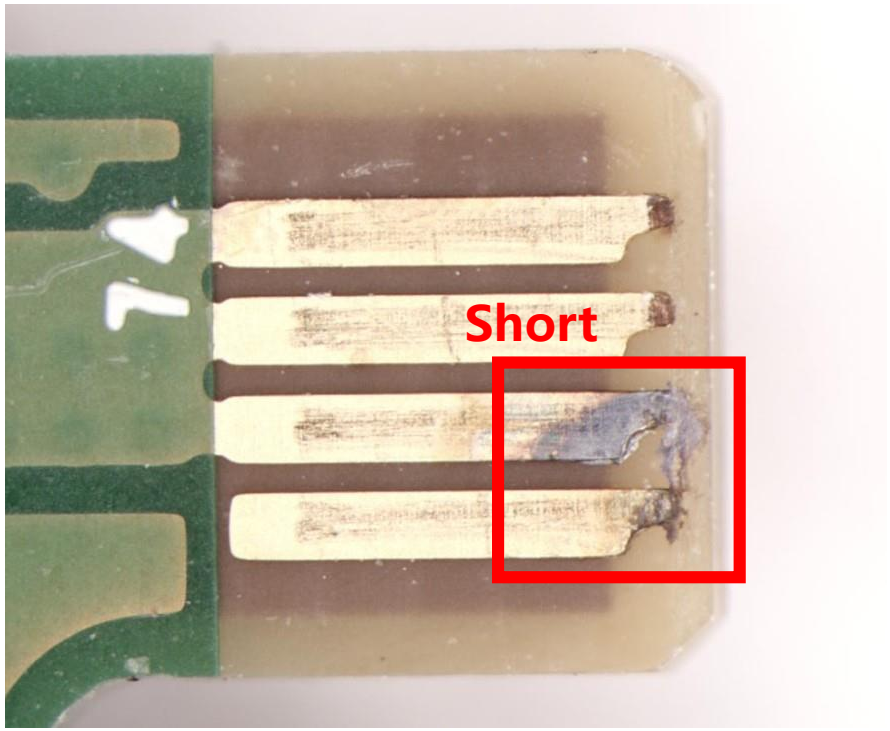

Corrosion Coupon

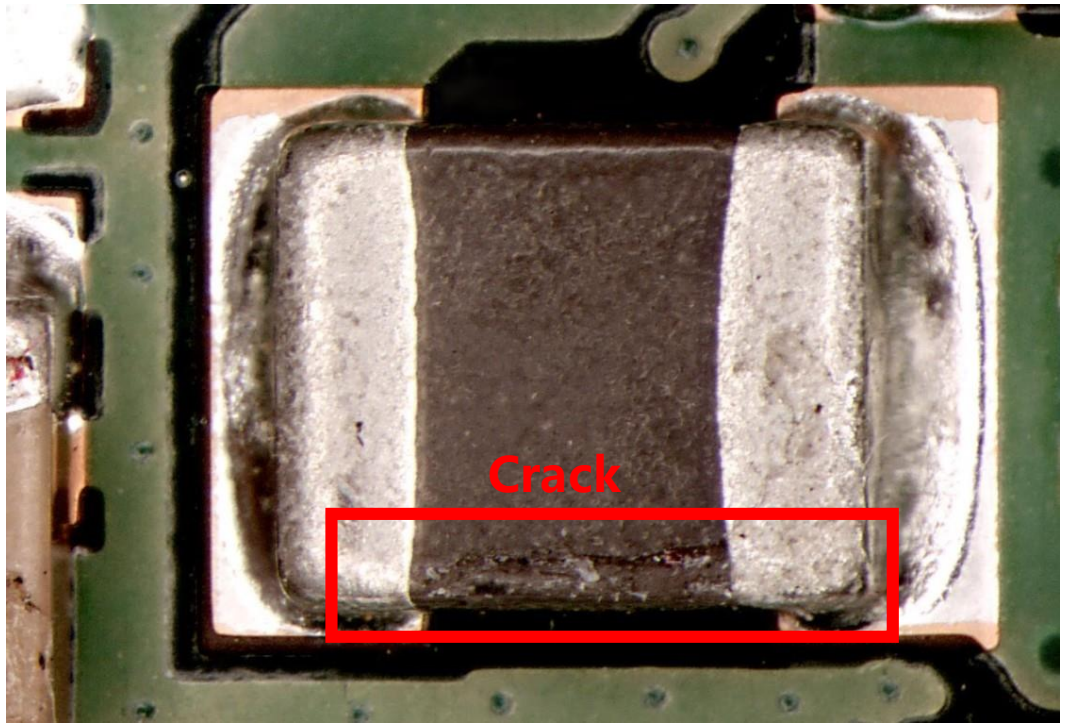
# Visual Inspection Criteria

| Ranking | Rank 0 | Rank 1 | Rank 2 | Rank 3 | Rank 4 |
|---|---|---|---|---|---|
| Corrosion Mode | No Corrosion | Pad/Edge | Light Creep (<1/3 Gap) | Light Creep (> 1/3 Gap) | Heavy Creep (Bridge) |
| Features Photo |   |  |  |  |  |
| Description | Oxidation or tarnishing is OK. | Corrosion limited to pads or holes only, no spread. | Corrosion spreading from pads or holes, but not bridging between features. | Corrosion spreading from pads or holes has potential bridging risk between features. | Severe corrosion, bridging between features already. |
| Results | **Passed** | **Passed** | **Passed** | **Failed** | **Failed** |

**However, the functional test will determine the final result which is Passed or Failed.**

# Severe Corrosion Samples



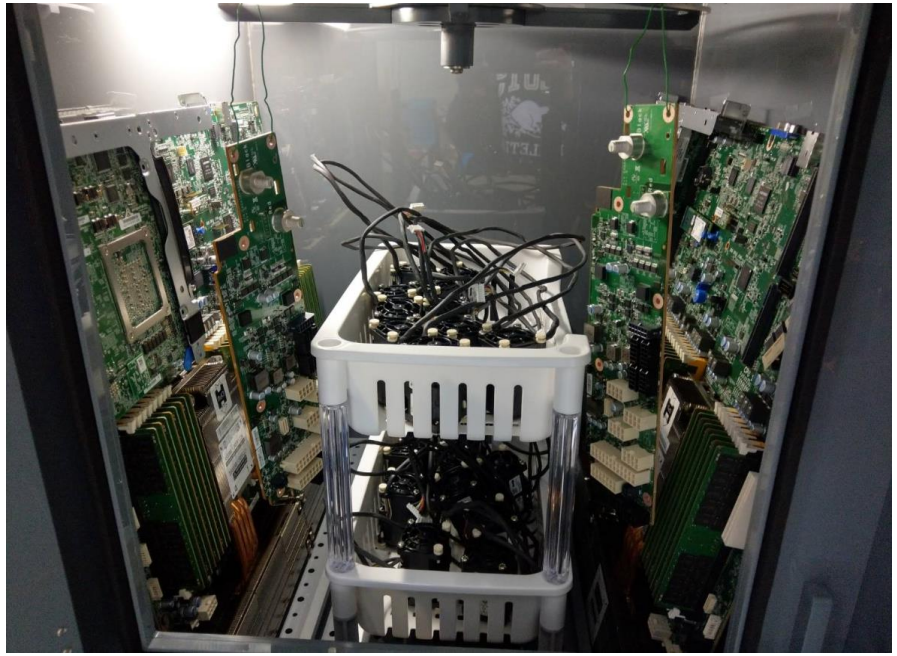

**MFG test samples from Microsoft PE4010 m.2 issue (DoE MFG).**

# Case Study

## a MFG test example

# Test Condition

| Test Condition for Project Ambrose | | | | | | |
|---|---|---|---|---|---|---|
| Temp | RH | Exchange Rate | $H_2S$ | $NO_2$ | $SO_2$ | $Cl_2$ |
| 40°C | 70% | 1,500L/hour | 1,700 ppb | 1,250 ppb | 750 ppb | 50 ppb |
| Test based on customized condition: **ISA Standard 71.04 - Severity Level G3** | | | | | | |



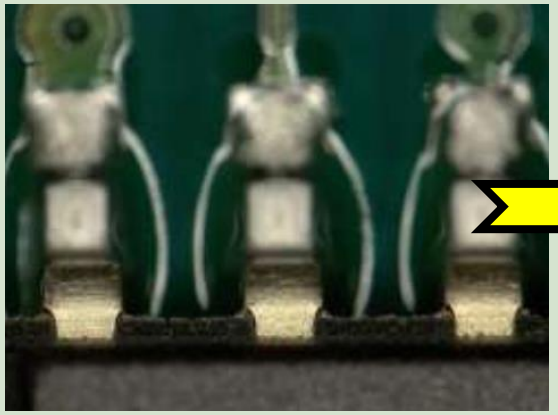
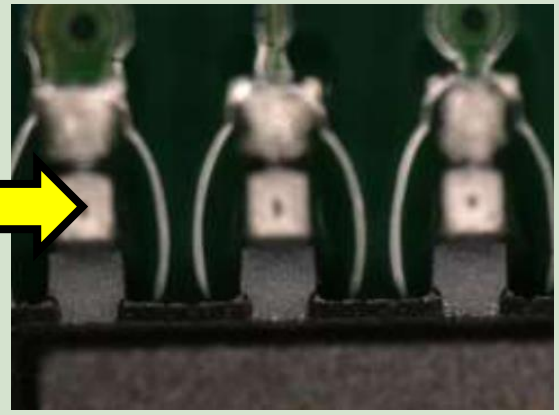
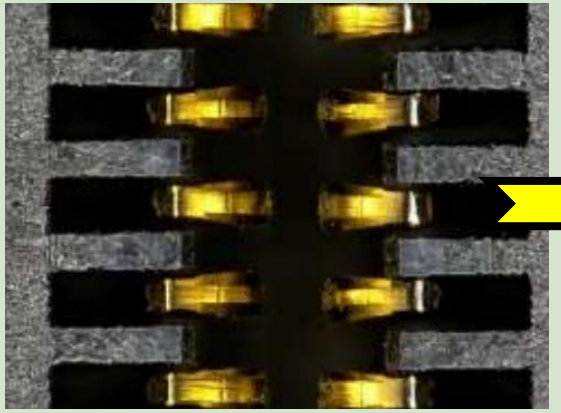
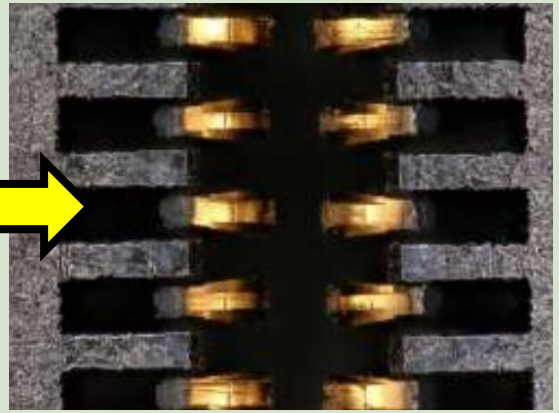
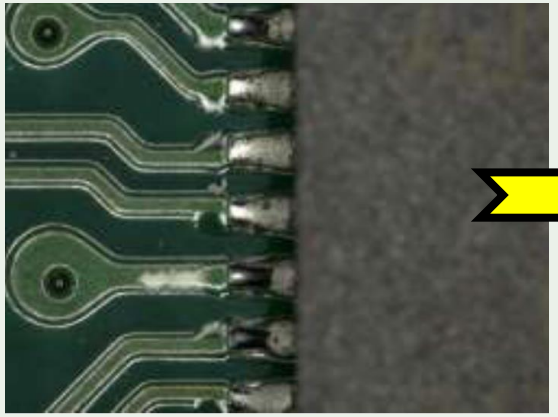
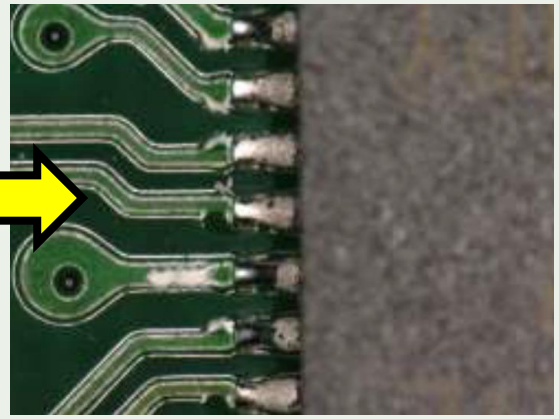
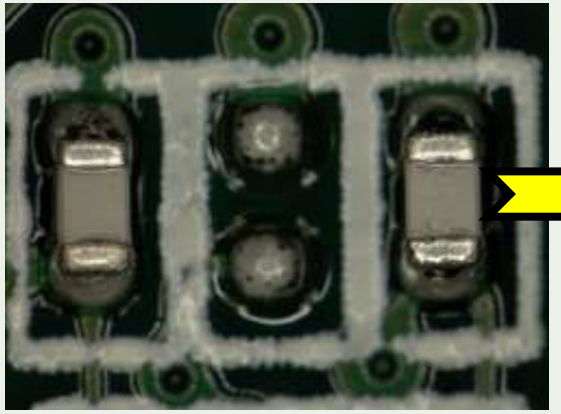
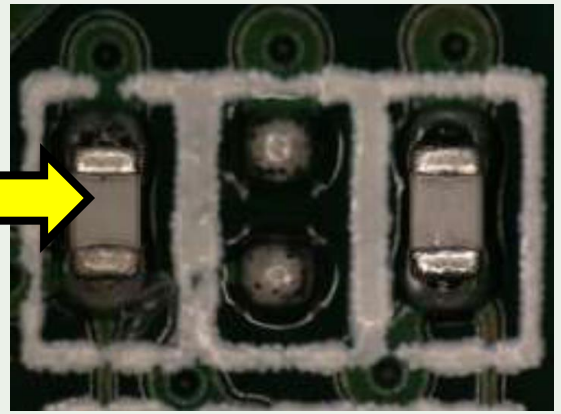
**MFG Test Chamber: Yamazaki GH-180-VL/M**

# Result (1/3) - Thickness Measurement

| Corrosive Reaction Thickness (Angstroms, Å) | | | | | |
|---|---|---|---|---|---|
| Type | Silver (Ag) | | Copper (Cu) | | |
| Symbol | AgCl | $Ag_2S$ | $Cu_2O$ | CuO | $Cu_2S$ |
| Thickness | 0 | 15,260 | 2,470 | 47,010 | 89,850 |
| **Total Thickness** | **15,260** | | **139,340** | | |

| Expected Film Thickness for Corrosion (Angstroms, Å) | | | | |
|---|---|---|---|---|
| ISA Standard 71.04 | Silver (Ag) | | Copper (Cu) | |
| G1 Severity Level (Month/Year) | 200 | 2,400 | 300 | 3,600 |
| G2 Severity Level (Month/Year) | 1,000 | 12,000 | 1,000 | 12,000 |
| G3 Severity Level (Month/Year) | 2,000 | 24,000 | 2,000 | 24,000 |
| **Accelerated Corrosion** | **15,260** | | **139,340** | |
| **Assessed Simulation Time for G1/G2/G3 Level (in Year)** | **6.35 / 1.27 / 0.64** | | **38.71 / 11.61 / 5.81** | |

# Result (2/3) - Visual Inspection

| Before MFG Test | After MFG Test | Before MFG Test | After MFG Test |
|---|---|---|---|
|  |  |  |  |
|  |  |  |  |

# Result (3/3) - Functional Test

| Sample # | Before MFG Test | After MFG Test |
|---|---|---|
| 1 | Stress test passed; no issue found. | Several sensor are no reading or not readable. |
| 2 | Stress test passed; no issue found. | Several sensor are no reading or not readable. |

# Summary

| # | Description |
|---|---|
| 1 | The functional test, which determines the final result, shows failed in this test run though the visual inspection seems to show passed. |
| 2 | The corrosion thickness growth can be satisfied the ISA 71.04 G3 severity level with 0.64-year warranty and 5.81-year warranty for silver and copper, respectively. |

# Thanks!