Cooling Environments





Before the Fluid: How Pre-Immersion Cleaning Chemistry Shapes Long-Term Electronic Reliability

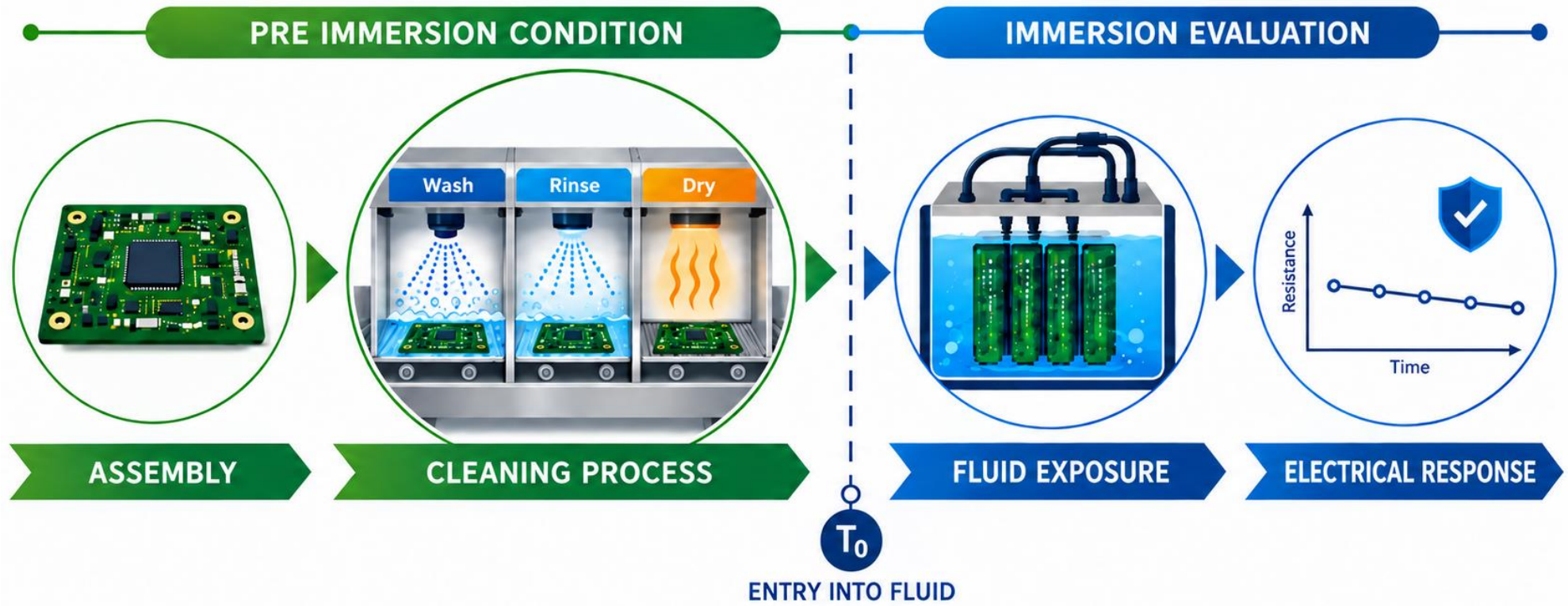
Immersion Project

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OCP BRONZE™ Member

Reliability Begins Before Fluid Exposure

Every assembly enters the fluid with a manufacturing and cleaning history.



How does pre-immersion condition influence behavior in the fluid?

OCP Guidance Establishes the Context

Manufacturing Residues and Cleaning

- Residual solder flux and process residues are recognized contamination sources.
- Cleaning and rinse conditions influence what enters the dielectric fluid.

Material Compatibility

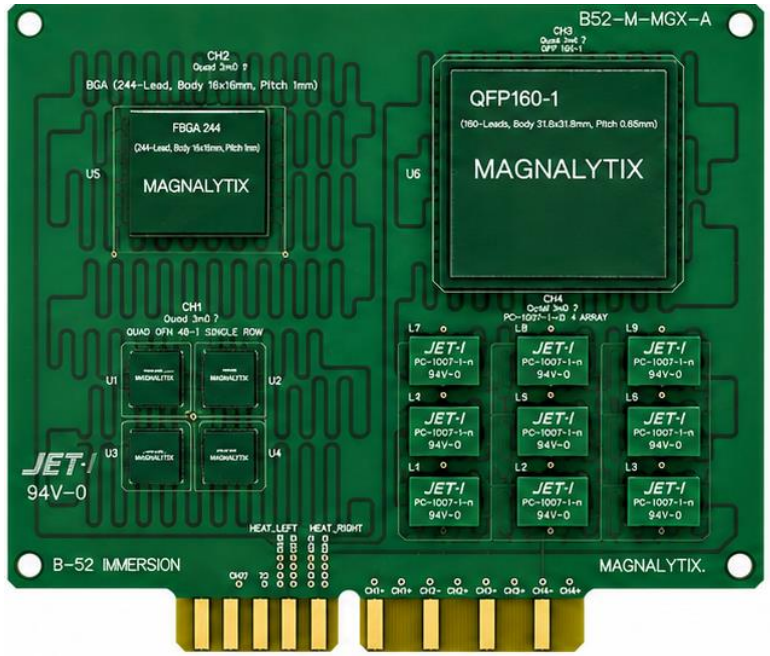
- Assemblies and supporting materials can interact with immersion fluids.
- Contaminant transfer and material compatibility are reliability considerations.

Fluid Condition and Lifecycle

- Fluid quality management includes contamination, fluid condition, and compatibility.
- Monitoring methods support long-term immersion reliability.



Experimental Design



10 TEST CARDS

2 CARDS PER CONDITION

4 ELECTRICAL CHANNELS PER CARD

All cards: SAC305 / ROL0 No-Clean flux. B and D: Solvent-based aqueous chemistry; C: Alkaline-based aqueous chemistry.

TEST CONDITIONS

A	**As Built**	Manufacturing condition retained
B	**Robustly Cleaned**	Complete flux removal
C	**Chemistry Mismatched**	Poor flux/chemistry solubility match
D	**Poorly Rinsed**	Complete flux removal. Poor chemistry rinse
E	**Post-Immersion IPA Rework**	Manual IPA cleaning after immersion fluid exposure

COMPARISON STRATEGY

A ↔ B	B ↔ C	B ↔ D	E
Residue Condition	**Chemistry Type**	**Rinse Completeness**	**Post-Immersion Rework**

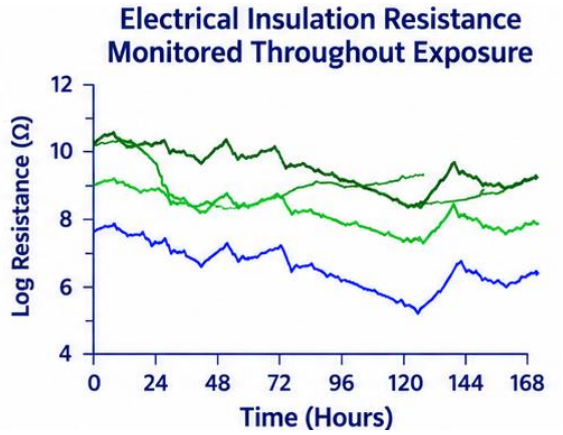
Fluid Exposure and Measurement Strategy

Initial Condition

- **A** As Built
- **B** Robustly Cleaned
- **C** Chemistry Mismatched
- **D** Poorly Rinsed
- **E** Post-Immersion IPA Rework

Fluid Exposure: Continuous EID Monitoring





Independent fluid for each condition

Two cards run in sequence; card 2 entered card 1's heated fluid

4 channels per card, logged every 30 s

Post-Exposure Analysis

Assembly

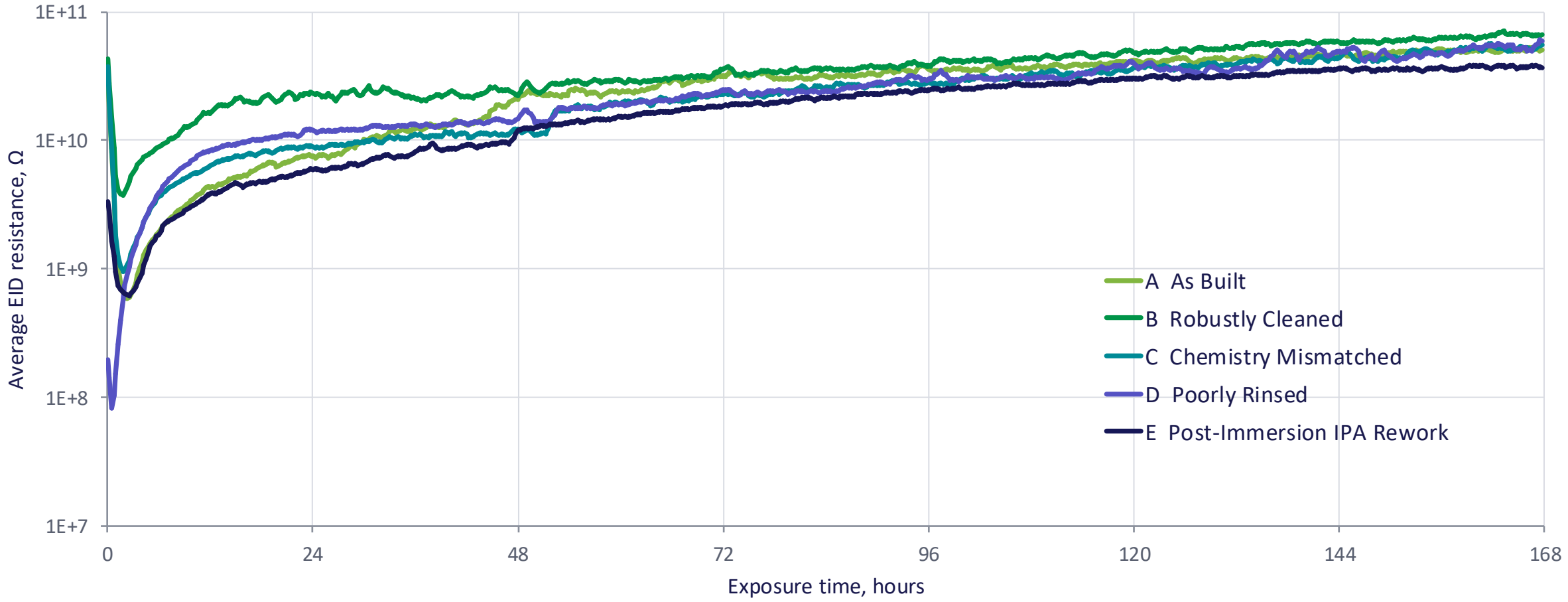
- Visual inspection
- Localized C3 extraction
- Ion chromatography

Fluid

- Baseline fluid sample
- Post-exposure sample
- GCMS / LCMS screening

Electrical Response: Defined by Recovery

Card 1, full 168 h exposure

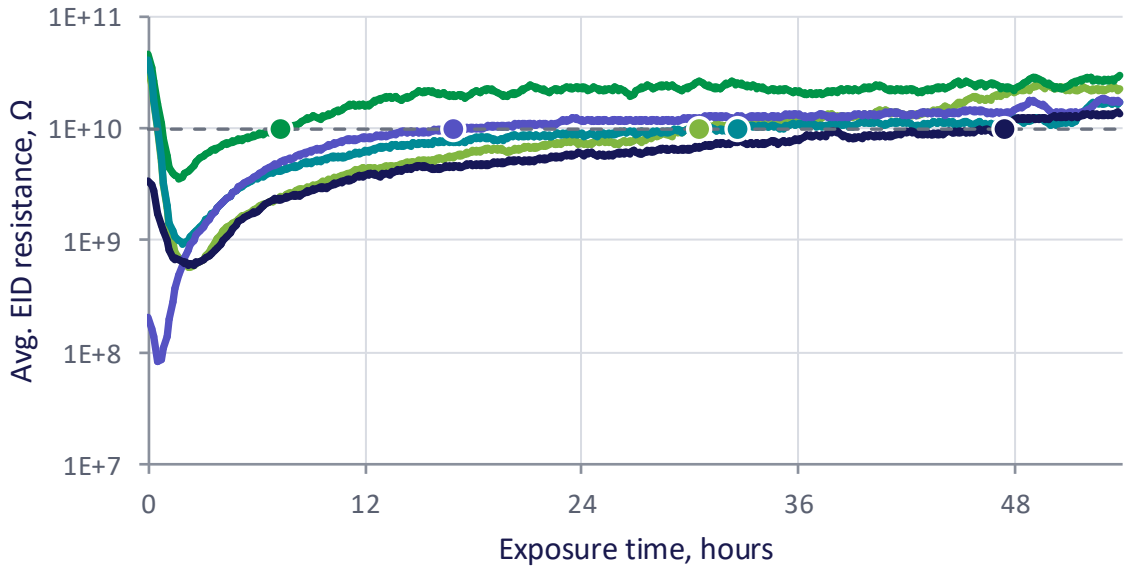


Source: Immersion Canary EID, card 1, 30 s logging. Log-average of all four channels (CH1–CH4), 1 h rolling average. C excludes CH3, which read at the instrument floor (7.3×10^5 Ω) for the full run.

Electrical Response: Defined by Recovery

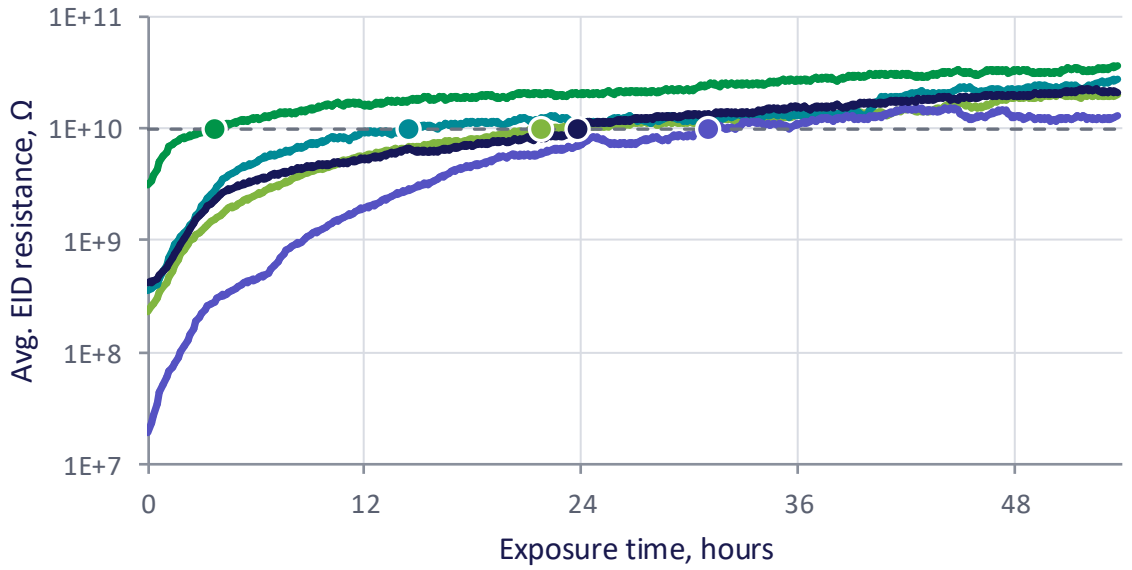
Card 1

Fresh fluid; heaters on 0.6 h after entry



Card 2

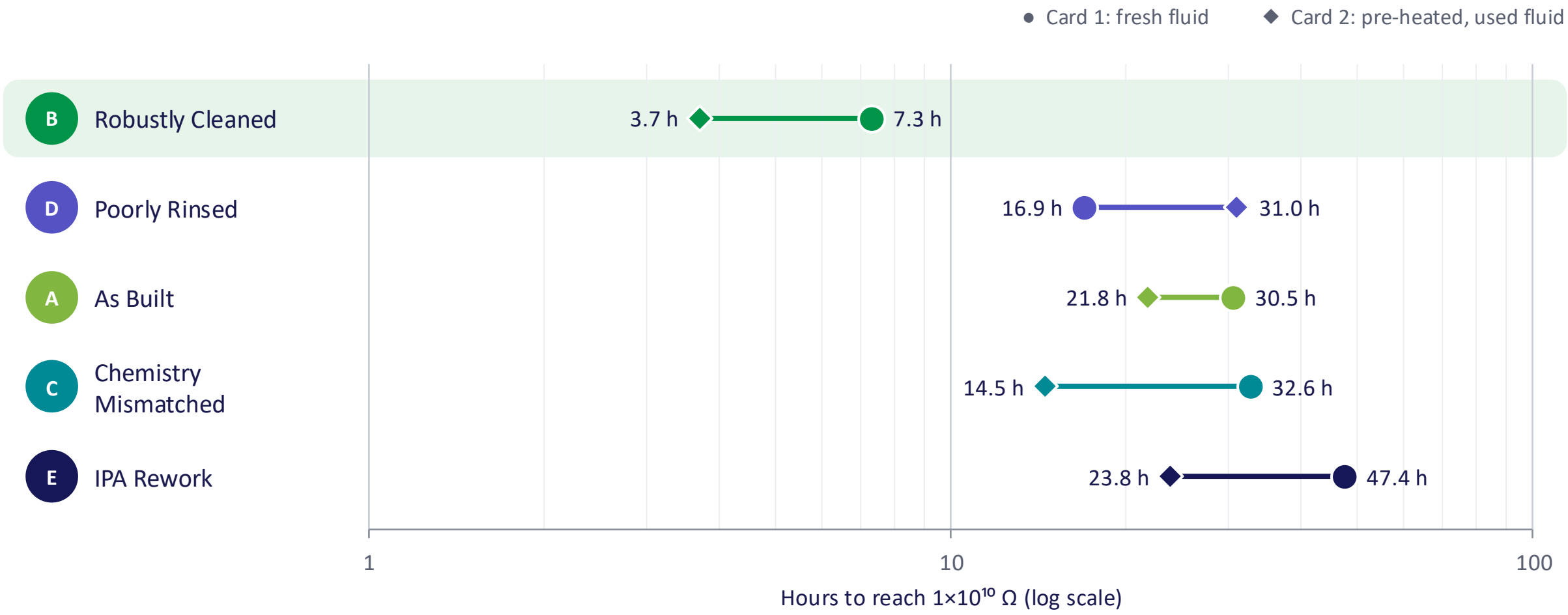
Same fluid, already heated; 54 h before power outage



Hours to 1×10^{10} Ω	B Robustly Cleaned	D Poorly Rinsed	A As Built	C Chemistry Mismatched	E IPA Rework
Card 1	**7.3 h**	16.9 h	30.5 h	32.6 h	47.4 h
Card 2	**3.7 h**	31.0 h	21.8 h	14.5 h	23.8 h

Log-average of channels, 1 h rolling average; C excludes Channel 3 on both cards.

Electrical Response: Defined by Recovery

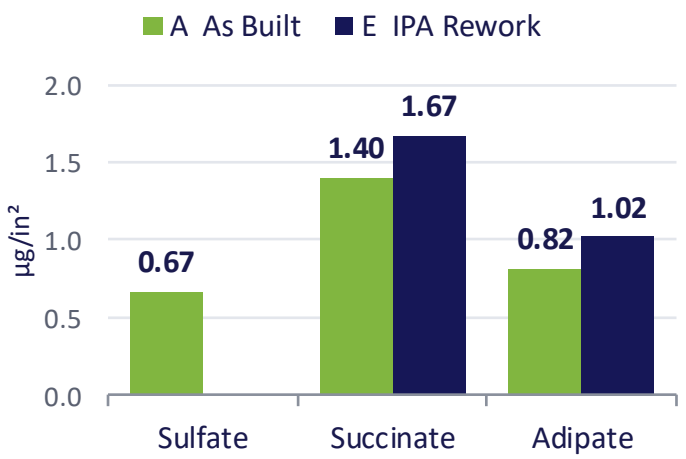


Log-average of channels, 1 h rolling average on log scale; C excludes Channel 3. Card 2 window: 54 h.

Post-Exposure Assembly Characterization

Localized C3 Extraction + IC

Channel 1 component site, after exposure



Sulfate not detected on E.

No species detected

B C D

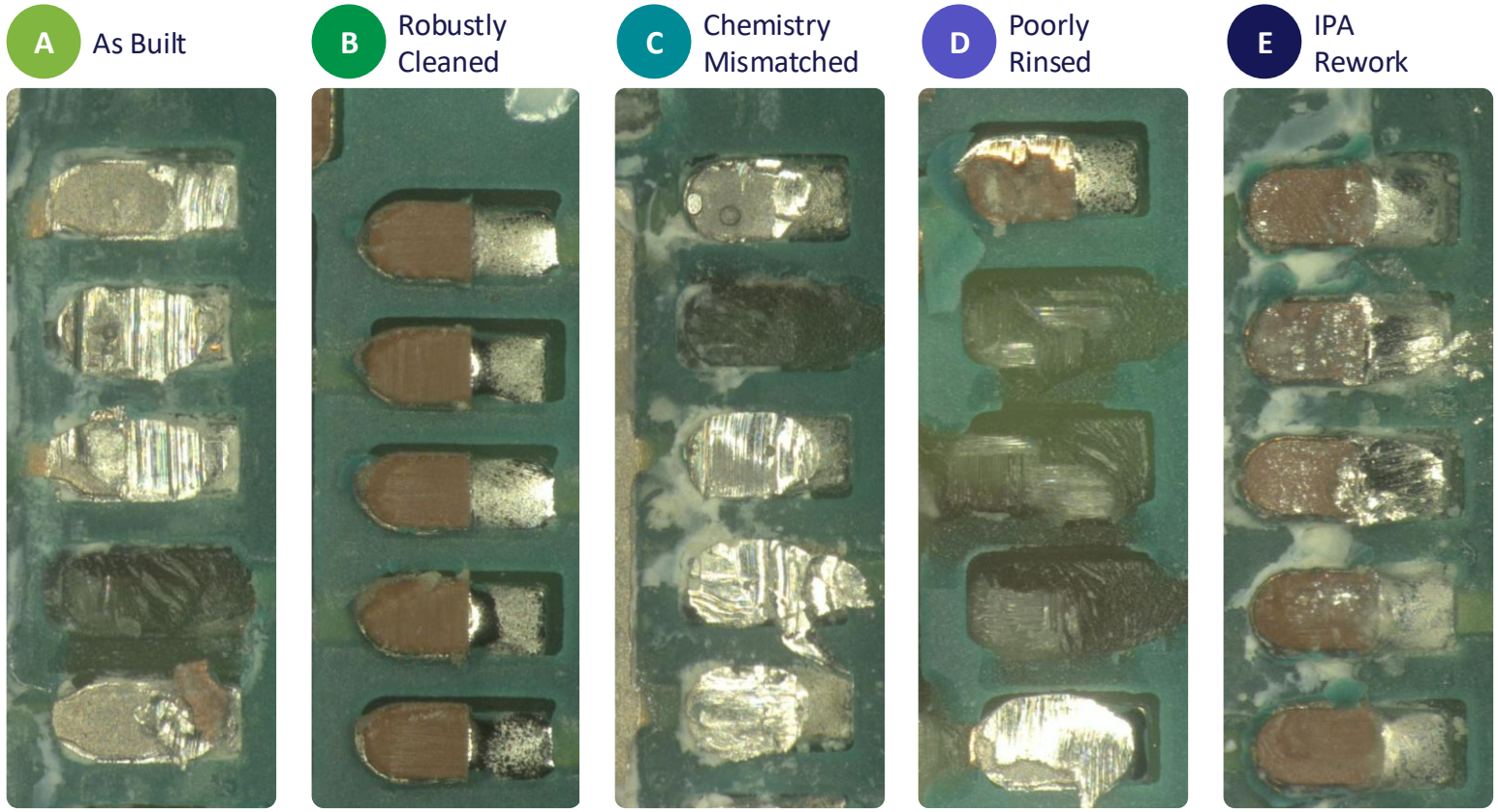
Weak organic acids

A 2.22 µg/in²

E 2.70 µg/in²

Localized extraction, not whole-board cleanliness.

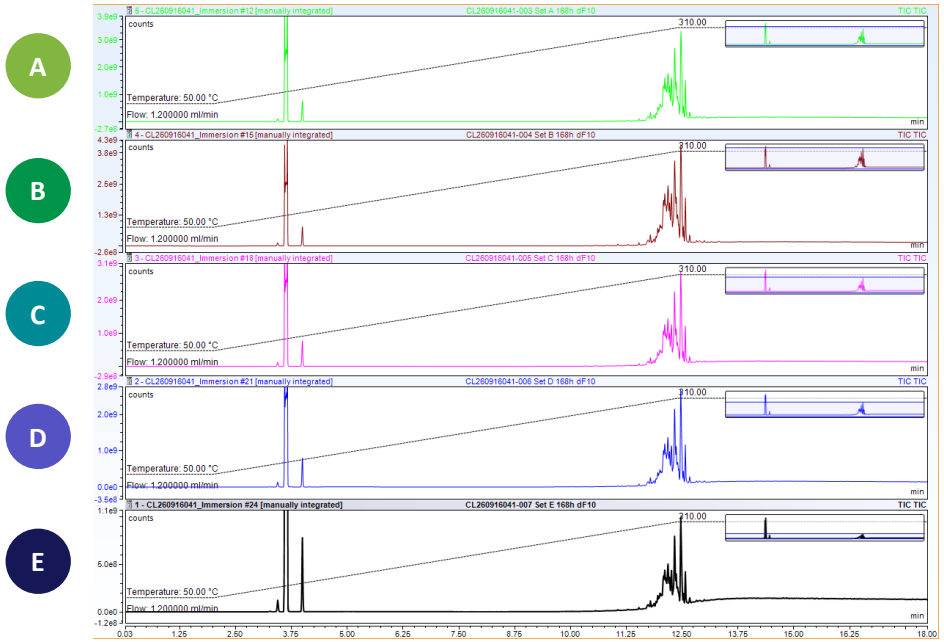
Post-Exposure Visual Inspection



Representative site for each condition after exposure; no cleaning after removal from fluid.

Fluid Analysis

GCMS: All Five Sets After 168 h



Every set matches the clean-fluid control (repeated at 332 h).

LCMS: 168 h, Zoomed 16–22.5 min



19.1 min

m/z 249.2065

Small peak in every exposed set; absent from the clean fluid.

Present regardless of cleaning: likely a minor extractable from the part.

Peaks at 18.6–18.7 min also appear in the blank.

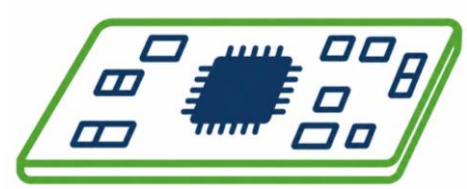
One minor common feature; no condition-specific signal.

Bulk fluid organic analysis did not differentiate the tested conditions.

Methods: GCMS, Thermo Trace 1310 GC / ISQ LT MS, 10× in n-hexane. LCMS, Agilent 1260 Infinity / 6545 Q-TOF, 10× in toluene. Organic screening only; not designed to quantify trace ionic contamination.
Source: J. Miller, Organic Chemistry Lab, Micron Technology, September 2026. LCMS for the 332 h set was not reported due to instrument noise.

Connecting Electrical, Surface, and Fluid Behavior

Incoming Assembly Condition



Pre-immersion condition was intentionally varied through residues, cleaning chemistry, rinse completeness, and rework history.

Electrical Response



Only robustly cleaned boards stabilized quickly on both cards. **Mismatched chemistry, poor rinse, and IPA rework were no better than no cleaning.**

Surface Characterization



Electrically recovered assemblies did not present identical post-exposure surface conditions. **Localized IC and visual inspection retained evidence of processing history.**

Fluid Analysis



Bulk organic analysis did not clearly distinguish the pre-immersion conditions at this test scale. **A dielectric-fluid ionic test method is still needed.**

Qualification Implication

Cleaning for immersion is a distinct process requirement: chemistry match and rinse completeness must be specified and verified. Electrical, surface, and fluid measurements are complementary.

Call to Action

How can we strengthen immersion qualification by better defining the incoming assembly condition?

- **Record incoming assembly condition in qualification**
  Propose adding cleaning chemistry, rinse verification, and T_0 cleanliness to the Immersion Fluids & Cleaning Guidelines.
- **Close the ionic gap in dielectric fluid**
  Organic screening did not separate the conditions; we need a method that measures ionic contamination directly in the fluid.
- **Align qualification practices**
  Build a shared framework across reliability, component compatibility, fluid lifecycle, and cleaning communities.

Join us in the OCP Immersion Cooling Fluids & Cleaning work. We're looking for partners to extend this with more boards, fluids, and labs.

OCP CE – Immersion Cooling

OCP CE - IC - Fluids - Cleaning Guidelines


Thank
You!
OCP
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October 12-15, 2026
San Jose, California