
# It's Time to Improve Component Standards and Measurement

## (Abstract: Component Cleanliness – Should Industry Care?)

IEC Electronics

SECURE COMPONENTS
Your Partner in Counterfeit Avoidance!

PRECISION ANALYTICAL LABORATORY

CORFIN INDUSTRIES
COMPONENT PREPARATION SOLUTIONS
Preventing Catastrophic Failures in Mission Critical Systems

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# History

- ✓ **Phase I** of our testing had a goal to correlate IPC Chemical and Electrical CAF **PCB test results**. The electrical testing utilized for the test coupons was found within the PCQR2 Database document. The chemical testing of the coupons utilized Ion Chromatography (IC) testing in accordance with IPC-TM-650, method 2.3.28.

- ✓ **Phase II** of our testing focused on **Component Cleanliness** utilizing referencing GEIA-STD-0006 in conjunction with chemical testing of the components via Ion Chromatography (IC) testing utilizing a hybrid approach via IPC-TM-650, method 2.3.28 with modifications.

- **Phase III** will target **Printed Circuit Board Cleanliness** and applying IPC-TM-650, method 2.3.28 to stage for our final phase.

- **Phase IV** application of **Cleanliness Reliability Limits**. In this Phase , our team intends on spurring industry focus to initiate as well as identify key ions of concern as well as ionic limits for high reliability electronics.

✓ Phase I – Printed Circuit Board (PCB) Cleanliness

✓ Phase II – Component Cleanliness

- Phase III - Printed Circuit Board Assembly (PCBA) Cleanliness

- Phase IV – Reliability Cleanliness Limits

# Agenda Today

- It's time to improve component cleanliness standards and measurement?
  - ✓ Start the discussion (Why should industry care?)
  - ✓ What is meant by "cleanliness"?
- What are the current industry techniques used for measuring ionic "cleanliness"?
  - ✓ Resistivity of Solvent Extract (R.O.S.E)
  - ✓ Ion Chromatography
  - ✓ GEIA-STD-0006, "*Requirements for Using Robotic Hot Solder Dip to Replace the Finish on Electronic Piece Parts*"
  - ✓ Data Comparison Study (R.O.S.E vs. IC)
- Where do we go from here?

# Our Mission

Cleanliness “Team” Members Mission:

To push the electronics industry towards improving the cleanliness measurement landscape and standards. Today we have a qualitative ROSE ruler, tomorrow we are promoting for an improved but manufacturing friendly IC analytical micrometer test and beyond ...

# What is meant by “Cleanliness”?

I. Electronics Industry - Cleanliness typically refers to ionic contaminates

II. Ionic Contaminates – 2 types
- a) Anion (Net negative charge)
  - $F^-$, $Cl^-$, $Br^-$, $NO_2^-$, $NO_3^-$, $PO_4^{3-}$, $SO_4^{2-}$
- b) Cation (Net positive charge)
  - $Li^+$, $Na^+$, $K^+$, $NH_4^+$, $Mg^{2+}$, $Ca^{2+}$

III. Other Contaminates
- c) Organic ions from process chemistries
  - Plating bath / HASL flux chemistries for printed boards
  - Flux used for reballing, lead tinning, assembly can yield
    - Organic acid residues depending on flux composition
      - Acetate, adipate, formate, maleate, succinate, etc.

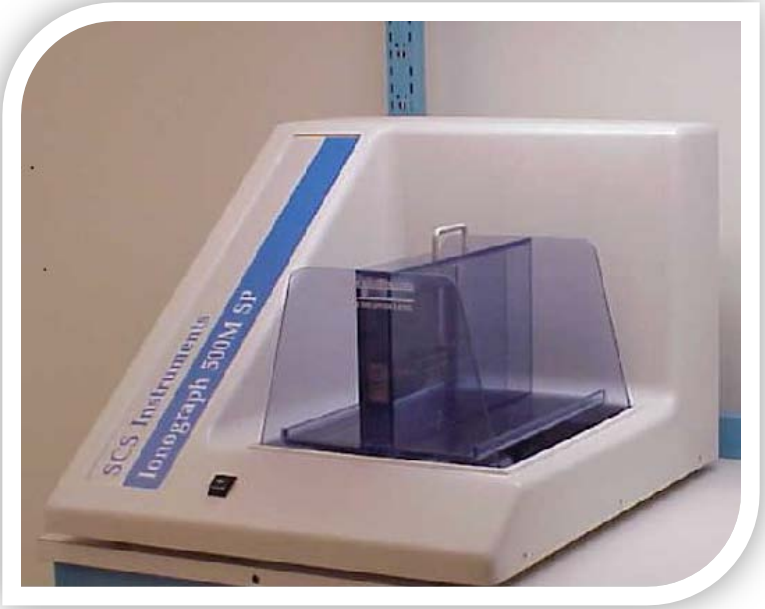
*Photograph taken from internet: EUROCORR 2016 Task Force “Corrosion Reliability of Electronics Devices and Materials”*

# Let’s start a discussion!

- Smaller devices + Increased function =
  - Tighter conductor gaps
  - Increased component density
  - Higher leakage risk from lower contaminate levels

# What are the current techniques for measuring ionic cleanliness?

Ion Chromatography (IC)




Resistivity Of Solvent Extract (ROSE)

# Resistivity Of Solvent Extract (ROSE)

| Pro's | Con's |
| --- | --- |
| X Cost | X Not Selective |
| X Ease of Use | X Not Sensitive |
| | X Results given as NaCl equivalents – but not an actual measurement of NaCl |

# Resistivity Of Solvent Extract (ROSE)

I. Principle of method was developed by R.J. DeNoon and W.T. Hobson of the Naval Avionics Center in the 70's.
   - Why 75 % IPA / 25 % IPA Water?
   - Conductivity was basis of residue measurement

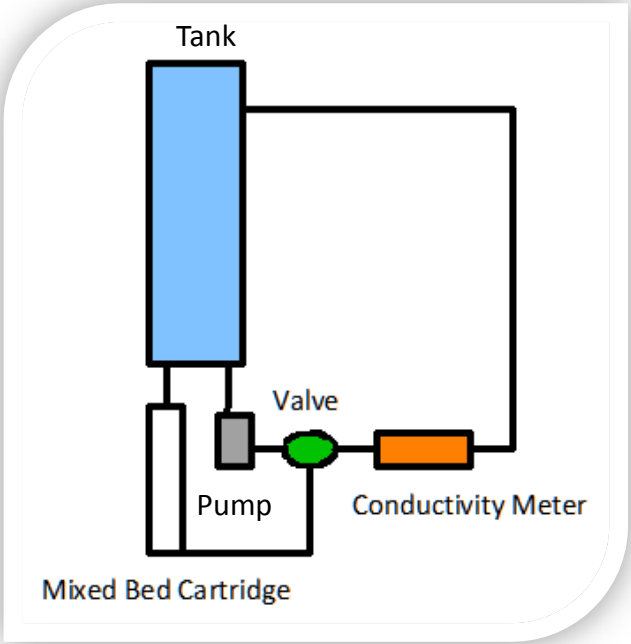
II. Their method became part of MIL-P-28809 (DoD Spec for Acceptability of Military PWA's).

III. This ultimately led to adoption of the method by the commercial industry, through MIL-P-28809, MIL-STD-2000, and eventually J-STD-001

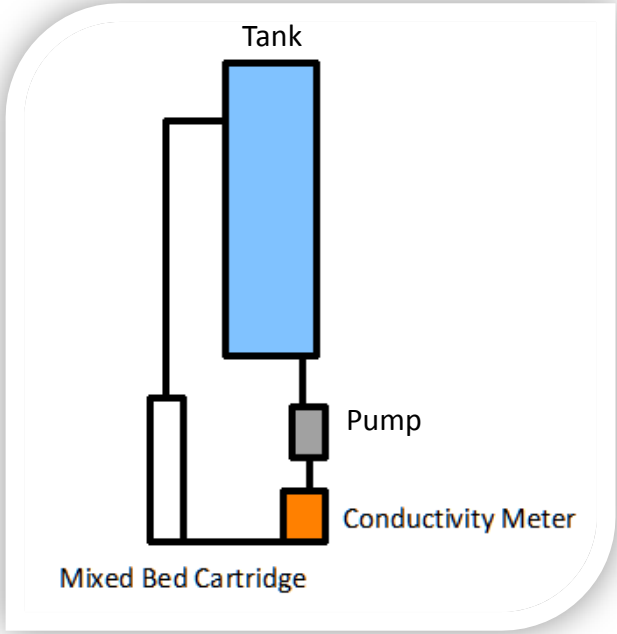
IV. Instruments were later developed (late 70's) to automate the test
   - Test became more prevalent
   - Transitioned from "process control" to "cleanliness"

# Resistivity Of Solvent Extract (ROSE)

- Static – Test runs for a set maximum period of 10 minutes, typically achieves reading in 1 minute.
- Dynamic – Test until no significant change is observed in conductivity (i.e. up to 1 hour).
- Typically no one runs the test longer than 10 minutes because it most likely means failure.




Static ROSE Device




Dynamic ROSE Device

# Resistivity Of Solvent Extract (ROSE)

## Applicability of ROSE Data

I. ROSE Test Limitations per IPC-TR-583
   - Showed that the ionic cleanliness testers (circa 1995) were neither repeatable nor reproducible, and that the “equivalency” factors were meaningless.

II. Modern fluxes, especially low residue, are not made to be soluble, at least at these conditions
   - This is a point for consideration for the next level of testing, but ought to be made for future reference.

# Ion Chromatography (IC)

| Pro's | Con's |
| --- | --- |
| X Selective | X Expensive |
| X Sensitive | X Longer Test Time |
| X Accurate | X Proficiency |
| X Analytical Insight | X Operator Capability |

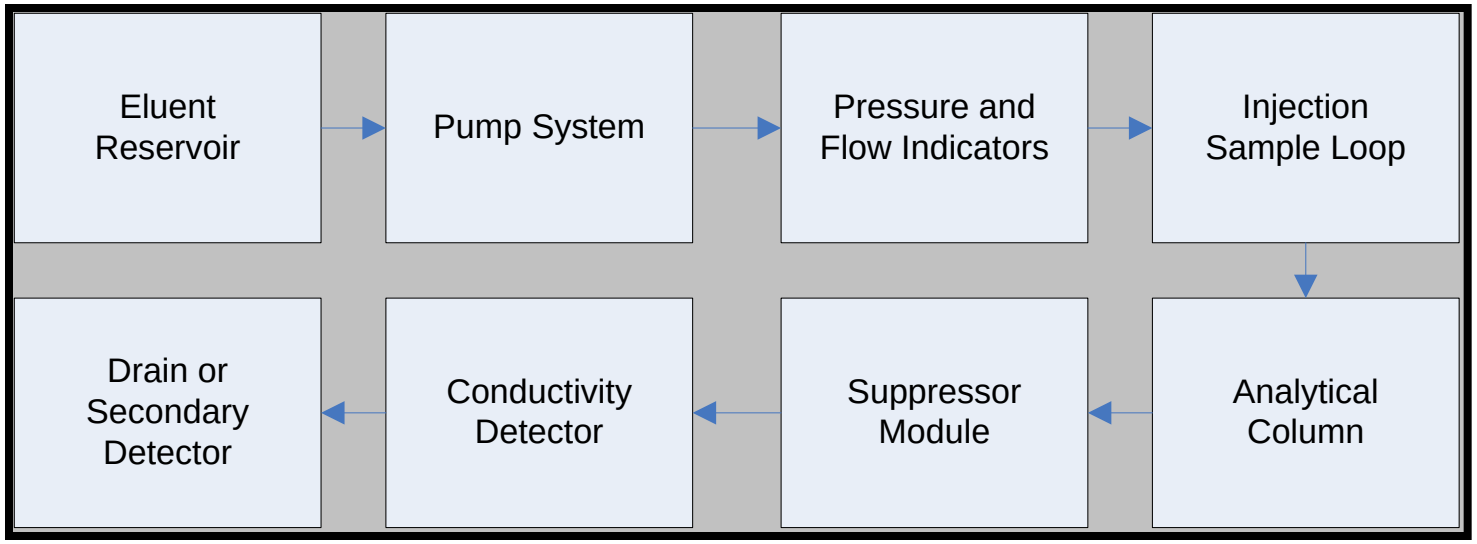
# Ion Chromatography (IC)

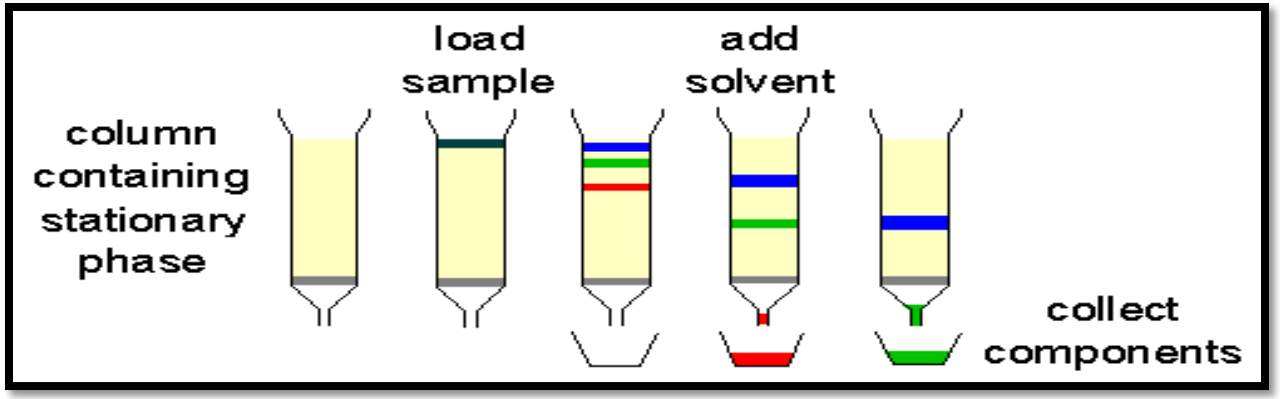
I. Developed in the 70's by Dow Chemical Company.

II. IC allows for the separation of numerous ionic species by incorporating the following:

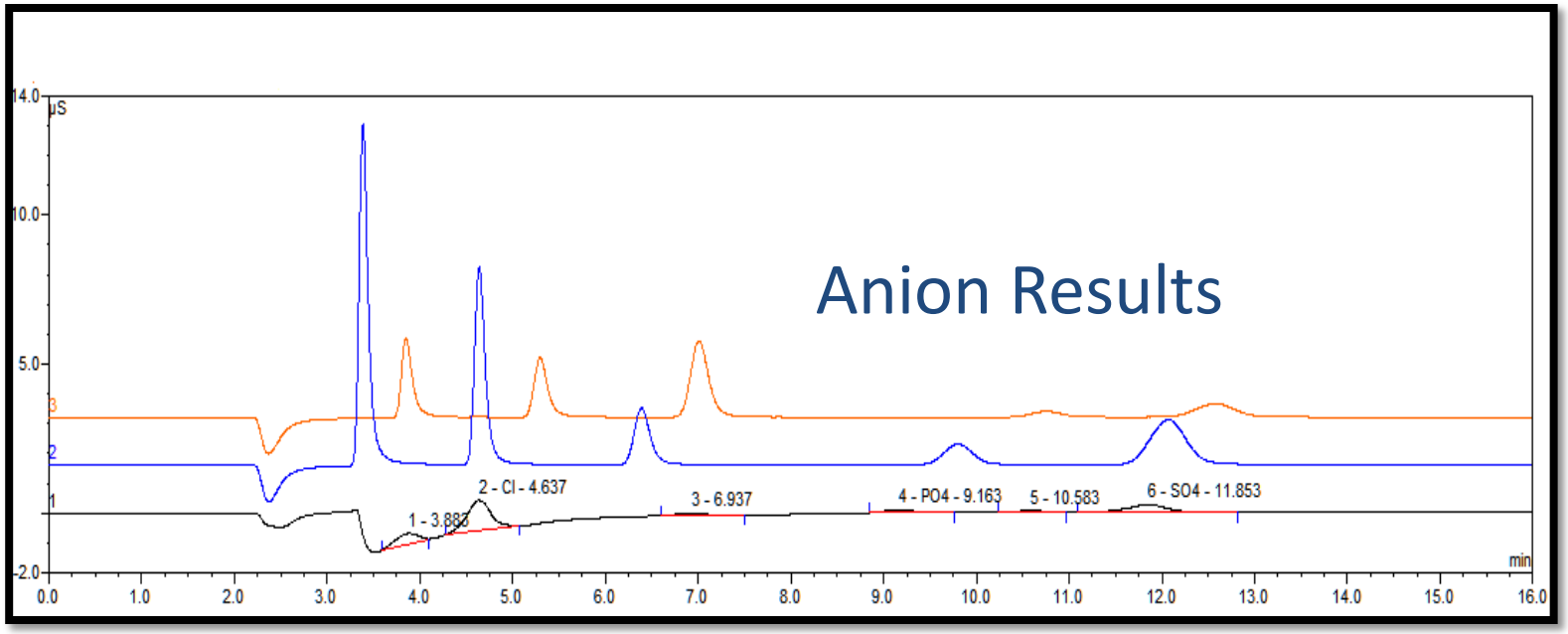
- Mobile phase = eluent (chemical for moving the ions through the column)
- Pump
- Solid phase = columns
- Suppressor = filters background noise from eluent
- Conductivity cell and detector

# Ion Chromatography (IC)



# Ion Chromatography (IC)



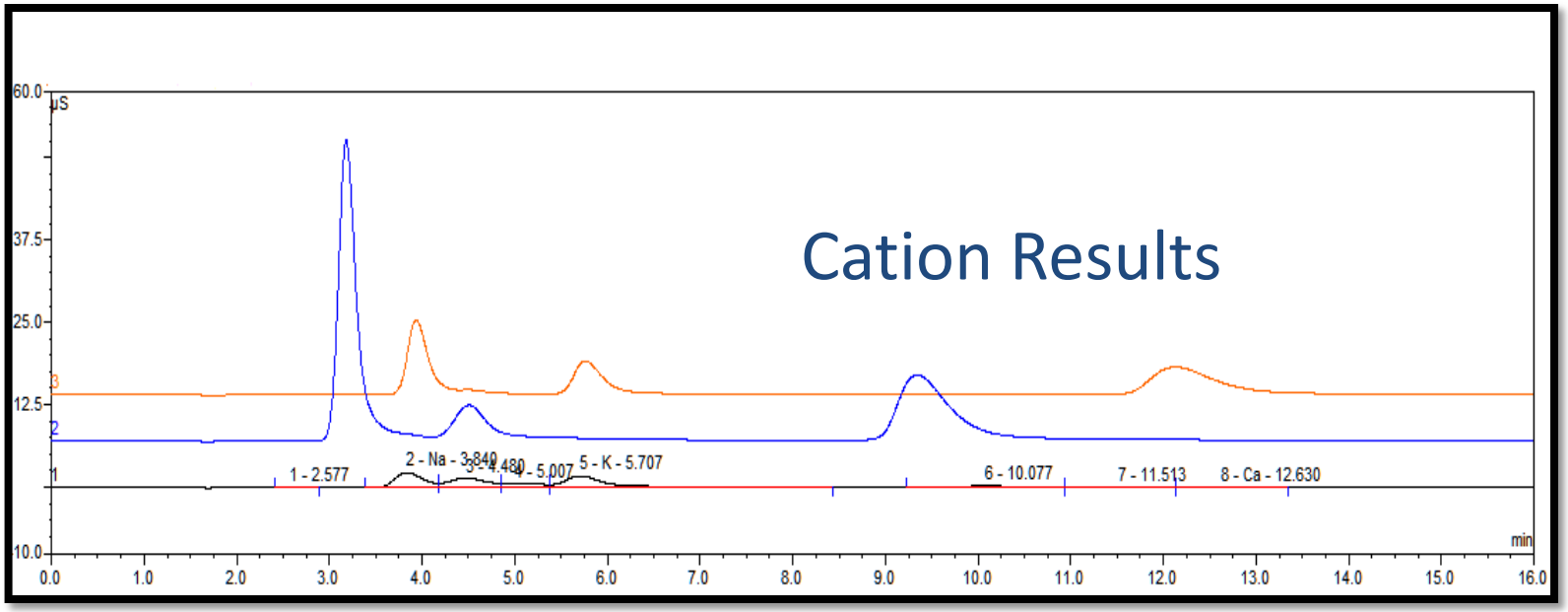

**Black Line = Sample**

**Blue Line = F, Cl, Br, PO4 and SO4**

**Orange Line = Formate, NO2, NO3, Succinate and Maleate**

*A typical chromatograph with control standards overlaid.*

# Ion Chromatography (IC)




**Graphs - Cations**

**Black Line = Sample**

**Blue Line = Li, NH4 and Mg**

**Orange Line = Na, K, Ca**

*A typical chromatograph with control standards overlaid.*

# Component Cleanliness ?

- ✓ **Phase II** of our testing focused on **Component Cleanliness** utilizing referencing GEIA-STD-006 in conjunction with chemical testing of the components via Ion Chromatography (IC) testing utilizing a hybrid approach via IPC-TM-650, method 2.3.28 with modifications.

- **Phase III** will target **Printed Circuit Board Assembly Cleanliness** and applying IPC-TM-650, method 2.3.28 to stage for our final phase.

- **Phase IV** application of **Cleanliness Reliability Limits**. In this Phase , our team intends on spurring industry focus to initiate as well as identify key ions of concern as well as ionic limits for high reliability electronics.

✓ Phase I – Printed Circuit Board (PCB) Cleanliness

✓ Phase II – Component Cleanliness

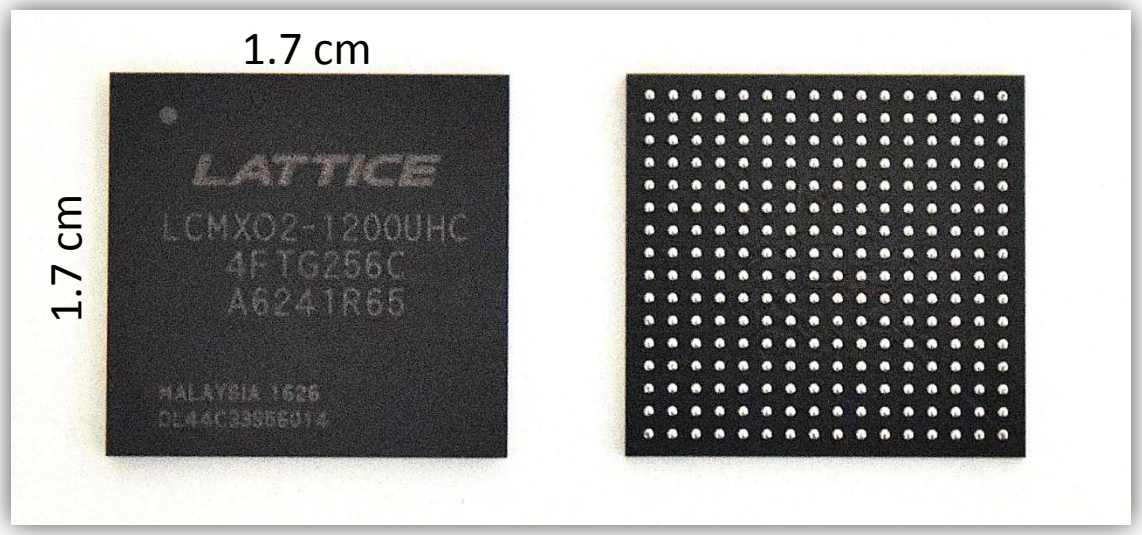
- Phase III - Printed Circuit Board Assembly (PCBA) Cleanliness

- Phase IV – Reliability Cleanliness Limits

# Components Selected

- Cleanliness Comparison of 5 Groups of Ball Grid Arrays (BGA's) before and after re-balling process:

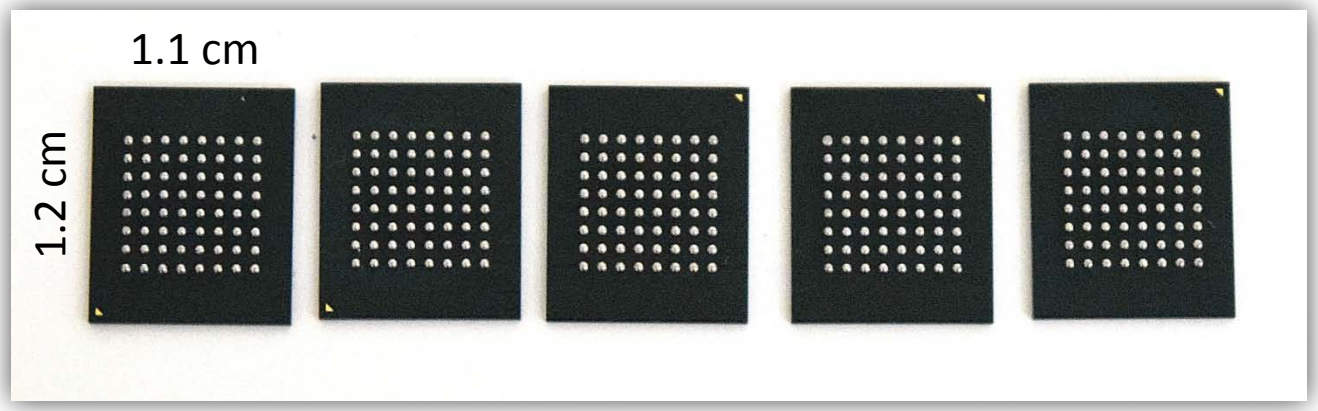
## Sample Group 1 (842-X1200UHC4FTG256C)




2 Parts / Sample

# Components Selected

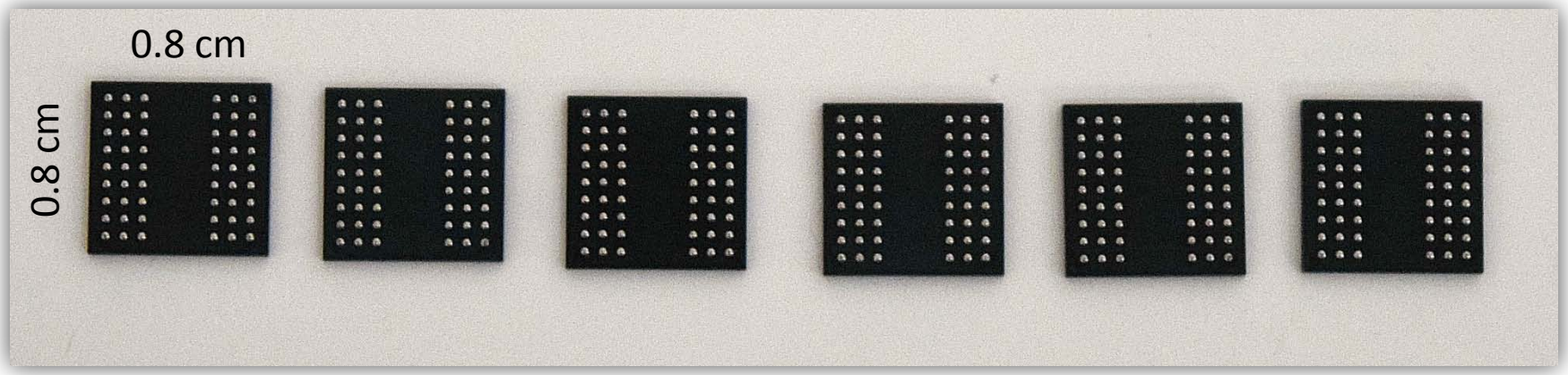
## Sample Group 2 (797-529GL512P12FF1V2)




5 Parts / Sample

# Components Selected

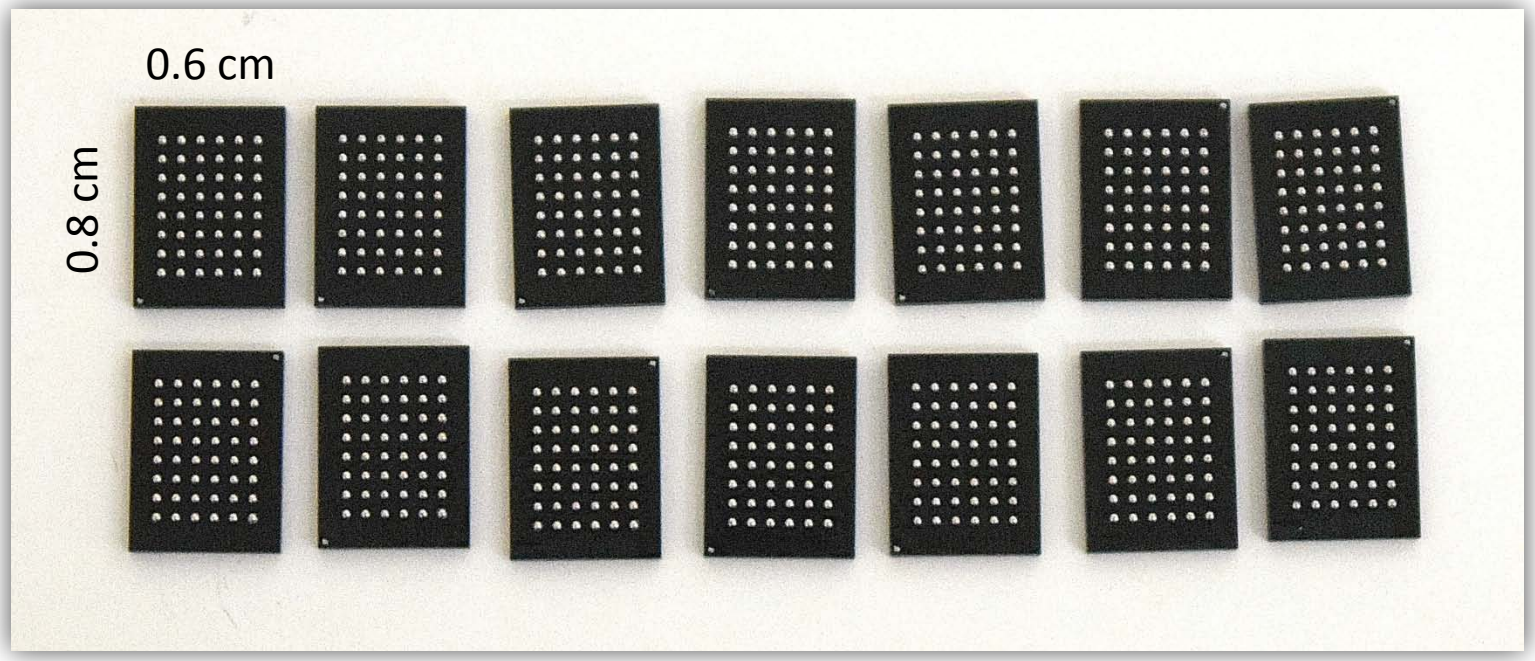
## Sample Group 3 (913-4816M16A2F46AIT)




6 Parts / Sample

# Components Selected

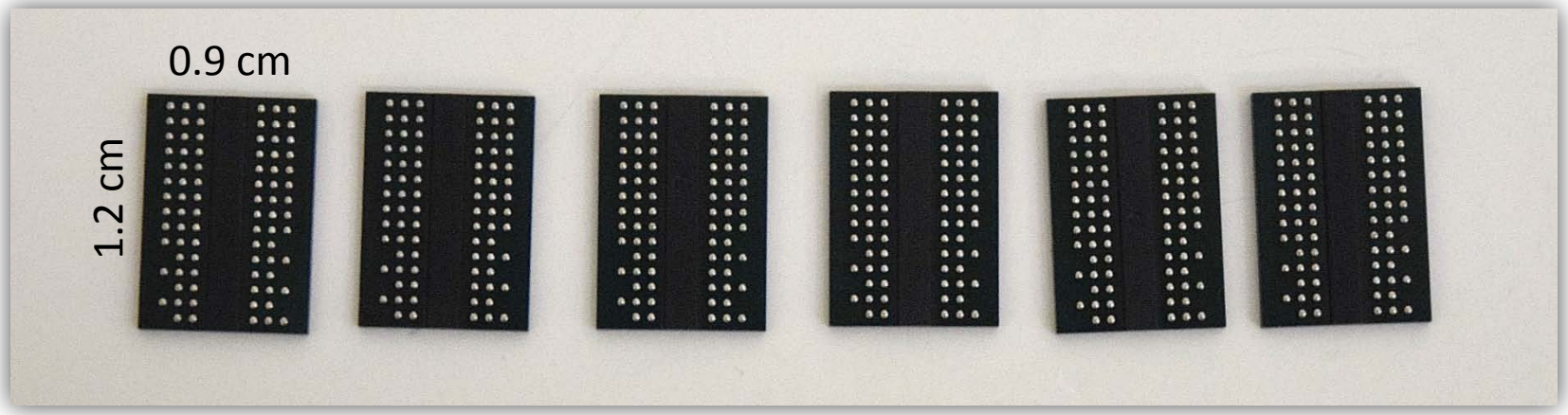
## Sample Group 4 (870-61WV6416EEL10BLI)




14 Parts / Sample

# Components Selected

## Sample Group 5 (913-47128M16PK25EITC)




6 Parts / Sample

# Industry Standards for Components

- **GEIA-STD-0006:** Requirements for Using Solder Dip to Replace the Finish on Electronic Piece Parts

- Per Section 11: Test Methods
  - **IPC-TM-650-2.3.25:** For ionic cleanliness testing limit 1.5 microgram/centimeter square or 10 micrograms/square inch. At least one square inch of piece parts area is needed for testing.

  - This standard does not apply to Ball Grid Arrays.
    - To address reballing of BGA's, IEC's TS 62647-4 Reballing standard is anticipated to be released late in 2017 and will likely follow the cleanliness requirements of GEIA-STD-0006 and has not determined if IC will be an option.

- **Currently there are no other requirements for component cleanliness!**

# Remember the current techniques for measuring ionic cleanliness?

Ion Chromatography (IC)

**IC Method**

- Solvent = 75% IPA / 25% DI water
- 5 mL's solvent used
- 1 hour extraction @ 80°C
- Anions and Cation evaluated
- IPC-TM-650, method 2.3.28

**ROSE Method**

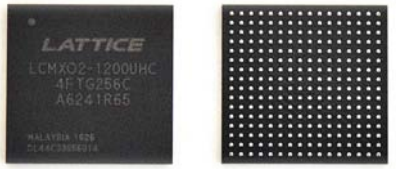
- Robotic Re-Balling Process
- Volume of the test chamber = 98 mL
- Total Volume: 3.7 liters
- Flow rate ~20ml/sec
- Solution: 75%25% IPA/H2O +/-2%
- Test time: 60 seconds (max is 10 minutes)


Resistivity Of Solvent Extract (ROSE)

# Component Cleanliness IC Data

| Ion Name | Chemical ID | 842-X1200UHC4FTG256C (Sample Group #1) | | | | |
|---|---|---|---|---|---|---|
| | | 1001-001-01 | 1001-001-02 | 1001-001-03 | Mean | Mean / Part |
| Lithium | $Li^+$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Sodium | $Na^+$ | 0.02 | 0.02 | 0.03 | 0.02 | 0.004 |
| Ammonium | $NH_4^+$ | 0.07 | 0.07 | 0.06 | 0.07 | 0.011 |
| Potassium | $K^+$ | 0.02 | 0.01 | 0.00 | 0.01 | 0.002 |
| Magnesium | $Mg^{2+}$ | 0.05 | 0.06 | 0.05 | 0.05 | 0.009 |
| Calcium | $Ca^{2+}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Fluoride | $F^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Chloride | $Cl^-$ | 0.01 | 0.01 | 0.02 | 0.01 | 0.002 |
| Nitrite | $NO_2^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Bromide | $Br^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Nitrate | $NO_3^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Phosphate | $PO_4^{3-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Sulfate | $SO_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Acetate | $C_2H_3O_2^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Formate | $CHO_2^-$ | 0.12 | 0.12 | 0.14 | 0.13 | 0.021 |
| Succinate | $C_4H_4O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Adipate | $C_6H_8O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Maleate | $C_4H_2O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Citrate | $C_6H_5O_7^{3-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |

I. Results in micrograms per square centimeter ($\mu g/cm^2$)
II. Baseline Result before Re-Balling Procedure
III. Two parts tested per sample (3 samples total)
IV. Red Results are the Cations
V. Black Results are the Anions
VI. Blue Results are the Organic Acids.



# Component Cleanliness IC Data

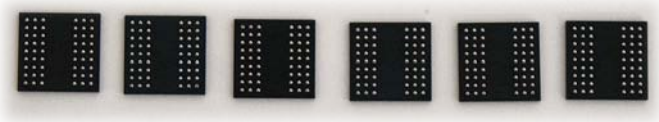
| Ion Name | Chemical ID | 797-S29GL512P12FFIV2 (Sample Group #2) | | | | |
|---|---|---|---|---|---|---|
| | | 1001-001-04 | 1001-001-05 | 1001-001-06 | Mean | Mean / Part |
| Lithium | $Li^+$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Sodium | $Na^+$ | 0.27 | 0.25 | 0.27 | 0.26 | 0.018 |
| Ammonium | $NH_4^+$ | 0.13 | 0.12 | 0.12 | 0.12 | 0.008 |
| Potassium | $K^+$ | 0.02 | 0.00 | 0.00 | 0.01 | 0.000 |
| Magnesium | $Mg^{2+}$ | 0.06 | 0.06 | 0.07 | 0.06 | 0.004 |
| Calcium | $Ca^{2+}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Fluoride | $F^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Chloride | $Cl^-$ | 0.08 | 0.08 | 0.06 | 0.07 | 0.005 |
| Nitrite | $NO_2^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Bromide | $Br^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Nitrate | $NO_3^-$ | 0.00 | 0.01 | 0.00 | 0.00 | 0.000 |
| Phosphate | $PO_4^{3-}$ | 0.02 | 0.02 | 0.03 | 0.02 | 0.002 |
| Sulfate | $SO_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Acetate | $C_2H_3O_2^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Formate | $CHO_2^-$ | 0.05 | 0.08 | 0.06 | 0.06 | 0.004 |
| Succinate | $C_4H_4O_4^{2-}$ | 0.22 | 0.30 | 0.27 | 0.26 | 0.018 |
| Adipate | $C_6H_8O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Maleate | $C_4H_2O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Citrate | $C_6H_5O_7^{3-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |

I. Five parts tested per sample (3 samples total)

# Component Cleanliness IC Data

| Ion Name | Chemical ID | 913-4816M16A2F46AIT (Sample Group #3) | | | | |
|---|---|---|---|---|---|---|
| | | 1001-001-07 | 1001-001-08 | 1001-001-09 | Mean | Mean / Part |
| Lithium | $Li^+$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Sodium | $Na^+$ | 0.09 | 0.15 | 0.11 | 0.12 | 0.006 |
| Ammonium | $NH_4^+$ | 0.06 | 0.05 | 0.05 | 0.05 | 0.003 |
| Potassium | $K^+$ | 0.00 | 0.01 | 0.01 | 0.01 | 0.000 |
| Magnesium | $Mg^{2+}$ | 0.04 | 0.04 | 0.03 | 0.04 | 0.002 |
| Calcium | $Ca^{2+}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Fluoride | $F^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Chloride | $Cl^-$ | 0.09 | 0.12 | 0.13 | 0.11 | 0.006 |
| Nitrite | $NO_2^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Bromide | $Br^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Nitrate | $NO_3^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Phosphate | $PO_4^{3-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Sulfate | $SO_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Acetate | $C_2H_3O_2^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Formate | $CHO_2^-$ | 0.23 | 0.25 | 0.22 | 0.23 | 0.013 |
| Succinate | $C_4H_4O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Adipate | $C_6H_8O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Maleate | $C_4H_2O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Citrate | $C_6H_5O_7^{3-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |

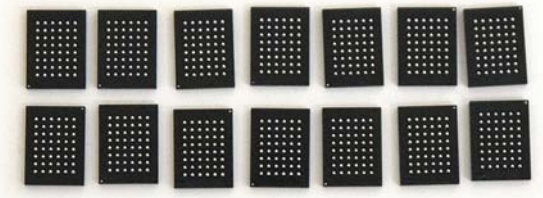
I. Six parts tested per sample (3 samples total)



# Component Cleanliness IC Data

| Ion Name | Chemical ID | 870-61WV6416EEL10BLI (Sample Group #4) | | | | |
|---|---|---|---|---|---|---|
| | | 1001-001-10 | 1001-001-11 | 1001-001-12 | Mean | Mean / Part |
| Lithium | $Li^+$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Sodium | $Na^+$ | 0.08 | 0.08 | 0.00 | 0.05 | 0.001 |
| Ammonium | $NH_4^+$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Potassium | $K^+$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Magnesium | $Mg^{2+}$ | 0.02 | 0.02 | 0.00 | 0.01 | 0.000 |
| Calcium | $Ca^{2+}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Fluoride | $F^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Chloride | $Cl^-$ | 0.03 | 0.05 | 0.04 | 0.04 | 0.001 |
| Nitrite | $NO_2^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Bromide | $Br^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Nitrate | $NO_3^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Phosphate | $PO_4^{3-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Sulfate | $SO_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Acetate | $C_2H_3O_2^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Formate | $CHO_2^-$ | 0.23 | 0.22 | 0.24 | 0.23 | 0.005 |
| Succinate | $C_4H_4O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Adipate | $C_6H_8O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Maleate | $C_4H_2O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Citrate | $C_6H_5O_7^{3-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |

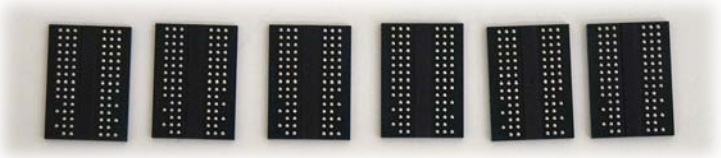
I. Fourteen parts tested per sample (3 samples total)
II. Yellow section indicates a misinjected sample and not enough sample for a second attempt.



# Component Cleanliness IC Data

| Ion Name | Chemical ID | 913-47128M16PK25EITC (Sample Group #5) | | | | |
|---|---|---|---|---|---|---|
| | | 1001-001-13 | 1001-001-14 | 1001-001-15 | Mean | Mean / Part |
| Lithium | $Li^+$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Sodium | $Na^+$ | 0.12 | 0.12 | 0.08 | 0.11 | 0.006 |
| Ammonium | $NH_4^+$ | 0.08 | 0.07 | 0.05 | 0.07 | 0.004 |
| Potassium | $K^+$ | 0.02 | 0.01 | 0.00 | 0.01 | 0.001 |
| Magnesium | $Mg^{2+}$ | 0.04 | 0.06 | 0.04 | 0.05 | 0.003 |
| Calcium | $Ca^{2+}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Fluoride | $F^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Chloride | $Cl^-$ | 0.10 | 0.08 | 0.09 | 0.09 | 0.005 |
| Nitrite | $NO_2^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Bromide | $Br^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Nitrate | $NO_3^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Phosphate | $PO_4^{3-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Sulfate | $SO_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Acetate | $C_2H_3O_2^-$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Formate | $CHO_2^-$ | 0.19 | 0.12 | 0.20 | 0.17 | 0.009 |
| Succinate | $C_4H_4O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Adipate | $C_6H_8O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Maleate | $C_4H_2O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| Citrate | $C_6H_5O_7^{3-}$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |

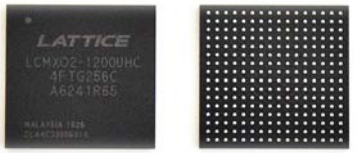
I. Six parts tested per sample (3 samples total)



# Component Cleanliness IC/ROSE Data

| Ion Name | Chemical ID | 842-X1200UHC4FTG256C (Sample Group #1) | | | |
|---|---|---|---|---|---|
| | | 1001-001-16 | 1001-001-17 | Mean | Mean / Part |
| Lithium | $Li^+$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Sodium | $Na^+$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Ammonium | $NH_4^+$ | 0.09 | 0.09 | 0.09 | 0.023 |
| Potassium | $K^+$ | 0.13 | 0.13 | 0.13 | 0.033 |
| Magnesium | $Mg^{2+}$ | 0.02 | 0.01 | 0.02 | 0.004 |
| Calcium | $Ca^{2+}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Fluoride | $F^-$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Chloride | $Cl^-$ | 0.14 | 0.12 | 0.13 | 0.033 |
| Nitrite | $NO_2^-$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Bromide | $Br^-$ | 0.13 | 0.09 | 0.11 | 0.028 |
| Nitrate | $NO_3^-$ | 0.00 | 0.02 | 0.01 | 0.003 |
| Phosphate | $PO_4^{3-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Sulfate | $SO_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Acetate | $C_2H_3O_2^-$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Formate | $CHO_2^-$ | 0.13 | 0.20 | 0.17 | 0.041 |
| Succinate | $C_4H_4O_4^{2-}$ | 0.10 | 0.11 | 0.11 | 0.026 |
| Adipate | $C_6H_8O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Maleate | $C_4H_2O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Citrate | $C_6H_5O_7^{3-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| | | Total Measured Ions (µg/cm$^2$) by IC | | 0.76 | |
| | | ROSE Results (µg NaCl eq / cm$^2$) | | 0.33 | |
| | | IC Results Na and Cl ions (µg/cm$^2$) | | 0.13 | |

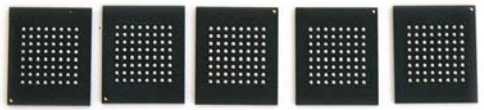
I. Two parts tested per sample (2 samples total)



# Component Cleanliness IC/ROSE Data

| Ion Name | Chemical ID | 797-S29GL512P12FFIV2 (Sample Group #2) | | | |
|---|---|---|---|---|---|
| | | 1001-001-18 | 1001-001-19 | Mean | Mean / Part |
| Lithium | $Li^+$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Sodium | $Na^+$ | 0.10 | 0.10 | 0.10 | 0.010 |
| Ammonium | $NH_4^+$ | 0.15 | 0.16 | 0.16 | 0.016 |
| Potassium | $K^+$ | 0.37 | 0.37 | 0.37 | 0.037 |
| Magnesium | $Mg^{2+}$ | 0.02 | 0.02 | 0.02 | 0.002 |
| Calcium | $Ca^{2+}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Fluoride | $F^-$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Chloride | $Cl^-$ | 0.23 | 0.26 | 0.25 | 0.025 |
| Nitrite | $NO_2^-$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Bromide | $Br^-$ | 0.16 | 0.16 | 0.16 | 0.016 |
| Nitrate | $NO_3^-$ | 0.02 | 0.03 | 0.03 | 0.003 |
| Phosphate | $PO_4^{3-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Sulfate | $SO_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Acetate | $C_2H_3O_2^-$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Formate | $CHO_2^-$ | 0.22 | 0.25 | 0.24 | 0.024 |
| Succinate | $C_4H_4O_4^{2-}$ | 0.07 | 0.16 | 0.12 | 0.012 |
| Adipate | $C_6H_8O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Maleate | $C_4H_2O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Citrate | $C_6H_5O_7^{3-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| | | **Total Measured Ions (µg/cm²) by IC** | | **1.43** | |
| | | **ROSE Results (µg NaCl eq / cm²)** | | **0.01** | |
| | | **IC Results Na and Cl ions (µg/cm²)** | | **0.35** | |

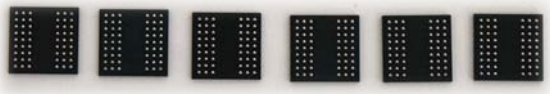
I. Five parts tested per sample (2 samples total)



# Component Cleanliness IC/ROSE Data

| Ion Name | Chemical ID | 913-4816M16A2F46AIT (Sample Group #3) | | | |
|---|---|---|---|---|---|
| | | 1001-001-20 | 1001-001-21 | Mean | Mean / Part |
| Lithium | $Li^+$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Sodium | $Na^+$ | 0.03 | 0.02 | 0.03 | 0.002 |
| Ammonium | $NH_4^+$ | 0.16 | 0.12 | 0.14 | 0.012 |
| Potassium | $K^+$ | 0.23 | 0.30 | 0.27 | 0.022 |
| Magnesium | $Mg^{2+}$ | 0.01 | 0.01 | 0.01 | 0.001 |
| Calcium | $Ca^{2+}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Fluoride | $F^-$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Chloride | $Cl^-$ | 0.26 | 0.27 | 0.27 | 0.022 |
| Nitrite | $NO_2^-$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Bromide | $Br^-$ | 0.12 | 0.16 | 0.14 | 0.012 |
| Nitrate | $NO_3^-$ | 0.05 | 0.03 | 0.04 | 0.003 |
| Phosphate | $PO_4^{3-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Sulfate | $SO_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Acetate | $C_2H_3O_2^-$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Formate | $CHO_2^-$ | 0.31 | 0.32 | 0.32 | 0.026 |
| Succinate | $C_4H_4O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Adipate | $C_6H_8O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Maleate | $C_4H_2O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Citrate | $C_6H_5O_7^{3-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| | | **Total Measured Ions (µg/cm²) by IC** | | **1.20** | |
| | | **ROSE Results (µg NaCl eq / cm²)** | | **0.02** | |
| | | **IC Results Na and Cl ions (µg/cm²)** | | **0.29** | |

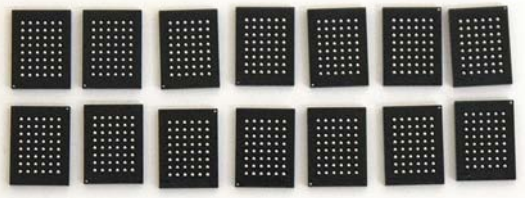
I. Six parts tested per sample (2 samples total)



# Component Cleanliness IC/ROSE Data

| Ion Name | Chemical ID | 870-61WV6416EEL10BLI (Sample Group #4) | | | |
|---|---|---|---|---|---|
| | | 1001-001-22 | 1001-001-23 | Mean | Mean / Part |
| Lithium | $Li^+$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Sodium | $Na^+$ | 0.06 | 0.03 | 0.05 | 0.002 |
| Ammonium | $NH_4^+$ | 0.13 | 0.14 | 0.14 | 0.005 |
| Potassium | $K^+$ | 0.48 | 0.25 | 0.37 | 0.013 |
| Magnesium | $Mg^{2+}$ | 0.01 | 0.02 | 0.02 | 0.001 |
| Calcium | $Ca^{2+}$ | 0.00 | 0.03 | 0.02 | 0.001 |
| Fluoride | $F^-$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Chloride | $Cl^-$ | 0.17 | 0.17 | 0.17 | 0.006 |
| Nitrite | $NO_2^-$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Bromide | $Br^-$ | 0.10 | 0.09 | 0.10 | 0.003 |
| Nitrate | $NO_3^-$ | 0.03 | 0.03 | 0.03 | 0.001 |
| Phosphate | $PO_4^{3-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Sulfate | $SO_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Acetate | $C_2H_3O_2^-$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Formate | $CHO_2^-$ | 0.38 | 0.35 | 0.37 | 0.013 |
| Succinate | $C_4H_4O_4^{2-}$ | 0.04 | 0.11 | 0.08 | 0.003 |
| Adipate | $C_6H_8O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Maleate | $C_4H_2O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Citrate | $C_6H_5O_7^{3-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| | | **Total Measured Ions (µg/cm$^2$) by IC** | | **1.31** | |
| | | **ROSE Results (µg NaCl eq / cm$^2$)** | | **0.10** | |
| | | **IC Results Na and Cl ions (µg/cm$^2$)** | | **0.22** | |

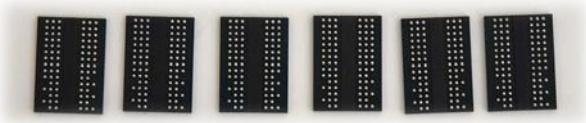
I. Fourteen parts tested per sample (2 samples total)



# Component Cleanliness IC/ROSE Data

| Ion Name | Chemical ID | 913-47128M16PK25EITC (Sample Group #5) | | | |
|---|---|---|---|---|---|
| | | 1001-001-24 | 1001-001-25 | Mean | Mean / Part |
| Lithium | $Li^+$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Sodium | $Na^+$ | 0.07 | 0.05 | 0.06 | 0.005 |
| Ammonium | $NH_4^+$ | 0.16 | 0.14 | 0.15 | 0.013 |
| Potassium | $K^+$ | 0.28 | 0.26 | 0.27 | 0.023 |
| Magnesium | $Mg^{2+}$ | 0.01 | 0.02 | 0.02 | 0.001 |
| Calcium | $Ca^{2+}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Fluoride | $F^-$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Chloride | $Cl^-$ | 0.16 | 0.17 | 0.17 | 0.014 |
| Nitrite | $NO_2^-$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Bromide | $Br^-$ | 0.10 | 0.12 | 0.11 | 0.009 |
| Nitrate | $NO_3^-$ | 0.02 | 0.03 | 0.03 | 0.002 |
| Phosphate | $PO_4^{3-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Sulfate | $SO_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Acetate | $C_2H_3O_2^-$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Formate | $CHO_2^-$ | 0.23 | 0.25 | 0.24 | 0.020 |
| Succinate | $C_4H_4O_4^{2-}$ | 0.06 | 0.00 | 0.03 | 0.003 |
| Adipate | $C_6H_8O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Maleate | $C_4H_2O_4^{2-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| Citrate | $C_6H_5O_7^{3-}$ | 0.00 | 0.00 | 0.00 | 0.000 |
| | | **Total Measured Ions (µg/cm²) by IC** | | **1.07** | |
| | | **ROSE Results (µg NaCl eq / cm²)** | | **<0.01** | |
| | | **IC Results Na and Cl ions (µg/cm²)** | | **0.23** | |

I. Six parts tested per sample (2 samples total)



# Conclusions

- **There are no industry standards for component cleanliness using ion chromatography.**
  - ✓ Electronics Industry focus to initiate ?
  - ✓ Identify key ions of concern as well as ionic limits ?
  - ✓ High reliability electronics imperative ?
- **The bulk data comparisons are qualitative**
  - ✓ Results are defined (µg/cm$^2$ vs. µg of NaCl / cm$^2$)
  - ✓ General (Broad Blade Ax) vs. selective (Surgeon's Scalpel) surface areas averaged via solution extractions
  - ✓ Bulk tank ROSE vs. Custom plastic bag IC extraction technique
- **Our team has illustrated both ROSE and Ion Chromatography Pro's and Con's in this presentation.**
  - ✓ Neither method is a guarantor of quality.
  - ✓ ROSE is an easier test for most manufacturing facilities. But many of those who religiously report adequate numbers subsequently incur functional issues from field returns.
  - ✓ Likewise , Ion Chromatography(IC) still requires knowledge of the materials involved ( e.g., Lead, Tin, Gold, Flux, Water Soluble , No Clean, etc.) and establish ions along with ionic limits relative to application ( e.g., Class 1, 2, or 3).

# Conclusions

- More important we are applying both of these to individual components not printed circuit board assemblies.

- Yesterday we promoted ROSE , Today promoting IC as better , Tomorrow we need a manufacturing friendly IC analytical micrometer board production test with Key Ions & Limits

# Cleanliness Dream Team
# Thank You!

- Corfin Industries as world class component preparation service
- Precision Analytical Laboratory Service
- Secure Components Procurement Service
- IEC Electronics Analytical Services Laboratory Service

# Where do we go from here?

- **Phase III** will target **Printed Circuit Board Cleanliness** and applying IPC-TM-650, method 2.3.28 to stage for our final phase.

- **Phase IV** application of **Cleanliness Reliability Limits**. In this Phase , our team intends on spurring industry focus to initiate as well as identify key ions of concern as well as ionic limits for high reliability electronics.

✓ Phase I – Printed Circuit Board (PCB) Cleanliness

✓ Phase II – Component Cleanliness

- Phase III - Printed Circuit Board Assembly (PCBA) Cleanliness
- Phase IV – Reliability Cleanliness Limits

# Questions?