

ENGINEERING PRACTICE STUDY

TITLE: Proposed Changes to MIL-PRF-38535 Concerning Requirements for Internal Gas Analysis (IGA) Test Flow, and Addition of a Process Monitor Program

November 26, 2024

EP Study Project Number: 5962-2024-009

Final Report

**Study Conducted by DLA Land and Maritime
Document Standardization Division (VA)
Active Device Branch (VAC)**

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Proposed Changes to MIL-PRF-38535 Concerning Requirements for Internal Gas Analysis (IGA) Test Flow, and Addition of a Process Monitor Program

- I. **OBJECTIVE:** The purpose of this Engineering Practice (EP) Study is to obtain input/feedback from the microcircuits manufacturers, test laboratories, OEM, users, military services and space community members regarding IGA packaged related test under the MIL-PRF-38535 specification.
- II. **BACKGROUND:** DLA has been requested to provide clarification to the current footnote 12/ of Table V Group D (package related test) Subgroup 6 as currently specified in MIL-PRF-38535. Herein this EP Study are proposed changes in MIL-PRF-38535 to update and add clarification for IGA accept criteria. Also proposing an Internal Gas Analysis (IGA) process monitor program in effort to aid in the determination criteria for lot acceptance.

The initial EP Study change proposals are highlighted **yellow** in attachments #2 & #3 to this EP Study and are based on updating MIL-PRF-38535 revision M dated November 01, 2022.

The EP Study is available at:

<https://landandmaritimeapps.dla.mil/programs/milspec/ListDocs.aspx?BasicDoc=5962EPStudies>

This is not an initial draft to MIL-PRF-38535, but a means to evaluate potential changes to the specification prior to inclusion into a formal draft.

DLA Land and Maritime-VAC is requesting interested stakeholders to review all attachment and send comments and feedback to DLA within the stipulated time for discussion and further development.

(Attachment # 1) – History progression timeline of IGA requirement.

(Attachment # 2) – Draft Proposal to IGA test for MIL-PRF-38535 Table V Group D (package related test) Subgroup 6.

(Attachment # 3) – Draft Proposal of adding process monitor program for IGA test.

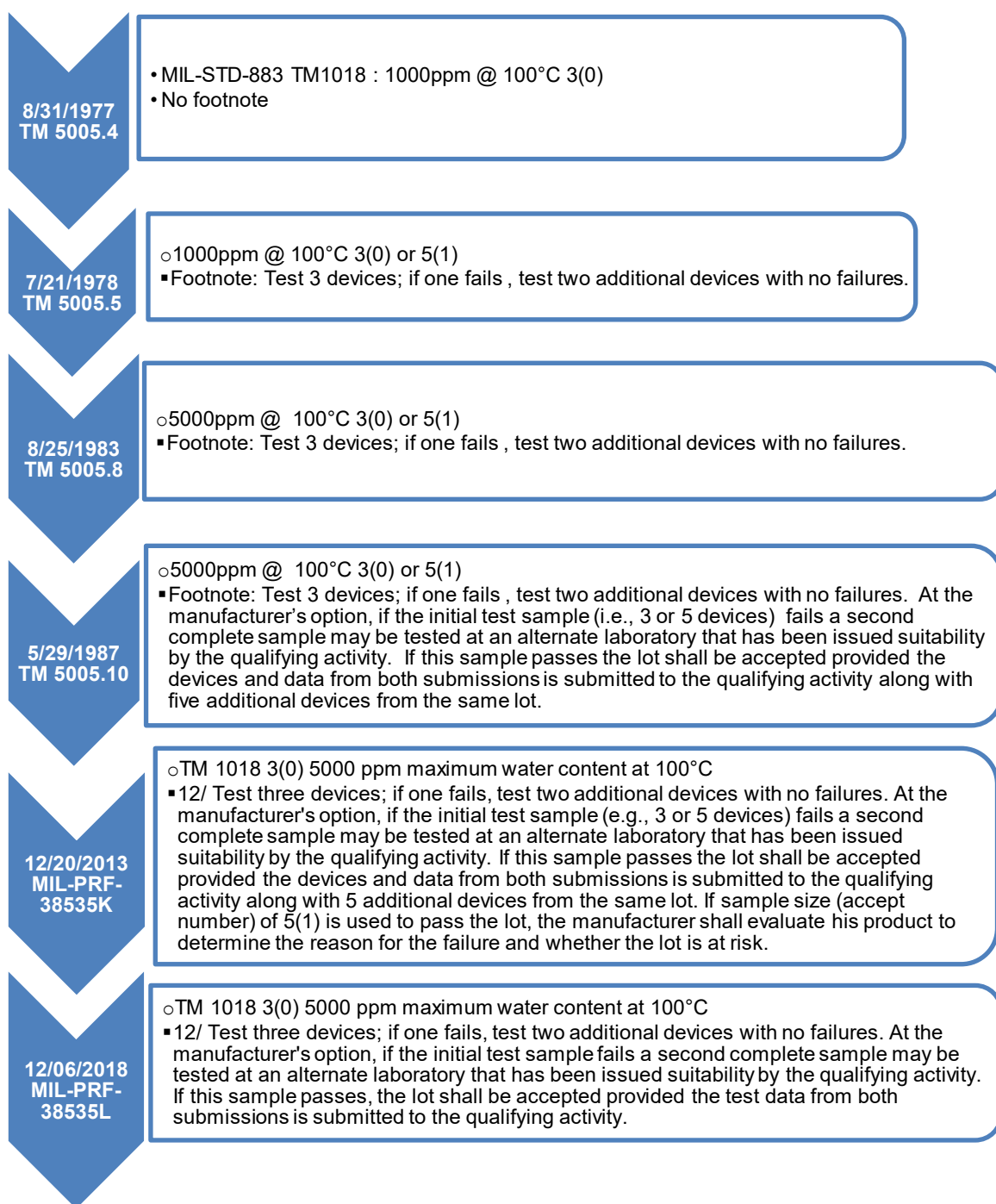
(Attachment # 4) - Survey questionnaire and received feedback summary.

- III. **RESULTS:** The EP Study project was initiated, and an initial draft was made available online and distributed to JC-13, CE-12, Government Working Group (GWG) and members of the space community on September 5, 2024, for review and comments. Feedback was solicited from all relevant stakeholders, including military services, microcircuit manufacturers, microcircuit distributors, original equipment manufacturers (OEMs), and user communities regarding the IGA proposal.
- IV. **CONCLUSIONS:** Feedback on this IGA EP study was provided by 14 device manufacturers, 4 OEM / users, and 2 consultants / subject matter experts (SME). The initial EP Study change proposals to footnote 12/ (Table V, Group D, Subgroup 6: IGA test) and IGA process monitor will undergo further review and discussion for consensus-building through the JEDEC JC-13.2 IGA task group. All Comments received to the survey questionnaire are summarized for review in *blue italicized text* of attachment #4.
- V. **RECOMMENDATIONS:** DLA Land and Maritime recommends for all military and industry representatives to review the comments summarized in attachment #4. DLA Land and Maritime recommends that modifications for an IGA process monitoring program and modifications of footnote 12/ in MIL-PRF-38535 undergo the coordination process, be updated, and this feedback be incorporated.

ATTACHMENT #1

History progression timeline of IGA requirement.

Time line history of IGA 3(0) requirement from MIL-STD-883 to the current revision of MIL-PRF-38535.



ATTACHMENT #2

Proposal to IGA test for MIL-PRF-38535 Table V Group D (package related test) Subgroup 6.
initial EP Study change proposals are highlighted yellow

MIL-PRF-38535 Table V Group D (package related test) Subgroup 6

Current requirement:

Subgroups	Test	Hermetic classes Class Q and V
Subgroup 6 <u>12/</u>	Internal Gas Analysis (IGA) Test (cavity packages)	TM 1018 3(0) 5,000 ppm maximum Water content at 100°C

12/ Test three devices; if one fails, test two additional devices with no failures. At the manufacturer's option, if the initial test sample fails a second complete sample may be tested at an alternate laboratory that has been issued suitability by the qualifying activity. If this sample passes, the lot shall be accepted provided the test data from both submissions is submitted to the qualifying activity.

Draft Proposed verbiage to add clarification to MIL-PRF-38535 Table V Group D (package related test) Subgroup 6, footnote 12/

(this is not considered a change to the requirement)

From:

12/ Test three devices; if one fails, test two additional devices with no failures. At the manufacturer's option, if the initial test sample fails a second complete sample may be tested at an alternate laboratory that has been issued suitability by the qualifying activity. If this sample passes, the lot shall be accepted provided the test data from both submissions is submitted to the qualifying activity.

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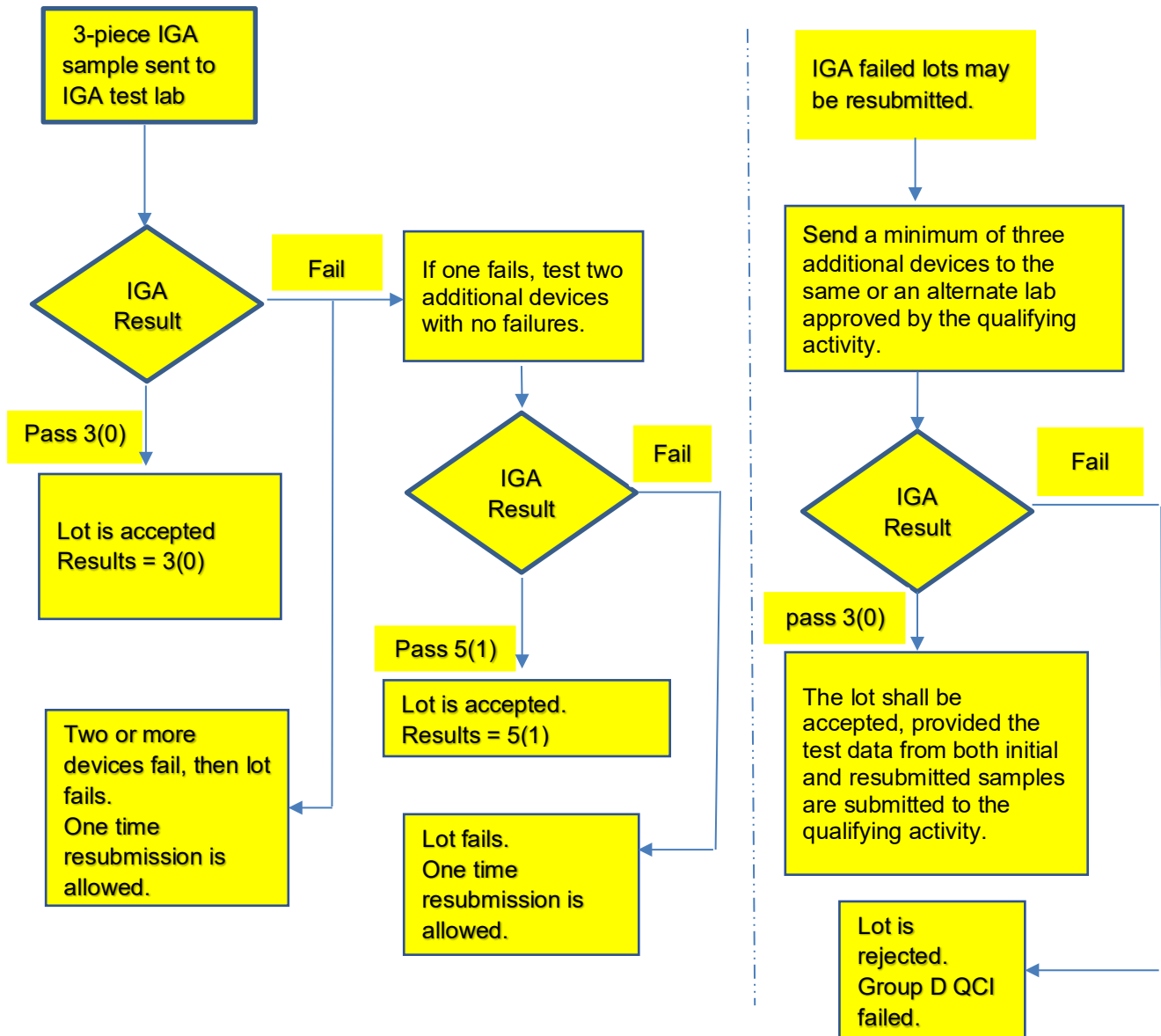
12/ Test three devices 3(0); if one fails, test two additional devices with no failures 5(1). If two or more devices fail from the initial test sample, the manufacturer may resubmit a minimum of three additional devices to the same or an alternate lab approved by the qualifying activity, with no failures allowed. If all resubmitted samples pass 3(0), the lot shall be accepted, provided the test data from both initial and resubmitted samples are submitted to the qualifying activity. The manufacturer shall evaluate any failure to determine the cause and potential risk to the lot.

ATTACHMENT #2 - Continued.

Draft Proposed flowchart to add clarification to MIL-PRF-38535 Table V Group D (package related test) Subgroup 6, footnote 12/

initial EP Study change proposals are highlighted **yellow**

(this is not considered a change to the requirement)



ATTACHMENT #3
Draft Proposal of adding process monitor program for IGA test.
initial EP Study change proposals are highlighted **yellow**

Add a new footnote 19/ for process monitor program in combination with group D subgroup 6

Subgroups	Test	Hermetic classes Class Q and V
Subgroup 6 <u>12/ 19/</u>	Internal Gas Analysis (IGA) Test (cavity packages)	TM 1018 3(0) 5,000 ppm maximum Water content at 100°C

Draft:

19/ The QML manufacturer shall establish a process monitor program for performing Group D subgroup 6 IGA test. The IGA monitoring program shall be in accordance with A.3.4.1.2.7 in Appendix A and be approved by the qualifying activity.

Add a new paragraph, A.3.4.1.2.7 IGA Process monitor control program requirements.

Draft:

A.3.4.1.2.7 Internal Gas Analysis (IGA) Process monitor control program requirements.

- 1) Package Moisture Content Monitoring: All manufacturers shall implement internal gas analysis monitoring within the manufacturing flow. The IGA must be performed during lot acceptance testing until sufficient data identifies which packages are susceptible to IGA failures.
- 2) Special Monitoring Schedule: A tailored monitoring schedule shall be established for packages identified as susceptible, continuing until all issues are resolved. The moisture content within the sealing environment must be controlled to prevent excess internal moisture.
- 3) Moisture Content Limits: The internal moisture content of hermetic packages shall not exceed 5,000 ppm when tested in accordance with MIL-STD-883, Test Method 1018, at +100°C.
- 4) Gas Analysis and Anomaly Detection: Manufacturers shall compare the known sealing environment with IGA results to detect anomalies. Variations in the presence of Nitrogen (N₂), Oxygen (O₂), Argon (Ar), Carbon Dioxide (CO₂), Hydrogen (H₂), Helium (He), Methane (CH₄), Ammonia (NH₃), Mass 69 fluorocarbons, and moisture shall be monitored.
- 5) Non-Production Periods: Monitoring is not required during extended non-production periods as defined in the manufacturer's Quality Management (QM) plan. Upon resuming production, monitoring shall be re-established according to the minimum IGA dataset requirements.
- 6) Corrective Actions: If IGA samples exceed control limits, the minimum sample size defined in the manufacturer's QM plan shall be used to verify the root cause of the failure and that corrective actions have returned results within control limits. New control limits must be reviewed and approved by the Technology Review Board (TRB), with records retained and submitted to the Qualifying Activity.
- 7) Documentation and Traceability: A documented procedure is required for the traceability, evaluation, and disposition of all units monitored since the last successful IGA test.

Attachment #4 Survey questionnaire and received feedback summary.
Comments received to the survey questionnaire are summarized in *blue italicized text*.

Questions: These questions are designed to gather insights into the practical aspects, challenges, and potential advantages of the current internal gas analysis IGA test flow and implementing a process monitor program for MIL-PRF-38535 microcircuit devices.

Feedback on the IGA EP study was provided by 14 device manufacturers, 4 OEM / users, 2 consultants/subject matter experts.

1. What are your overall thoughts and concerns regarding the proposed clarification in attachment #2 (Footnote 12/ and flow chart)?

Device Manufacturers:

- *8 agree with the proposed verbiage for greater clarification of footnote 12/.*
- *6 agree with the proposed footnote, however, disagree to last sentence: "The manufacturer shall evaluate any failure to determine the cause and potential risk to the lot".*

OEM / Users:

- *3 users recommend deleting footnote 12/.*
- *1 user express concerns about greater confidence needed to pass IGA test.*

Consultant / SME comments

- *Eliminate infrequent 3(0)/5(1) sampling. Adopt AQL sampling plans for each seal lot.*

2. Should the allowance option for testing IGA at an alternate laboratory be allowed and why?

Device Manufacturers:

- *13 manufacturers support the use of alternate labs as a confirmatory test, citing concerns that the initial test results may have been impacted by poor handling, equipment and test procedure...etc.*

OEM / Users:

- *3 users responded no for testing at an alternate laboratory. Citing this creates opportunities to invalidate the first IGA lab test results and recommended incorporating process monitoring.*
- *1 user cited, "...the notion of using alternate laboratories is not necessarily a concern as long as the requirements for approving each lab and the criteria for granting suitability to each lab remains the same."*

Consultant / SME comments

- *Testing at an alternate laboratory, even in a second instrument at the same laboratory, should be avoided.*
- *Never ever consider doing a "round robin" study between labs*

3. Is a minimum of three additional devices a sufficient sample for "resubmission of failed lots for IGA test"? See attachment #2 flow chart.

Device Manufacturers

- *13 device manufacturers agree that resubmitting of second complete sample three devices minimum is sufficient.*
- *1 device manufacturer also recommends 2nd resubmission should use a tighter samplings scheme.*

OEM / User:

- *3 users responded no, citing that three devices are insufficient for resubmission and recommend resubmission should be doubling the original sample size (i.e., 6 samples, zero failures).*
- *1 user responded that current and proposed IGA test sampling and pass/fail criteria would be limited by several aspect such as test technology capability, precision, and accuracy.*

Attachment #4 Survey questionnaire.

4. Should the option for testing two additional samples for achieving sample size (accept) 5(1) be removed?
- a. For example, should the MIL-PRF-38535 move to a single submission 3(0)?

Device Manufacturers

- 13 manufacturers responded to keep the requirement as is and do not recommend moving to a single submission of 3(0).

Additional device manufacturer comments

- Due to accuracy and repeatability concerns with IGA testing, if one fails testing additional two samples has been historically an accepted practice. Removing this option may potentially result in scrap of acceptable material that may lead to continuity of supply issues to our customers.
- One manufacturer responded, "Before removing options such as allowing a 5(1) and prevent resubmission to alternate lab, it is imperative to establish first the confidence level about each lab's equipment accuracy, and equipment-to-equipment and lab-to-lab correlation."
- Keeping the option to test two additional parts within a submission seems reasonable, as it provides a larger sampling size. I recommend keeping this option available.

OEM / Users:

- 3 users recommended Yes, MIL-PRF-38535 should move to a single submission 3(0).
- 1 user responded that current and proposed IGA test sampling and pass/fail criteria would be limited by several aspect such as test technology capability, precision, and accuracy.

Consultant / SME comments

- Sample size 3 was selected based on analytical chemistry practice, generally, to analyze samples in triplicate.
- A problem was that analysts were not sure just how good mass spectrometers (or any of the other methods) were at quantitative analysis of exceedingly small amounts of water vapor. There were no primary (NIST-certified) standards for calibration (and still aren't). So, the 5(1) contingency was added to the 3(0) criteria, where if 1 of the first 3 units was non-compliant, 2 additional units could be tested. If there were no further non-compliances, a shipment was declared acceptable. Hence the 3(0)/5(1) sample plan.
- The idea was to avoid possible rejection of good product caused by measurement uncertainty. The idea was **NOT** to allow a 20% defect rate, though it can be argued that was the practical result. Air Force scientists driving the development of TM 1018 had their own uncertainties about analysis systems and agreed to the 5(1) contingencies.

5. If the lot passes 5(1), should the data from the results be submitted to the qualifying activity for lot acceptance?

Device Manufacturers

- 11 manufacturers recommended that there is no need for QA review for analyzing two additional devices with no failures.

Additional device manufacturers comments:

- Lot passing 5(1) could be an anomaly occurred during testing unrelated to assembly process, making QA submission unnecessary.
- Submitting data to QA could cause delays in manufacturers ability to dispositions the lot.
- reports should be available only upon request.

OEM / Users:

- 3 users recommend specification requirements should be stricter, with a 3(0)-acceptance criterion. Footnote 12 should be removed to ensure that any failure results in a failed lot.

Additional OEM / user comments

- An IGA failure in Group D jeopardizes not just the current lot but also all lots produced in the previous six months up to the last known passing results.
- Emphasize the need for analysis and corrective action to assess the extent of lot jeopardy.

Attachment #4 Survey questionnaire.

6. What are your overall thoughts and concerns regarding the proposed process monitor being implemented in MIL-PRF-38535?
- Will this process monitor support IGA test evaluations to determine whether a lot is at risk?
 - Do you have any suggestions to modify this process monitor program?

Device Manufacturers

- 1 abstention & 13 manufacturers take exception to the process monitor for various reasons.*
- 4 manufacturers suggest "accuracy and repeatability" and "lab to lab" correlation studies should be conducted before proposing additional IGA requirements.*

Additional device manufacturers comments:

- It could be very difficult to find root cause/actions therefore, implementing control limit that imply corrective actions when out of control will be too ambitious from our point of view. The process monitor should be allowed as an option/alternative but not as a requirement.*
- Lots should be accepted or rejected based on the test criteria outlined in attachment 2. The process monitor requirement adds no value to determining risk to a lot.*
- This will be a challenge with our high mix, low volume, parts mix.*
- Most manufacturers have an established and robust assembly process already. This should be implemented on manufacturers to which IGA issue is encountered.*
 - recommend implementing this process monitor only in cases where multiple lots have demonstrated failures.*

OEM / Users:

- 4 users support implementing a process monitor would reduce the amount of lot jeopardy when IGA failures occur.*

Additional OEM / user comments

- This monitor will not provide evidence of lot risk for every lot-as only some lots will be assessed with IGA.*
- Control of the sealing environment is important but equally if not more important is the control of materials used inside the package (think 5011 certification) and the use of sufficient cure cycles to minimize outgassing post seal of the part.*

Consultant / SME Comments

- "Monitoring" plans where 3 or 5 units are analyzed infrequently are only a snapshot in a moment of time. They are virtually useless in providing ongoing assurance of moisture control for any given package type or sealing process.*
- "Corrective Actions" The paragraph uses the term "control limits". "Control limits" (to me) implies Upper and Lower 3-sigma (or other variable) limits around a process mean, defining consistency and magnitude of variability of a material or process. In the context of Item No. 6, 5,000 ppmv is not a control limit, it's a "specification limit" or an "acceptance criterion".*