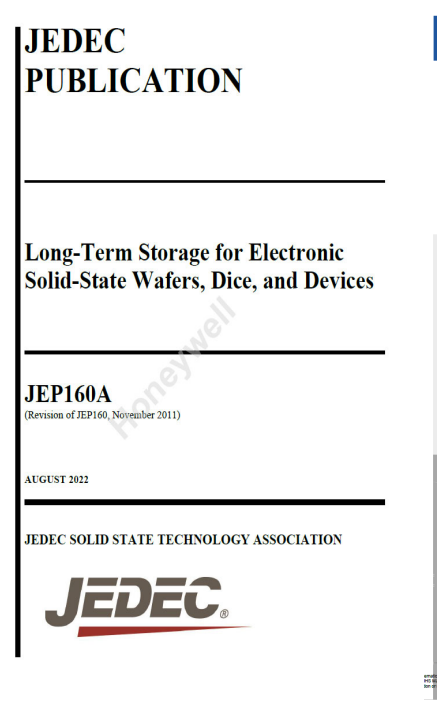

JEDEC PUBLICATION

Long-Term Storage for Electronic Solid-State Wafers, Dice, and Devices

JEP160A
(Revision of JEP160, November 2011)

AUGUST 2022

JEDEC SOLID STATE TECHNOLOGY ASSOCIATION

JEDEC

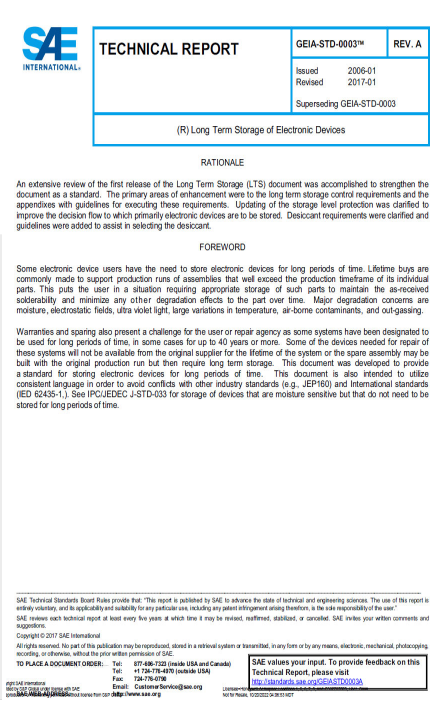

IEC 62435-1
Edition 1.0 2017-01

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Electronic components – Long-term storage of electronic semiconductor devices –
Part 1: General

Composants électroniques – Stockage de longue durée des dispositifs électroniques à semiconducteurs –
Partie 1: Généralités


SAE INTERNATIONAL

TECHNICAL REPORT

GEIA-STD-0003™ REV. A

Issued 2006-01
Revised 2017-01

Superseding GEIA-STD-0003

(R) Long Term Storage of Electronic Devices

RATIONALE

An extensive review of the first release of the Long Term Storage (LTS) document was accomplished to strengthen the document as a standard. The primary areas of enhancement were to the long term storage control requirements and the appendixes with guidelines for executing these requirements. Updating of the storage level protection was clarified to improve the decision flow to which primarily electronic devices are to be stored. Desiccant requirements were clarified and guidelines were added to assist in selecting the desiccant.

FOREWORD

Some electronic device users have the need to store electronic devices for long periods of time. Lifetime buys are commonly made to support production runs of assemblies that well exceed the production timeframe of its individual parts. This puts the user in a situation requiring appropriate storage of such parts to maintain the as-received solderability and minimize any other degradation effects to the part over time. Major degradation concerns are moisture, electrostatic fields, ultra violet light, large variations in temperature, air-borne contaminants, and out-gassing.

Warranties and sparing also present a challenge for the user or repair agency as some systems have been designated to be used for long periods of time, in some cases for up to 40 years or more. Some of the devices needed for repair of these systems will not be available from the original supplier for the lifetime of the system or the spare assembly may be built with the original production run but then require long term storage. This document was developed to provide a standard for storing electronic devices for long periods of time. This document is also intended to utilize consistent language in order to avoid conflicts with other industry standards (e.g., JEP160) and International standards (IED 62435-1). See IPC/JEDEC J-STD-033 for storage of devices that are moisture sensitive but that do not need to be stored for long periods of time.

ACTIVE PACKAGING FOR LONG TERM STORAGE OF HIGH RELIABILITY PARTS

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2-May-2024

Honeywell

This presentation is “Not Subject to Export Regulation”

OUTLINE

1. **Introduction**
2. **Active Package Definition**
3. **Moisture Controls**
   - JEDEC J-STD-033
4. **Corrosion Control**
   - Oxygen Scavenger (Getter)
5. **Ethylene Getters**
   - Activated Charcoal (Carbon)
6. **The Savings**
7. **Future Developments**
3. **Final Notes & lessons learned**
4. **Conclusions and Recommendations**

INTRODUCTION

- If one removes Oxygen, Water Vapor, and Volatile Organic Compounds (VOCs) from an air-filled closed container, the results would be dry nitrogen with traces of noble & inert gases.

- Per MDA-QS-003-PMAP-REV C (Missile Defense Agency Parts, Materials, and Processes Mission Assurance Plan):

  - Uninterrupted storage of parts in dry nitrogen may have **unlimited shelf life** and the contractor shall provide specific information for cases when that applies.

Major constituents of air, by mole fraction[8]

Dry air			
Gas		Mole fraction(A)	
Name	Formula	in ppm(B)	in %
Nitrogen	N_2	780,840	78.084
Oxygen	O_2	209,460	20.946
Argon	Ar	9,340	0.9340
Carbon dioxide (April 2022) (C)[13]	CO_2	417	0.0417
Neon	Ne	18.18	0.001818
Helium	He	5.24	0.000524
Methane (2022)(C)[14]	CH_4	1.91	0.000191
Krypton	Kr	1.14	0.000114
If air is not dry:			
Water vapor(D)	H_2O	0–30,000(D)	0–3%(E)

notes:

- (A) Mole fraction is sometimes referred to as volume fraction; these are identical for an ideal gas only.
- (B) ppm: parts per million by molecular count
  - The total ppm above adds up to more than 1 million (currently 83.43 above it) due to experimental error.
- (C) The concentration of CO_2 has been increasing in recent decades, as has that of CH_4.
- (D) Water vapor is about 0.25% *by mass* over full atmosphere
- (E) Water vapor varies significantly locally[11]

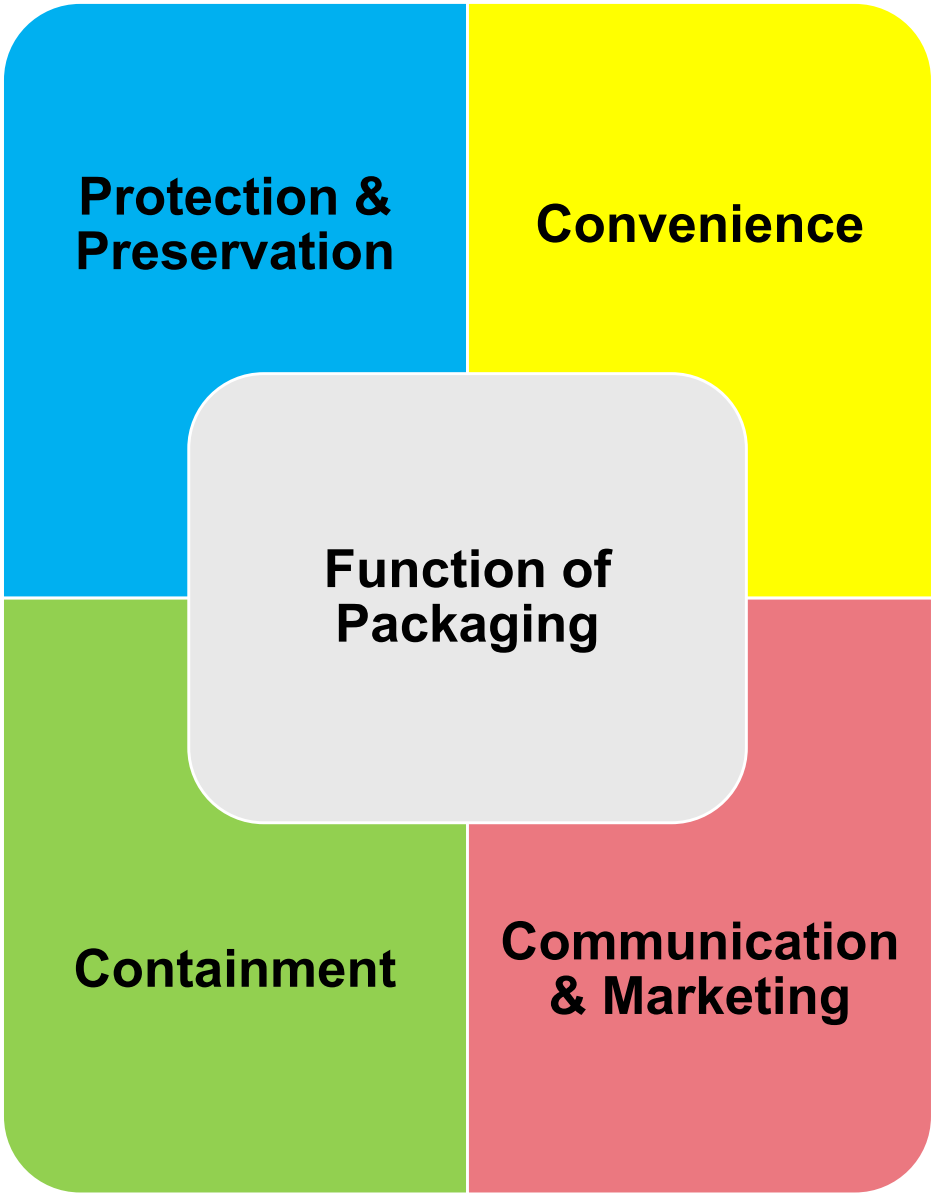
Credit: Wikipedia

ACTIVE PACKAGE DEFINITION

The terms active packaging, intelligent packaging, smart packaging and connected packaging refer to packaging systems used with foods, pharmaceuticals, and several other types of products.

They help extend shelf life, monitor freshness, display information on quality, improve safety, and improve convenience.

Credit: Wikipedia



ACTIVE PACKAGE DEFINITION (CONT.)

Partial List of Functions:

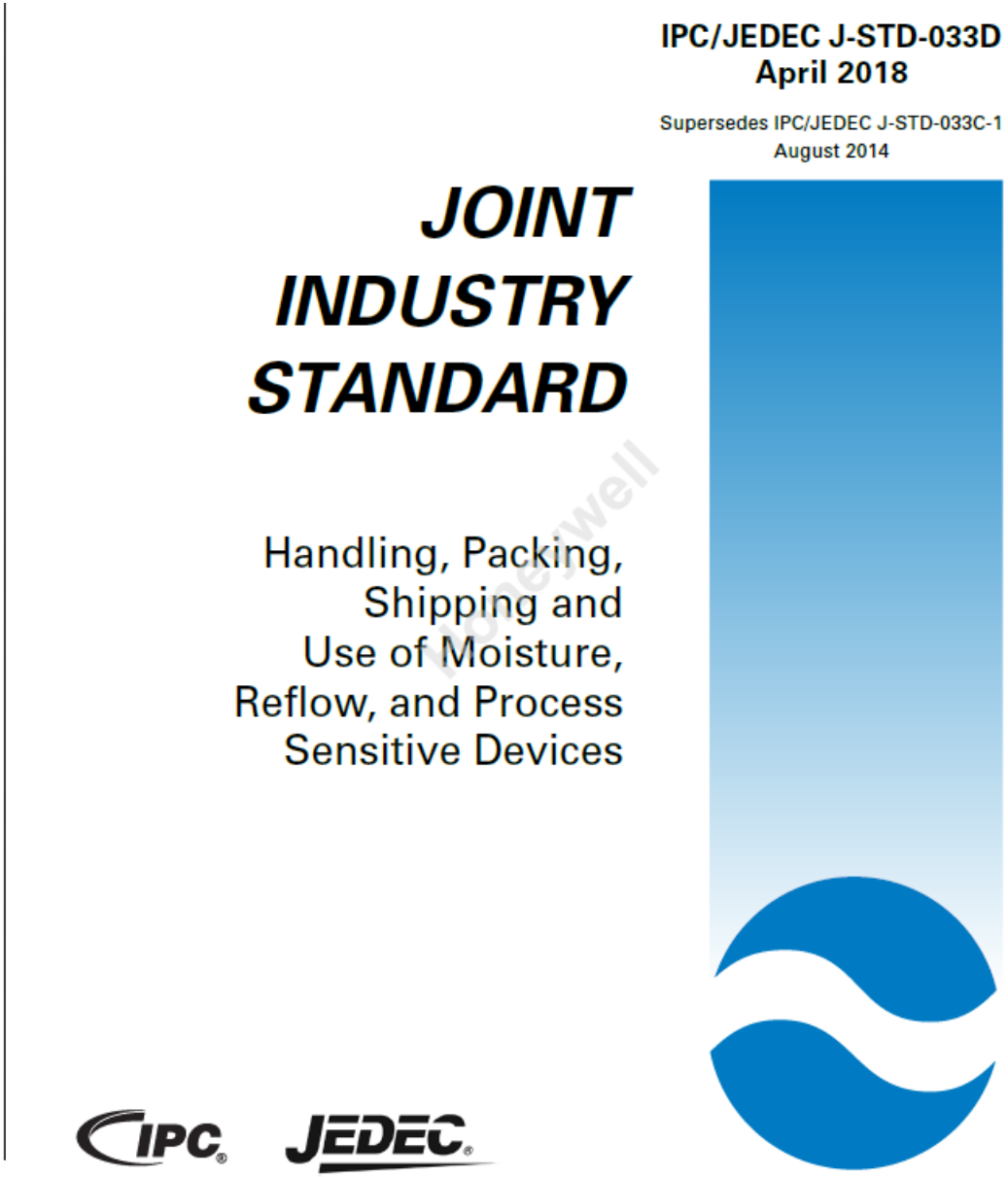
1. Moisture control
2. Corrosion Control
3. Metal chelation
4. Oxygen control
5. Atmosphere
6. Temperature monitor
7. Controlling package temperatures
8. Dispensing
9. RFID
10. Security
11. Microwave packaging
12. Shock and vibration
13. Antimicrobial control

Credit: Wikipedia

MOISTURE CONTROLS

- Package all parts as if they were moisture sensitive in accordance with J-STD-033
- The use of non-dusting desiccant is recommended
- The number of desiccant units should be tripled* for longer shelf life

* J-STD-033 provides for 12-month minimum shelf life, 36 months is typical (anecdotal); triple desiccant is recommended for a 9 to 10-year shelf life



OXYGEN SCAVENGER (GETTER)

Journal of Food Science and Technology

2024 Feb; 61(2): 242–252

Published on line 9 Feb 2023

Role of oxygen absorbers in food as packaging material, their characterization and applications

Prerna Gupta

"One of the smartest ways of maintaining the quality of fresh and highly perishable food products is by **using oxygen absorbers**."

"These absorbers preserves the food against **oxidative damage** from within a packed environment and provides better storage with improved food security."

OXYGEN SCAVENGER (GETTER) CONT.

Oxygen Absorbers are used to remove oxygen from within a sealed environment, creating a nitrogen environment for long-term food storage

They are used when dry foods are packaged in sealed containers

When used with proper packaging and sealing, the oxygen in the packaging is greatly reduced

Our absorbers bring the oxygen level down reliably to .01% or less

Credit: https://www.usaemergencysupply.com/information-center/packing-your-own-food-storage/oxygen-absorbers-and-long-term-food-storage

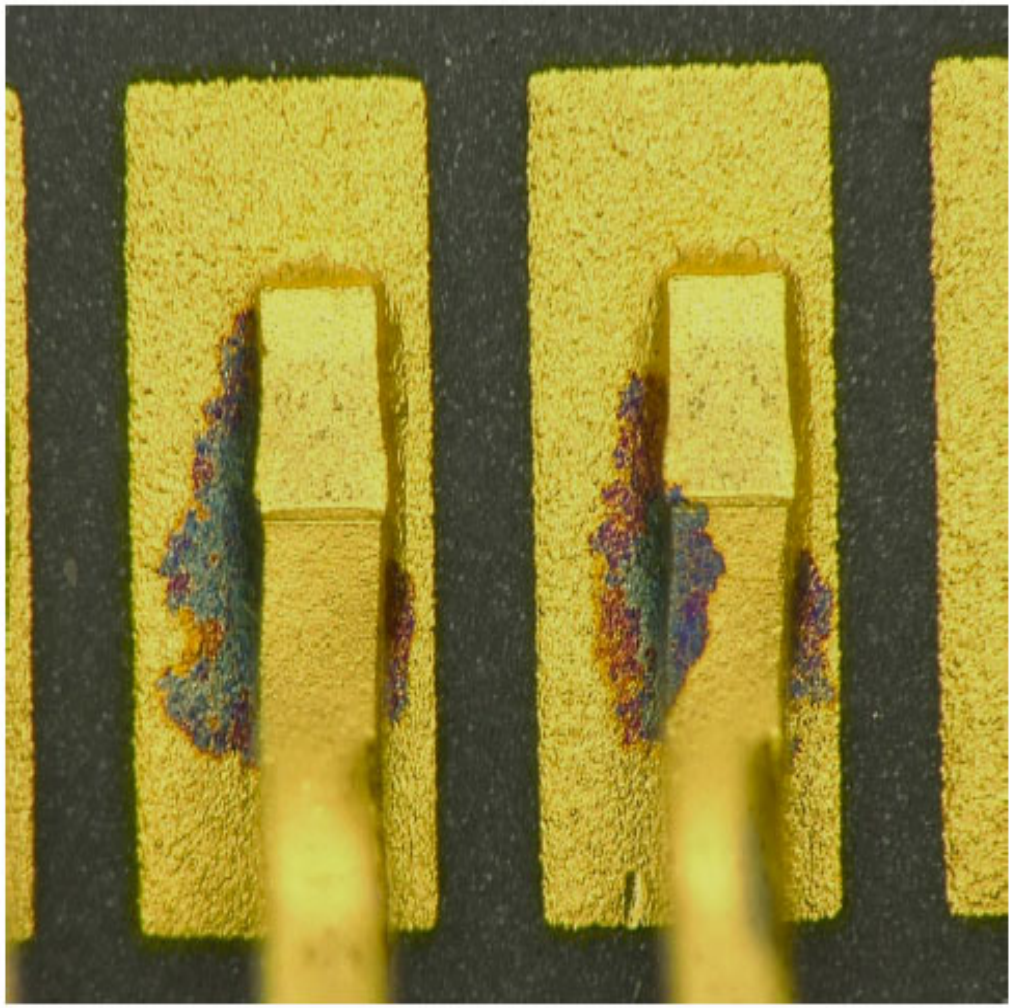
ACTIVATED CHARCOAL (CARBON) USES

Studies in Environmental Science, Volume 61, 1994, Studies in Environmental Science

The Use of Activated Carbon in the Removal of VOC's

H.Von Kienlea et al

This chapter discusses the *use of activated carbon in the removal of volatile organic compounds (VOC's).*



Credit: Honeywell FAL at Clearwater

ACTIVATED CHARCOAL (CARBON) CONT.

Journal of Hazardous Materials
Volume 394, 15 July 2020

Release of harmful volatile organic compounds (VOCs) from photo-degraded plastic debris: A neglected source of environmental pollution

Tommaso Lomonaco et al

Plastic debris photo-degradation releases harmful VOCs in the environment

Polystyrene-based plastic debris emits aromatic compounds

Polyethylene-/polypropylene-based plastic debris emits oxygenated hydrocarbons

All samples released harmful compounds (e.g., acrolein, benzene, propanal, methyl vinyl ketone, and methyl propenyl ketone)

ACTIVATED CHARCOAL (CARBON) CONT.

Acrolein - As an electrophile *may promote corrosion; water soluble*

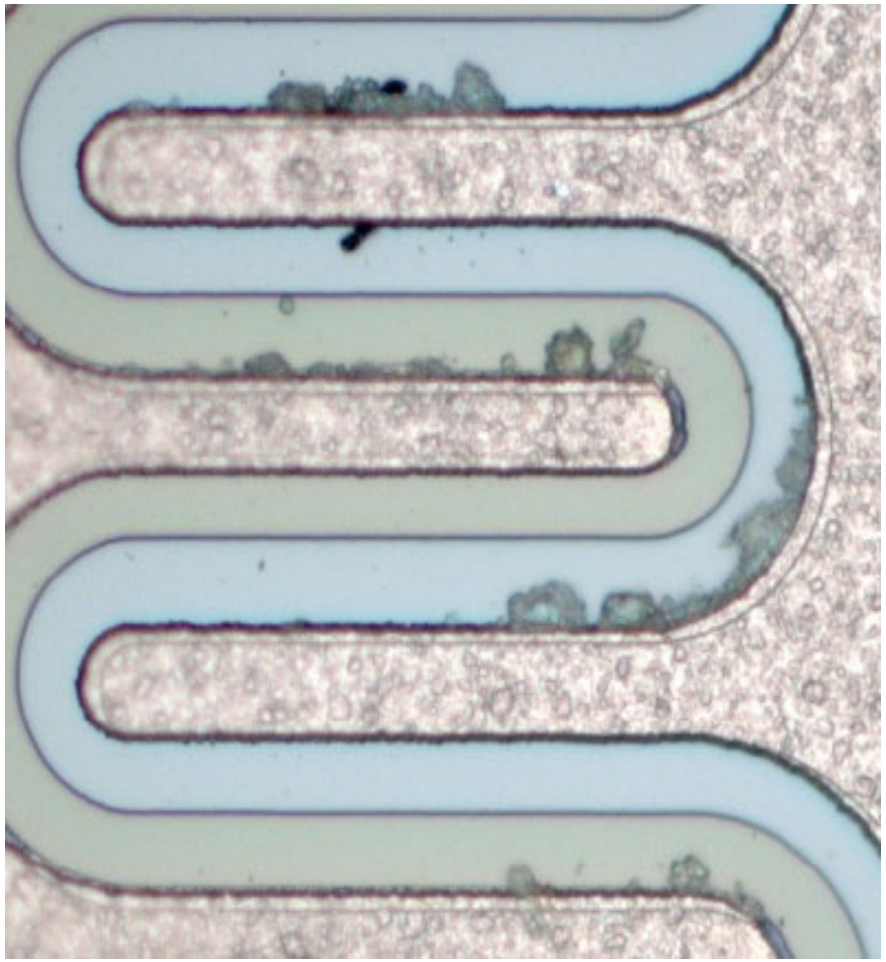
Benzene - Aromatic hydrocarbon with limited use in consumer items because of its toxicity

Propanal – Flammable and *Corrosive; water soluble*

Methyl vinyl ketone - flammable, highly toxic, and *corrosive; water soluble*

Methyl propenyl ketone - an oxygenated hydrocarbon lipid molecule; toxic

Note: ESD safe plastic materials are formulated to prevent VOCs, but 100% elimination is not guaranteed. Over long periods, VOCs should be anticipated



Credit: Honeywell FAL at Clearwater

Activated Charcoal (carbon) will trap these!

WHY ACTIVATED CHARCOAL (CARBON)?

Credit: Honeywell FAL at Clearwater

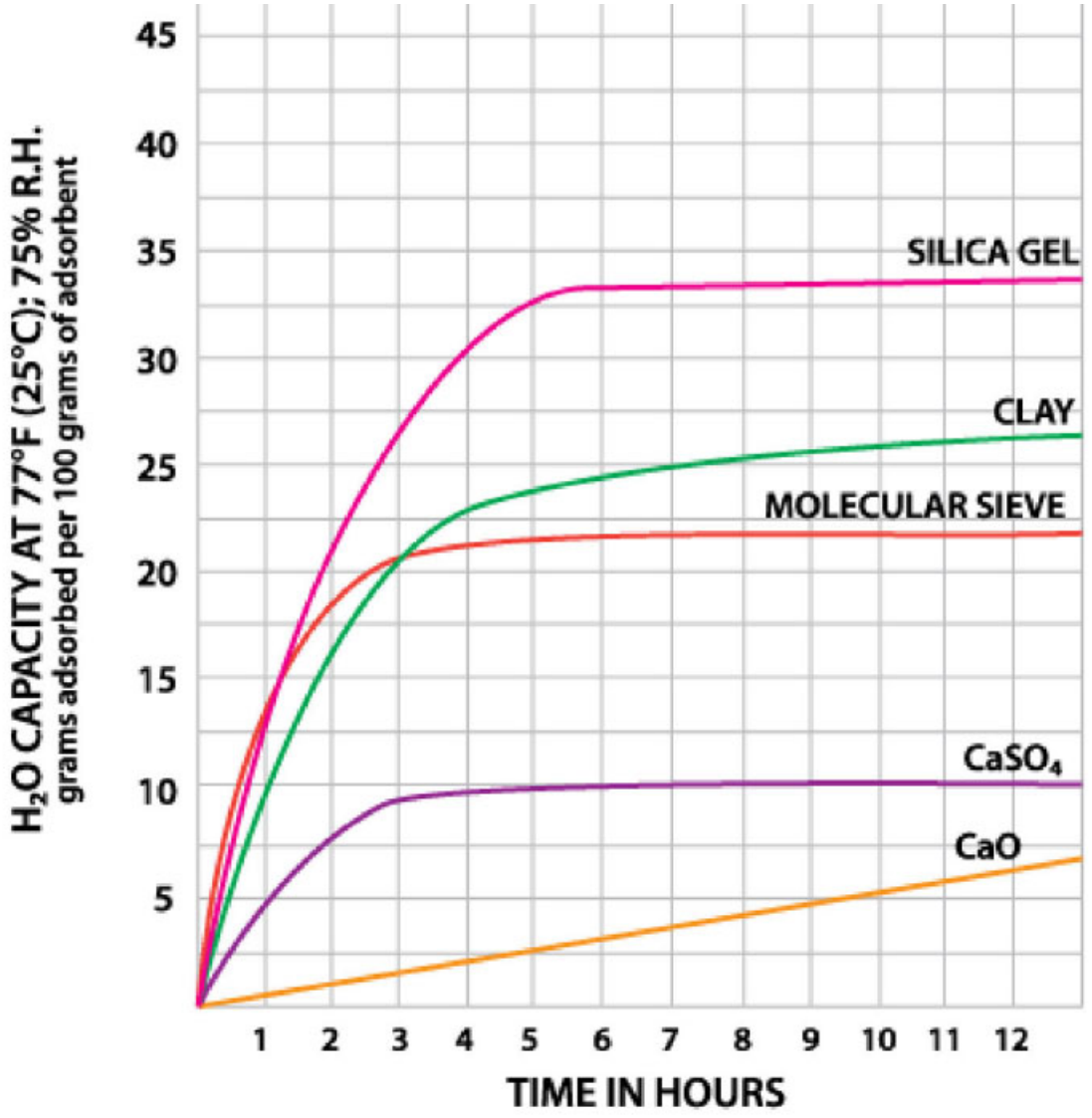
- **Monolayers of water (moisture) should be anticipated (1/) in metal and semiconductor surfaces at room temperature**
  - **These layers of water will not be trapped by the desiccant because the bonds between these layers to the metal are strong**
- **Due to the minute amounts of water in these surfaces, *the molar concentration of the water-soluble VOCs could be extraordinary* thus promoting undesirable corrosion processes**
- **The soluble VOCs can be trapped effectively by activated charcoal (carbon)!**

THE SAVINGS

- **For many programs at Honeywell, shelf-life extension routines imply heavy testing on a 100% basis.**
  - For a few programs, shelf life is unlimited if desiccants, oxygen getters, and activated charcoal packets are used, thus preventing re-life testing
- **For other programs, extensive sequential qualification tests are required for each lot (i.e., copper bond wire)**
  - The use of desiccants, oxygen getters, and activated charcoal packets may allow the acquisition of a life-time quantities (very large lots), consequently preventing repeated qualification tests.
- **The cost avoidance of preventing corrosion during storage is significant.**
  - Failure Review Boards, Failure Analysis, lost inventories, lost production schedule

FUTURE DEVELOPMENTS

- As desiccants absorb water, they gain weight
- The dry bag is a closed system
- One could ascertain the integrity of the dry bag by weighing the bag (with parts and getters) at the time of sealing, recording the weight on the bag label, and repeating periodically
- If the dry bag wight remains constant, the dry bag seal integrity is verified without opening



Credit: Sorbent Systems online presence of IMPAK Corporation

FINAL NOTES & LESSONS LEARNED

1. Electrostatic Discharge (ESD) sensitive devices shall be handled in accordance with the approved local ESD prevention procedures.
2. Moisture Sensitive parts shall be handled in accordance with **J-STD-033** (Material handling, Packing, Shipping and Use of Moisture / Reflow Sensitive Surface Mount Devices) or the approved local procedures.
3. If the parts are permanently inside a functional dry-box (nitrogen flowing continuously), the recommendations herein may not be applicable. However, not all dry-boxes satisfy all the recommendations listed herein.
4. Consider a double dry bag (redundancy) for the most critical uses. The outer shell would take the abrasion from transportation, handling, and shelf vibration preserving the inner dry bag integrity over longer periods.
5. Consider revamping data retention processes. Over longer periods, establishing the part provenance and chain of custody will be critical.
6. Inventory control (physical parts count) will introduce handling risk.
7. Good quality labels are important over longer periods. Consider light shields.
8. Allocate the risk. Consider multiple dry bags with lower quantities at separate “secured” localities.
9. Only store “Known Good Parts.”

CONCLUSIONS & RECOMMENDATIONS

By researching Active Packaging from adjacent industries (food & pharmaceutical) it is recommended to protect electronic components in three (3) levels:

Level 1 uses desiccant, moisture barrier bag, and humidity indicator cards (HIC) as indicated in J-STD-033 except that additional units of desiccant are recommended to mitigate against humidity over longer periods

Level 2 is identical to Level 1, except that oxygen scavenger (getter) packets are recommended to mitigate against trapped oxygen

Level 3 is identical to level 2, except that activated charcoal (carbon) packets are recommended to mitigate against trapped Volatile Organic Compounds (VOC)

Level 3 offers the best storage method for the longest periods at any location globally

REFERENCES & CREDITS

1/ Tom Green, Bob Lowry; "White Paper: Why Three Monolayers of Moisture Are Important"

This research would not have been possible without contributions from the Honeywell Clearwater Failure Analysis Laboratory, dialogues with numerous Honeywell and Industry colleagues, specially from PepsiCo, Kraft Foods, Lockheed Martin, The Charles Stark Draper Laboratory, and Northrop Grumman.

Thank You!

QUESTIONS OR COMMENTS?

DELIVERING AFFORDABLE, INTELLIGENT SOLUTIONS

HONEYWELL HAS UNEQUALLED EXPERTISE IN DEVELOPING AND MANUFACTURING HARDWARE AND SYSTEMS TO MEET THE HIGH-PERFORMANCE DEMANDS OF SPACE MISSIONS

WE ARE HELPING TO CREATE THE NEXT GENERATION OF SPACE FLIGHT EXCELLENCE

THANK YOU

Honeywell