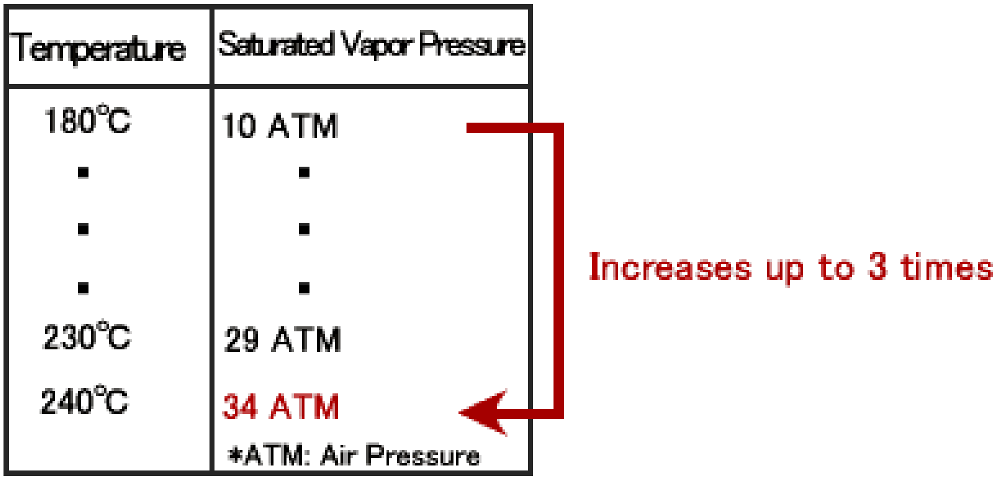
Combating Oxidation and Inter-metallics in Moisture Sensitive Components

To avoid the damage of micro cracks and delamination during the processing of electronic components, it is essential to provide appropriate environmental storage. The introduction of lead-free soldering and the higher processing temperatures involved increases the consequent saturated vapor pressure within components considerably (up to 30 bars). The same component that could safely be processed before lead free becomes a moisture sensitive device with limited floor life. The difference is often 2 sensitivity levels higher classification (MSL) and shorter allowable exposure time (“floor life”)



Temperature	Saturated Vapor Pressure
180°C	10 ATM
▪	▪
▪	▪
▪	▪
230°C	29 ATM
240°C	34 ATM
	*ATM: Air Pressure

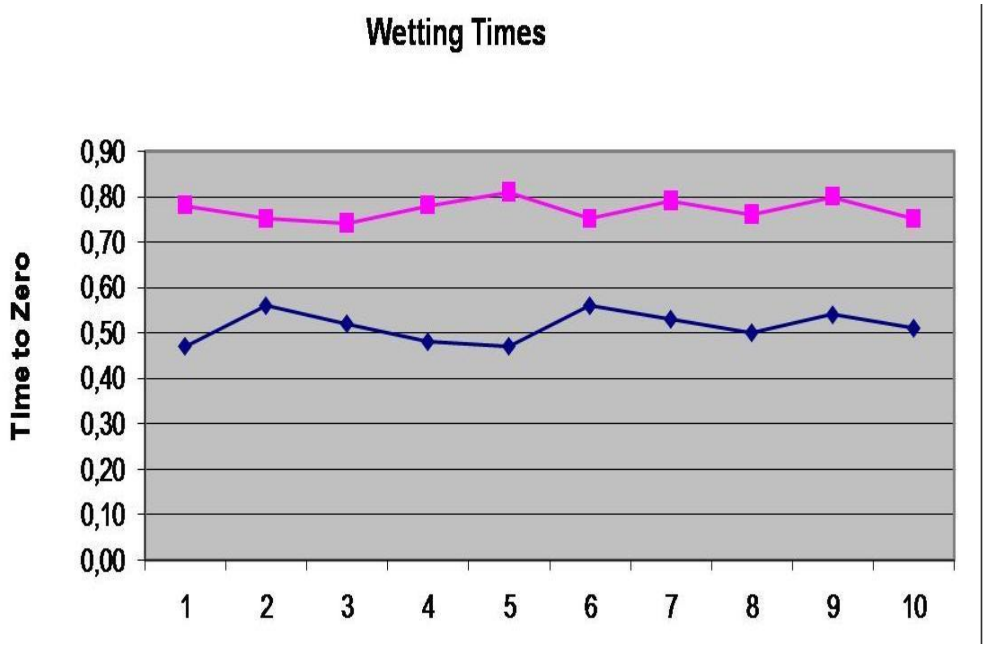
Increases up to 3 times

Manufacturers deliver these moisture sensitive components in effective protective packaging to avoid absorption of humidity during transport and storage. After opening the package the time begins during which the components absorb humidity. Depending upon ambient humidity and temperature, the components can be safely used only within a limited time period. This time period is classified by the IPC/JEDEC J-Std 033C.

When a component has exceeded the allowed exposure time the component can be dried through a baking process, after which the component should be processed immediately. A repeated absorption of humidity must be avoided because the baking process should not be repeated.

Even one exposure to baking induces oxidation and inter-metallic growth, which reduces the wetting ability of the connection surfaces. In addition, inter-metallic thickness has shown to increase by approximately 50% when baking at 125C for 4 days. Thicker inter-metallic layers can lead to a reduction in solder joint integrity and in extreme cases reduce solder ability.

SOIC 14 Chip, 60/40 Sn/Pb alloy, type R flux, 4 hours @ 100 C
SOIC 14 Chip, 60/40 Sn/Pb alloy, type R flux, as received



To fight this well-known effect, many suppliers of baking ovens provide an additional reduction of oxygen by means of a nitrogen atmosphere or vacuum during the drying

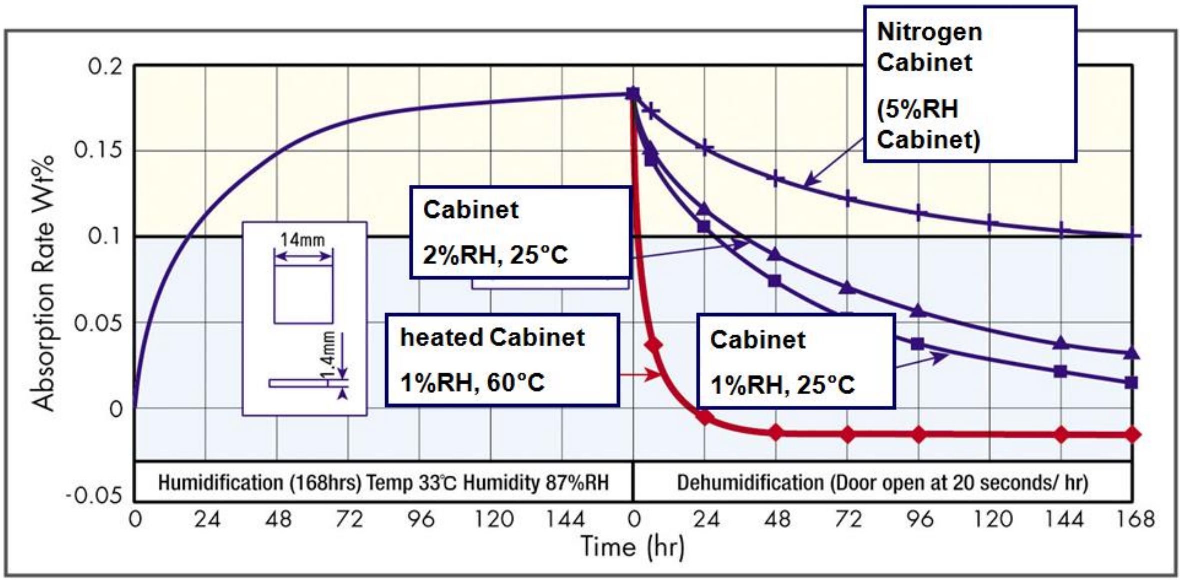
process. Setting the clock back to zero for the component can take in excess of 72 hours, inevitably bringing along considerable costs for nitrogen, and only a low rest-oxygen content of less than 13 ppm stops the oxidation.

Lead Free Soldering Alloys

Because of the considerably higher content of tin in lead-free soldering alloys, the need to consider oxidation protection during storage has increased in importance. This is caused by higher oxidation tendencies of these alloys and the generally more difficult wet ability and flow properties of lead-free soldering alloys.

The Oxidation Process

The oxygen causing the oxidation originates from two different sources. The first is the oxygen molecule O^2, found world-wide in our atmosphere. However, because of its atomic bond it only occurs at temperatures higher than 40°C. The second and in fact more aggressive bearer of oxygen is the water molecule H^2O. The oxygen atom is only weakly connected, and considerable oxidation can be observed at low temperatures. This means that not the content of oxygen, far more the content of humidity is decisive for the oxidation percentage in stored components. Technically it is possible to solve both problems at the same time. However it is important to avoid heating above 40°C thereby eliminating the air-oxygen as reaction partner, and to provide a strong dehumidification of the air at the same time. To achieve this, dry storage systems have been designed that can produce internal atmospheres of below 1% RH. With this extremely low content of humidity it is possible to protect the components against the additional absorption of moisture and also to remove the moisture already absorbed. As the diagram below shows, even storage in very clean nitrogen does not provide actual dehumidification of components as levels under 0.1 Wt % are not possible.



Modern Desiccant Technology

Ultra low humidity desiccant technology is now available that can sustain a low rest-humidity of <0.5% RH (0.05 grams H_20/m^3) effectively a “moisture Vacuum.” The latest technology also provides recovery times (after door openings) of less than three minutes. This provides practical working access throughout the day without raising the average RH above the J-Std-033C specified safe storage level.

Unlike clay or silica, these storage areas (which can be thousands of cubic feet in size) use a crystal known as Zeolite. It is a molecular sieve — that is to say, the size and shape of its structural openings are that of H2O molecules. And those water molecules are literally sifted from the air inside the cabinet. The desiccant is never touched by operators, and it never needs replacing, because the systems have automatic regeneration cycles.

This 0.5% RH enables not just safe storage, but an effective drying of components, even at room temperature. This is impossible to achieve with nitrogen alone. (Disagree? Put an apple in one of each type of cabinet and see what they look like after a day).

Components stored in ultra low RH cabinets utilizing such technology are thus dehumidified, even at ambient temperature. Increasing the temperature to 40C (the point as noted previously, at which most alloys will not oxidize) while maintaining 1% RH can further accelerate the drying time of components without oxidation or inter-metallic growth, and at 10% of the operating cost of high temperature baking.

By virtue of the oxidation protection explained previously, longer periods of storage without the use of moisture barrier bags are also practical. Safeguarding the quality and reliability of electronic assemblies starts with the controlled storage of components and PCBs.