Inflatable
Packaging Systems
Under High Altitude Conditions

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Introduction

Inflatable packaging systems are finding their way into the main stream of packaging as more and more companies are looking for efficient, effective and environmentally friendly cushioning and dunnage alternatives. Using positive air pressure, inflatable packaging systems secure products in place while providing an air barrier of protection.

One of the potential concerns with inflatable packaging systems is the material's ability to maintain air pressure under high altitude conditions. Currently, there is not an industry recognized or accepted test standard to evaluate the effects of altitude. Typically, inflatable packaging systems are tested to 8,000 feet since most major airlines, including air carriers such as United Parcel Service and Federal Express, pressurize their large jet aircraft to approximately 8,000 feet.

Some users test their inflatable packaging systems to 12,000 feet to simulate ground movements over certain passes in Colorado. Even with testing to 12,000 feet, companies using inflatable packaging systems, such as Motorola, were experiencing air loss in some of their inflatable packaging systems.

Motorola's concern for air loss in their inflatable packaging systems prompted an analysis of the "real-world" altitude dynamics to determine the range of altitude packaged-products may experience in the distribution environment.

All major airlines and air-carriers (UPS, FedEx, DHL, etc.) do pressurize their aircraft to approximately 8,000 feet. However, packaged-products may experience altitudes greater than 8,000 feet when transported via air. If the aircraft is pressurized to 8,000 feet, then how can packaged-products experience altitudes greater than 8,000 feet?

To find the answer, look no farther than the destination of the shipment. If the destination is to a remote area not immediately served by a major airport, then the packaged-product is introduced into a feeder-aircraft network.

In a feeder-aircraft network, the packaged-products are off-loaded from the carriers' large jets and loaded into a feeder-aircraft that serves the remote destination. Many of these feeder-aircraft do not have a pressurized cargo area. As long as the cabin is equipped with oxygen, the feeder-aircraft may fly at altitudes greater than 10,000 feet.

To illustrate, a package being shipped to Jackson, Wyoming, via UPS Next Day Air, first goes to Salt Lake City, Utah. From Salt Lake City, the packaged-product is transported to Jackson in a Cessna 404 (CN4), which has an un-pressurized cargo area but is equipped with oxygen in the cabin. Due to mountain ranges and certain weather conditions, the CN4 flight plan includes altitudes greater than 8,000 feet.

Studying the Real-World Express Air Environment

To analyze the “real-world” altitudes of the express air distribution environment, we identified key locations served by un-pressurized feeder-aircraft that have a high probability of reaching altitudes greater than 8,000 feet. Five destinations (Trinidad, CO; Pocatello, ID; Fairbanks, AK; Jackson, WY and Tohopah, NV) were selected as altitude tests sites based on this criteria.

Measuring the in-flight altitudes to the designated destinations requires the use of a pressure logger. UPS Professional Services used a HOBO® Pressure Logger, which is a general purpose pressure logger, measuring pressures in the range from 3% to about 110% of atmospheric pressure and altitude ranges from 0 to 32,000 feet.

To conduct the test, the HOBO® Pressure Logger was configured to record the altitude, in feet, for a duration long enough to capture altitude data for the outbound and return shipments. The pressure logger was then packaged in a UPS Next Day Air Express Box and shipped to the designated destination via UPS Next Day Air. At the destination site, the pressure logger was immediately returned via UPS Next Day Air. At the end of this cycle, the data in the pressure logger was downloaded for analysis purposes. The test was conducted to Alaska twice and each of the other sites four times, to ensure accurate data collection.

Research Results

The test results confirmed our expectations, as 28 of the 36 flight segments experienced altitudes greater than 8,000 feet. Chart 1 summarizes the highest recorded altitude for each destination.

Destination Site	Highest Recorded Altitude (feet)
Alaska	13,211
Nevada	16,101
Colorado	14,011
Idaho	14,662
Wyoming	15,742

Chart 1

In addition to conducting the altitude tests, we contacted Ameri Flight, Floyd Saltz Air, Martin Air, Inc. and Superior Aviation to corroborate cruising altitudes and worst-case scenario flying altitudes.

Each of the airlines confirmed that feeder-aircraft typically fly at altitudes greater than 8,000 feet. Although cruising altitudes are typically between 10,000 to 13,000 feet, 16,000 feet is a common flying altitude. Each airline also considered the worst-case scenario to be approximately 19,000 feet. The difference between 8,000 feet and 19,000 feet, from a pound per square inch standpoint, equates to an increase in pressure of 108%.

An increase in pressure of that magnitude may result in adverse affects such as bursting the corrugated shipping container open (typically at the manufacturers joint), rupturing the inflatable packaging system, causing air retention concerns with the inflatable packaging system and/or damaging the product. These potential adverse affects are why a standardized test procedure needs to be developed for in-lab simulation purposes.

The findings from the high altitude research are being used to develop an industry recognized test standard for determining air retention of inflatable packaging systems as well as how pressure affects the product and/or package.

The test will be conducted by vacuum method, using any suitable transparent container capable of withstanding approximately one atmosphere pressure differential fitted with a flat-vacuum-tight cover.

The samples must be tested to altitudes that best simulate the “real-world” environment to evaluate the inflatable packaging systems ability to maintain air pressure at high altitudes. Therefore, the “test-to” altitude will be a two-phase process with a first-phase altitude of 8,000 feet, simulating the transportation segment when the packaged-product is in a pressurized aircraft prior to the feeder-aircraft. The second phase simulates the feeder-aircraft segment of transport.

Altitudes experienced in the feeder-aircraft network vary based on geography and weather conditions. To offer the greatest testing and simulation flexibility, a three level assurance strategy will be developed. Level I is a high level of test intensity and has a low probability of occurrence. Level III is a low level of test intensity and has a high probability of occurrence. Level II is between these extremes.

- ⊗ Assurance Level I: 13,000 feet
- ⊗ Assurance Level II: 16,000 feet
- ⊗ Assurance Level III: 19,000 feet

Conclusion

It has been widely thought and accepted in the package engineering profession that the highest altitude experienced is approximately 8,000 feet if transporting packaged-products via the express air environment. However, the feeder-aircraft network is an element of the distribution cycle that has not been fully understood.

The findings from the altitude data acquisition tests confirmed that packaged-products may experience altitudes up to 19,000 feet in the express air environment, increasing the pressure from 3.8 PSI to 7.9 PSI.

Understanding the significant impact increased pressure may have on packaged-products, it is strongly recommended for manufacturers and users of inflatable packaging systems to test to the proposed test standard to ensure the complete production of the product during transit using the most efficient materials and methods possible.