

## NOTE #05-07

## Vacuum Drying

## SCOPE

This application note covers the topic of vacuum drying by using vacuum and heat to remove bulk and absorbed water or other solvents from a product. The liquid to be removed is typically a naturally occurring part of the product, a residue from a previous operation, or is used to dissolve, mix, or apply a chemical as part of the process design. Though freeze drying utilizes vacuum in the drying process, the freeze drying process is not covered in this application note. Additionally, the process of vacuum baking to remove small amounts of water and other contaminants from a product for high purity applications is covered in Application Note 05-12 Vacuum Bake-out of Parts.

## BACKGROUND

Vacuum is often employed as a process for removing bulk and absorbed water (or other solvents) from a product. Combined with heat, vacuum can be an effective method for drying. High degrees of dryness can be attained at relatively low temperatures. This allows for fast and effective drying of temperature sensitive products. Lower moisture content can be achieved when using vacuum and heat than can be achieved with heat only (particularly with parts that are porous or have a very high surface area). Additionally, drying under a vacuum can prevent oxidation of sensitive product that cannot be dried in the presence of air. Vacuum drying systems can also recover the solvent that is removed from the product, if required.

Often the part to be dried is placed into a vacuum drying chamber. However, if the part can withstand, and is designed for vacuum, the inside of the part can be evacuated and dried without the use of a vacuum chamber.

## DESCRIPTION

A vacuum drying system consists of a vacuum chamber, a mechanical vacuum pump with gauge and valves as well as a source for providing heat to the product to be dried. Both oil-sealed and oil-free (dry) mechanical vacuum pumps can be used. A condensate trap (typically cooled to very low temperatures) is also used to pump and trap the liquid(s) to be removed. Base pressures of less than 0.1 Torr are often required, depending on the liquid to be removed and the temperatures. Care should be taken to protect oil-sealed pumps from the liquid and operating the pumps properly to minimize the impact of the liquid vapors being ingested into the pump (often with the use of a gas ballast and/or gas purge).

The vacuum drying process often involves multiple steps of applying heat and vacuum. Reducing the pressure (applying vacuum) at the surface of a liquid (such as water) will allow the liquid to evaporate without elevating the temperature. The evaporation of the liquid will continue until the part is dried or until enough heat is removed (through evaporation) that the remaining liquid freezes. At this point the drying process continues as sublimation which is much slower compared to evaporation. In general, this is not desirable. The purpose of heat is to maximize drying while preventing freezing of the liquid.

There are several methods of applying heat to the product being dried. Some products have temperature limitations which may impact which methods may be employed. These methods include:

- Preheating the product using a variety of methods prior to placing into the vacuum chamber.
- Preheating the product in a specially designed vacuum chamber that is configured to provide convection heating as well as vacuum.

## DESCRIPTION (CONTINUED)

- Heating the walls of the vacuum chamber. Heat from the chamber walls is normally not a very efficient method of heating a part under vacuum. Radiation is the primary method of heat transfer.
- Heating the shelves inside the vacuum chamber. This technique can apply heat directly to the product by contact to the shelf.
- Flowing hot gas, such as nitrogen, into the chamber. This can be done using a variety of techniques.
- Using infrared heating sources. This non-contact method can be an effective method of transferring heat to a product under vacuum

## SUMMARY

The use of vacuum and heat can be an effective method of drying product without the use of elevated temperatures. Customized equipment is often needed to meet the unique process needs.

## PRODUCTS

LACO Technologies designs and manufactures standard and custom vacuum chambers and turn-key systems that can be used to vacuum dry all types of product.

## REFERENCES

- Application Note 05-12 Vacuum Bake-out of Parts