The processing of organic powders brings with it the possibility of explosion.

The chance of explosion is further increased in operations where volatile solvents are evaporated from the powder during drying operations. In all of these cases, the design of powder processing equipment must include an explosion-protection strategy. Stress Engineering Services, Inc. (SES) is active in a number of major areas of powder-handling explosion protection, including:

1. Development of specifications elaborating design approaches for explosion protection of new and existing (upgraded) systems.

2. Sizing of explosion venting systems.

3. Structural analysis of existing systems to insure their ability to withstand an explosion and design of retrofits to improve strength where necessary.

This article describes work performed on fluid bed dryer (FBD) systems.

FBD systems are typical of powder processing operations used in a variety of industries, including pharmaceutical and food manufacturing.

Figure 1 shows a schematic of a FBD system, including the FBD vessel (machine tower), forced- and induced-draft fans, dust collectors, and associated valves and instrumentation.
The explosion design of such systems must include the following:

- Zonal division of the system into explosion classes
- Selection of an explosion containment or mitigation strategy for each zone and each piece of equipment within that zone
- Confirmation that the pressure rating of each piece of equipment is adequate for the explosion containment/mitigation strategy selected

Figure 1 also shows a typical zonal division. Within each zone the system designer can select any of the following strategies for protecting personnel and equipment from an explosion:

- Containment
- Venting
- Suppression
- Inerting

Containment seeks to withstand the maximum pressure of an explosion. Venting and suppression strategies seek to reduce the maximum pressure to a level that can be withstood by weaker equipment. Inerting seeks to eliminate the possibility of forming an explosive atmosphere within the equipment. Pressure versus time curves for the first three strategies are shown in Figure 2.

Current design practice uses the containment strategy for the protection of the FBD machine tower itself. The machine tower is typically designed to withstand 11 barg (145 psig) of explosion pressure. This is adequate to contain the maximum pressure seen during the explosion of a pharmaceutical or food powder, as indicated by data provided in NFPA 68 and by testing of specific powders. Older systems, however, were typically designed for vented service.

Other dryer systems, such as spray dryers, are often too large to make containment of 11 barg feasible and either venting or suppression must be used to control possible explosions. In these cases, the explosion strength of the vessel must be determined and, if necessary, improved through retrofit to match the available protection scheme.

A typical example of this situation is shown in Figure 3. This figure shows an older FBD designed for vented explosion protection. A finite element collapse analysis of this vessel indicated that the support structure for the lower plenum of the vessel would fail due to gross yielding and tearing at 1 barg, substantially below the 2 barg specification for vented service.

Based on this analysis, SES developed a retrofit strategy that would enable the vessel to withstand a 2 barg explosion. An important consideration in this retrofit was the intention to redesign the system as an “explosion pressure shock resistant design.” This design philosophy accepts that substantial deformation will occur in the
event of an explosion, perhaps rendering the equipment unusable, but aims to protect personnel and other plant components in the event of an explosion. This approach contrasts with an “explosion pressure resistant design” approach, in which the normal boiler and pressure vessel rules are employed, leaving the equipment undamaged following an explosion.

Given the low probability of explosions, the cost of strengthening existing equipment, and the particular difficulties seen in welding 300-series stainless steel that has been in service for 20-30 years, the use of the explosion pressure shock resistant design philosophy has significant attractions.

Ancillary equipment in FBD systems can present significantly greater challenges for explosion-protection design than the machine tower. Typical of these challenges is the protection of dust collectors. Figure 4 shows a dust collector in a FBD system. Newer dust collectors are protected either by venting or suppression and are designed accordingly.

Legacy equipment, however, was frequently installed with little thought given to explosion protection. This leaves suppression as the only viable means of protecting an existing dust collector. Unfortunately, many existing dust collectors cannot withstand the 4-5 psig peak pressure experienced during a suppressed explosion. Worse yet, the stitch-welded stiffeners that were frequently used to strengthen the flat walls of dust collectors do not have adequate strength and will break loose during an explosion. The stress analysis included in Figure 4 shows an example of this behavior, with the entire wall of the dust collector yielded and bulging at only 1.3 psig internal pressure.

The only viable solutions to this problem are to: 1) scrap the old dust collector, or 2) heavily reinforce the walls with an external cage of structural steel. Reinforcement is frequently selected and can be made to work at a reasonable cost if it is part of an explosion pressure shock resistant design. Proper analysis, or elimination, of stitch-welded joints is critical to the successful design of this type of structural cage.

Explosion protection of powder processing equipment requires a careful, multidisciplinary approach which includes equipment design, system layout, and explosion-protection strategy implementation. SES’s ability to bring together project teams containing experts in systems design, structural analysis, flow and thermal analysis, as well as electrical and civil specialists enables us to provide a comprehensive answer to the questions raised by these systems.

![Figure 4 Stress in Dust collector walls at 1.3 psig explosion pressure](image)
About Stress Engineering Services

Established in 1972, SES is employee owned. Our staff covers a score of engineering disciplines including mechanical, civil, electrical, metallurgical, materials, water chemistry, theoretical and applied mechanics. Over 80% of SES engineers hold advanced degrees, most are licensed P.E.’s and the average engineer has more than 15 years experience.

For More Information About
Explosive Design Expertise
Call SES Today

CONTACT INFORMATION

Houston
13800 Westfair East Dr.
Houston, TX 77041
Phone: 281-955-2900

Cincinnati
5380 Courseview Dr.
Mason, OH 45040
Phone: 513-336-6701

New Orleans
3314 Richland Ave.
Metairie, LA 70002
Phone: 504-889-8440

Baton Rouge
9191 Siegen Lane, Suite 3A
Baton Rouge, LA 70810
Phone: 225-769-9772

www.stress.com

© 2010 Stress Engineering Services, Inc.