



Hygienic Feeder Design

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Specifying a hygienic bulk solids feeder is not a simple task. The wide variety of requirements needed for specific applications are similar in scope to explosion proof environmental requirement variations. However, unlike explosion proof requirements, a classification system does not exist to easily identify requirements for hygienic applications. The requirements from each producer vary as widely as the products they make. The material being fed, operating environment, cleaning and sanitization requirements, regulatory requirements, food producer requirements and perception, and cost are all significant factors in the design of a feeding solution. Therefore, in order to find a solution that is appropriate for a particular application, it is necessary for feeder manufacturers to offer feeders that cover a variety of hygiene levels.

Design Philosophy

There is a wide variety of requirements for a particular hygienic feeder design, but there are some basic design criteria common in all levels of hygienic feeder design. Therefore, we will discuss some of the general design guidelines used in designing hygienic feeders as well as dry, washdown, and regulated feeder requirements. We will cover materials of construction both within and outside the product stream, methods of separating product and non-product contact surfaces, manufacturing methods, surface finishes, and general guidelines to prevent product build-up and ease cleaning. We will also discuss some regulatory requirements that separate these three levels of hygienic design.

General Design Guidelines

Product Contact Materials

Product contact surfaces, as defined in 3-A® Standard 81-00, are “Those surfaces which are exposed to the product directly and surfaces from which liquids or materials may drain, drop, diffuse, or be drawn into the product.” In most cases, stainless steel is the preferred metal for use in product contact. Its strength, resistance to corrosion, and relatively low cost make it an excellent choice in most applications. Typically, AISI 304 (1.4301 or 1.4303) stainless steel is used for metallic product contact surfaces. It is the most common stainless steel alloy used and is one of the least expensive. In situations requiring higher resistance to acids, particularly at elevated temperatures, AISI 316 or 316L (1.4401 or 1.4404, respectively) can be used.

If it is necessary to use a plastic product contact material in a hygienic application, choose one with FDA acceptance. This ensures that the material is inert, non-toxic, and will not add any objectionable flavor or odor to the product. Typical plastics used in hygienic feeder design are polyethylene, Ertalyte® (PET-P),

and particular grades of Nylon. In addition to their FDA acceptance, these plastics are popular choices due to their resistance to a variety of chemicals, ease of machining, and aesthetic appeal of their natural colors.

Similar to plastics, rubber or rubber-like materials should also have FDA acceptance when used in product contact applications. Typical rubber or rubber-like materials used in hygienic feeder design are silicone, EPDM, and various urethane compounds. Similar to the plastic materials mentioned above, these compounds are widely used for their FDA acceptance, good resistance to a wide variety of chemicals, and appealing natural appearance.

Regardless of what material(s) are used in product contact, the surface should be smooth with no crevices or pits. If a feeder is to meet certain regulatory standards, specific surface finishes may be required. For example, the 3-A® Sanitary Standard for Auger-Type Feeders, Number 81-00 dictates that all product contact surfaces must have a maximum surface roughness of R_a 32 $\mu\text{in.}$ (0.80 μm) and be "...free of imperfections such as pits, folds, and crevices in the final fabricated form." Surface roughness is defined as the total area of the peaks and valleys divided by the evaluation length of a section of material (Figure 1).

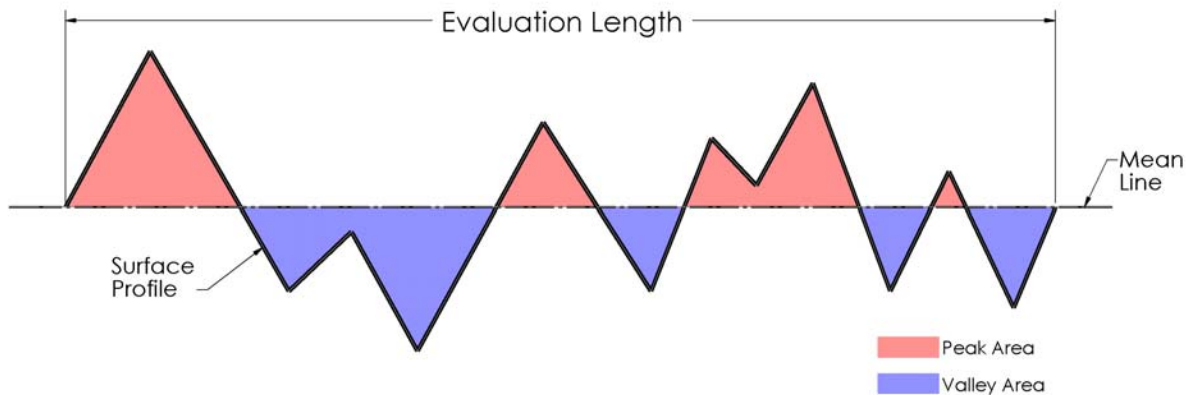


Figure 1: Surface roughness

Non-Product Contact Materials

Non-product contact surfaces are defined as any exposed surface which does not qualify as a product contact surface. As in product contact, stainless steel is also a popular non-product contact metal. This is especially true in situations where corrosion resistance for the entire feeder is necessary, such as in washdown areas. In most cases, AISI 304 (1.4301 or 1.4303) will be used since the increased corrosion resistance of other grades is rarely needed outside the product stream.

Outside the product stream, metals such as aluminum or mild steel are widely used. However, in a hygienic application, it is important to protect these metals from corrosion. Preferred methods for achieving this are powder coating and plating with corrosion resistant metals such as zinc or nickel. Painting is another common option for protection, but is not as durable as the previously mentioned methods.

Plastics, rubber, and rubber-like materials are also used extensively as non-product contact materials. Since they are outside the product stream, they do not require FDA acceptance. Even so, FDA accepted materials should be considered if there is potential for them to enter the product stream during normal operation or cleaning. For all non-product contact materials, care should be taken to ensure these materials will not be damaged by cleaning/sanitization solutions, heat and pressure of cleaning, or the operating environment.

Manufacturing Methods

When manufacturing parts for use in a hygienic feeder, care must be taken to prevent cracks and crevices where material can accumulate. When material is allowed to sit for too long, it may spoil and lead to contamination of other material. Lingering material can also foster excessive bacteria growth. Therefore, whenever possible, a one-piece design with smooth surfaces and large corner radii to ease cleaning is preferred (Figure 2).



Figure 2: 3-A® approved feeder flexible hopper and feed screw

There are times when a single piece design is not feasible. In these cases, welding is the preferred joining method as a weld can be ground and polished to the point where it is difficult to distinguish between the welded area and the base material.

Bolting is not a preferred method because it creates a deep crevice between the two mating parts. Wherever possible, stand-off spacers should be used to create sufficient distance between large flat surfaces to allow access for cleaning. If mating parts must be bolted, they should be easy to disassemble for cleaning and gaskets should be used to eliminate crevices. Also, threads should never be in product contact and effort should be taken to eliminate or minimize exposure (Figure 3).



Figure 3: (left to right) Industrial leveling foot assembly, 3-A® leveling foot assembly, leveling foot, and leveling foot mount.

In order to prevent contamination of material from outside sources, it is also important to include features in the design that will prevent contaminants from coming into contact with the material being fed.

Gaskets and seals are commonly used to seal the interface between mating parts. For example, gaskets are commonly used in the interface between hoppers and covers to provide a water-tight or air-tight seal, preventing contaminants from entering the product stream while allowing disassembly for cleaning or inspection. Seals are similarly used in situations where a shaft must pass from a non-product contact area to a product contact area for devices such as feed screws or internal agitation devices (Figure 4).



Figure 4: Industrial shaft seals (left) and 3-A® approved shaft seals (right)

Devices can also be implemented in a hygienic design to prevent unwanted substances from dripping onto the feeder and coming into contact with the material being fed, potentially causing contamination. Drip rings are commonly used on the feeder discharge to isolate the material leaving the feeder from the

exterior of the feeder (Figure 5). Any material on the exterior of the feeder that travels down the discharge nozzle can not contact the material discharging from the feeder since it will drip off the end of the drip ring first.



Figure 5: Industrial nozzle (left) and 3-A® approved nozzle with drip ring (right)

When designing a hygienic feeder, it is always desirable to make disassembly of the feeder as simple as possible. By eliminating the need for complete disassembly and providing the ability to disassemble the feeder from the non-process side, cleaning personnel will not be required to move the feeder or remove large components such as extension hoppers in order to clean it (Figure 6). Minimizing the amount of time necessary to clean the feeder can significantly reduce costs. Consider a feeder that can have the critical components disassembled, cleaned, and reassembled in 15 minutes compared to one that requires 30 minutes to complete the process. If the feeders are cleaned once per day, in a 10 year life span, 650 hours of cleaning will be saved by using the first feeder. Also, consider the time and money that can be saved when the cleaning personnel require less sophisticated training to clean a feeder with simpler, more intuitive disassembly.



Figure 6: Non-process side feeder disassembly (chronologically left to right, top to bottom)

Another feature that is desirable in hygienic feeder design is mass flow. Material hoppers that are designed for mass flow allow the first material into the hopper to flow out of the hopper first (Figure 7). This is preferred over funnel flow where the majority of the material into the hopper first will be the last out. When the first material into the hopper is the first out, you minimize the amount of time the material will sit in the hopper, reducing potential for material spoilage.



Figure 7: Screw feeder designed for mass flow.

In order to reduce the potential for material build-up, it is important to minimize flat horizontal surfaces on the feeder (Figure 8). These surfaces will hold material and can allow pools to form from unwanted substances dripping onto the feeder or from feeder washdown. These pools can lead to excessive bacteria and/or fungus growth, possibly leading to material contamination. Components with large, flat horizontal surfaces, such as covers, can be replaced with components designed with watershed angles to facilitate draining, preventing these problems (Figure 9).



Figure 8: Feeder mainframe with bottom surface designed for watershed.



Figure 9: Domed hopper covers

Low Level Design Requirements – Dry

The lowest level of hygienic feeder design is intended for dry, non-perishable food products and additives (Figure 10). Typical applications include basic food ingredients such as flour or sugar which will be baked or otherwise cooked. This feeder would be placed in a dry environment and the feeder would not be washed down for cleaning. Also, clean-out of the feed hopper would generally not be required between production runs.



Figure 10: Low level design screw feeder

As stated in the general design guidelines, the product contact materials of the low level feeder are all FDA approved or FDA accepted. Product contact areas are manufactured to a smooth finish and welds are cleaned. Motors typically meet an environmental rating of IP55 (or better) to prevent dust from entering the motor and for the motors to endure occasional wet cleaning.

Mid Level Design Requirements – Washdown

The mid level of hygienic feeder design is intended for dry materials in a wet or wet clean-up area. Some typical applications include dried fruits, nuts, and spices, as well as applications similar to the low level feeder. This feeder would be placed in a wet or dry environment and cleaning of the feeder would typically be done via water washdown. The feed hopper could potentially require clean-out between production runs.

Product contact materials should be FDA approved or accepted and surface finish is generally the same as the dry feeder. In addition to the basic requirements of the dry feeder, exterior cracks and crevices are sealed with either silicone sealant or epoxy (Figure 11), both of which are FDA approved. Washdown duty motors and bearings are also used in construction of the mid level feeder.



Figure 11: External crevice at base of hopper sealed with FDA approved epoxy.

High Level Design Requirements – Regulated

The highest level of hygienic feeder design is intended for use in specific food applications requiring acceptance via requirements such as 3-A® Sanitary, EHEDG, or USDA Meat and Poultry (Figure 12). Applications for such a feeder are typically perishable food products such as milk powder and cellulose. These products can be wet or in a wet environment. Clean-up is typically quite extensive and includes intense physical scrubbing and the use of chemical cleaning and sanitizing agents. These chemicals can be acidic, alkaline, or caustic.



Figure 12: 3-A® approved screw feeder.

At the very least, product contact materials used for this type of feeder must be FDA approved. Often times, there will be further testing a material must undergo to achieve this type of approval, such as the lactic acid test for 3-A® approval. Typically, surface finish is required to be a certain surface roughness or smoother, such as the 3-A® Sanitary requirements mentioned earlier. Exterior cracks and crevices must also be eliminated, preferably by designing components without them, but they can be sealed if this is not possible. Special sealing requirements may be necessary, such as the use of sanitary tube fittings for discharge nozzles and auxiliary device connections. Since the regulated feeder will undergo frequent cleaning, it also features washdown duty motors and bearings.

Due to the perishable nature of the material being fed by this type of feeder, care must be taken to prevent material contamination and bacteria growth. Therefore, most of the design techniques mentioned in the manufacturing methods section will be utilized.

When designing or specifying a hygienic feeder or feeding system, it is important to understand the basic guidelines for design and manufacturing, the perishability of the material fed, the cleaning processes used, and any applicable sanitary regulations. Equipment designed to the appropriate requirements and operated accordingly can reduce overall costs while improving the hygienic nature of the process.

References

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