

WHITE PAPERS

FOOD PROCESSING PLANT DESIGN



PREFACE

The design of your food processing plant can be a lengthy and tedious process, but is where the most critical decisions will be made. Your architects and engineers will assess your plant's physical requirements, but will also want to look at your product's manufacturing and sanitation needs, in addition to anticipated production volume and optimal workflow. In this white paper, we'll take a look at how these factors influence design and why a utility matrix is an important tool in your plant's design. We'll also look at how plant owners are using Building Information Modeling (BIM) to make better business decisions.

FOUR MAJOR DECISIONS THAT IMPACT THE DESIGN OF YOUR FACILITY

FOOD PROCESSING PLANT OWNERS MUST ANSWER A FEW KEY QUESTIONS PRIOR TO THE DESIGN OF ANY FACILITY

1. **Location** – Plant owners often select a location that will be most efficient from a supply and demand standpoint, opting for sites that offer the best transportation access. Yet depending on the region of the country the plant will be located in, designers often must begin with a thorough analysis of weather issues and permitting issues related to that location. Are there seismic concerns that will dictate construction materials? Are there wind speed issues that may impact the building's exterior and how piping is integrated into the building? Owners and engineers should work together to understand these issues, as these conditions will guide many decisions in the design process.
2. **Building structure** – The actual building material used for both the interior and exterior of the building will play an important role in the overall design of the plant and its systems. Concrete often limits the height of the building due to its weight, and can limit where room and process openings can be placed. Steel buildings may offer more flexibility, but also must be assessed as part of the overall food safety program (i.e., typically, a ceiling would be required). Equipment layouts, piping, electrical, lighting and HVAC ducts will all be affected by the types of building materials selected.
3. **LEED requirements** – Obtaining LEED certification often requires a more detailed approach to material selection and the overall design. The first step is determining the level of certification the owner desires so designers can properly document and design for those requirements. LEED affects virtually every aspect of the design of the building including the energy model, water and wastewater usage and recovery, piping systems, lighting selection and much more. Once the design has begun, it is difficult, and costly, to modify these systems significantly.
4. **Insurance** – As the preferred insurer for most commercial projects, Factory Mutual has rigorous specifications and standards so it's important to address those requirements during the initial design phase. See our previous post on Factory Mutual ([link](#)) for more detailed specifics on the requirements.

HOW PRODUCT, PRODUCT MIX, AND PRODUCTION VOLUME IMPACT DESIGN

Preliminary discussions with your food processing plant architects should include a thorough discussion of your sales and marketing goals. Your plant's specific products, product mixes (including future products), and production volume all impact decisions made during the design process.

Here are some of the specific design issues impacted by product, product mix and volume:

PRODUCT

1. Site selection – Your product's waste stream may dictate your site selection to a large degree. For example, meat plants produce a significantly different waste stream from a bakery. Many municipalities don't have the facilities to process the high level of waste from a meat plant, which may drive site selection.
2. Materials – The product sanitation requirements will play a large role in the materials selected for use within the plant. Meat plants require frequent wash downs, stronger cleaning chemicals, and temperature control, so stainless steel is often used in work areas. Bakeries, on the other hand, working with dry ingredients and fewer sanitation requirements, can select from a wider range of materials for processing areas.
3. Equipment – Dry ingredients, such as flour or sugar, can automatically be transferred via more continuous systems, while meats are often moved in bulk via stainless steel vats or other manual methods. This impacts workflow and room layouts, as moving product with vats often requires refrigerated corridors, vat wash areas, and larger processing spaces.

PRODUCT MIX

1. Sanitation – If your product mix includes allergens, you may need separate process areas for allergen and non-allergen production areas. Alternatively, work areas may require frequent changeovers, which impact water and steam requirements including utility distribution, volume, and pipe sizing, as well as the actual utility generation systems themselves (quantities and/or sizes).
2. Packaging – Many plants are now expanding their packaging options to meet consumer desires. A variation in package sizes, such as bulk and individual, require completely different packaging lines and, therefore, impact compressed air and electrical load profiles.
3. Hygienic zones – Plants that handle both raw and ready-to-eat (RTE) products must have separated hygienic zones ensuring appropriate filtration levels as required, and no air movement from the raw side to the RTE side. Likewise, dry ingredients and packaging areas often require humidity control, which also dictates separated hygienic zones.
4. Separation of lines – Plants with a risk of cross-contamination that run multiple products at the same time need fully separate production lines with each line having its own HVAC and/or refrigeration system. This full separation also allows for sanitation on a given line while other lines remain in production.
5. Welfare areas – Plants that handle both raw and RTE products are better served to provide fully separated entrances, welfare facilities and point-of-entry clean rooms for workers.

PRODUCTION VOLUME

1. **Redundancy** – A high-volume production plant with a single product is often designed to run 24/7. Therefore, equipment redundancy is important to ensure there are no operational downtimes.
2. **Multiple operational lines** – High production of a single product may be spread across multiple processing lines for efficiency, which helps spread the plant's load requirements. Running multiple lines with different products presents another set of design challenges to accommodate frequent changeovers and wash downs.
3. **Design for peak demand** – Food processing plants should be designed with peak demand in mind, not for a steady operational state. For example, considering a plant's total water consumption, the vast majority of that water is likely required during a peak demand driven by clean-in-place (CIP) operations, sanitation, wash down, and refilling use tanks. This results in a large demand in short intervals and the associated utility system should be designed to accommodate this accordingly.

BEST PRACTICES FOR DEVELOPING A FOOD PROCESSING PLANT UTILITY MATRIX

Every single piece of equipment in a food processing facility – from processing equipment to compressors, chillers and the machine room – requires some form of power whether it's electricity, steam, hot water, or compressed air. Determining the utility requirements of the plant's operating systems is a critical part of the design process that involves the plant's owner, as well as the mechanical and electrical engineering team.

Plant owners need to play an integral role in developing the plant's utility matrix, which outlines detailed specifications on each piece of equipment, so engineers can determine the plant's utility requirements. To many engineers, this is the single most critical document during the design phase. It can be a painstaking process for a plant owner to complete the matrix, but having the right level of detail can save time and money in the long run.

KEY ATTRIBUTES OF THE UTILITY MATRIX SHOULD INCLUDE

- The matrix is a single document that should be clear and concise and contain information needed by both mechanical and electrical engineers to appropriately size their systems to meet the plant's needs.
- Ideally, plant owners can provide the specific manufacturer requirements for each piece of equipment. This will allow engineers to determine the exact power requirements, circuit sizes, voltage, and distribution panels for the entire system.
- Engineers can also gather the necessary information to calculate power source needs. If natural gas is used to power equipment, what amount and pressure is required to keep the systems operating efficiently? For processes that require water, what flow rate and temperature is needed? What are the voltage and horsepower requirements of each machine?
- As the project progresses and more information is added to the matrix, engineers can see how the systems are impacting the load and determine if design changes or modifications are needed. For example, if the compressed air load goes up slightly, engineers may need to re-address the projected number of air compressors.

- Gathering the data and information necessary to complete the matrix encourages plant owners to plan ahead for future needs. If they know the company is planning a future line, it's important to include it in the matrix. Most engineers will use a phased approach that shows immediate versus future utility needs of the plant.
- Engineers can forecast energy costs based on the plant's utility requirements. This may be helpful in selecting one equipment manufacturer over another based on projected energy costs. For example, the matrix may help determine whether selecting a central natural gas water boiler versus a local electric water heater is more cost effective based on initial costs and ongoing energy usage.

While the matrix is a very valuable tool in developing a plant's design, keeping the information up to date and informing team members of changes is just as important. A design project manager should oversee this process to ensure that all teams are updated throughout the process.

SHOULD YOUR PLANT USE BUILDING INFORMATION MODELING (BIM) FOR YOUR NEXT DESIGN PROJECT?

Food processing plants are embracing building information modeling (BIM) as the new standard in facility design. BIM's 3-dimensional data rich format allows designers to give plant owners, managers and employees a virtual walk-thru of the facility with the ability to see actual construction elements such as walls, windows, slabs and roofs to make the most informed decisions on process and work flows.

THE FIVE KEY BENEFITS OF USING BIM FOR FACILITY DESIGN ARE

1. 3D visualization allows plant managers to visualize and make decisions based on workflow, budget issues, energy costs and much more. Designers can actually show employee movement throughout the facility and perform simulations so owners can determine the best workflow processes to improve productivity. This ability can identify potential problems early on, especially in work areas where a sanitary workflow is required.
2. Effective budgeting is one of BIM's biggest benefits, allowing plant managers to look at cost comparisons and operational considerations to select the most appropriate design layout and/or equipment.
3. Interdisciplinary design teams can more effectively collaborate on the different design aspects of the facility as BIM centralizes the design and data into a single-source. BIM allows external parties involved in different aspects of the design and construction to efficiently transfer and share information with each other.
4. Energy modeling through BIM allows engineers to recommend and design the most resourceful systems within the facility from an energy use and efficiency standpoint. BIM modeling can actually simulate how the building and equipment will perform once actually constructed, so efficient energy use decisions can be made.
5. Facility managers can integrate their facility management software with a plant's BIM data to provide more efficient plant maintenance. A 3D virtual view of the entire facility shows facility managers information on specific equipment, and locations of the equipment, within the facility. For example, if air units need servicing, facility managers can use BIM data to determine how to best access the equipment.

FOUR WAYS BIM ALLOWS FOOD FACILITIES TO MAKE BETTER DECISIONS DURING DESIGN REVIEW

When performing a design review, BIM gives all of your food processing plant's stakeholders — operations, maintenance, safety, and engineering teams — an opportunity to explore the facility in a three-dimensional mode. Viewing the design in this 3D model helps visualize the building space so owners can make more informed decisions in these areas:

1. **Maintenance** — Plant owners often find it beneficial for their maintenance team to be present at the design review to provide input on parts of the building that require maintenance access, such as the attic/interstitial space, utility rooms, and maintenance room. The 3D BIM model allows maintenance supervisors to envision their crew navigating through these spaces, which is more challenging on two-dimensional plans. They are able to raise red flags for what they foresee as problem areas or ones that would pose a safety concern. For example, are clearances between structural steel members, ductwork, and pipe runs in the interstitial space too narrow? Is access to equipment in the ceiling impeded by the supporting beam or column?
2. **Product flow** — Plant owners have always been able to follow the product flow throughout the facility on 2D plans. The 3D model now allows them to follow the product flow at floor level. This view provides a more valuable perspective to help owners understand the design of building components such as walls, floors, drains, columns, lighting, etc. in relation to process and sanitation equipment, and how it will all function as one.
3. **Coordination** — Plant owners are interested in having the most efficient building arrangement and layout to support their operations. A two-dimensional plan typically uses drawing sheets dedicated to a particular discipline, which can create conflict when rooms, building components, pipes, and equipment are rearranged during an owner review. The 3D BIM model allows the design team to overlay all disciplines into one model and gives owners a better perspective on interdisciplinary conflict coordination.
4. **Energy efficiency** — There are many different ways to achieve energy efficiency throughout the building from equipment selection to lighting to the strategic placement of walls and windows. Using a 3D model such as BIM allows the design team to perform analyses and studies to determine the most energy efficient solutions. For example, conducting a natural lighting study on areas of the facility will help determine artificial lighting requirements for the space.

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