How to Plan an Efficient Layout in a Small Production Plant

by John Larkin

Whether it’s your first foray into production roasting or you are growing to the next level, careful up-front planning can help you lay out a manufacturing plant that meets your goals and efficiently delivers to your expectations. This well-designed plant will have equipment sized to your needs and matched in terms of throughput capability, space large enough to accommodate the equipment and maintenance zones around it, storage areas for green and roasted bean plus consumables and supplies, a loading/unloading area, and (for efficiency) a layout that to the extent possible flows in one general direction. Depending on your budget, this well-designed roasting plant may also position you to accommodate additional growth further down the road.

**what are your goals?**

When starting to plan a production facility, it’s important to define your immediate and long-term goals. Will your business be whole bean, ground, flavored or a combination of these? How much green bean, and how many types, will you be storing? How much coffee do you need to roast, degas, quality check and package (and perhaps blend, grind and/or flavor) in what time frame? How long will you need to store your roasted product? Will you deliver or ship roasted coffee daily, weekly or on some other time schedule? The answers to these questions will help determine equipment needs (see Figure 1 on page 54) and space requirements and will have a direct impact on the project budget.

**what kind of space should you consider?**

The adage of “location, location, location” is true even in coffee. Make sure that the space you choose is in an industrially friendly location, or you may have to move again sooner than you’d planned. You need to factor in traffic, parking, hours of operation and emissions—all of which can become issues with neighbors, particularly in neighborhoods that are being reinvigorated with new or updated housing. For ease of your operations, good highway access is a plus and an accessible loading dock for receiving and shipping is an important feature for efficiency and growth.

The ideal space for your manufacturing facility fits the scale of your equipment, material handling and storage needs with some additional room for growth. For example, you may want to start production-roasting by offering roasted whole bean and ground coffee, although down the road you’d like to introduce flavored beans as well. Later, you may want to add a larger grinder or even a second roaster. If you can afford extra floor space with future goals in mind, it might help you postpone a subsequent move.

An often overlooked but significant factor in space selection...
is ceiling height, with 25–45 feet being optimum with the roof directly above that. You want as much as possible to have a straight vertical run for stacks required by the roaster, cooler, destoner and pollution control (afterburner). Before signing anything, be sure that codes and landlords permit the roof penetrations required for these stacks. Then, always have roof penetrations performed by qualified roofers to be sure landlords permit the roof penetrations required for these stacks. Then, always have roof penetrations performed by qualified roofers to be sure that stacks and flashings are correctly installed, which will help to prevent problems in the future. A high ceiling means you can let gravity work for you, necessitating fewer pieces of conveying equipment and resulting in lower energy costs. One vertical conveying system with well-planned vertical distribution, for example, can feed several pieces of equipment in one vertical run, which can help minimize costs. The floor of the space is another extremely important consideration. It must have a per-square-inch weight capacity to accommodate all of the pieces of equipment and storage that you intend to place on it. You will want to look at whether the floor construction is acceptable for food manufacturing and if there are enough restrooms for employees, plus first-aid stations and equipment cleaning/maintenance locations. Be sure, too, that the space you’re considering has enough gas/oil/propane, electric, water, compressed air and drainage to meet the combined requirements of the equipment you’re installing. More than one roasting plant has added thousands of dollars to a budget by having to get gas pressure boosted or electric service changed to meet equipment needs. Also review HVAC (heating, ventilation and air conditioning) requirements and light levels.

Remember noise when planning your office and conference spaces as roasters, afterburners and compressors can be loud when operating. Knowing your requirements is the first step. Some of these improvements can then be negotiated with the building owner, preferably before signing the lease.

Finally, be sure to factor into your budget the ingress and egress of the building. If your equipment will not fit through existing doors, loading docks, stairwells or elevators, there will be additional expenses to break it down and reassemble it.

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**2-Kilo Coffee-Tech Solar Automatic Roaster**

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The keys to successful equipment selection and layout planning are (1) defining and quantifying your process flow goals, (2) trying to arrange the process flow as much as possible in one general direction to minimize production floor traffic jams and redundant motion, and (3) keeping the individual pieces of equipment that implement the flow in balance with each other in terms of their capacities. For example, it doesn’t usually make sense to pair a single roaster that produces up to 500 pounds of coffee per batch with a packaging machine that handles 5,000 pounds per hour. While it may sound as if you’re anticipating growth to do so, you either won’t have enough product to keep the packaging machine running in an efficient way or you will need to buy more expensive bin space to store enough roasted coffee to operate the packaging machine efficiently.

The roaster, of course, is the heart of everything, and it is a good place to start your planning and layout for the following reasons. To save money, time and trouble, plan to locate it as close as possible to utilities such as gas/propane, electric and water, and place it where you can make a straight vertical run through the roof for the stack. Additionally, a fire-suppression system may be required by the local authorities.

The green bean storage area is often near the roaster, or between it and the loading dock. The product flow starts with the unloading of green coffee at the loading dock and the transport of the green bean through the plant to the green storage area. Be sure to allow aisle space for this material handling which may even necessitate room for a forklift to navigate with a skid of green beans. Refer to Current Good Manufacturing Practices (CGMP) for specifics about how much space is required for product away from walls, how much space is required for aisles, incorporating pest control programs into the physical space, appropriate product conveyance methods, and storage of potential contaminants, such as chemicals, tools and glass away from product. Your business insurance company may provide free advice on safety considerations such
as forklift training, proper lifting techniques, fire evacuation routes, first aid kits and other safety equipment.

The work flow then follows the direction of the green bean as it moves from the storage area to the roaster and cooler.

A one-roaster production plant is typically a batch type facility with a 60- to 350-kilo (120- to 500-pound) roaster that can do one to four bags of coffee per batch, and roughly three batches per hour. In one shift a day, five days a week, a one-roaster plant using a 350-kilo machine at three hours an hour can potentially roast about 3 million pounds of coffee a year. The two principal roasting technologies on the market are drum and fluidized bed, and there are a number of good roasters that offer these technologies.

Starting with the technology that you already know and like—the one that has gotten you where you are—means a shorter learning curve and a seamless transition when growing to the next level.

The capacity of these production roasters means they have larger footprints that need to be factored in when selecting a production space. They will also have a proportionately larger cooler. As batches get above 25 pounds, additional equipment will also be required to load the coffee into the roaster. This might be a motorized lift, an eductor or an airveyor, any of which needs to be factored into the throughput balance and spatial considerations.

When choosing a coffee transfer mechanism, be sure to bear in mind your final product. If it is roasted whole-bean, you will want a gentler transfer mechanism, and you always want to keep runs as straight and short as possible for any type of bean to minimize hang up and breakage.

After the cooler, you will need a destoner to remove foreign debris. The possible types of debris are remarkable and may range from stones, slag metal and jewelry to anything else that is not roasted coffee. This debris may get overlooked as you process larger batches and can wreak havoc with grinders and/or customers if it is not removed.

In a system that includes a destoner, the cooler discharges into a destoner boot. Vertically moving air raises only the beans through the destoner riser (tube) on up to the destoner hopper, leaving debris behind for removal via a cleanout door. The air is adjustable for speed and volume making the system appropriate for whole bean or ground coffee purveyors. We recommend as short a riser as possible for manufacturers doing dark roasts. In all cases, a smooth, unobstructed surface inside the riser is best.

Additionally, we recommend using magnets at various stages in the production flow, starting at the dump station all the way through to packaged coffee, to capture metal debris. Clean-out access to remove the debris should be provided. In fact, throughout the plant, emphasis should be on short pipe runs, as few angles as possible and frequent clean-out access.

Pollution control is also an important consideration in this day and age. We recommend addressing it up front, even if it doesn’t seem to be an immediate issue with your locality, because eventually it will become one. As hard as it is for us coffee lovers to believe, just one complaint about the aroma of coffee in the air, even in an industrial area, can lead to expensive repercussions in terms of time, money and public relations.

The type of pollution control device needs to be matched to your roaster and will probably be some sort of afterburner/thermal control. These are easier and less expensive to install and integrate when first setting up a plant than to retrofit later (although that can certainly be done).

Addressing the issue up front also shows a sense of responsibility, which can win points down the road.

When selecting and combining the roaster, cooler, destoner and pollution control, it is always best to stick with the roaster manufacturer’s recommendations. Using a spreadsheet to compare information on various packages can help you make an educated choice about the best dollar value that meets your needs. Expanding the spreadsheet to include footprint dimensions of the various pieces of equipment helps to define spatial requirements. Be sure to allow extra space—usually three to five feet—for the various pieces of equipment for maintenance activities. Also, allow space for cleaning pipes. This is critical work to minimize the chance of fire.

What happens next depends on your business focus, but all roasting plants will need to address conveying and storage (before and after packaging) and packaging. Whole-bean suppliers will flow their product on to temporary storage and then packaging via gentler conveying mechanisms (tubular conveying systems, continuous bucket elevators, totes or sacks), so as not to damage it. Ground and/or flavored coffee purveyors will need to factor in additional equipment, such as grinders, ribbon blenders and centrifugal mixers, and will direct their flow, or a percentage of their flow, to those areas prior to packaging.

Flavoring presents an additional challenge of cross-contamination and may best be located in a separate room and performed on dedicated equipment. Flavorings and flavored product may also require special storage depending on fire codes.

Storage space before packaging will depend on your packing schedule and should factor in the volume of coffee that must be stored prior to packaging and whether this will be required overnight or over weekends. If you’re storing for hours or days, you can probably skip pricey, big bins or silos and opt instead for mobile plastic or metal totes or fabric bulk sacks. Totes tend to be more expensive and take up more space than bulk sacks (which can be folded up when not in use). On the other hand, bulk sacks need to be replaced more often.

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The packaging process again is a function of what you’re selling—whole-bean, ground, pillow pouch, square-bottom bag. Packing whole-bean can still be most economical with a weigh scale and hand bagger. For ground coffee, a single tube machine will form, fill and seal, and degassing of ground coffee can be accomplished in the totes or bulk sacks. State licenses may be required for scales used to measure items sold by weight.

Dedicated packaging equipment can become a consideration when your product line features more than one product, such as whole-bean, ground and/or flavored coffees, as the changeover between types can be time consuming and labor intensive as you work to remove all residue of the other type to prevent cross-contamination. For the same reason, store coffee and other products away from packaging materials to avoid contamination from aromas.

Ground coffee suppliers moving into a production mode will sooner or later want to step up from a plate mill to a roll mill to support business growth. When you get to the higher production end of a one-roaster plant and consider a larger grinder, you should also consider an exchange head program with the manufacturer, in which a worn grinder head is swapped out for a sharpened one as required.

Once the coffee is packed, the next stage in the flow is after-packing storage (warehousing), which is a separate area from green coffee storage in order to prevent flavor/aroma contamination. After-packing storage can just be shelving, except possibly in the case of flavored coffees. The amount of storage area required is also estimated, this time based on delivery schedules. The key question here is, how much packed coffee do you need to store for how much time? Allow space to rotate inventory for stack management as well as enough space for current GMP/pest control.

From this final storage area, the process flow will take this roasted and packaged bean on to the shipping or loading area. Once again, be sure to allow enough aisle space in your planning for the material handling to occur, perhaps even accommodating a fork truck.

**bringing your layout to life**

Once the planning is done, the space procured, and the equipment is arriving, it is time to bring the layout to life. Equipment placement and installation involves rigging and re-assembling, and is more economically accomplished when the site is ready. While this might sound obvious ahead of time, it is easy to get caught between honoring leases, meeting production demands and dealing with site issues. You may be up against a move deadline and have a loading dock in the new facility that isn’t finished or a parking lot that’s a sea of mud, or utilities—like electricity—that aren’t available but are necessary.

**whether to buy new or used equipment is always a question, and the answer is new equipment is usually desirable if you can afford it. New equipment first and foremost is a warranted, known quantity. It is in top condition, it is state of the art, and it comes with manufacturer’s support in the form of manuals, wiring diagrams, instructions and replacement parts. New equipment may also be more energy-efficient, which can help honor both the bottom line and green initiatives.**

Buying used equipment can be a viable option for incremental growth. But it can also be like buying an uncertified used car—will it include all the components you’re expecting and will they be in working order when they get to your place? Moving used equipment and correcting unexpected deficiencies (missing equipment, non-working components, mismatched equipment) can end up being nearly as expensive as buying new. Also, you may not have access to manufacturer’s support—including manuals, wiring diagrams, instructions and replacement parts—particularly with dated technologies.

Our advice before buying used equipment is to watch it in operation if at all possible, know your seller and/or check references, and get a second opinion on exactly what it will take to make the equipment operational in your particular facility. In the used equipment world as in the used car world, if the deal sounds too good to be true, it probably is, so buyer be careful.
to operate the power tools required to assemble the equipment. An experienced project manager can be a worthwhile investment so that you can run the business you have while the new location is coming together.

Actual placing and assembling of equipment involves the following:

(i) Verifying space allocation and layout flow
(ii) Placing larger pieces of equipment in the desired locations (roaster, cooler, destoner, pollution control, airveyor or tube conveyor [if applicable], grinder [if applicable], packaging machine [if applicable])
(iii) Re-assembling pieces of equipment that have arrived partially assembled for shipping purposes
(iv) Connecting pieces of equipment and running process piping as required
(v) Running vent and outlet piping to meet roof penetrations
(vi) Hiring professionals to configure and hook up utilities
(vii) Performing start-up to be sure that everything has been integrated correctly and is functioning properly (and fine-tuning it if it isn’t)

The amount of time that it takes to bring an efficient new roasting plant online depends on planning, coordination and budget. Help and advice are available along the way from manufacturers, plant layout and installation specialists, and project managers. Once the space is ready and the equipment is all on site, with good advance planning, you can be roasting in four to six weeks or less.

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[online resources for roasters]

IT IS IMPORTANT to remember that you will be producing a product for human consumption, so you will need to select a space that is or can be made appropriate for this type of manufacturing. Depending on your location, you will be meeting the requirements of your municipality in establishing, operating and maintaining your facility. Guidelines have been developed by the federal Food and Drug Administration (FDA) and include Hazard Analysis and Critical Control Points (HACCP) and Current Good Manufacturing Practices (CGMP). A small roaster will (hopefully) grow into needing these and third-party inspection at some point, so it can be useful to become acquainted with them early.

The following resources will help roasters navigate these guidelines:

- Hazard Analysis and Critical Control Points (HACCP)
  - www.fda.gov/food/foodsafety/hazardanalysiscriticalcontrolpointshaccp
- Current Good Manufacturing Practices
  - www.fda.gov/Food/GuidanceComplianceRegulatoryInformation/CurrentGoodManufacturingPracticesCGMP
- OSHA worker-safety standards
  - www.osha.gov

For Whole-Bean Roasting

- Green bean storage
- Roaster
- Cooler
- Destoner
- Pollution control
- Gentle transfer mechanisms between pieces of equipment (so as not to break beans)
- Blending area (if combining beans into custom blends)
- Packaging equipment
- Finished product storage/warehousing

For Ground Coffee

- All of “Whole-Bean Roasting” (except transfer mechanisms may not have to be as gentle because breakage is less of a concern)
- Grinder
- Dedicated packaging equipment (if also doing whole-bean, because changeover time from one to the other can be a consideration)

For Flavored Coffee

- All of “Whole-Bean Roasting”
- If flavored coffee is ground also, all of “Ground Coffee” too
- Ribbon blender and/or centrifugal mixer (maybe even a separate room and/or a ventilation system to minimize cross-contamination)
- Dedicated packaging equipment (can be even more important here so that non-flavored varieties don’t end up accidentally flavored)
- Equipment for clean-out (wash station or chemical cleaners prior to changing flavors)

Other Considerations

- Current Good Manufacturing Practices
- Integrated post control
- HVAC airflow requirements
- HACCP requirements
- OSHA requirements for employees (including first-aid stations)
- Storage for packaging: master cartons, film, labels, tape, etc.,
- Storage for chemicals, glass and flavoring (MSDS documents)
- Space for palletizing and staging orders for shipments (including shrink wrap, if required)
- Incorporating quality control/quality assurance into plant plans
- Shipping stations by the case, pallet or truckload

[figure 1] One-Roaster Plant Equipment Requirements