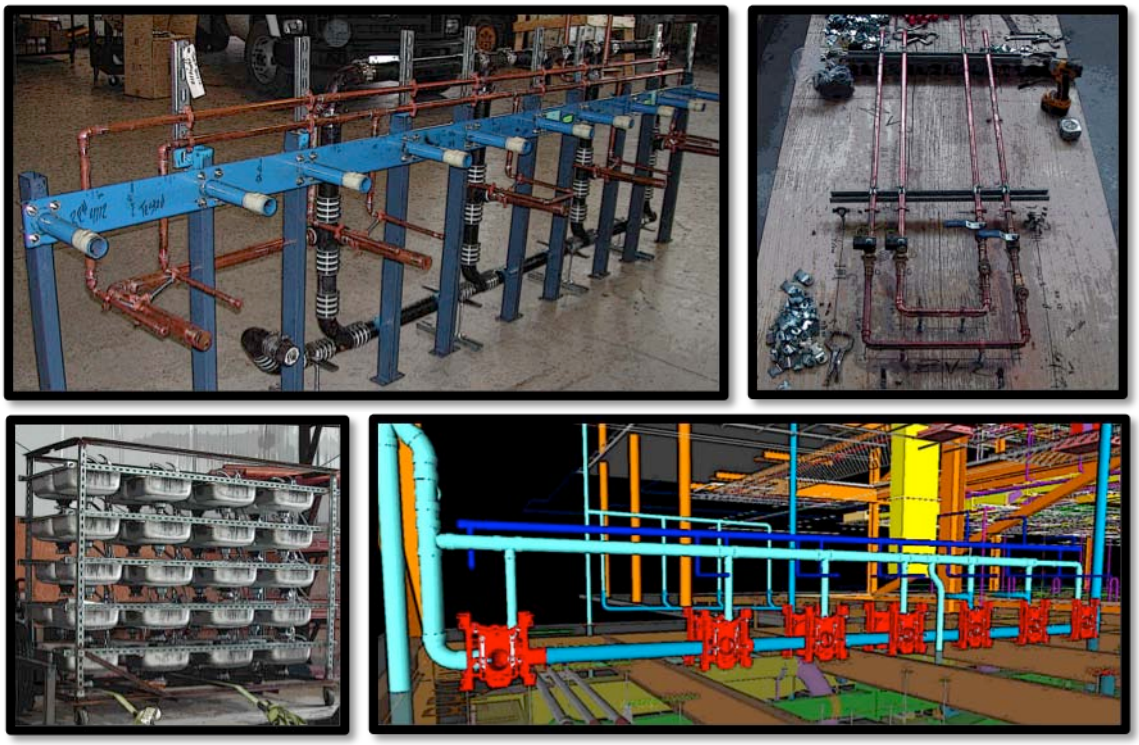
# Pre-Fabrication Operations Guide For Plumbing



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## Chapter One – Introduction

Pre-fabrication is not a new concept within the construction industry. Simply put, pre-fabrication is the process of producing and assembling parts in a controlled environment. These assemblies are then shipped to the jobsite ready for installation with a minimum of onsite assembly.

Pre-fabrication technology and tooling have evolved over time, providing plumbing contractors with new opportunities to enhance productivity and profitability.

Contractors who have mastered pre-fabrication have seen the benefits: significantly reduced labor costs through productivity gains, reduced onsite installation timelines, increased quality and reliability of their work and reduced waste. Contractors who do not take advantage of pre-fabrication do so at their own peril, particularly when competing against a contractor that is a master at pre-fabrication. That disadvantage increases with the size of the project.

There is good news for those seeking to take advantage of pre-fabrication—the basic tools and equipment are already part of your operations. You do not need to hire new employees right away or purchase a new facility. Pre-fabrication can be done on a small scale in a small area within your current operation. Throughout this publication, we will introduce a number of successful pre-fabrication concepts to demonstrate how pre-fabrication can optimize your business. Expanded information about each of these concepts will be provided in the subsequent chapters.

The main advantage of shop fabrication is that the work is done under close supervision, in a controlled environment, using manufacturing and production processes to increase productivity and quality control. To make the most of pre-fabrication, you must begin by modifying your operations into a production/manufacturing format. Such a format:

- Takes advantage of repetitive tasks;
- Has efficient work areas;
- Uses a progressive station-to-station (assembly line) system for the fabrication of components;
- Considers one-man operations; and
- Reduces material handling.

Complex pre-fabricated pipe ready for shipment

In a production format, efficiency is the goal and waste is the enemy. Manufacturing your plumbing assemblies in a shop environment affords you the opportunity to scrutinize your shop labor operations for productivity, affording the opportunity to eliminate waste from sources such as extra handling, lost time and mistakes.

By evaluating every task for efficiency on an ongoing basis, you continuously receive information that will help you further drive down labor costs and reduce waste. While this process can appear daunting, it comes with an attractive result—added value and increased profit margins. It cannot be done alone, however; involve your shop people in the process and listen to their ideas about ways to save time, reduce costs and improve quality.

Fabricating piping, sub-assemblies and modules in a shop will result in greater efficiency, higher quality and lower cost than completing the same work in the field. So, how is a plumbing contractor to start?

## Getting Started in Fabrication

Once management has committed to performing plumbing fabrication, some capital will have to be earmarked for the process. Getting started requires only a small investment. As your company gains experience with fabrication and the volume of work in the shop expands, more resources can be committed for additional tooling and equipment such as copper end prep machines, chop saws, band saws, power cast iron snappers, tee-pulling stations, jig tables, power mockup tables, etc. These additions can be made incrementally.


*Copper pipe cut-off and end prep stations save time by cutting pipe to length, de-burring it and cleaning the end.*

During the planning phase of the project, the old approach was to look at a project and ask, "What can we pre-fabricate?" Today's successful contractors instead look at a project and ask, **"What *can't* we pre-fabricate?"**

When beginning fabrication, all the work in the shop can be completed by working from hand drawings, with CADD spool sheets being added and/or intermingled as needed going forward. The handling and flow of the drawings (document control) from the field/CADD department to the shop and back out to the field is an important process, and drawings can be done by hand without losing their effectiveness.

## Material Handling

Material handling is a major factor affecting output per hour. When laying out a pipe fabrication shop and investigating the cutting and clamping alignment process, fabricators should ask themselves the following questions:

- Are pipe storage racks arranged for the best use of material handling time?
- Does material flow smoothly through the shop in one direction from the raw material area to the finished product?
- Is mater being handled as infrequently as possible?
- Are bottlenecks prevented?
- Are forklifts, carts, trailers and cranes being used for the most efficient movement of material between processes?
- How much time is required to move material to and from these stationary pieces of equipment?
- How much material handling time is needed to remove scrap and unused product?

Strive to have the material stay at one height as it moves from station to station through the shop. When the material/fabrication changes height, it costs time and money.

## Productivity

The overarching advantage of shop fabrication is that the work is done under close supervision, in a controlled environment, using manufacturing processes and productive craftspeople. As a result, significant productivity gains are made versus completing the same tasks in the field.

***The best way to improve productivity is to start tracking it.*** There are many ways to measure productivity. This publication provides an overview of various methods and calculations. Each company must determine which method best suits their business.

It takes time to develop your shop's specific productivity performance goals. The objective is to continuously drive time out of every task you perform. Wasted seconds add up to wasted hours over the course of large projects.

It is estimated that most contractors who perform pre-fabrication achieve reductions of between **25 - 55%** of the field installation hours.

So, we see that the decision to fabricate can have a positive effect on the bottom line. If managers believe that anything that can be measured can be dimensioned, and anything that can be dimensioned can be fabricated, they are off to a good start in adapting pre-fabrication.

## Advantages of Fabrication

Pre-fabrication allows the contractor to step back and consider the whole job. By doing so, they are able to proceed with the job in a way that maximizes cost control and leaves as little as possible to chance. This is best accomplished at the estimating/planning phase of the project.

In general, the advantages of pre-fabrication fall into four categories, each of which could contribute to a larger margin on a job:

1. Increased productivity
2. Process control
3. Better tools
4. Environmental control

The actual advantages to each company will vary based upon local Collective Bargaining Agreements (CBA) and the company's standard operating procedures.

## Increased Productivity

Pre-fabrication achieves productivity increases in a number of ways. By shifting work from the jobsite to the fabrication facility, contractors might experience these benefits:

- ***Less Manpower on the Jobsite –*** Reduced manpower at the jobsite results in less lost time at the jobsite. Common productivity killers like "starts and stops," walking to the workstation, material preparation, tool preparation and finding the right part are minimized.

- ***Less Lost Time from Breaks*** – Fewer people at the jobsite means there is less time lost to breaks and lunch.

- ***Shorter Onsite Installation Time –*** Pre-fabricated assemblies can be stored well ahead schedule, then shipped to the jobsite when the schedule calls for them, reducing the onsite scope of the job. Onsite installation occurs immediately upon arrival.

- ***More Accurate Purchasing*** – Properly planned and detailed fabrication makes material purchasing more accurate because purchasing can be rendered from the bill of material generated from the detailing process. This helps alleviate waiting on shorted material, trips to the supply house and excess stock due to over-buying.

- ***More Efficient Workflow*** – In the shop, tools and materials are at hand and readily available. In the field, crews may have to go a long way to get everything together.

- ***Advance Assembly –*** Shop pre-fabrication work can proceed independently from work in the field, giving contractors the ability to assemble systems well before they will be needed onsite. This enables plumbing contractors to maintain a level workforce in both the shop and the field.

## Process Control

When a portion of a job is performed in a fabrication facility, the contractor gains control over materials, delivery schedules, storage, manpower, site costs and quality. The amount of control is directly related to the amount of pre-fabrication that is done.

- ***Inventory Control*** – By performing shop pre-fabrication, contractors can reduce the amount of material being stored onsite. This, in turn, leads to reduced material handling costs because materials need not be relocated for storage, or moved at the General Contractor's request to remove an obstacle for another contractor or vendor.

- ***Theft Reduction*** – Pipe, valves, fittings, fixtures, faucets, etc. are less likely to be stolen when they are delivered to the site already assembled. And, because these pre-fabricated assemblies require fewer tools onsite to install, tool theft is also reduced.

- ***Reduced Transportation Costs*** – On a traditional large project, a plumbing contractor may have multiple company trucks onsite at the same time. With fewer men onsite thanks to pre-fabrication, fewer company trucks are needed for fewer days, saving gasoline and wear and tear.

- ***Controlled Crew Costs –*** Depending on the terms of your CBA, you may find cost savings by using helpers, metal tradesmen, or pre-apprentices to install the pre-fabricated assemblies onsite.

- ***Reduced Site Materials –*** With fewer people onsite, fewer tools, trailers, and other support items are required, reducing the costs related to these items. Fewer people on the jobsite also minimizes challenges associated with "stacking of trades."

- ***Better Drawings –*** The construction documents used today are usually produced electronically. This means that the drawing is designed nearer to the actual product date, and complex assemblies can be produced in controlled environments.

*Assembled materials make it more difficult to steal. Photograph courtesy of P1 Group.*

*The more pre-fabricated materials, the fewer trucks on the jobsite.*

## Better Tools

Pre-fabrication offers contractors the ability to utilize specialized tools and equipment that can be too expensive for onsite distribution, too heavy for use onsite or require specialists. These items might include the following.

- ***Custom Jigs –*** Custom jigs can be improvised in the shop, making repetitive work highly efficient. Because of the shop logistics, most tasks performed are usually "one-man operations."

- ***Specialized Tools*** – It would be impractical and expensive to have a pipe grinder or a tee puller at every jobsite. Utilizing a fabrication shop allows you to purchase tools that can increase your company's overall quality and efficiency.

*Using a lift table can enable one man to work at the correct working height. Photo courtesy of P1 Group.*

## Environmental Control

While you might not be able to control worksite conditions as much as you would like, you *can* control shop conditions. Working in the shop offers many advantages, including:

- ***No Weather Delays –*** There are no rainouts, snow days or inclement weather in the shop. Work can continue regardless of bad weather or other unfavorable site conditions.

- ***Multiple Shifts*** – Fabrication shops are able operate 24 hours a day in multiple shifts.

- ***Onsite Oversight –*** In the shop, the shop supervisor closely monitors the accuracy and quality of the assemblies. In the field, the foreman may not be able to spend enough time with each crew at their worksites.

- ***Increased QA/QC*** – There are many opportunities to catch fabrication errors as the material flows through the shop. Catching the errors allows corrections to be made in the shop, where they will be less costly.

- ***Better Testing Procedures –*** It is very easy to do Non-Destructive Examination (NDE) in the shop. Tasks like hydro testing on assemblies or modules are very easy in the shop environment.

- ***Improved Worksite Conditions –*** Doing work in the shop reduces the number of hours worked at the site. This results in less onsite exposure to safety issues such as slips and falls, cuts, eye injuries, injured backs, etc.

- ***Increased Safety –*** Safety is improved in shop fabrication. Housekeeping is easier, equipment has built-in safety guards, and the same crew performs repetitive tasks without cramped working conditions or poor ventilation. Material handling is safer and more efficient, and the use of personal protective equipment (PPE) and presence of unsafe conditions can be monitored and corrected promptly.

*Complex assemblies can take up a lot of storage space. Photo courtesy of P1 Group.*

## Disadvantages of Fabrication

With every new process, there will be some obstacles to overcome. As you overhaul your company fabrication philosophy, you will hit many roadblocks. While the benefits of proper pre-fabrication outweigh the risks, disadvantages must be considered before beginning pre-fabrication. Some of the key issues to consider include:

- ***Floor Space to Pre-fabricate –*** With as little as 2,000 square feet, contractors can begin plumbing pre-fabrication. If space is not available at your headquarters, consider leasing space at first or pre-fabricating parts of the job in the limited space available. As your company's reliance on pre-fabrication increases, space can be scaled up.

- ***Storage Space –*** Another factor to consider is the need to store the completed fabricated assemblies. The storage space required may be quite large depending upon the size of the project and the project's schedule. Some pre-fabricated assemblies may be able to be stored in secure areas outdoors; however, weather and theft need to be considered.

- ***Capital Investment –*** Capital investment will be required to purchase the tooling needed for the fabrication shop. The amount will vary based upon a contractor's current tool inventory. New equipment, such as roller conveyors, copper end prep machines, automatic cast iron snappers, etc. may need to be procured to increase productivity.

- ***Geographical Limitations –*** The distance from the fabrication shop to the jobsite will dictate whether pre-fabrication will be profitable for that job. Increases in the costs of shipping the completed assemblies may reduce or eliminate the gains made through pre-fabrication. This must be considered during the estimating phase of the project, and contractors must decide whether to pre-fabricate at the shop. In some cases, contractors have found that setting up temporary fabrication facilities closer to big projects can mitigate transportation costs or jurisdictional issues.

- ***Jurisdictional Concerns –*** Contractors that pre-fabricate work in one jurisdiction that will to be installed in another jurisdiction may be met with union resistance. This can create difficulties that vary by location. Some areas allow freedom of movement of fabrication; other areas prohibit the practice. To avoid any misunderstandings, it is best to contact the Business Manager where the jobsite is located and get permission to ship in the fabrication. This should be done at bid time, with the agreed-upon terms confirmed *in writing*. If this is not done, some labor from the installing jurisdiction may need to be shipped in to perform the pre-fabrication.

- ***Foreman Compliance –*** Achieving foreman buy-in is one of the key challenges when making the transition to pre-fabricating a significant portion of the work in the shop. Foremen may be reluctant to relinquish the work hours and control of their projects to others.

- ***Culture Change*** – When shifting to a pre-fabrication culture within your company, you must also get buy-in from estimators and project managers. These individuals frequently want to have complete control at the jobsite.

- ***Redundancy –*** The craftspeople who work in the shop are often assigned to very repetitive tasks. Not all workers can adapt to sustained repetitive tasks over an extended period. There are people who like this type of work, but it may take time to find them.

- ***Communications –*** Pre-fabrication takes a coordinated effort among many members of your team. It is particularly important to maintain

constant and detailed communication between the shop supervisor, the field foreman, the estimator, the project manager and the detailing department to ensure that jobs run on schedule, and fabrication details are correct. The errors that result from ineffective communication may erase any productivity gains your company had hoped to achieve.

## Chapter Two – Changing the Company Culture.

*Everything* a plumbing contractor does starts at the top, including the decision to begin shop fabrication. While the idea to utilize shop fabrication may come from anyone in the company, the dedication needs to come from the owner if the shop is to be profitable and effective. Without the owner's backing, equipment cannot be purchased, processes cannot be modified, space cannot be allocated, and more importantly, the workforce will not buy into the concept.

Once the decision to perform shop fabrication has been made, it is imperative that management reiterates the company's commitment to successful shop fabrication. Most employees respect management desires regarding improving productivity, especially when research has proven the benefits.

Supervisors can use this "executive commitment" as a tool to impress upon workers that prefabrication will be part of the company's future. For example, the shop supervisor may simply need to say, "We are doing this work in the shop because that is what the boss wants us to do," if confronted by an employee. Making the switch from the field to the shop requires strong management and supervision commitment and leadership.

### Communicating the Fabrication Culture to Employees

Resistance and challenges accompany any change, even change for the better. Creating a culture of fabrication means overhauling the way your company thinks about performing work.

The best way to avoid resistance is to educate employees about the advantages of shop fabrication.
Let it be known that the maximization of off-site plumbing fabrication is a top priority for your company. Look for every opportunity to move man-hours from the field to your fabrication facility.

Let employees know that this isn't only about profit. The company also values the improved safety and more efficient work that can be achieved in the shop. Workers in the shop are much safer than they would be when working in confined spaces or unstable conditions.

Plumbers in a fabrication facility are able to work faster, with more support, in a clean and controlled environment. Other trades aren't in their way, their tools are always in place, and their workspace is theirs.

There are other benefits for the plumbers as well. In a shop, they have access to high-quality, fully-coordinated 3D virtual designs. These can now be produced for an ever-increasing number of projects and offer better guidance than hand drawn diagrams.

It will be easy to demonstrate that fabrication ensures a high-quality product and uses resources more cost-effectively in a safer, controlled work environment.

*Modular assembly tables allow for flexible tasks.*

**In the shop you can have:**

- Ergonomic modular assembly stations;
- Specialized fixture jigs, carts and carriers;
- Automated copper and cast iron cutting operations;
- Roll grooving equipment;
- Tee drilling; and
- Press fit tools in addition to
- Improved worksite conditions, better lighting and organized tools.

*Automatic pipe snappers allow for quick clean breaks in under a minute. Photo courtesy of CFI Mechanical.*

*Custom tool applications like this tee drilling station are great for productivity in the shop, but impractical in the field. Photo courtesy of SA Communale.*

*Custom carriers are a valuable way to store, transport and install prefabricated assemblies onsite. Photo courtesy of the P1 Group.*

## Common Complaints and Responses

Resistance to fabrication can come from every type of personnel. Craft workers, project managers and even management may be resistant to the new process. Below are some common complaints and suggested responses.

| Common Complaint | Suggested Response |
|---|---|
| *I can build this just as well in the field as I can in the shop.* | *In the shop you have better tools, better working height, and you can control the environment 100% of the time.* |
| *The extra coordination involved to pre-fabricate plumbing is not worth my time as a project manager.* | *Let me determine how you best utilize your time. The overall benefits gained in scheduling, safety, and productivity make up for your extra coordination.* |
| *I don't want to lose my best field foremen because we are fabricating everything now.* | *If your field foremen are good, they will understand how fabrication is an improved process. If not, you are better off without them, no matter how much it hurts to let them go.* |
| *I don't want to install someone else's work.* | *I can send the people in the shop to the jobsite to install, or you could take a turn in the fabrication shop yourself. Another option is to send your shop supervisor to oversee and coordinate the installation on the jobsite.* |
| *I got a piece that had mistakes in it.* | *Robots don't make our assemblies, people do. They are human just like you. Mistakes are made in the field, too. When mistakes occur in the field, they are corrected and you move on. Treat this the same way.* |
| *I don't want to send this to the shop because I don't want to add any additional shop burden (overhead) to this project.* | *The onsite job cost will be higher once you factor in additional manpower, tool rental, consumables and expendables.* |

Some detractors may believe that the extra material handling costs and delivery of assembled units could run up the cost of shop fabrication. What appears on the surface to be a lot of wasted time and money, moving pipe and parts to your shop and back to each jobsite, can be minimized with three basic proactive planning efforts:

1. As your estimator pulls out the items that can be economically prefabricated or pre-assembled, they also pull out the stock list of material. These items are then shipped directly to your shop rather than to the jobsite. In the shop, you can also use a lot of short, cut-off pieces that would otherwise be thrown into a jobsite dumpster.

2. Coordinating your prefabrication deliveries with the general contractor and other trades can minimize crane or forklift rental. Good coordination will also put your fabricated items on each floor or in each enclosed area as they are constructed.

3. Small assemblies can be built on an inexpensive, tagalong trailer bed that fits the ball hitch on your pickup trucks. This enables your foreman to deliver those items during his routine trips to the jobsite.

## Finding the Right Fabrication Shop Personnel

The move to shop fabrication will require a shift in the culture to which craft personnel are accustomed. They have to switch from doing plumbing installations the traditional way to working in a manufacturing facility where they will often be performing redundant, one man tasks, sometimes all day long.

It is important to find supervisors who readily support doing offsite fabrication. They will be able to suggest crafts people who would be willing to work under those conditions. These same supportive supervisors would be best suited to working with the jobsite foreman to get buy-in from the field.

By training apprentices in the fabrication shop, you ensure that they begin their careers with the proper mentality, even if they will be working in the field most of the time. This is also a good way to identify personnel who work well in a fabrication facility environment.

*For some fabrication shop workers, this is the most important jobsite condition.*

Achieving buy-in from project managers, estimators and the field foreman is as important as finding the right fabrication shop personnel. These individuals often have the ability to control how much of their project will be completed in the shop. Being successful with the fabrication shop will help them switch their paradigms. During project reviews, make sure they are pushing as much as possible through the fabrication shop.

## What's Next?

Once the decision to transition to off-site fabrication has been made, you need to determine what work will take place in the shop. This may come as the result of a foreman evaluating his project for redundant tasks. Redundant tasks are the low-hanging fruit of prefabrication. Productivity gains are easily made in the controlled environment of a fabrication shop where jigs and carriers make it easier to repeatedly duplicate the same piece.

Most often, however, the estimator, project manager, or upper management decides which work to do in the shop during the estimating phase. Planning fabrication from the start also provides the easiest way to get buy-in from the employees.

**It is imperative that the project foreman be supportive of the company's desire to have a portion of the project be shop fabricated**.

*Redundant tasks are easy targets for productivity gains. Photo courtesy of MMC Contractors*

You may want to start small, and as you begin to get feedback on productivity, scale up to larger projects.

The mentality during the estimating phase will evolve over time. Once the "What *can't* we fabricate*?*" mindset is established, you will begin to look at projects more efficiently.

After being awarded the project, present it to the team. The estimator and project manager will review all the bid documents with the estimate and prepare for the "turnover meeting." At this meeting, the construction team will be presented with the plan for the project. This will include a complete explanation of what will be shop fabricated. It is at this point where you need to achieve buy-in from the rest of the project team.

Since the selected foreman is part of the turnover meeting they will know what is expected of them regarding shop fabrication. If there is no fabrication plan

in place and the idea is openly discussed with the foreman, too much work can be shifted away to the field. If the estimator and the project manager come into the meeting, having already decided what can be fabricated, the foreman will have a harder time arguing for more field work. This may be seen as teaming up on someone, but the method is quite effective at moving more work to the fabrication shop and having the foreman buy in from the start.

In the beginning, it may be difficult to find the right foreman to promote the fabrication process. You want to find one who is willing to do what it takes to manage their people and prevent a groundswell of contempt for shop fabrication.

## Getting "Buy-In" from the Field

As mentioned in the first sentence of this chapter, *everything* starts at the top. There is definitely a "trickle-down effect" in changing corporate mentality. Owners, executives, project managers, estimators, operation managers, superintendents, foreman, etc. must have the desire to make off-site

*Sending QA/QC-inspected complex assemblies to the jobsite goes a long way to getting buy-in from the field. Photo courtesy of SA Communale.*

fabrication work. Without their support you will not get buy-in from the field. The goal is to have field foremen *want* to have more fabrication on their jobs. This can only be accomplished by building on previous successes and building trust between them and the fabrication shop.

## Keys to Selling Shop Fabrication to Foremen

Once foremen see the advantages of shop fabrication, they are likely to support it. Assemblies can be scheduled to arrive "on time," when they are needed. Because the assemblies will

**The first time a foreman receives fabricated assemblies that arrive on the jobsite mostly completed, organized and perfectly assembled, they will see the value of shop fabrication.**

arrive organized and partially assembled with all of the necessary components attached, they will be ready for immediate installation.

As more work is transferred to the shop, foremen will be able to have fewer mechanics on the site, making the job easier to manage. The scope of the work will also be geared towards the crew's talents.

Small crews require fewer onsite materials. With fewer tools and plumbing service trucks onsite, it

becomes easier to monitor, control, and be more proactive about safety.

Project quality also increases because management can assign the better craft workers to do more of the work. These workers will have access to better tools and working conditions in the shop, which leads to improved quality. As quality improves, less work will need to be redone, freeing foremen to install the job and move on to the next job more quickly.

The shop superintendent and the project manager should continuously monitor each field foreman's willingness to send work to the shop. In particular, they must monitor site visits to ensure that complex assemblies are being built in the shop. If complex assemblies being built on the jobsite, the shop superintendent and the project manager need to ask, "Why wasn't that fabricated in the shop?"

If particular foremen repeatedly fabricates in the field rather than in the shop, management will need to have a conversation with them to find out why. A lack of communication, a personal problem or bad customer service may be at fault, and these foremen may need to be brought into the office for more detailed training. This continual evaluation of foremen's resistance to off-site fabrication may lead to the discovery of a bigger problem, such as transportation failures or pipe quality.

*Rotating labor in and out of the shop can be a costly mistake. Keep your best workers in a rhythm.*

## Good Intent, *Bad Idea*—Rotating Crews In and Out of the Shop

One of the most common mistakes companies make is rotating craftspeople in and out of the fabrication shop. Using the shop as a labor pool, or as a place to "send him into the shop for a couple of days," is detrimental to a productive shop operation.

It is far more productive to keep the same crew in the shop. After all, they have already spent the time learning how to operate the equipment and be effective in the fabrication shop. They have learned the tools, know what the shop supervisor expects, understand the flow of material through the shop, and are familiar with the safety and quality control requirements of the shop. Because each new person in the shop needs to learn these things, rotating crews puts time pressure on both the supervisor and the craft worker.

When someone decides to "rotate" some of the personnel to the field and bring in new crews, there is a profound

negative impact on the morale and productivity of the shop crew. As the new people learn how to "work in the shop," their training time hurts productivity and has a negative impact on existing shop workers.

If the volume of fabrication work slows, however, there is nothing preventing you from using shop crews in the field. They can be called back into the shop when needed. Because they already understand shop work and won't require training, they should fit back in without much effort.

## Using the Shop as a Labor Pool

Another common mistake is when the operations manager, project manager, field foreman, or superintendent uses the shop as a labor pool. Unless the shop is sufficiently slow that crew won't be missed, you are better off taking crew from other jobs or the hall before replacing shop crew with untrained people.

This also leaves the shop supervisor constantly reshuffling work laid out for the next few days. When the shop supervisor unexpectedly finds out that new people were sent in to work in the shop for a couple of days, they have to spend their valuable time showing the ropes to the new guys, rescheduling manpower and taking into consideration training time.

Time is also taken from the more productive shop employees that may need assistance. Moving manpower in and out of the shop is a definite de-motivator to the steady shop workers. Shop workers thrive on routine. Any variance to this routine can also cause problems when they return to the shop. Their work is completed in a much more efficient manner when it is scheduled out days in advance. Nothing makes a craft worker's day go by faster than when they know what tasks they have to complete for the next few days and they can focus on the tasks at hand.

## The Anti-Prefab Foremen

Occasionally you will have a foreman that resists every attempt to support the movement to fabrication. Negative foremen can poison the job-site crews when fabrication shows up. They can look for every opportunity to blame the shop on assemblies, regardless of fault. When a fabrication mistake actually does occur, *everybody* hears about it. Yet, any mistakes that he or his crews may make on the site are quickly corrected and kept quiet.

When confronted with this situation, your first impulse might be to send him back to the hall. The best way to handle this is to have him go through any company training regarding prefabrication that you may have.

If you do not have formal training available at your company, you can utilize the section regarding Fabrication from the UA/MCAA's foreman certification course.

In some cases, you can re-assign problem foremen to projects that have no fabrication. Finding jobs for a foreman that is against fabrication is only going to make your job more difficult, if your company plan is to fabricate as much as possible, this will be a detrimental effort. Also keep in mind that any project this foreman will be assigned may suffer if there are tasks that should be done in the shop.

Finally, if he digs in his heals, refuses to change, or continues to poison the attitudes of other workers, then you would have little choice but to terminate his employment. Losing a longtime foreman can be a painful thing, but keeping on someone that negatively impacts your business will only undermine the process.

## Chapter Three - Personnel

Pre-fabrication affects all of your employees—not just those in the shop. In order for pre-fabrication to be whole-heartedly adopted within the organization, *all* employees will need to change the way their job is performed. While some employees will be affected more than others, everyone plays a role in the process.

### Owners

If a company's leadership does not adopt a pre-fabrication mindset, efficiency will always suffer on some level. It is imperative that management be totally committed to shop fabrication in order for it to be successful. Otherwise, improvements cannot be purchased, direction cannot be given and processes cannot be mandated.

***An owner plays many roles with pre-fabrication, including:***

- Idea champion
- Encourager/enforcer
- Productivity evaluator
- Cost of investment analyzer

The term "owners", as used above, may mean different things to different companies. An individual, family, group of people, or a larger company may own a plumbing company. A company may have various forms of management. Whatever the company structure, all the top management must be committed to the fabrication concept for it to be successful.

Management must drive change and plan the course in order to establish and maintain a successful plumbing fabrication shop. They need to be continuously monitoring progress and evaluating efficiency. While a company's owners may not be evaluating the day-to-day progress, they should be aware of the total process. There is more to pre-fabrication than making investments in acquiring tools and manpower. The system needs continuous evaluation to drive efficiency.

That is not to say that everything has to be done at once. A company can test pre-fabrication on its jobs to develop effective processes, communication and planning. Once the company has "taken the plunge" into fabrication, constant monitoring and evaluation of the results are essential.

***Don't just build a fabrication shop, maintain it:***
One of the most common mistakes that owners make is that once they build a fabrication shop, they don't continue to evaluate its productivity.

This constant evaluation is so vital because added productivity helps a company to bid projects effectively. Any increase in productivity from your fabrication facility ***goes directly towards your profit margin and/or more competitive estimates.***

Expect a learning curve as your company's employees modify the way they perform and think about how work will be completed. Those most heavily vested in this process will include:

- Top management
- Estimators
- Project managers
- Purchasing agents
- Scheduling people
- Field foremen
- Shop supervisors
- Craftspeople

It is important to involve all of these individuals and to gain their support for the switch to shop fabrication. Owners need to visit the shop regularly to see what is being done and where improvements can be made. They should know the craftspeople who work in the shop and the shop supervisor(s) and support their efforts while at the same time evaluating them fairly.

The more familiar management is with operations, the better the decisions regarding additional investments in the shop, such as: determining what tools to purchase, what facility enhancements to make and where to invest in the support disciplines that assist the shop's efforts (i.e., BIM, advanced scheduling software or productivity tracking tools).

Management must gather information about the shop's productivity in order to make decisions regarding what purchases will further enhance production. Owners must evaluate:

- Materials or productivity they will receive;
- How long it will it take to pay back the initial cost of new equipment; and
- The effectiveness of the fabrication shop supervisor.

Productivity will be discussed in Chapter Four.

## Fabrication Shop Supervisor

The shop supervisor is the single most important cog in the machine. They must be able to manage time, manpower, inventory, drawings, scheduling and field foremen. They need to be knowledgeable about all of the shop processes. They have to know the best way of doing *everything* in the shop, and are open to suggestions from the crews if a better way is presented.

Shop supervisors might not own the ball club, but they manage the team. They must be trained to coach and develop their people, to encourage involvement, and boost morale. They build teams that pull together, share ideas, and get the right things done.

***A fabrication shop supervisor has several roles,***

- Leader
- Motivator
- Communicator
- Scheduler
- Instructor
- Evaluator
- Manager

The supervisor must communicate effectively, work with people to set expectations for continuous improvement and give constructive feedback. They collaborate with peers and work together to solve day-to-day problems.

They also communicate with the field, the fabrication shop and project managers. They schedule manpower to determine the best balance between effectiveness and cost efficiency. They evaluate personnel to make sure they operate efficiently within a fabrication environment. They make recommendations on when to scale manpower up or down according to job volume.

Supervisors in fabrication shops also must help develop their crew's skills and determine the strengths and weaknesses of the shop personnel. They are also the ones who set the pace within the shop. If they are not hard-working, efficient and organized, their crew will not be either.

Supervisors are the most essential piece for companies to achieve higher levels of quality, productivity and service.

**How do you find the right one?**
After reading the qualifications above, you may think that this superhero doesn't exist. Most companies evaluate their current foremen for the fab shop supervisor position or rely upon their existing manpower pool. It stands to reason that if you are just starting out in fabrication you wouldn't go out and hire an "all star" performer. The prospective supervisor needs to express a deep desire to take on the challenge.

**Some of the things to consider when choosing a fabrication supervisor:**

1. The individual *must* be innovative, creative, and personable. This is the most important trait to look for.
2. They are always looking for ways to reduce the time it takes to perform a task.
3. They have demonstrated that they "think outside the box"
4. They are one of your highest skilled journeymen.
5. They must be organized and able to multi-task.
6. They have communication skills and able to coordinate between estimator, project manager, field foremen, craft workers and customers.
7. They have demonstrated strong safety skills and possess the OSHA 10 or 30 hour certifications.
8. Must be knowledgeable regarding plumbing codes, technical standards, and have the ability and willingness to obtain information regarding codes and various technical standards that they are unfamiliar with.
9. There are a number of unique "processes" that are utilized in shops that are not available in the field; do they have knowledge of these operations?

It is rare to find a journeyman who fills all of the above requirements. Many of the specifications listed are outside a foreman's standard job duties. If a potential applicant for the position lacks any of the above skills, additional training will need to be provided in order for them to be successful in the new position.

Unfortunately, there is no one place for a new supervisor to obtain training in all of the above-mentioned areas. One possible solution is to send your supervisor to the annual MCAA Pre-Fabrication Conference. At the conference, they will have the opportunity to tour one or more MCAA member fabrication shops and see how those operations are set up. The conference also allows your supervisor to meet other fabrication shop supervisors from around the country who can form a professional network.

The members of your peer group may be willing to have your supervisor visit their shops to see how a successful fabricator operates. If you are not part of a peer group, industry leaders outside your territory (located in noncompeting locations) may be willing to have your shop supervisor observe their shop processes.

***Your best field foreman is not always your best shop supervisor**: The right job requires the right tool. When looking at field foremen as potential candidates for the role of shop superintendent, they possess as many of the skills listed in this chapter as possible.*

Making one of your current foremen the shop supervisor doesn't always work. Even though your foreman is successful in the field, that doesn't always mean they will be a success in the shop. They may not possess the right mix of multi-tasking, leadership and communication skills for the position. If you try a field foreman in the shop and it doesn't work out, that foreman could go back out to the field and have positive results.

If the supervisor is unable to balance all of his or her roles effectively, you have to be willing to find someone else. The position is too essential to your organization to have it run by the wrong person.

Shop supervisors who are very productive in a small shop may have trouble adapting as the volume of work going through the shop increases. In these cases, the supervisor generally falters because they are not adept at time management. If they cannot learn the skill, it might be time to find someone that is a better fit.

## Additional Areas to Consider

**Time Management**
The shop supervisor must demonstrate that they have been efficient with recent jobs.

Often, the shop supervisor will need to be exposed to a variety of scheduling tools. It is important that they have a rudimentary knowledge of logistics and their software applications.

Have they been able to set schedules and meet deadlines on previous projects? Have they demonstrated that they are organized?

**People Management**
Handling the crews in the shop is very important. Before the beginning each shift, the supervisor must plan the work that each crew will be doing that day.

They must assign crews to complete certain tasks and verify that the crews have the knowledge to complete those tasks. When assigning the duties to the crews, the supervisor needs to take into consideration:

- **Safety** issues related to the tasks to be performed
- **Tools and equipment** required
- **Manpower** required, and whether the crews assigned to the tasks have the right skills
- **Materials** availability and readiness
- **Information** availability, such as drawings, sketches, code requirements, etc.

In order for the shop operation to be successful, the shop supervisor must be given the authority and responsibility to control the shop crews. The supervisor will determine how many workers are needed in the shop and who those people should be. If the shop supervisor is not empowered to make those decisions, shop productivity will suffer. Conversely, the shop supervisor must have the expertise and demonstrate good judgment when exercising their authority.

The supervisor also must be able to handle fluctuations in crew size with minimum impact to productivity.

**Flexibility**

The shop supervisor must be kept abreast of new technologies and improved processes and be willing to integrate these improved processes into their shop.

The ability to adapt to constantly changing plans is also essential. The supervisor must be flexible when a situation arises that creates a conflict with the plan, whether it's due to a machine that breaks, a crew member with a specific skill who is out, an "emergency" on a field project that needs immediate attention or late delivery of needed materials. Each of these situations requires the supervisor to call an "audible" and readjust, quickly changing direction while at the same time maintaining productivity in the shop. The supervisor needs to know which projects are the most important, what can be pushed back and where there is time to make up. Project importance in typically conveyed in weekly status meetings.

Work that is sent to the shop is constantly changing; the crew may be working on copper, no-hub, plastic, hangers, batteries or modules. They may be making three or three hundred of an item. No matter the situation, the supervisor needs to be very creative (think outside the box) and always be searching for ways to do things better.

**Communication**

There are several ways in which a shop supervisor can develop good communication skills on the job.

- ***Information*** – Get enough information and have all the information needed to make effective decisions and avoid delays. This may mean getting additional information from the project manager, field foreman or estimator before communicating with the crew.

- ***Direct Communication*** – Encourage face-to-face communication with workers, both individually and as a group, on critical issues or problems in the shop. This may mean having a meeting every morning in the shop before the crew starts work to discuss what is going on with the various projects. Not only is face-to-face communication more effective than other methods, the crews will appreciate being "in the loop" when it comes to what is happening in the shop. Direct communication with the crews also eliminates the chance the message may be misunderstood.

- ***Two-way Dialogue*** – Recognize that members of the crews may have viewpoints and ideas different than your own. Listen to all viewpoints and then make a decision. Pre-fabrication is constantly changing and your crews may have ideas for making their work more productive. Make them feel like valued members of the team by listening to, and seriously considering, their ideas. Whether their ideas are for improvements to efficiency or procedures or requests for new or added tooling, they could have a major impact on the shop's productivity.

- ***Clarity*** – Encourage the crews to ask questions or come back to you for further explanation in order to get the job done right the first time. Not only is this more productive, but it will also give your shop a reputation for doing the job right the first time—a reputation that any shop wants.

The shop supervisor will have a significant amount of communication with project managers and field foreman regarding job fabrication requirements.

Open communication between the field foreman and the shop must always be maintained. **The field force is the shop's most important customer.** Weekly meetings with project managers are recommended to help the supervisor stay on top of all work being sent through the shop.

It is very important that management be kept up to date on any areas of concern. This is generally accomplished through periodic meetings. These meetings might also involve the project managers, estimators, purchasing, scheduling and operations.

***Topics of discussion at weekly project update meetings include:***

- Current workload
- Future workload
- Materials delivery/shortages
- Field requirements
- Shipping
- Shop manpower

Discussions at these meetings need to be a two-way street. Meetings are generally scheduled weekly or biweekly, depending on the workload.

The shop supervisor will be with and around the crews during most of the workday. This requires openness between the workers and supervision. The crews will receive most of their training from the shop supervisor, including things like safe work practices, using the various tooling in the shop, how to increase productivity and improving material handling through the shop. The shop supervisor needs also to be open to feedback from the shop crews.

**Inventory and Logistics Management**

With long lead times and advance drawings, a fabrication shop can look more like a storage warehouse than a manufacturing facility. The shop supervisor must be aware of timing and space. The supervisor must know when pieces need to be installed, production timelines, manpower loading, what they have room for and if the proper materials are scheduled for on-time delivery.

Inventory costs are another consideration. Receiving material too far in advance not only clutters the shop, it ties up financial resources. On the other hand, not having materials when you need them stops the entire project. Find a balance and create a rule that allows for a little give in your process to accommodate fast-track pieces and changes.

Fabrication drawings are usually prepared well in advance of the actual fabrication. These drawings will list out all the material that will be used to "spool out" the fabrication, giving plenty of lead-time to procure the components.

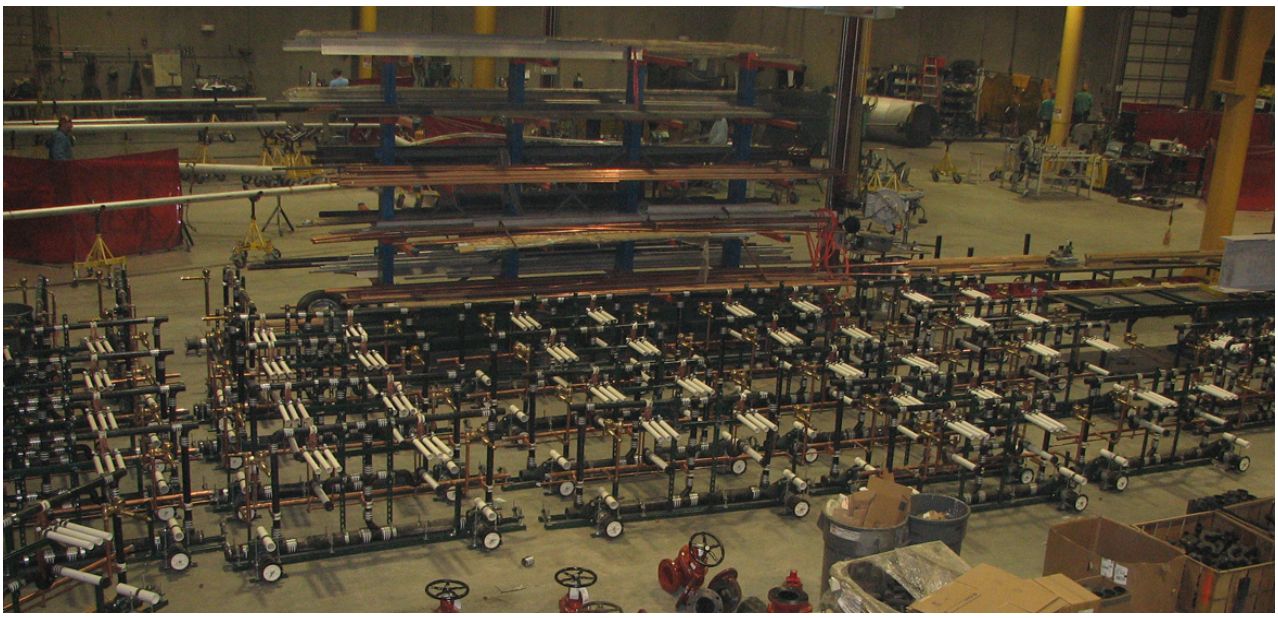
After a determination has been made as to when each spool sheet is scheduled for fabrication, the material will be ordered for on time delivery.

Once a delivery has been made, it needs to be checked for back orders. ***Avoid beginning any fabrication until all the material for a spool sheet scheduled for fabrication has been received.***

If there is equipment with a long lead-time, that material must be ordered and received prior to commencing the assemblies.

Inventory management includes the little things like consumables and expendables. Items such as gasses,



*Do you have enough room for your inventory? Photo courtesy of MMC Contractors*

end prep abrasives, solder, glue and cleaner are vital to shop processes. Running out of these items when you have all of the other necessary components is one of the worst mistakes you can make.

When manpower, time and big ticket materials are waiting on little things like end prep adhesives, what could have been easily avoided becomes a very costly mistake. The shop supervisor must always know the inventory, how much is needed for upcoming jobs and when deliveries are scheduled.

Shop supervisors must also consider the amount of available space in the fabrication facility. While the amount of space required to do the actual shop fabrication is usually minimal, the space required to store the fabricated assemblies could be quite large. This may require leasing additional inside or outside storage, depending upon the material.

## Shop Craft People

Regardless of their skill level, craftspeople who go into the shop for the first time will need training on shop processes and procedures. The drawings, tooling and machines that are provided to workers are different than what they see in the field. Things like tee pulling machines and hydraulic snappers are not utilized in the field.

New crewmembers need to understand the proper use of these items, the safety precautions involved and how material flows through that equipment.

*Custom-built machines like this tee-pulling station take training on operations and safety for all new workers. Photo courtesy of SA Communale.*

Workers in a shop are expected to do their component of work shown on the spool drawings. The craft workers need to be mentally prepared to repeat one task (i.e. cutting copper piping) during their whole shift.

They must also be flexible enough to move from one redundant task to another at a moment's notice. All this needs to be accomplished while performing their tasks safely, efficiently, and with a high degree of quality.

Not every worker from the field or the hall will be perfect for the manufacturing environment. They might not be able to handle the redundancy or have personality conflicts with the process. There are workers who thrive in a production environment. They like staying busy and enjoy having a controlled environment, better tools and an indoor restroom. Do your best to find those workers, and weed out the ones that aren't suited to shop work.

## Metal Tradesmen

Many local collective bargaining agreements (CBAs) and National Agreements contain language that allows a shop to utilize a Metal Tradesman worker classification. If your agreement allows you to employ them, familiarize yourself with the tasks that trade classification is (or is not) allowed to perform. Usually when the CBA contains language allowing Metal Tradesmen, it will limit their duties.

***Metal tradesmen can typically perform the following tasks:***

- Material handling
- Pipe cutting
- Pipe end preparation
- Hangers and supports

***Metal tradesmen are* not *allowed to do the following:***

- Solder pipe
- Glue pipe
- Join pipe in any way
- Make completed assemblies

## Apprentices

The shop environment can be an ideal place to introduce apprentices to the company "mindset." They become exposed to various company procedures like safety, CADD, scheduling, estimating, time keeping, productivity tracking and supervisor/worker relationships.

***Most importantly, apprentices get trained in a pre-fabrication mindset.***

Utilizing apprentices is also a way to reduce the average hourly rate, especially if you are located in a jurisdiction that does not allow the use of Metal Tradesmen. Their wage rate reduces the crew costs to enhance job profitability.

It is important to make sure the apprentice has the skills to perform the assigned tasks safely, efficiently, and with a high degree of quality.
Keep in mind that the use of apprentices in the shop environment should be limited to between three and six months.

If an apprentice has been assigned to a shop for long periods of time, they could end up becoming journeymen who are less well-rounded and do not possess all the required skill sets.

## Estimators

Once the shop is operational, is the time to begin collecting data regarding shop productivity. This is a continual process and should be evaluated regularly. The information gathered needs to be forwarded to the estimators.

The estimators will evaluate how production in the shop compares to that in the field and apply the differential to the estimate. This creates a situation where bids can reflect the savings realized by doing shop fabrication. The estimate will be more accurate and help in bidding the job with greater profit potential.

As the shop continues to improve its processes, new and more accurate data will be gathered and periodically provided to the estimators so bids may be further refined. Most often the determination as to what to fabricate or not to fabricate is made by the estimator. That being said, for larger projects it is preferred that other members of the management team be involved in making the decision regarding what will be fabricated. In addition to the estimator, that team could include the project manager, field superintendent, and field foreman. Collectively they would determine which items can be fabricated and have the adjusted productivity labor factors applied to the job bid.

The estimator also has to research the shop's workload during the time that the current bid is scheduled to be completed. If the shop will be overloaded, it may be necessary to work the shop on overtime or work two shifts. Although productivity typically dips when utilizing second shifts and working overtime hours, it is still more profitable than doing the work in the field. If overtime or a second shift is required the estimate will be impacted as a result of the higher costs to work the overtime or second shift.

## Project Manager

Once you have been awarded a contract, it is time to get the project manager involved with the job. The estimator gathers all the information involved in creating the bid, such as the drawings, specifications, scope of work, addendums, schedule and all communications with the owner/engineer during the bid phase. After all this information is gathered, the estimator then presents the job to the project manager.

The project manager then schedules a "turn over meeting" with the construction team, which includes the shop supervisor. This team is presented with the plan and assumptions that were made during the estimating phase regarding what was to be fabricated. The team will evaluate the assumptions, offer suggestions and make the final determination as to what will be fabricated during this turn over meeting.

Prior to the turn over meeting the PM will be allocating the budgeted costs and budgeted labor hours to the individual cost codes for the job. There will be a number of cost codes that will be assigned to the fabrication shop. It is very important that the PM defines the cost codes by providing accurate descriptions of each code, and allocates the budgeted costs and budgeted labor hours to those tasks that allow tracking of productivity. When the shop is reporting time and cost they need to be very diligent; the productivity data gathered will be based upon this reporting. The reporting process will be discussed in greater detail in Chapter Four.

The project manager, working with the shop supervisor and field foreman, creates the schedule and plan for the project to be fabricated. Expectations, scheduling and conditions are coordinated.

The project manager then presents the fabrication plan to the owner or general contractor. It is important to have the customer in the loop so they can have buy in with the pre-fabrication process. Not all contractors that do pre-fabrication keep the customer in the loop.

***It is important to get buy in from the owner if you want to receive payment for the work completed in the fabrication shop and not yet delivered to the jobsite***.

On projects where the contract allows for stored material to be paid at 80% of the value, you need to differentiate between material and fabricated assemblies. You have expended labor hours on the fabrication, so you need to get paid for that "earned value." It may be necessary to negotiate this up front and have any specific terms become part of the contract.
The project manager is also responsible for setting up the flow of communications for the job. There will

be internal communication on an ongoing basis among the following: fabrication shop supervisor, field foreman, CADD department, estimators and purchasing agent.

The preceding group needs to be able to talk with each other openly and as needed. If any decisions are made, the project manager needs to be notified and kept in the loop.

The PM also must communicate with the Owner/GC, keeping them apprised of the current job status. It is also important that the PM work closely with the other trade contractors regarding your pre-fabricated assemblies. What you are doing in the fabrication shop may impact the other contractors. For example, you will want to have sleeves in before floors are poured and some assemblies completed before walls are located.

## Purchasing Agent

Contractors handle purchasing in many different ways. Purchasing may be done by a purchasing agent, the PM, estimator, field foreman, shop supervisor, or any combination of the above. Although it is not necessarily important who is doing the purchasing, it is important that they work with the shop supervisor. The shop needs to have the delivery of the material be per the schedule (on time delivery) for that job. Dealing with suppliers that deliver the material with a minimum amount of back orders is extremely important.

**Back orders are a disaster to shop productivity**. It may be necessary to have multiple suppliers for a project so backorders can be avoided.

The purchaser needs to receive feedback regarding a supplier's performance, quality, reliability and flexibility. For instance, will they bag and tag? The best value supplier may not always have the lowest price, but, they are dependable and meet our other criteria.

The procurement of subcontractors presents some unique challenges. Some companies may have the project manager, field superintendent, or an administrative assistant, handle the subcontracting process. Companies that have a purchasing agent (PA) will usually assign the procurement of subcontractors to that PA. Using the PA will result in uniform terms and conditions in the subcontract agreements.

On occasion there may be a need to have subcontractors go to your shop to complete some of their work. An assembly or module may need painting, insulation, electrical, sheet metal or other subcontracted work. Allowing them to go into the shop to do their work may result in a savings to both you and your subcontractor.

## CADD Department

Computer-aided Design and Drafting (CADD) became popular as an alternative to hand drafting. As offices became more reliant on computers, CADD became the standard for many design- and construction-related industries. Compared to hand drafting, CADD has significant advantages in terms of speed, collaboration, embedded information, portability and efficiency.

Since many projects are now electronically designed using CADD/BIM (Building Information Modeling) multiple design plans can be included and checked before installation. Electrical, plumbing, heating, ventilation and air conditioning systems, and all elements of the building, can be placed into a single CADD/BIM design and checked for clashes and design conflicts.

We will cover BIM, CADD and other technology in more detail in Chapter Eight.

For the plumbing contractor, many of the drawings that need to be produced for the pre-fabrication shop can be hand drawn. Most often, these are done by the field foreman.

That being said, when the owner/engineer has provided electronic design of the project and the files for the project are available to the contractor electronically, it becomes very easy to do the shop drawings electronically.

Once the coordination drawings have been completed depicting all the MEP without interferences, it is time to generate the spool drawings for the shop.

The spool drawings should show and define all the material that will be needed for that particular drawing, all the cut lengths of each piece of pipe, and the configuration of the piping indicated. The CADD department also needs to verify that what is shown on the drawings matches the specifications.

The CADD department will be generating RFIs to the engineers as discrepancies with the drawings and or specifications are discovered. They need to keep the project manager in the loop in case a change order needs to be processed.

There must be a continuous process of quality control regarding the spool drawings that are provided to the shop. These drawings must be easily interpreted by the craftsworker in the shop. The material required, the pipe lengths, the configuration and the QA/QC checks are to be clearly defined.

## Field Foreman

Field foremen can be pre-fabrication's biggest advocate or its biggest obstacle. Transitioning from doing all the piping work in the field to doing a significant amount of the piping work in the shop is sometimes difficult for the field foreman to accept. They need to be nurtured from the beginning and all the through the project. Their support of shop

fabrication for their job is extremely important to the profitability of the job.

They need to provide constructive feedback, not complaints, to the fabrication shop supervisor and understand that when fabrication is done properly and coordinated correctly, it makes everyone's job easier.

The field foreman should have an open line of communication with the shop supervisor and the CADD/BIM leader.

Emerging issues like the following must be resolved:

- Relaying any onsite changes that could affect the design of the fabrication.
- Providing information regarding handling issues, building restraints, tight spaces and lay down area. It is important that the assemblies shipped to the site be able to fit into the building.
- Providing information as to what will be installed first. For example, it is necessary to load the trucks so that the last piece of fabrication loaded is the first piece needed at the site.

The field foreman is an integral part of the fabrication process and the success thereof. If at any time he demonstrates resistance regarding shop fabrication, upper management must get involved early to head off any morale problems that would result in a lack of productivity, resulting in a loss of profit.


***The Fabrication Shop Keystone**:*

While every part and player is important to the pre-fabrication process, the fabrication shop supervisor ties everything together.

This individual must be very **safety conscious**, **innovative, creative** and someone who is continuously looking for ways to **reduce the time** it takes to complete the various tasks performed both in the shop and in the field.

## Chapter Four - Productivity

Productivity is the brass ring everyone is always chasing. The concept of the fabrication shop in itself began as a way to be more productive than a jobsite. Thus, everything you do in the fabrication shop is done with the goal of increasing productivity and/or improving the schedule. Plumbing contractors need to maximize the value of their labor force and that only comes through productivity improvements.

Labor is a volatile cost that can be impacted by a number of factors related to project-specific issues and/or market issues. Labor-related shop costs can account for up to 50% of the total labor hours on the project. Even a 10% labor erosion in one cost code/task can wipe out the profit margin of an entire project. One of the most important keys to maintaining the gross profit margin is to focus on labor.

Labor productivity is not always just about direct work efficiency. A significant part of each worker's day is spent on indirect operations, material handling and ineffective operations. Through effective preplanning, various indirect operations and ineffective operations can be efficiently organized and streamlined. With proper shop layout and effective use of crew mix, material handling time and cost can be reduced. The time saved in each worker's day can be applied to direct labor activities, thereby increasing labor productivity.

Eliminating waste is a serious concern in the fabrication shop. Time is literally money when it comes to labor hours. Even small savings add up over the course of projects. By saving a few minutes per task, you are saving a few dollars each time. Consider the following labor example.

Journeymen are valuable assets in your company. They are highly trained and as such are well paid. Make sure that you can maximize their work to more effectively use their time. The more they have their heads down working at their stations; the more effectively they are being used.

***Labor Example:***

To help understand how small productivity gains add up in the fabrication shop, consider the following example:

- Cost for journeymen plumbers: $75/hour ($600/day)
- Average time/day spent on material handling: 40%
- Applied labor cost for material handling: $240
- Applied labor savings/day – material handling reduced 20%: $48/man

***If apprentices and helpers are utilized for material handling, costs can be reduced even further.***

Consider what tasks journeymen are asked to perform in the fabrication shop. Are they doing end prep, looking for tools, preparing shipments or waiting on someone else? Reducing or eliminating these indirect operations will make them more productive.

Contractors need to take both a narrow and wide view of the operations.

Sometimes only one step of the fabrication process is analyzed when appraising labor costs, product quality, and delivery time. Consideration needs to be given to the entire cutting and clamping alignment process, including shop layout, material handling, cutting, grinding and alignment before making the joints to maximize cost savings.

**Process efficiency, material handling, and safety are major factors affecting output per hour. Fabricators should ask themselves the following questions when laying out a plumbing fabrication shop:**

- Are pipe storage racks arranged for the best use of material handling time?
- Does material flow smoothly through the shop in one direction from the raw material area to the finished product?
- Is the number of times material is handled minimized? Are bottlenecks prevented?
- Are forklifts, carts, trailers and cranes being used for the most efficient movement of material between processes?
- How are large, permanently mounted saws and pipe cutting equipment used? How much time is required to move material to and from these stationary pieces of equipment?
- Are material buffer zones between processes arranged to accommodate the difference in processing times?
- How much material handling time is needed to remove scrap and unused product?
- Can small, portable cutting systems be used to limit material handling?
- How much bending, squatting or lifting is required when handling materials?
- Is shop scheduling optimized to accommodate improved process times and prevent production bottlenecks?
- Is each workstation organized? Does it include all the proper tools necessary?
- Is the crew mix optimized so that apprentices and helpers are reducing indirect operations of journeymen?

## Material Handling

The easiest productivity gains in the fabrication shop come from reducing the amount of time that materials are handled. Due to the nature of fabrication facilities, up to 45% of a journeymen's day can be spent moving and handling materials. For every step that a worker doesn't have to take, time is being saved. Small changes in distances have a cumulative effect in the long run.

Although you want to reduce the distance traveled, you must avoid bottlenecks. If everyone has to pass through the same area, it slows the whole process down. Use buffer zones so that materials do not bottleneck outside workstations.

Materials should move through the fabrication shop in an orderly pattern with as little overlap or congestion as possible. More of these design concepts are covered in greater detail in Chapters Six and Seven.

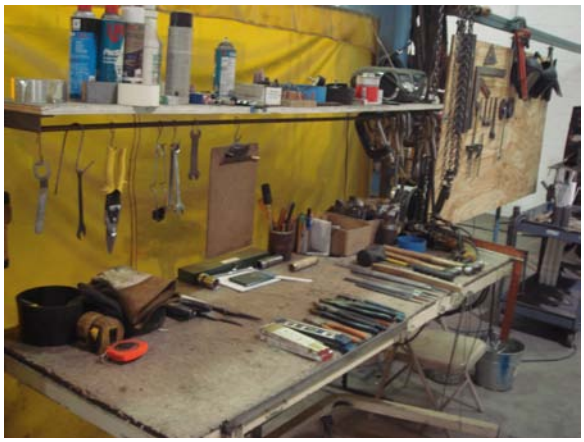
*Moving and handling materials can account for up to 45% of your craft workers' time in a fabrication shop. Photo courtesy of Binsky & Snyder.*

## Equipment

Equipment can sometimes be seen as the silver bullet to increase productivity. Having the right tools accessible is imperative to proper productivity. There are limits though; having an expensive piece of equipment can sometimes never be fully justified.

## Tool Organization

In addition to having the proper equipment, each workstation should have an organized set of tools for *that station only*. Time spent searching for tools is lost time. Keep each workstation stocked with an organized set of working tools and supplies.



*"A place for everything and everything in its place." Tools should be organized and in good condition. Photo courtesy of Dunbar Mechanical.*

## Ergonomics

Another concern in your fabrication shop is ergonomics. You want to make sure that craft workers are working at the proper height **(typically 42 inches off the ground**) as much as possible. The less time spent squatting, reaching, lifting from the ground and working at

odd angles, the more productive your workers will be. Use adjustable height tables in workstations and use wheels to transport as much as possible through the fabrication facility.

Keeping the work at the proper height also reduces the amount of wear and tear on those performing the work. This makes your craft workers more effective and healthier in the long run.

***The elevation of materials is another important consideration. Each time a component is lifted or lowered adds man-hours to the process.***

## Time Analysis

Time analysis in a fabrication shop is much more than just a study of labor functions. Done correctly, it considers the total picture of an operation; estimating, CADD department, management practices, shop layout, material flow, shop functions and purchasing activities are all areas of concern if you want to maximize your shop's efficiency.

## Estimating

The best time to start considering pre-fabrication is during the estimating phase of a project. Wherever there is repetition, plumbing fabrication can benefit you in both time and cost savings.

***Typical project candidates for plumbing fabrication include but are not limited to:***

- Hotels
- Office buildings
- Retail and shopping centers
- Sports complexes
- Hospitals and long-term care facilities
- Prisons

***Typical systems include:***

- Waste, vent and domestic water wall rough-ins
- Precut cast iron underground piping
- Medical gas wall rough-ins
- Finish trim for lavatories and sinks
- Water meter pit piping
- Medical gas
- All types of plumbing modules
- Lead roof flashings
- Floor and wall sleeves
- Wall brackets and stands
- Hanger assemblies

On most projects, it is the estimator that determines what to fabricate. Again, it is important that estimators look at the project from the viewpoint of **"what *can't* we pre-fabricate"** as opposed as to **"what can we pre-fabricate."** It is best if management plays some role in determining what to fabricate.

When possible, the estimator should review the project with upper management, the shop supervisor, project manager, field foreman and others that may offer a different perspective regarding the fabrication opportunities.

***Regarding Modules:***
Plumbing modules are designed and customized with exacting standards according to the type of construction, room configuration and number of units needed. In order to avoid problems prior to production, a prototype module could be built for inspection by other trade contractors. This allows them an opportunity to assure that the module's design and installation are compatible with their needs.

Plumbing system modules are fabricated in the shop rather than the field. This assures not only greater quality control, but also increased speed in the construction process leading to significant savings.

On design assist or design build projects, pre-fabrication/modularization should be considered in the bid phase.

We can assist architects, engineers and customers in developing configurations that best utilize space leading to construction cost savings.

## Profitability

In the end, profitability is the key decision maker in most business actions. As stated throughout this manual, there are many advantages to plumbing shop fabrication. Most of the advantages are reflected in the bottom line as increased profits.

When starting shop fabrication, the jobs have already been bid the traditional way using the tried and true labor factors. Since the new shop goes through a learning curve, the increase in profits could be somewhat reduced. As the fabrication shop becomes more of a manufacturing facility the profits will increase.

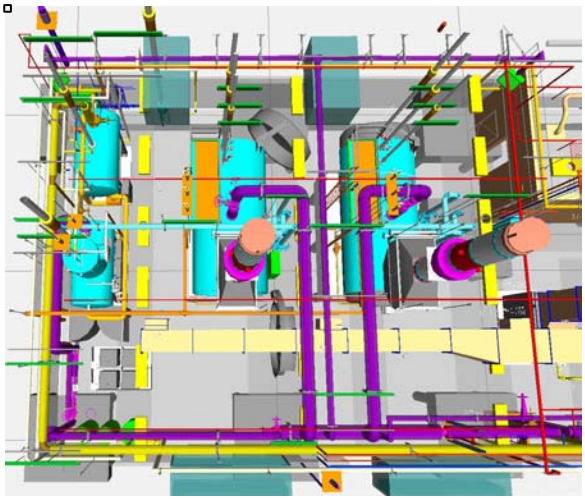
The real advantage comes when you can utilize performance data to adjust your labor rates on future estimates. The more empirical data regarding the shop's performance that can be applied to future estimates, the more competitive and profitable your company will become.

## Scheduling

As contractors continue to improve their knowledge of pre-fabrication, they are seeing the benefits of lower-cost production, increased process and schedule control, improved safety, better use of skilled labor and the ability to adapt new technologies to the construction process. The result of these efforts should show up not only in

the bottom line, but also in better customer service and on-time delivery. What makes plumbing fabrication seem like a new trend is the convergence of new technologies, such as 3-D CAD, BIM, joint technologies and the needs of owners to build more complex building systems with shorter project completion times.



*As electronic drawings become more accurate, more possibilities are open to pre-fabrication.*

The accuracy of the electronic drawings that are provided today allows the contractor to pre-fabricate and store the assemblies, then wait for the delivery request. This means that you can pre-fabricate with your shop crews, fitting the fabrication into your schedule and well ahead of the site schedule. Pre-fabricating the project in this manner allows you to maintain a level work force both in the shop and in the field.

## Productivity Tracking Methods

Nobody knows how productive their operations are until they begin to measure their shop's performance. You won't find problem areas until you start measuring how well you perform each task.

### MCAA *WebLEM*®

Most contractors use the labor units from the MCAA *WebLEM*® to formulate their plumbing estimates. These labor hour units are based on joint type.

**Here is an example:**

| Joint Type | Hours |
|---|---|
| 1" copper 90 ell 95-5 | 0.63 |
| 1" copper 90 silfos | 0.69 |
| 1" copper 90 silver solder | 0.75 |
| 1" copper 90 ProPress | 0.17 |

Even though all the above fittings are 1" copper 90 ells, the labor units vary by **joint** type.

When preparing an estimate, the estimator extracts the information from the *WebLEM* and applies it to the quantities from their "take off." The *WebLEM* is a complete and methodical system of estimating labor to perform a vast variety of mechanical industry operations and tasks. However, it is based on the hours it would take to perform these tasks in the field, not the fabrication shop. Most contractors using this method use the *WebLEM* hours as a starting point and apply a "labor factor"

to each process that is fabricated in their shop, depending on how well they complete each joint type.

For the purpose of estimating and tracking fabrication, using the information based on system type works best *until* you get more sophisticated measuring the results.

A "labor unit," for purposes of the manual, is expressed in terms of man-hours to install a unit of material (such as a foot of pipe) or an individual item (such as a fitting or valve).

In developing the labor units set forth in the manual, MCAA reviewed the many elements that make up installation labor. They are:

- Receiving
- Unloading
- Stockpiling
- Distribution
- Handling and erection
- Fitting and joining
- Pressure testing

Keep in mind that the productivity that is associated with your craftspeople will result in different "actual hours" than the hour units that are in the *WebLEM*. Comparing the actual hours to those in the *WebLEM* will provide you with labor productivity factors or "labor factors" that you would apply to future estimates.

When estimating labor for shop fabrication, one approach would be to use the labor from a "cap." To approximate the labor for one joint in the shop, collect some data from actual shop productivity, and develop your own internal multipliers to use on labor units for shop fabrication.

**Cost Coding Method**

Cost coding is another popular method of tracking productivity in the fabrication facility. In this method, the project is broken down in sections and estimates are made for the number of hours it would take to perform each section.

As the project continues, project managers update the amount of time spent and forecasted on each section. This information can be tracked and used to estimate processes in the future, find weak spots in processes or see who is best suited to certain tasks. The estimate for the project should be broken down to facilitate tracking the job costs and productivity. Most plumbing contractors break down the estimate based upon tasks, systems, unit quantities, or joint type. There is normally a computer cost code that is assigned to each item breakdown.

## Sample Computer-Generated Report

| Cost Code | Description | Hour Budgeted | Hours Incurred | Hours Forecasted | % Comp | Earned Hours | Prod. Factor |
|---|---|---|---|---|---|---|---|
| 2110 | 2" and down DOMESTIC WATER BELOW GRADE | 96.00 | 104.50 | 104.50 | 100% | 96.00 | 0.919 |
| 2115 | 2" and down DOMESTIC WATER ABOVE GRADE | 262.00 | 256.00 | 256.00 | 100% | 262.00 | 1.023 |
| 2120 | SANITARY WASTE & VENT BELOW GR | 310.00 | 288.00 | 288.00 | 100% | 310.00 | 1.076 |
| 2125 | SANITARY WASTE & VENT ABOVE GR | 284.00 | 298.00 | 298.00 | 100% | 284.00 | .953 |
| 2130 | STORM DRAIN BELOW GRADE | 34.00 | 28.00 | 28.00 | 100% | 28.00 | 1.124 |
| 2610 | PLUMBING FIXTURES | 449.00 | 24.00 | 250.00 | 9.6% | 43.10 | 1.796 |
| 2640 | APPLIANCE INSTALL | 52.00 | 3.00 | 32.00 | 9.4% | 4.88 | 1.625 |
| H2110 | SHOP DOMESTIC WATER BELOW GRADE | 36.00 | 34.00 | 34.00 | 100% | 36.00 | 1.059 |
| H2115 | SHOP DOMESTIC WATER ABOVE GRADE | 80.00 | 71.00 | 71.00 | 100% | 80.00 | 1.127 |
| H2610 | SHOP PLUMBING FIXTURE ASSEMBLY | 120.00 | 115.00 | 135.00 | 85.1% | 102.12 | .889 |

A typical labor report could show the following:

- **Cost Code** – The computer number assigned to track hours and costs.
- **Description –** Describing the task that is being performed. It should include size and joint types if applicable.
- **Hours Budgeted –** The hours, taken from the estimate, initially anticipated to complete each task.
- **Hours Incurred –** The actual hours expended per task/cost code through the pay period.
- **Forecasted Hours –** The hours that the Project Manager forecasts will be expended when that particular task/cost code is 100% complete.
- **Percent Completed –** The Foreman and the Project Manager determine the estimated percent complete. It is based on knowledge of the day-to-day operations and overall flow of the project.
- **Hours Earned –** Budgeted hours (estimated hours) multiplied by the percent complete of that particular cost code/task. The purpose is to gauge how actual hours compared to budgeted hours.
- **Productivity Factor –** Hours Earned divided by Hours Incurred (Actual). This is where you can determine how effective you were at performing each task.

Notice the sample labor report is broken down by system as opposed to type/number of joints. If you are going to break down the estimate by system you should go one step further and break the system down by large bore and small bore. In general, the large bore will be a different material/joint type than small bore allowing the contractor to get feedback by joint type. Comparing two values, earned hours/actual hours, derives productivity calculations.

Looking at cost code 2120 you can see that that task is complete. The forecasted hours and the hours to date are identical. The estimate had the cost code budgeted at 310 hours. Since that cost code/task is complete, the earned hours = 100% * 310 hours = 310 hours. The actual hours expended is 288.

**Productivity factor** = 310 earned hours/288 actual hours or 1.076. Meaning that we beat the estimate for that task by 7.6%.

Compare that result with cost code 2125 where the earned value = 284 hours and the actual hours expended is 298.

Productivity factor = 284 earned hours/298 actual hours or .95, meaning that we exceeded the budget by about 5%.

By doing these calculations you will see productivity trends providing data to support modifying the way in which you estimate projects.

Notice in the "Sample Computer-Generated Report" that there were cost codes for the shop work. They are delineated by the cost code having the prefix H in the cost code field.

*It is important to separate the field hours from the shop hours*. Track both hours separately to accurately gauge productivity. Make sure you are providing the production reports for your fabrication activity to the shop supervisor.

How can you see where you are going if you cannot see where you have been? Even a simple report is better than no report at all. The shop supervisor can write down the item worked on and check off what was done to it. With that, management can see what was done and not done and what is ready for the next step in the process.

The production report gives you a way to check your shop's efficiency. It also gives you a starting point for estimating your shop's production capacity. The project manager can use the report to see how long it took to fabricate an item and then compare that to the budget.

Tracking productivity as shown above is probably the easiest and most cost effective method. There are other methods where you could track the

labor output by tracking by individual joints, inches, pounds, material, or drawings completed. These types of reports may be much more accurate but highly costly.

If you are spending too much time trying to find out all the small problems, it may not be worth the cost of the feedback. That being said, minutes add up. If you can identify small problems that will consistently affect productivity, it could save a lot of time over the course of the year.

The field should also be following the procedures above to track their productivity. By tracking the shop and the field production separately, the results of the overall impact of shop fabrication will be more evident.

It is important to stress that tying together the estimators' and the project manager's approach to the project is extremely important while setting up the cost codes/tasks for reporting and tracking. This is best done while going through the formal process of preparing for the "turn over meeting" (see MCAA's *Project Manager's Manual* for more information).

During the turn over process, Estimators, Project Managers, Field Foremen and the Operations Support Manager meet to review the estimate and get buy-in from all parties as to the role fabrication will play in the project's success.

## Evaluating Tools and Equipment

You are having an apprentice clean and end prep copper four (4) hours every day. But, what if he could do the same amount of work in half the time using a powered "end prep" machine? This information can help to determine the return on investment (ROI) for buying this piece of equipment.

Buying good used equipment for an attractive price may be the way to go. In some cases, the tool you would like to use is no longer manufactured.

Craftspeople and the machines have to work well together for maximum productivity. If productivity isn't where it should be, one of those two factors is usually the cause.

## Material

When evaluating plumbing systems, the estimator/project manager often has the option to choose from many different types of material for a particular system. For example, the specifications for 1" domestic potable water may allow you to use sweat copper or ProPress copper. In this situation, you have to evaluate the purchase price of the fitting and the labor required to make the joint for each type of fitting to determine the most profitable method. It may be that you would go one way in the shop and the other way in the field or a combination of the two based upon field conditions.

## Chapter Five - Tools

Tools are one of the biggest advantages of shop fabrication. A specialized shop facility allows you to use tools suited for the manufacturing process that can boost productivity and increase quality. Many of these tools would be impractical for the jobsite because of their size, lack of portability, cost or maintenance.

In this chapter, we will cover more than just the physical tools.

***When speaking about tools, this chapter covers:***

- Specialty tools
- Maintenance
- Ergonomics
- Specialty jigs

## Specialty Tools

This chapter addresses some of the tooling that may be used in the shop. Your shop may or may not have these types of tools. You don't necessarily need to have a full complement of expensive specialty tools to begin fabrication. Even using well-maintained tools similar to those used on the jobsite will be beneficial. As you get more involved with different aspects of pre-fabrication, some of the specialty tools from this chapter can significantly increase your productivity.

## Maintenance

The condition, quality and maintenance of shop tools are usually major improvements over those experienced in the field. Tooling is easily maintained in the shop. As soon as a piece of equipment malfunctions, it can be taken out of service and repaired. While it is out of service, another piece of equipment can be used as a substitute. Doing this will enable production to continue, even if the productivity of the replacement tool does not equal that of the broken tool.

## Ergonomics

Ergonomics can be used to increase productivity in the pre-fabrication facility. Proper tools, equipment, and jigs can make most of the operations ergonomically compatible.

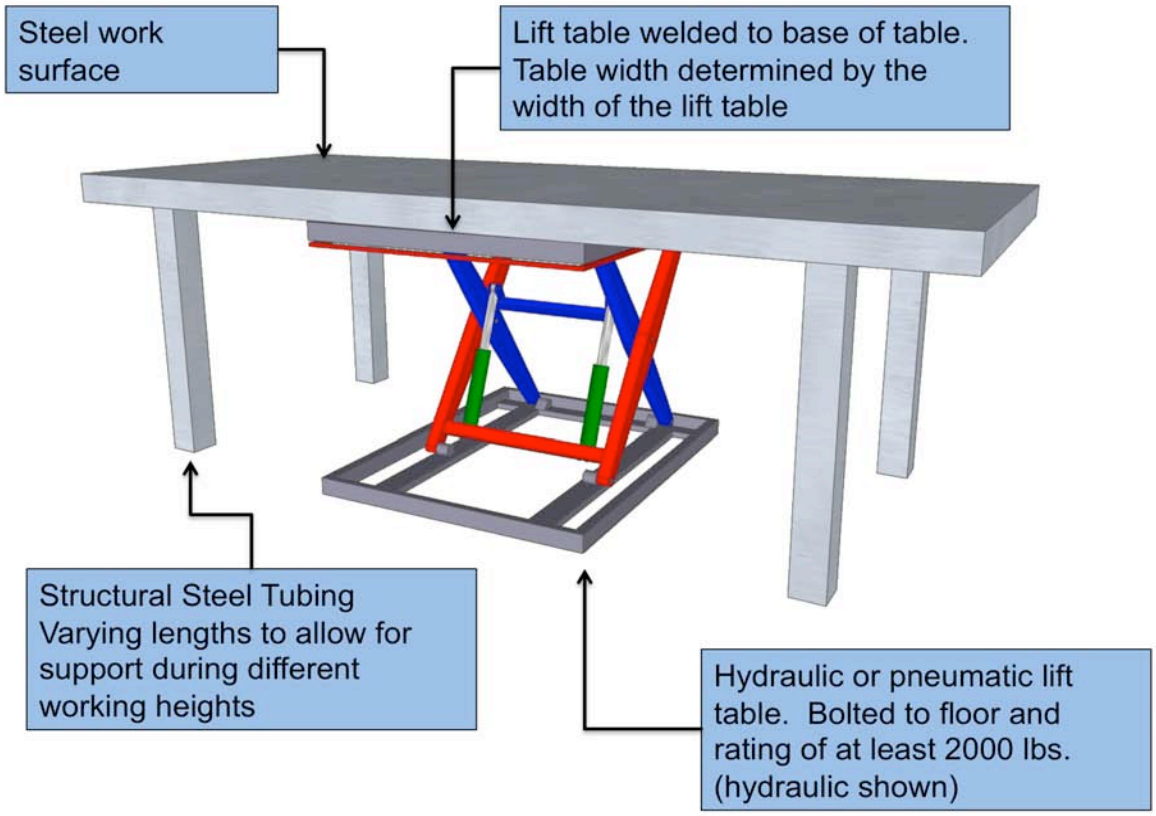
The keys to ergonomics are working height and position. On average, the proper working height is around 42" off the ground. Since your craftsworkers will be of varying sizes and perform work at different heights, their workstations need to be adjustable.

***Forty-two inches:***
The average working height is 42". By keeping as many tables and devices that transport assemblies and materials at 42", you increase productivity and reduce back strain.

*An adjustable height table allows you to perform work at a comfortable height. Photos courtesy of the P1 Group.*

This can be accomplished by incorporating a hydraulic or pneumatic lift under a worktable so that the working height can be raised and lowered as needed.

Unfortunately, you cannot just go to your supplier to buy the lift; you will need to build it yourself. When constructing the lift, be sure to purchase either a hydraulic or pneumatic lift device rated for at least 2,000 lbs. A pneumatic air bag system, as shown in the photos to the left, involves an air bag and no hydraulic fluid. Also be sure to build in structural steel supports as reinforcements. Most shops have "leg" sections in different lengths that support the weight once the table is lifted to the appropriate height.



## Specialty Jigs

Jigs and stands hold the material in a comfortable position and height for work, thus giving productivity an additional boost. They also allow a variety of repetitious work to be performed quickly by having angles already calculated, lengths already determined and pipe held in place. Depending on the complexity of the task, it can be advantageous to set up a jig table for even two or three pieces.

Fixed and rotating jigs hold pipe and fittings while making joints, eliminating the need to physically handle the assembly while trying to make the joints.

*A jig allows many similar pipe configurations to be assembled in less time.*

## Workflow

Fabrication shops differ in size, shape, layout, tools and equipment. Regardless of what's in the shop, workflow is one of the most important factors affecting productivity. Bottlenecks will slow down the process in all stations.

These bottlenecks can be eliminated with the proper tooling.

As stated previously, improvements in material handling can help reduce costs and increase profits.

Material handling starts when the truck delivers material to the shop. Whether your process involves unloading the material by hand, using a forklift or using an overhead crane, what is important is what you do with the material to minimize the cost of handling.

Piping should be stored in wheeled racks and fittings should be in bins that are readily accessible and movable.

*Piping stored on moveable racks.*

## Workstations

Most workstations are built by the type of material used. This allows for specialty tools to be located in a designated area so that manpower does not overlap in the pre-fabrication shop.

***For most piping fabrication processes, the steps are similar to this:***

- Move pipe to the cut station
- Measure the pipe
- Cut the pipe
- Prepare the end for fitting
- Prep the fittings
- Make the joint
- Assemble the pieces

**Copper**

Raw lengths of copper piping are best handled when stored on mobile storage racks. The racks allow piping to be easily moved to the cut station.

Once the piping has been located near

*Mobile pipe storage racks allow pipe to be moved with ease.*

the cut station, the lengths of pipe are then placed on the cut table or conveyor.

*Simple chop saw set up with jacks for cutting copper pipe.*

Pictured above is an inexpensive set up showing the chop saw using jack stands for the feed.


*Larger chop saw with conveyer and fixed ruler measure.*

The saw shown above has a measuring tool attached to the feed table. This eliminates the need to use a rule/tape to measure and mark the pipe.

The cut pieces and fittings then move to the end prep stations.


*New style copper end-prep machine.*

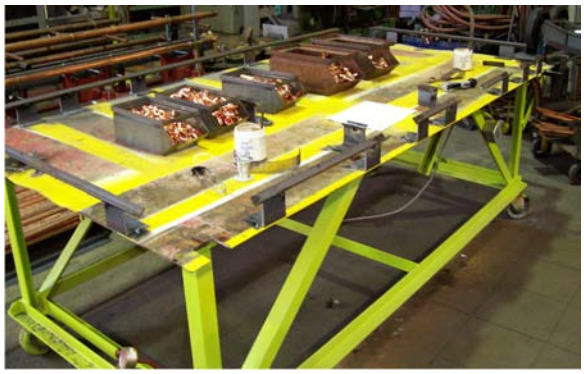
*Older style copper end prep machine. Photo courtesy of Dunbar Mechanical.*

When the copper end preparation is completed for the pipe and fittings, the material moves to the fit up station. Here, tables and jigs are used to hold the pipe and fittings while the joints are made.

*Jig built for copper fabrication. Photo courtesy of Dunbar Mechanical.*

***Do you have a shelf under your worktable?***
*More often than not, this is a place where junk goes to die. Clean it off and put the table on wheels so that it can be moved out of the way when not in use.*

*A jig frame used to fabricate copper DWV.*



*Fit up table for copper pre-fabrication.*

The photos above illustrate a jig and a fit up table for copper assembly. The wheels on the fit up table make it easy to move the table out of the way when it is not being used. The table design is simple—there are no shelves to collect junk or add weight to the table, which would make it more difficult to move.

The fabricated copper then moves to the next station for final assembly before shipment.

*Final assembly of copper pipe and fittings.*

Here, the fabricated pieces are mounted on assemblies and tested before being completed and shipped to the jobsite.

Soldering and brazing are familiar methods of joining copper. The newer ProPress offers another option and can be used for both copper and stainless steel applications.


*A typical ProPress tee.*


*A ProPress tool can really speed up fittings.*

A ProPress tool is an efficient way to speed up fittings. It can be used on sizes through 4”. Both battery and corded power tools are available.

*Pre-fabrication shop ingenuity. This contractor mounted a ProPress tool for two-handed control.*

The photo above shows how one contractor exercised ingenuity to make it easier to use the ProPress tool. After mounting the ProPress tool, the contractor zip tied the trigger so that it was continually on. The contractor also added a foot pedal actuator (not shown) that allows the plumber to control the on/off switch with his foot while both hands control the work. This example demonstrates that tools typically used in the field can also be used in the shop.

Another tool used on copper installations is the Tee Drill. When considering this tool, keep in mind that there may be some code restrictions regarding the use of the “Tee Pulling.”


*Handheld tee pulling drill. Photo courtesy of T-Drill*

If the code allows it, you can use a hand held tee puller to perform the operation on a manifold or section of pipe.

There is not currently a manufactured tee pulling station that would allow you perform these actions more accurately. Some contractors have built sophisticated tee pulling production machines like the one shown below.

In this machine, the pipe sits in the fixture and the tee drill slides back and forth while staying at the top dead center of the pipe. This allows for greater control and accuracy when drilling the pilot hole as well as extracting the collar.

**PVC**

Very few tools are needed to fabricate PVC and PEX pipe and fittings, and those tools do not require a tremendous investment. The tools can have an immediate impact on productivity.

There are two very important fabrication processes that make the pre-fabrication of PVC pipe and fittings advantageous.

The first is the method used to cut the pipe. Pipe and fittings need to be close at hand and at a normal working height.

The PVC pipe is fed to the cut line.

After the pipe is cut, it moves to the fabrication table. The table is set up with jigs that hold the pipe and fittings in position for gluing. These jigs are adjustable so the “pitch” of the drain lines is at the correct angle. By having the pitch built into the horizontal piping on the fabrication table, all the fittings can be installed at the appropriate angle and easily plumbed for the vertical rises. In the field, PVC pipe is often cut using handsaws and the pipe and fittings are installed in position under jobsite

conditions. In the fabrication shop, we have conveyors, power saws, and fit up tables, and the testing equipment is readily available.

**PEX**

There are no PEX pre-fabrication specialty tools that can be used in the shop. The tools are identical to what would be used in the field.

*A PEX crimping tool with a gauge.*

*PEX tubing cutter.*

*Pneumatic crimper.*

The last photo shows a pneumatic crimp tool that can be used to automate PEX plumbing installations. This tool includes attachments that enable it to be bench mounted for shop fabrication.

**Plastic Fusion Process**

Plastic butt fusion welding equipment like that shown here is available from many different manufacturers. This type of joint requires few other tools.

*Bench mounted plastic fusion for socket fittings.*

When choosing a machine, it is important to determine what size and type of machine will best fit your shop's needs. Both handheld and bench mounted options are available. This process does not require any other unique tools.

### Cast Iron No Hub

Shop fabrication of cast iron no hub pipe and fittings is an area that has really grown in the plumbing industry. It is very "user friendly" with the advent of CADD and BIM. The first step is to feed the no hub pipe to the cut station.

With cast iron you have a couple of options in the fabrication shop. You can use field tools at first, like the hand snapper, but two other fabrication shop alternatives can save a lot of time.

### Abrasive Cast Iron Cutting Station

There are both advantages and disadvantages to cutting cast iron pipe with an abrasive cut off saws. These saws are inexpensive and the cut time is relatively fast. However the consumables are expensive and making the cut is very dirty.

*A cast iron abrasive cutting station.*

### *Hydraulic Pipe Cutter*

The cast iron hydraulic cut station is an alternative solution. This tool can be complemented with roller conveyors on the front and back ends to facilitate fast pipe movement, measurement, cutting and off-loading.

*Hydraulic pipe cutters can snap pipe 1 1/2" to 6" in seconds. Photo courtesy of CFI Mechanical.*

A hydraulic cast iron no hub cut station is very well suited for shop work. It is a clean process and has little expendable cost. The initial investment is a little greater but the ROI is attractive.

From the cut station, the material moves to the assembly area. When there is a need for multiple similar assemblies, a jig is typically made for each assembly.

The jig will enable your workers to assemble many similar pipe configurations in less time.

The material that will be used to make plumbing batteries would be assembled on to the fabrication table.


*Electric cordless no-hub coupling driver.*

The impact driver shown above greatly increases productivity over the hand torque wrench that is used when assembling no hub pipe in the field. Plan to have this tool at every station.
After the batteries and piping are fabricated, moving them around the shop and the jobsite requires special equipment.

*Material handling can be as simple as using dollies*

*Carts can be used, depending on the complexity*

*Temporary frames with wheels can be constructed*

The use of “crazy dollies,” carts and temporary frames will be very helpful. As illustrated above, the wheels used to handle the battery can be removed when the unit is in place and sent back to the shop for reuse. Most of the structural supports used for fabrication remains and is consumed in the installation.

## Hangers

Most contractors can improve their productivity by fabricating hangers in the shop. Each hanger fits a specific design or configuration and needs to be dimensioned and built. Normally the hangers are measured onsite. A sketch may be developed for the hangers and then the hangers are constructed.

Building hangers in the shop can provide a productivity advantage because the tools available in the shop for cutting structural shapes and rods are not available onsite. The dimensions are determined either in the field or in the CADD department, and then sent to the shop for the hanger fabrication.

*Finished hanger assemblies on a skid, ready for shipment.*

## Structural Cut Station

Most structural cut stations have two structural shapes cut lines. One typically uses a band saw while the other utilizes an "ironworker" machine. The ironworker is able to cut angles, channels, flat bar and punch holes very quickly. To optimize material handling, both lines should have conveyors for inbound and outbound material. Keeping these rolling conveyers at the proper working height adds to the productivity increases. This method works very well and is inexpensive to set up.

*Simple cut station for hanger rod. Photo courtesy of Pan acific Plumbing & Mechanical.*

Examples of a simple cut station for rods and structural shapes (above) and a sample dimension sheet for hangers (below) are shown.

**Sample Copper Hanger Cut Sheet**

| Tag # | Qty | Rod Size | Rod Length | Hanger Size | Hanger Type |
|---|---|---|---|---|---|
| L4CW1 | 2 | 3/8" | 5'-1" | 1.5" | Erico/Loop #101 |
| L4CW2 | 1 | 3/8" | 5'-2" | 1/2" | Erico/Loop #101 |
| L4CW3 | 1 | 3/8" | 5'-3" | 1/2" | Erico/Loop #101 |
| L4CW4 | 3 | 3/8" | 5'-2" | 3/4" | Erico/Loop #101 |
| L4CW5 | 1 | 1/2" | 3'-6" | 3/4" | Erico/Loop #101 |
| L4CW6 | 2 | 3/8" | 3'-4" | 3/4" | Erico/Loop #101 |
| L4CW7 | 4 | 3/8" | 3'-7" | 3/4" | Erico/Loop #101 |
| L4CG1 | 1 | 3/8" | 5'-2" | 1/2" | Erico/Loop #101 |
| L4CG2 | 3 | 3/8" | 4'-6" | 3/4" | Erico/Loop #101 |
| L4CG3 | 1 | 1/2" | 5'-3" | 3/4" | Erico/Loop #101 |
| L4CG4 | 1 | 3/8" | 2'-11" | 3/4" | Erico/Loop #101 |
| L4CR1 | 2 | 3/8" | 3'-2" | 1/2" | Erico/Loop #101 |
| L4CR2 | 2 | 3/8" | 3'-6" | 3/4" | Erico/Loop #101 |
| L4CR3 | 1 | 1/2" | 3'-10" | 3/4" | Erico/Loop #101 |
| L4CR4 | 2 | 3/8" | 4'-2" | 1/2" | Erico/Loop #101 |
| L4CR5 | 1 | 1/2" | 4'-6" | 3/4" | Erico/Loop #101 |
| | | | | | |

## Carrying Racks and Fixture Jigs

Trimming out all fixtures at the shop provides another way to gain a competitive advantage. Examples of some of the tools and jigs used to trim out fixtures are shown below.

*This fit out jig can be rotated to attach trim pieces to both the top and bottom of the sink.*

These jigs can be made from almost any material; all it takes is a little ingenuity.

*Plywood jig built to handle a double sink. Photo courtesy of CFI Mechanical.*

A jig can be built for almost any fixture using plywood as shown above.

Once fixtures are trimmed out, additional productivity gains can be realized both in the fabrication shop and onsite by building carrying racks. These racks can be built with wheels that allow you to store and move completed pieces around the fabrication shop.

*Wheeled racks of pre-assembled lavatory faucets.*

When they are ready for delivery to the jobsite, these racks can be loaded and immobilized on a truck. At that point, they can be lifted to the proper floor either with built-in eyehooks for cranes or with elevators. Your onsite teams can then wheel the racks down hallways as completed sinks are dropped into place.

*Racks of fixtures loaded ready to ship.*

This procedure can be used for all types of fixtures, urinals, sinks, lavatory sinks, water closets, etc.

*Bins work well to organize, store and transport materials. Photo courtesy of CFI Mechanical.*

Bins, crates, racks, and rollers all work well to organize, move and store materials in a fabrication shop. Bins are shown above. The bins can be easily moved using a forklift or pallet jack.

The fabrication/manufacturing principles also work well for medical gas materials and equipment.

**Heavy Tools**

The majority of the work in a plumbing fabrication shop is not very heavy. One or two men can lift most completed work. If you have large plumbing batteries or modular assemblies, you made need heavy hoisting equipment such as an overhead crane, forklift, "davit"/jib crane/boom or a small cherry picker.

*A jib crane is bolted to the floor for added lifting strength.*

Place the jib crane where most of the heavy work will be completed. It is important to fasten the crane to the floor so it is not moveable.

Some facilities have overhead cranes, which also work well for the heavy lifts in the shop. Be aware, however, that hoisting with overhead cranes is a slow and costly process. If crews are not educated about when it is appropriate to use an overhead crane, productivity may suffer.

Forklifts are fast, safe, and can hoist most of the items in a plumbing fabrication shop. Be sure to include forklift safety training for your employees so that they learn how to unload and load trucks with forklifts and move materials quickly, safely and correctly.

## Chapter Six - Processes

This chapter explains fabrication processes, including design flow, material flow, fabrication/assembly and information flow. All of these things contribute to determine how everything moves throughout your organization, which will determine how efficient and profitable you will be.

### Design Flow

What follows is a step-by-step summary of the typical design flow process. For more information, see the Design Flow Process diagram at the end of this section.

1. ***Drawings Received –*** The contractor receives the drawings from the owner or GC as part of the bid package. The drawings are sent to the estimator or project manager for design review.

2. ***Design Review –*** The drawings and specifications received from the architect/engineer/construction manager/owner are reviewed and clarifications are made regarding the design and the products specified. At that time, some assumptions are made about what can and should be fabricated. The estimator also may offer suggestions to the architect, engineer, construction manager or owner regarding the possibility of pre-fabricating some of the systems. This could reduce the construction cost, especially if you are involved with the group at the conceptual level or on a design/build project.

3. ***Take-off –*** The estimator then completes the take-off and prices the material, or sends the material takeoff to the purchasing department for pricing. The estimator then applies the various labor factors to the take-off for both the shop and field portions of the work. These factors are a result of applying empirical data regarding your company's productivity.

4. ***Pre-Bid Review –*** The final labor factors are usually determined as a result of communication among the group that puts the final "number" together. The group may be comprised of the estimator, project manager, shop supervisor and upper management.

5. ***Bid –*** Once the bid has been finalized, it is submitted to the owner or general contractor. If your company is awarded the bid, the "turnover process" begins.

6. ***Turnover Meeting –*** The estimator and project manager begin by meeting to thoroughly review the scope of work, the estimate, all addendums, schedule and any other information related to the execution of the job. They gather all information as indicated in the MCAA turnover meeting agenda. And, they meet with the shop supervisor and operations manager to develop a pre-fabrication plan.

7. ***Pre-fabrication Plan Review –*** During this stage of the review, the team looks at the design and determines what can be fabricated and what cannot. The resulting plan, including any assumptions made regarding fabrication at bid time, is then presented to the construction team during the turnover meeting.

8. ***CAD/BIM Review –*** The CAD/BIM department may be involved if the project requires coordination/ modeling drawings or fabrication spool drawings. The CAD operator can create complete system of individual line drawings using the electronic engineering drawings and submittal drawings provided by the customer, engineer, or supplier. These drawings may have been provided as part of the bid documents or "for construction" drawings.

9. ***Field Verifications –*** Measurements for CAD drawings developed using engineering or submittal drawings may need to be field verified. This step helps resolve discrepancies between the engineers, drawings and actual field conditions. A CAD operator, field foreman, or journeyman/apprentice can do the field verification. The field verification procedure may not be required if the drawings provided are detailed isometric or electronic drawings.

10. ***Deliverables Log –*** The CAD or BIM operator will generate a deliverables log. This log will include a list of all spool sheets needed for fabrication and the bill of materials with the dates they are needed.

11. ***Spool Sheets*** – Spool sheets are the core document in the fabrication process. They are the "carrier" or router for the fabrication process, providing a visual orientation on how the components fit together. The drawings also provide the fabrication shop with the key information needed to build the spool piece and include an area in which to document the QC checkpoints.

    A bill of materials is paired with the spool sheet. It is sent to purchasing, and is developed using the spool.

    Once created, the CAD operator reviews the spool and checks it for material type, orientation etc.

***A spool sheet should include:***

1. Spool number
2. Job name/number
3. Cost code
4. Due Date (communicated to fabrication and shipping for QC checks)
5. System type
6. Material type/quantity
7. Cut lengths
8. Specifications for material processing
9. Additional information as needed (i.e., a spool information sheet)

12. ***Purchasing*** – Most CAD spooling software shows the material required on each drawing. The software also collates and summarizes the material required for the entire job. The project manager can use this information to generate the requisitions that will be provided to the purchasing department so they can get updated pricing.

    Purchasing then checks the availability, pricing, and shipping information and places the orders. As stated previously, it is important that the material be delivered on time and without backorders. Backorders impact the fabrication process in a negative way.

13. ***Fabrication Work Schedule*** – The shop foreman, who was part of the team that decided what would be fabricated, now works with the site or home office schedulers to create the fabrication work schedule.
    He also works with the operations manager to determine the availability of manpower and the requirements for storage of fabricated assemblies and shipping to the site. The shop supervisor will also work very closely with the field foreman.

    The shop foreman reviews the spool sheets before fabrication begins and makes any additional comments on the spool sheets that may make it easier for the shop crews to do their job. He will use this review to help plan manpower, processing and workload requirements. He will sequence the fabrication of spool sheets to accommodate the required delivery dates, material on hand and workload. As each spool is started, the material and fittings are pulled from the staging area and brought to the fabrication area. *From this point forward, the spool sheets and the bill of materials should travel with the assembly until the final installation.*

14. ***Field Installation*** – When the field foreman receives the fabricated pieces, he should also receive the spool sheet and the bill of materials for any connections or pieces that need to be installed in the field.

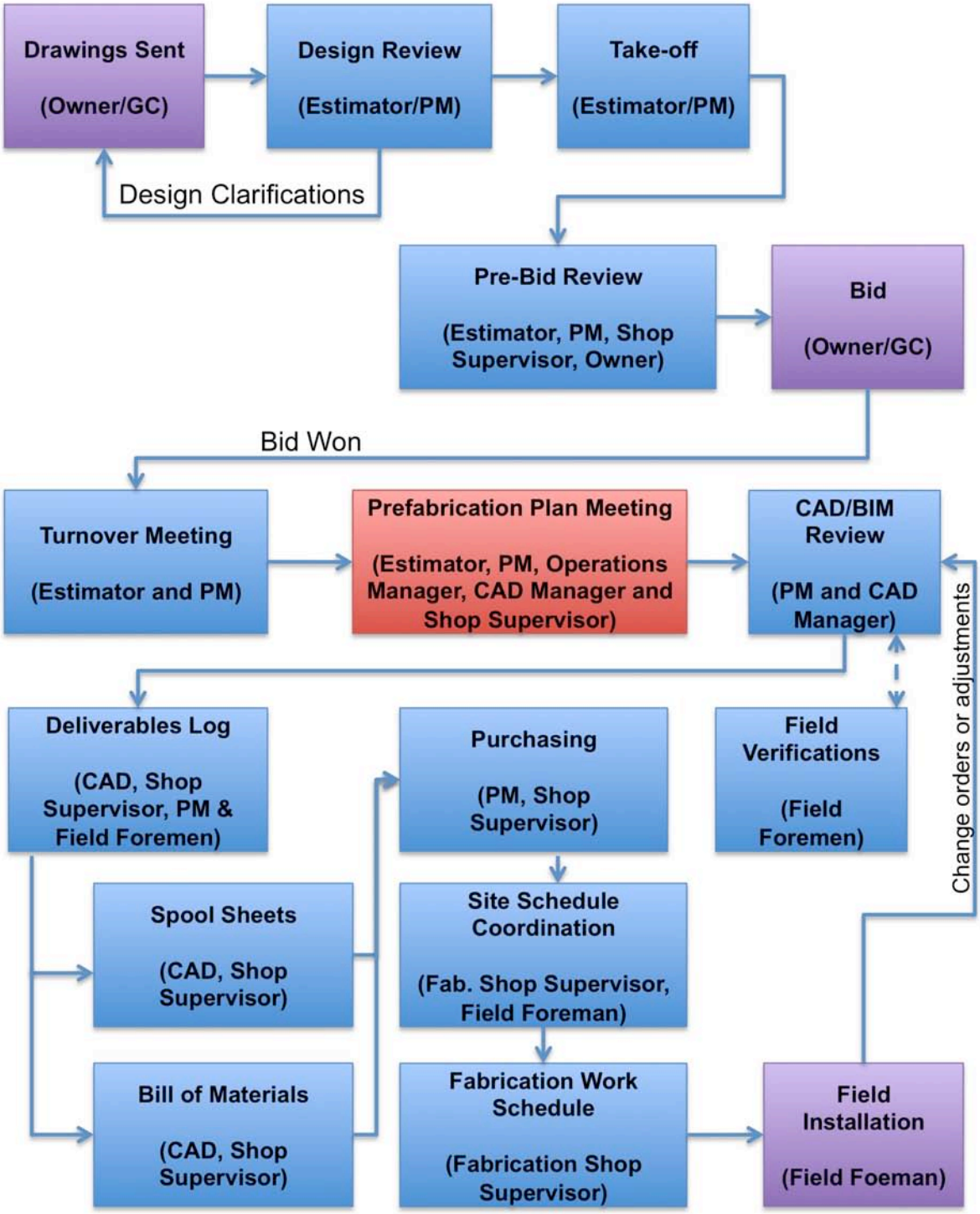
    The foreman must work with the site schedulers and transmit the information to the shop so the fabricated pieces will be delivered to the site for on time installation. It is very important that the foreman notify the shop regarding any changes or change orders that originate in the field.

    If any changes need to be made or a change order must be performed, the field foreman will need to get in touch with the shop foreman and the CAD manager to determine the appropriate course of action. It might require additional design, different materials or re-working of fabrication pieces.

    Management of RFIs is another function that the field foreman/project manager must control. The coordination between the shop, field, and the engineer/owner regarding the RFI status is an important function that will slow down construction if it is not maintained.

## Design Flow Process



## Material Flow

The material flow process begins when the project is awarded and ends with the final installation onsite. The biggest considerations concerning material flow are space, availability and timing.

Most contractors will be limited by the amount of space they have in their materials storage area, their fabrication facility, the trucks transporting the materials to the jobsite and the jobsite itself. In a perfect world, we would have space available at any location at any time, but that is never the case.

Timing needs to be considered when it comes to material flow because projects are going to overlap. If you are storing materials for multiple projects in the same area, they need to be clearly marked and accessible. When you are working on multiple projects in the fabrication facility, identification of those pieces needs to accompany the work.

Material availability has been mentioned multiple times throughout this guide. When it comes to the material flow, the unavailability of one piece can stall the entire process. It is vital to have all the parts for each pre-fabrication piece and have them separated from other projects and assemblies.

1. ***Material Procurement –*** Once a project has been awarded and it has been determined that there will be shop fabrication, the material must be procured. This process may involve the estimator, project manager and/or shop supervisor meeting with the purchasing department to discuss the details of the order.

2. ***Materials Receipt –*** Once the material has been ordered, a system should be in place to receive and organize the inbound materials. These materials should be staged/sorted in a location by job number.

   All materials received must be inventoried for accuracy, and back orders should be noted and researched to determine the revised delivery date.

*Material should be sorted and organized by each job.*

***Logging Materials:***

A log sheet should be located at each material staging area (typically organized by job number). The log sheet is used to make note of any material that is taken from one job and used on another. As backorders are received, the material taken from the prior job can be replaced from the latter.

Along with the pipe, valves, fittings and hangers, the shop will be receiving equipment like pumps, tanks and fixtures. These items also need to be staged in the assembly area.

3. ***Verify Consumables –*** Consumable and expendable materials need to be verified to ensure that you have all of the auxiliary supplies for the project being worked on. Nothing kills budgets more than having all the materials ready and not enough consumables.

**Storing vs. Staging**
There is a difference between *storing* material and *staging* the material. Material that is received but will not be used for quite some time is *stored*. These materials should be located separately from the fabrication facility.

Material should not be *staged* in the fabrication shop near the assembly until it is already in the fabrication schedule and will be used soon.

## Fabrication/Assembly

4. ***Pipe Cutting –*** The piping that will become part of the fabrication needs to be cut to length for each part of the assembly. The materials need to be taken from the staging area to the cut station.
   In a plumbing fabrication shop, the cut station will depend on the material type. Additionally, some assemblies require multiple material types.

5. ***End Prep –*** These cut lengths are then sent to the end prep station. End preparation will depend on the type of materials being used. Locate the end prep stations close to the pipe cutting stations so that they feed into one another like an assembly line. This will reduce handling time.

6. ***Pipe Joining –*** Next, the cut pieces of pipe move from the end prep station to the area where the components will be joined to the pipe.

   By this time, the fittings/valves, etc. will have been pulled from the staging area and been located at the fit up area.

   You can have apprentices prepare materials for the journeymen to fit up and make the joints. Keep the journeymen as productive as possible.

Sometimes multitasking is necessary. Make sure that those manufacturing the assemblies are working making the joints. This is accomplished by having all the parts, pieces and tooling readily available for the journeyman at all times.

Multiple trips looking for tools or materials must be eliminated. Remember that **waiting = wasting**.

Drawings that are associated with the fabrication *must* travel with the piping throughout the entire process.

*Plumbing battery fabrication table.*

At the assembly table, the tools, materials, information (drawing) and equipment must be readily available to maximize productivity.

***The Right Person for the Job***

It is important to have the right people staging, and prepping. No need to have a journeyman prepping the copper pipe.

*Copper fabrication table showing quick clamps.*

The copper table should include a method to quickly clamp the pipe and fittings to facilitate making the joints. In the photo above, the contractor is using quick clamps to hold the pipe before the joint is made. In more complex fit up tables, the clamps can be repositioned easily and adjusted for slope when needed.

7. ***QA/QC –*** Before any piece leaves the shop, inspect all assemblies to verify that all components are manufactured, installed correctly, in the correct configuration and ready for shipment. A shop is most efficient when it isn't fixing its own mistakes that are discovered in the field. During the entire fabrication assembly process **the craftsperson who is going to perform the next task should be the *de facto* QA/QC inspector for the prior task.**

   All testing must be completed, including hydro testing, X-rays, medical gas purity/cleanliness and other NDE (non destructive examination).

8. ***Finishing –*** When testing is complete, painting and/or insulation is completed prior to shipment. With the high theft rate of copper on jobsites, some companies paint all their copper black to deter thieves from identifying it quickly.

*Fabrication staged in the shop prior to shipping.*

9. ***Shipment Preparation –*** Preparation for shipment includes capping and protecting all open ends. The assemblies should be protected from damage and theft. There is no point wasting man-hours being productive in the shop just to have the assemblies subsequently ruined.

   Have all components like screws, washers, bolts, gaskets and loose valves attached to the assemblies. All the drawings for the fabrication should also be attached.

   When the fabrication is placed on racks and secured, it should be labeled indicating the final destination and the location where it will be installed in the building.

10. ***Site Communication –*** Communicate with the field to make final arrangements for the delivery. This will include weight, delivery time, installation schedule and site constraints.

    The field foreman will review the schedule to let you know which pieces they need to install first and the shipment should be staged accordingly. The pieces that are need first should be loaded last. That way, when the shipment arrives onsite, those will be the first pieces unloaded.

    Make sure that there's communication with the field concerning site restraints and physical limitations like door openings, elevator capacities and whether the racks can be flown in place.

    In some cases the racked material will need to be hoisted by crane at the site to get it to the proper floor. In such instances, the shop should prepare the racks for such lifts.


*Copper racked and ready for shipment.*

The coordination between the shop and the field regarding shipments is very important, since the jobsite has to be prepared to receive the fabrication.

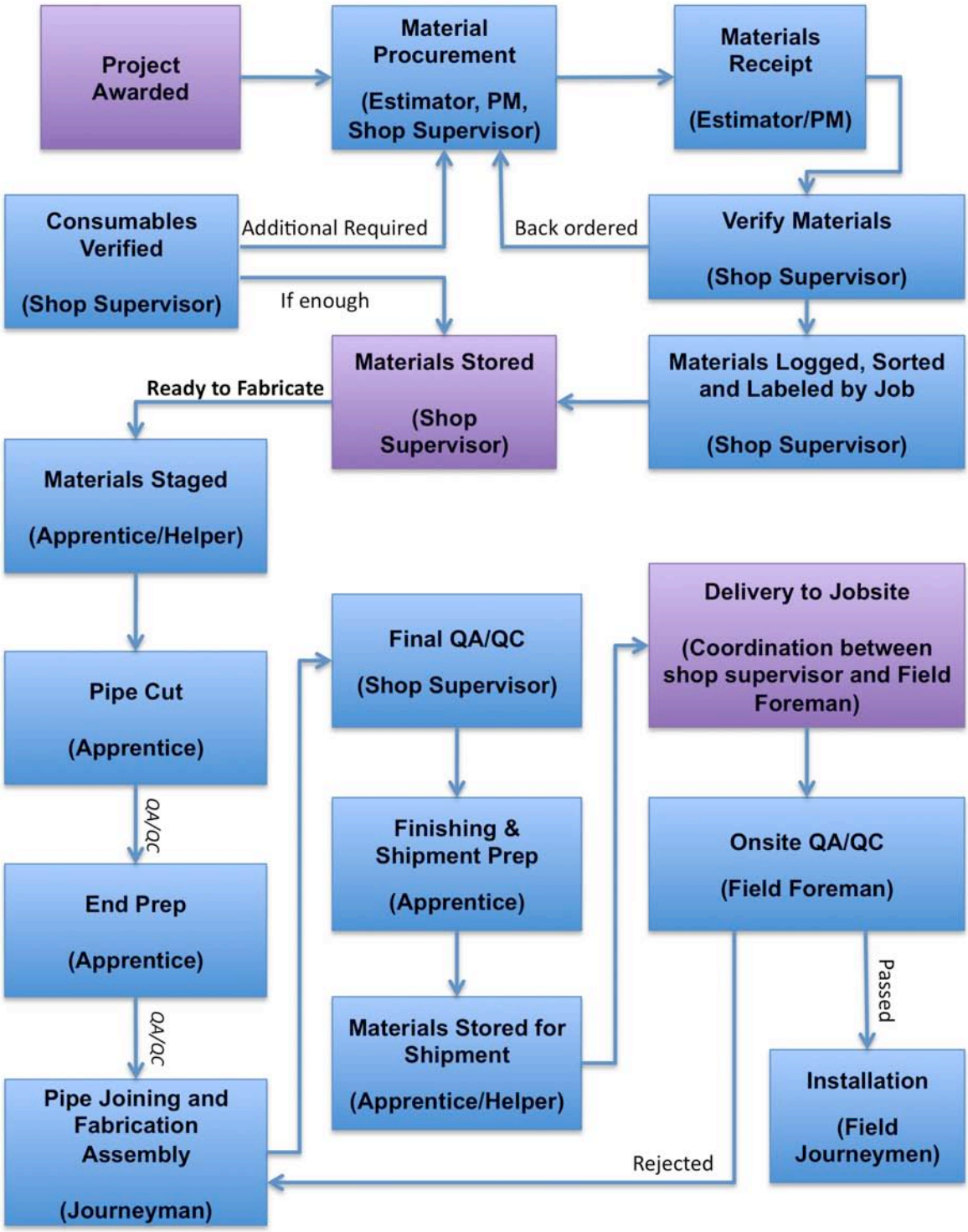
Getting prepared may require notifying the general contractor, having manpower available to offload, scheduling cranes/forklifts and tools.

11. ***Delivery –*** Once the assemblies have been received onsite, the foreman needs to inventory and organize the fabrication for installation. If the shipment can't be installed immediately, it has to be secured to prevent damage and or theft.

    Fabrication that was significantly damaged in transit might need to be returned to the fabrication facility for repair or replacement. Field personnel should be able to fix slight damages or make slight modifications.

12. ***Installation –*** Prior to installation, the fabrication needs to be checked to ensure that all components are included and no modifications to the design are necessary. In addition, the right people must be assigned to perform the installation and field verify that the installation is correct.

# Material Flow Process



## Information Flow

While perfection may be seen as unattainable, improvement does not occur unless the system is constantly evaluated and changes are implemented accordingly.

Feedback is required on all levels to evaluate and correct processes as well as modify future estimating data. If a field foreman does not communicate issues to the fabrication shop, they will continue to impact productivity and quality.

There needs to be a formalized structure in place to get feedback and status updates to the shop. In most cases, this is accomplished with a weekly status meeting.

Having a weekly meeting involving the shop supervisor, project managers and the operations manager is an effective way to air concerns, schedule upcoming work in the shop, get feedback from the field and improve morale. The meeting *should not* be a session filled with complaints, finger pointing or dodging responsibility. Keep the meeting positive and strive to solve problems. If people feel like they can't come forward with small problems, they will try to correct the problem on their own and this can create bigger problems. If problems are occurring, ask them to recommend solutions, not assign blame.

***At the weekly meeting, the agenda should hold a spot for the fabrication shop superintendent to discuss:***

1. Projects that they are working on at the moment (with priorities)
2. Timing and scheduling of deliveries to the field
3. Timing and scheduling of supplies
4. Qualities of materials received
5. New process recommendations
6. Manpower and certifications required for the upcoming projects
7. Storage or staging area for completed fabrication that can't be delivered
8. Man-hours estimated to complete each fabrication project
9. Percent complete of current fabrication projects
10. Change orders

The shop superintendant should briefly discuss the projects in motion so that priorities can be adjusted. The meeting also allows project managers and the field foreman to see what else is on the shop schedule.

Deliveries will also need to be coordinated during this discussion, including any changes in delivery method. This is also the time to discuss what materials are set to arrive in the shop and any quality or service issues with vendors or suppliers. If the materials are inferior, late or rejected, project managers and estimators need to be made aware of this so that they can make adjustments in future bids.

The agenda should also include any process recommendations and discussions regarding the manpower requirements for the shop.

There may not be anything recommended during this agenda topic, but it is important that everyone knows that they have a place where they can make improvements to their process. If a field foreman is irritated by the way he receives materials, they will want to find a way to change it. Small changes to the process that make the people involved happier can lead to productivity gains.

Other methods of maintaining the flow of information include e-mails and telephone calls. It is imperative that the communication between the shop and field be immediate. When a problem surfaces at the site, it means that the installation has stopped and the crew had to be assigned to another task until the problem is resolved. This is not the time to send an e-mail or text message; get on the phone immediately. If the shop supervisor and the field foreman have open communication, down time can be minimized.

The field foremen are the end customers for the fabrication shop. If the end customer isn't happy, the shop supervisor needs to find out why.

Some of the issues the field foreman may raise to the shop supervisor may include:

- Are assemblies accurate or were there flaws that needed to be corrected by the field?
- Did the field receive the assemblies efficiently?
- Were parts damaged or missing?
- What needs to be changed to improve the process?

Some of the best ideas for improving productivity come from within. It is important to keep an open mind to suggestions from the crews. Their ideas may greatly reduce the cost of specific tasks. At approximately a dollar a minute, saving minutes could add up over time resulting in greater profits. To help put crews in the mindset of looking for improvements, some companies offer small incentives to the crew when one of their time saving suggestions is implemented.

As we discussed in Chapter Four, tracking productivity data helps the estimating department produce more competitive estimates. The data also helps the shop supervisor with the performance of the crews and helps with accurately scheduling the work through the shop. Productivity reports may show where there is a bottleneck in shop processes, which would suggest that perhaps a new piece of equipment would be able to reduce the time at that station.

Calculating the ROI using the data may show that a new tool would pay for itself very quickly. Having the productivity information for the various tasks also provides information to the shop supervisor regarding the performance of the crews, especially on redundant tasks. If the output shows signs of declining productivity, the supervisor may have to rotate a new craftsperson to that task.

Finally, if the shop supervisor is knowledgeable regarding the shop's output, he will improve his ability to assist the project manager with forecasting the job outcome.

# Chapter Seven – Design

## Shop Space Size

Space will always be the first concern when designing a fabrication shop. Many contractors beginning the process may ask, “How much is enough?” In truth, it does not require much space to begin. Certain elements of fabrication can be performed in spaces smaller than you may believe.

Most contractors start small when beginning pre-fabrication so that processes can be ironed out on a small scale. The advantages of performing plumbing fabrication clearly justify beginning the process. Even small operations can yield big gains.

***How small is too small? Consider these issues:***

1. How much space is required for the actual fabrication?
2. How much storage space is required for the completed fabrication?

Successful plumbing fabrication requires an area of approximately 2,000 square feet. Although this might seem small and limiting, there are some advantages to having the workstations near one another. The amount of time it takes the crews to move from station to station and the distance the material has to travel are reduced.

*Large batteries can be fabricated in limited space. Photo courtesy of Humphrey Mechanical.*

Determining the area needed to store the fabricated assemblies and equipment, such as plumbing fixtures and large batteries, is a bit trickier. The determining factors are the amount of fabrication that needs to be performed, and the length of time these items need to be stored before delivery to the jobsite. On large projects, a contractor may find that while have the schedule to build the pre-fabrication they do not have the space in which to store it.

***Alternative storage solutions:***

1. Adjust the schedule and manpower to perform pre-fabrication within a shorter timeframe.
2. Adjust the installation schedule.
3. Use secure space at the jobsite or in a parking lot to temporarily store the materials.
4. Lease warehouse space in which to store the materials.

Adjusting your schedule may eliminate the need to store some of the completed fabrication. If your facility can accommodate an increase in the number of workstations, you may be able to perform for just-in-time delivery, thus eliminating the need for storage.

Another alternative is to coordinate with the general contractor and subcontractors to install your fabrication at an advanced schedule.

There may be storage space available at the jobsite or in your parking lot. If the space is outdoors, it is best to:

- shrinkwrap the fabrication to protect it from the elements
- Secure the location and camouflage materials to deter theft, especially in the case of valuable pieces like copper.

Leasing space in a warehouse is another alternative. Whether it's the right solution depends largely on the value of the materials and the amount of space needed. If projects are delayed, note that lease spaces can add extra burden to your project.

*Completed batteries require storage space. Make sure that storage is considered when scheduling jobs.*

## Components of a Fabrication Facility

Most plumbing contractors will begin fabricating in a space that they already have available. The facility may have overhead doors, truck docks, truck wells or grade doors.

Whatever the situation, work with what you have. Plumbing contractors looking to build or improve a fabrication facility will benefit from these recommendations:

### Entrances and Exits

Grade doors have proven to be the most efficient in plumbing fabrication shops. Most often, truck wells take up valuable indoor space because they are not used for loading or unloading for any length of time each day.

With grade level doors, you can move materials by moving the delivery truck in and out or by using Bobcats and lifts to move the materials in and assemblies out. Next to every grade door, there should be a standard door for to ensure that personnel can quickly enter and exit the building.

*Grade level doors allow for the movement of materials without truck wells, which take away valuable floor space.*

The optimum material flow is one directional. Material is received at one end of the building, gets processed, and is shipped from the other end of the building. In reality, many shops will not have this option available to them because they have only one door available for entrance and exit. In this case, the shop can be laid out so that the material comes in the door, travels from station to station around the perimeter of the shop, and then goes back out the same door.

**Overhead Cranes**

Some fabrication shops have high-load-capacity overhead cranes that run the length of the shop. **Do not be concerned if your fabrication facility does not have an overhead crane**. A forklift is an efficient solution for handling the majority of your work, and can be faster, less costly and more efficient than a crane. Pipe can be unloaded onto wheeled carts or directly onto the "ready rack."

*This rolling pipe rack is versatile enough to store, stage and move pipe throughout the facility.*

A "ready rack" is the framing that holds the piping and feeds the cut station. It is at working height, and may have a roller conveyor.

**Materials Storage Area**

Since most fabrication shops have limited space available to store pipe, valves, fittings and equipment, it is imperative that the space be used wisely. Develop relationships with your vendors that will enable you to receive the materials as needed, also called "just-in-time delivery."

The previous chapter clarified the difference between "storage" and "staging." When materials are received, but will not be fabricated for some time, the material should be *stored* near the entrance and away from the fabrication area. The available floor space in the production facility should be kept clear.

*Avoid storing pipe in a production area.*

## Staging Area

Materials that have been received and will be fabricated within the next few days should be *staged* near the point where they would enter the fabrication process. Piping could be placed on rolling carts or on a ready rack that feeds the cut table. Fittings should be organized near the fabrication line with each lot identified by its job number.


*Materials are staged near the fabrication line.*

## Copper Pipe Cutting Area

Once the material has been received, the shop supervisor will be provided with the pipe spool drawings. The foreman will use these drawings and the fabrication schedule to plan which materials will be staged for the next few days of work. Piping will then be taken from the staging area.

*Copper pipe going from the staging area to the cut station.*

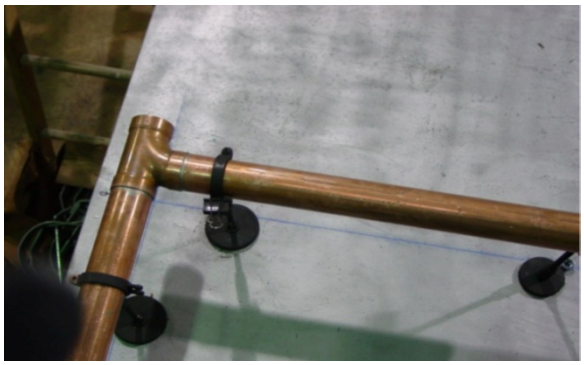
Copper pipe can be cut to length using a Rigid power cutter, chop saw, band saw, etc. After cutting, the pipe moves to the end prep station.

## Copper End Prep Station

The end prep station should be as close to the cut station as possible in order to maximize productivity. End prep tools for copper may include a copper end prep machine or inside cleaning brushes and sand cloth.

### Jig Table

The fabrication of copper pipe frequently ends at the jig table. A jig table is a surface with pre-set mounts for repetitive assemblies. They are especially common for task such as assembling shower/tub mixing valves and supplies to hospital fixtures. Jig tables have spring clips mounted on the surface to hold the copper pipe in place so that *one* person can make the joints. With measurements already performed and one person doing the all the fitting, productivity increases dramatically.



*This jig table includes a sheet of galvanized metal. After a chalk line is snapped on the table to plot the design, magnetic fasteners hold the pipe. A simpler version can be built with a sheet of plywood and spring clips.*

### Plastic Pipe Cut Station

PVC and other plastic pipe flows through the shop much like copper piping. Plastic pipe can be cut be by band saws, abrasive saws or radial/bench saws.

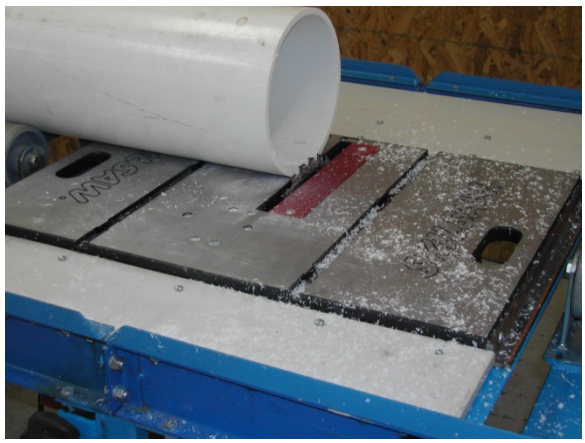


*Table saws can be used to quickly cut PVC or plastic pipe in the fabrication facility. This one has rollers to keep the pipe in place as it is cut.*

End prep for plastic pipe and fittings is usually minimal and does not require a separate end prep station. Rather, a brush or file is used to remove the excess plastic debris from the cut pipe.

After cutting, plastic pipe moves to the assembly area. Ideally, the assembly table for PVC DWV will be preset with the horizontal mains and branches at the desired pitch.

*This jig assists plumbers in pushing together large bore PVC.*

### Cast Iron

Pre-fabricating cast iron assemblies can be very profitable. The pipe can be cut to length at the pipe cut station using a soil pipe snapper, band saw, hydraulic snapper or abrasive cut-off saw.

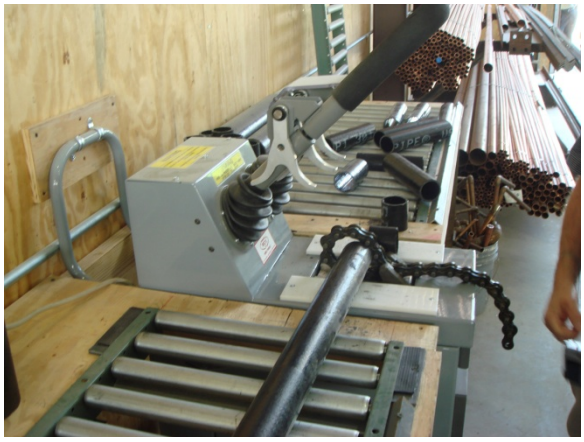
### Abrasive Saw Station

An abrasive saw is probably the least desirable of the aforementioned cutting methods. Although it provides a clean edge, it uses a lot of consumables, is a dirty process and requires a man to be present during the whole cut.

*After a couple cuts, your abrasive saw will never look this good again.*

### Hydraulic Cast Iron Pipe Snapper

While the edges of the break will not be perfect, a hydraulic snapper takes a few seconds to cut cast iron pipe and does not pollute the air with iron dust.



*Hydraulic Cast Iron Pipe Snapper. Photo courtesy of CFI Mechanical.*

### Hand Soil Pipe Snapper

Hand soil pipe snappers operate in the same way a hydraulic snapper works. They may require more than one person and require more physical exertion to make the cut, thus they are better suited to the field than to a fabrication shop.

*Hand soil pipe snappers are perfectly acceptable when you are first building a fabrication shop.*

### Band Saw

Industrial band saws are available that lend themselves to a fabrication shop. They are expensive, however, and require both maintenance and blade replacement. The cut may take more time than other cutting methods, however once the process begins the craftsperson is free to perform other tasks. The cuts are clean and can be automated with some industrial band saws.

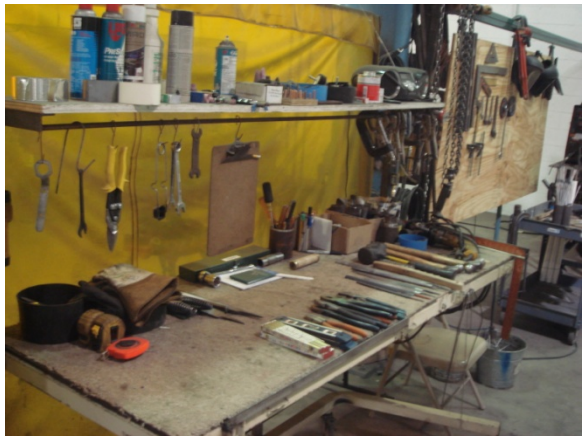
*Industrial band saws deliver clean cuts with less dust than abrasive saws.*

### Cast Iron End Prep

Cast iron systems require virtually no end prep. The materials move from the cut station and fitting staging area directly to the assembly station.

### Workstations

Each workstation should include all the tools needed to complete the tasks. The tooling available at each station should be able to handle all of the joint types that may be required. Each workstation also needs to include an area for the spool drawings that travel through the shop with the fabrication. The shop supervisor should keep any full-size CADD drawings and P&IDs in the shop office.



*Make sure that workstations are organized and include space for all the necessary drawings.*

### Assembly Area

Larger assemblies will require an assembly area. Ideally, assembly tables will include a hydraulic lift that enables the craftsworker to work at the proper working height throughout the assembly. (*See Chapter Five for more information on hydraulic lift tables.)*

## Final Touches/Shipment

Codes or customer requirements may involve inspection points as the work moves through the shop. It is important that these quality checks be documented as they occur. Remember, “if it isn’t documented it didn’t happen.”

During this stage, fabrication is end capped or plugged to protect it from contamination.

If the fabrication becomes part of a skid, there may requirements for painting, insulation, additional support framing or electrical work. If your company does not self-employ all of these trades, you may need to hire a subcontractor to complete that portion of the work in your shop.

***When working with skids or large assemblies, consider:***

- The physical dimensions of the skid. Can it travel down the road without special permits?
- The weight of the skid. Will the overhead crane or forklift in the shop and in the field be capable of handling the weight?
- The security of the items on the skid. Is everything secured to avoid damage during shipment?

## Design Considerations

### Working Height/Distance Traveled

Eliminating elevation changes as the pipe and fittings move through the shop will enhance productivity. A comfortable working height is about 42". That height can be maintained using wheeled jack stands, tables, roller conveyors, forklifts and carts. It is essential that the shop floor be flat so the wheels roll smoothly over the floor and materials travel safely.

It is also important to keep the distance materials must travel from one station to the next as short as possible. Time is money, so a shorter distance traveled results in cost savings. By reducing the amount of space between, stations you also increase the available storage space in your facility.

### Utility Requirements

Flexibility is important when setting up a fabrication shop. You want to be able to use the available space to handle whatever materials and configurations move through the shop. 110 volt outlets should be regularly spaced around the perimeter of the shop, and 220/440 volt outlets should be placed at key locations in the shop for welding machines, band saws, grooving machines and other equipment.

Compressed air needs to be incorporated throughout the fabrication shop, with numerous outlets available. While some facilities have inert gas piped through the shop, it is far more common to have inert gas dispensed utilizing bottles on carts.

**Additional ways to improve productivity in your shop design:**

- Utilize a vertical storage rack system if shop storage/staging space is limited. This will help keep the fittings near the workstations.
- Have break and bathroom areas near the shop to keep walking time to a minimum.
- Light the facility well and paint it a bright color (white is preferred). This will help with both quality and morale, particularly at the prep stations and workstations.

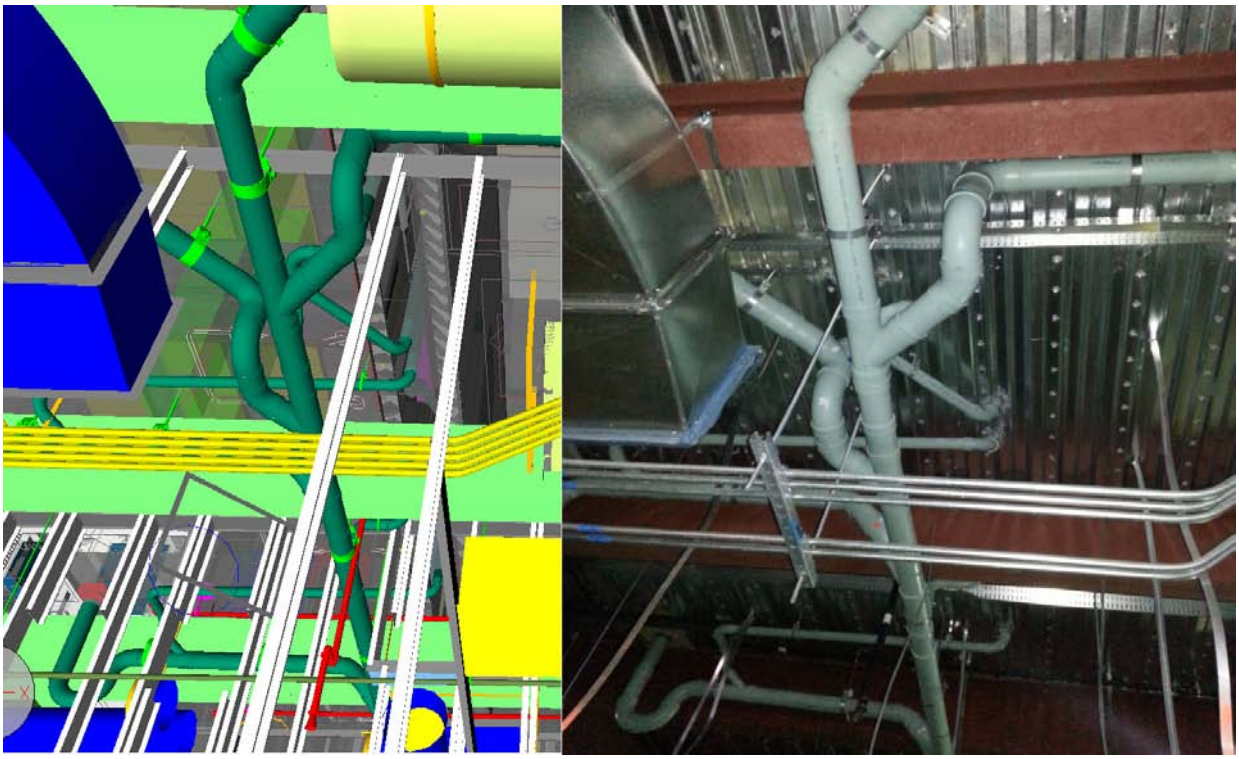
- Keep the shop clean. Work areas should be swept, tools put away, and all scrap removed each night. A complete “roll back” should be done monthly.
- If needed, set aside an area to store tools and consumables that must be shared among the crews. Make sure to have a policy requiring that these items be returned after use so that time isn’t wasted looking for them when they are needed.

## Chapter Eight – Technology

The pre-fabrication process has received a big technological boost in the last decade. Building Information Modeling, or BIM, has added a new dimension to the process of pre-fabricating plumbing components and systems. BIM is a three-dimensional collaborative building process among the architect, engineer, prime contractor, owner and specialty building trades contractors. It generates geometrically accurate, intelligent digital information for use in the design, construction and maintenance of a building.

With BIM, trade contractors use contract design documents and specialty 3D CAD software to spatially coordinate and determine the exact location and routing of their systems' components in relation to the building's structure and other contractors' components. BIM's primary goal is to resolve interferences among trades and to equitably establish the spatial boundaries of each trade's installation. This includes the access required to install and maintain each component. Successful BIM enables the team to virtually construct a geometrically accurate duplicate of what will be built. This includes exactly where it will be built, the sequence in which it will be built, and the materials from which it will be built.

Successful BIM contractors have found that once journeymen and foremen no longer have to fight with other trades for space and gain confidence that everything will fit, they begin to focus on innovative ways to pre-fabricate,



*BIM offers virtual plumbing system design with complete accuracy before installation. Photo courtesy of Kinetics.*

transport and rig components into place. BIM also enables contractors to devise strategies for getting into and out of an area as soon as it is released to them by the general contractor. This helps avoid the typical construction congestion that develops when walls start to go up, other contractors begin staging their materials and access becomes difficult or limited.

BIM itself is a complex process and an attempt will not be made to fully cover it here. Rather this chapter explains some of the direct benefits obtainable when BIM is used to create a comprehensive plan to pre-fabricate as much of the plumbing installation as is feasibly possible and profitable. Watch for the upcoming MCERF/MCAA/SMACNA/ NECA joint publication *The MEP Contractor's Guide to the Spatial Coordination Process* for a detailed guide to BIM and spatial coordination.

## 3D CAD Specialty Plumbing and Piping Software

The heart of the plumbing contractor's BIM spatial coordination process is specialty 3D CAD software. This software allows the user to create a model comprised of intelligent 3D objects. Think of it as taking components such as sanitary tees, Ys, carriers, p-traps, unistrut and piping off of a cyber-shelf and assembling them in your design just as you would on the jobsite.

The heart of the 3D software is its digital database where these components reside. The database maintains the objects' exact three dimensional geometry as well as additional information such as size, schedule, part number, manufacturer, cost codes, etc. Even items such as gaskets and socket depths are accounted for. This information can be easily extracted from the model into tables or bills of material using software formats such as Microsoft Excel or Adobe Acrobat.

Tie-ins to compatible estimating software can be established to quickly prepare cost estimates from any area or portion of the model.

This type of software generally contains additional functionality that provides sloped router lines with automatic or semi-automatic placement of pipe and fittings, auto-placement of hangers and predetermined assemblies, auto generation of individual spool drawing fabrication sheets, and direct tie-in to laser-guided survey equipment such as line of sight total station units.

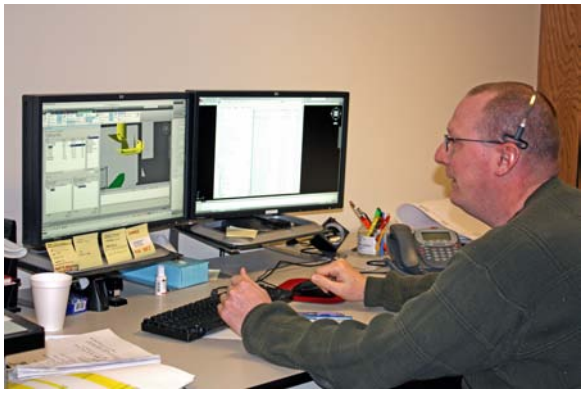
## When and Where to Use BIM

Many large projects, including most large healthcare and university projects, require that BIM technology be used. Some plumbing contractors view this as just one more obstacle or requirement that has to be met in order to get the job. In such cases, BIM usually becomes an added cost to the project that eats away at the profit potential.

Others have recognized the opportunities that BIM presents and have created comprehensive pre-fabrication strategies around it.

For non-BIM jobs, BIM-capable contractors will often model their installations in 3D even though it is not required by the job specs. In such cases, decisions must be made regarding which pre-fabrication provides added value and which does not. This, in turn, often determines which components and systems will be modeled in CAD and which will be field-routed and installed.



*CAD Detailers have taken on the additional role of information handlers. Photo courtesy of Mechanical Inc.*

## Determining Deliverables

Successful pre-fabrication must be preplanned. A major part of that preplanning when utilizing CAD/BIM is determining which deliverables will be created and used by the project team.

***There are two types of deliverables on BIM projects:***

1. Deliverables required by the general contractor or construction manager as part of the project requirements.
2. Internal deliverables required by individuals and groups within your company.

Pre-fabrication deliverables are the drawings, documents, spreadsheets, material lists and computer files generated by a company's CAD detailers and forwarded to the project manager, fabrication shop and/or field.

***The scheduling and delivery of these items are absolutely crucial to the success of any pre-fabrication plan. In order to schedule manpower, purchase materials and schedule pre-fabrication, the fabrication shop and field must know exactly what to expect, when to expect it and how it will be used.***

***A successful deliverables strategy will consider the following:***

1. What's needed and when
2. How deliverables be used
3. Naming conventions
4. Site logistics
5. Special scenarios

**What's Needed and When**
At the earliest possible opportunity, and preferably as part of a project constructability review or project turnover, the project manager and his team should meet with the CAD department to determine which deliverables will be required for the project. This is the when specific types of pre-fabrication will be evaluated and a determination will be made as to which are appropriate for the specific project. **This is perhaps one of the most crucial times of your pre-fabrication plan** and adequate time must be allotted for its completion.

Once the deliverables have been determined, they ***must be managed***. A list or log should be created, preferably in the form of a spreadsheet. Your company should create a naming convention that uniquely identifies each deliverable or group of deliverables.

Once the deliverables list or log has been created, the project team should plug in due dates based on the project schedule. Many successful projects focus on the ability to get in and out of an area quickly and efficiently before the obstacle of construction congestion develops. In order to do that, the right materials and pre-fabrication assemblies must be in the right place at the right time.

Once dates have been plugged in, the deliverables log in effect becomes a deliverables schedule. Maintaining and updating this schedule on a regular basis is absolutely critical to the overall success of your pre-fabrication process.

**How Deliverables Will Be Used**
All members of the project team must have a clear understanding of how the deliverables will be used. This is an area where skilled tradesmen often come up with innovative new ways to take advantage of the potential of virtual construction. The CAD detailer and field foremen will need to meet to review drawings and spreadsheets before parts are and assemblies are delivered and installed.

**Naming Conventions**
The nomenclature used to sort and identify parts and assemblies and where they are to be delivered, staged or installed, must be understood by all parties. Strategies for bagging and tagging, color coding, and/or barcoding should be considered and clearly communicated to all team members.

**Site Logistics**
Field personnel must communicate to the CAD and fabrication departments all limitations and special circumstances that may impact the size or configuration of assemblies. Plans must be developed for how items are to be handled once they get to the site. Special consideration should be given to doors, construction openings, elevators, etc.

Limitations for the same should be communicated to the CAD department. Adequate three-way communication among the CAD department, the fabrication shop and the field are paramount. Please refer to the Ongoing Communication and Teamwork section later in this chapter for specific suggestions as to how to make this happen.

**Special Scenarios**

The installation of pre-fabricated hangers is one example of a unique process. In order for it to be successful, the hangers must be identified, sorted and shipped in the order in which they will be installed in the field. This is particularly important with sloped piping. If this is not done, workers in the field will have to figure out what's what, which will unquestionably eat away at anticipated profit margins.

Just as the CAD detailer is responsible for timely release of deliverables to the project manager and his team, the project manager is responsible for timely delivery of the material and equipment submittals needed to generate accurate BIM models. The assumption that there is plenty of time to obtain submittals for equipment that is months away from installation does not hold true with BIM. Holes in the model midstream changes to materials inevitably have a negative impact on a closely coordinated model. This can result in schedule delays, errors and/or rework when the size or configuration of material or equipment varies substantially from that which was originally anticipated.

A submittal schedule should consider what will be needed first and assign responsibilities and dates for obtaining submittals.

Whenever possible, vendors should be pressed to provide electronic 3D models of equipment in order to save time and money modeling the installation. Project managers should verify that all applicable information is contained on the submittals, particularly dimensional information on size, type and location of all connections.

## Types of Pre-fabrication that can be Extracted from BIM Models

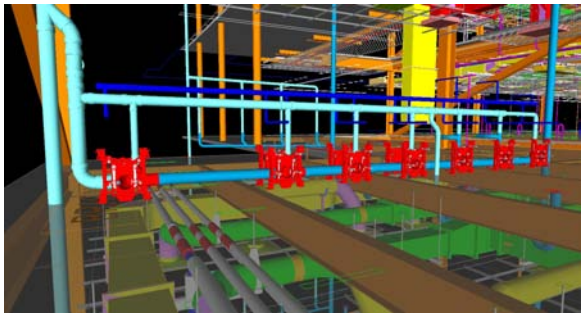
Truly, the sky's the limit in determining what can be extracted and exploited from the information-rich building models as it relates to increased productivity through pre-fabrication. Some forward-thinking contractors pre-fabricate virtually everything they install.

For those just entering the BIM world, it may be wise to ease into the workflow rather than trying to do everything at once. Review your options and consider:

1. What will be the easiest?
2. What will bring the most value?

Focus on developing your abilities and confidence in those areas. As your company gains experience and proficiency with pre-fabrication, you will most certainly expand your capabilities. Some of the typical pre-fabrication options are discussed below.



*A plumbing battery pulled from a BIM model. Photo courtesy of MMC Contractors*

**In-Wall Plumbing Chase Assemblies (Plumbing Batteries)**

These are complete assemblies built on steel frames such as unistrut, plate or channel iron that include carriers, threaded rod, stub outs, brackets, all drain waste and vent piping, domestic water lines and valves. 3D CAD technology allows for the complete virtual assembly of these complicated assemblies which, in turn, allows the detailer to ensure the structural and architectural design is adequate to allow for installation. When changes must be made to the structural framing or chase wall dimensions so that everything will fit, that information can be communicated to the architect and engineer via RFI prior to building erection.

Specialty CAD programs quickly generate fully-detailed fabrication drawings, including a complete bill of materials with cut lengths for all piping pieces. Designs for these assemblies, however, must be closely coordinated among CAD detailers and qualified licensed plumbers. Special consideration must be given to how the units will be shipped and moved into place, including limitations on size and length.

Close scheduling of fabrication, delivery and installation of these assemblies is critical. The installation window is usually very small and an attempt to install them after typical construction congestion develops may necessitate cutting them apart.

**Other Skids, Modules and Assemblies**

Just as plumbing batteries can be designed and fabricated with specialty CAD software, so too can groups of equipment such as filters, softeners, pumps and backflow assemblies be pre-assembled onto frames or skids with all interconnecting piping valves and supports included. The same design, accessibility and scheduling considerations mentioned above for plumbing batteries must also be afforded to this type of pre-fabrication. Timely acquisition of approved submittals by the project manager is essential to this process.

**Underground**

Pre-fabrication of underground piping is considered to be counterproductive by some contractors while others fully embrace it. Plumbing contractors must decide what is best for their company based on:

- Material type
- Handling costs
- Transportation costs
- Labor costs.

3D specialty software allows for the creation of highly detailed installation drawings. Coupled with technology such as laser total stations and self-leveling rotating lasers, the exact locations and elevations can be easily extracted from the model and used to readily lay out installations. This can give contractors the confidence needed to precut and bundle piping lengths along with bagging and tagging fittings, knowing that they will fit. As confidence, skill and capabilities develop, consideration can be given to using the specialty software spooling capabilities to pre-fabricate sections of underground pipe (especially PVC) to be dropped in the ditch and joined utilizing appropriate methods.

**Hangers**

One of the biggest strides the use of BIM technology has provided is in the pre-fabrication, layout and installation of hangers and supports. With fully coordinated, signed-off coordination drawings, MEP contractors have reserved their space in the ceilings, chases and plenum spaces.

Additionally, line-of-sight laser-guided total station units[1] can be used in conjunction with 3D piping specialty software. Coupled with newly developed computer tablets that tie into these systems, any given point in the full BIM drawing can be quickly and accurately located in the field. The combination of these technologies facilitates the layout and pre-fabrication of nearly every hanger on the project, something that was virtually unthinkable as recently as 10 years ago.

Some of the specialty piping software used by plumbing contractors places hangers and supports automatically. This information can generally be extracted into a bill of materials. Some contractors create custom spreadsheets that assign unique hanger numbers and provide information on hanger type, pipe size, rod size, bottom of pipe or cut length elevation, insulation thickness, and structural attachment elevation. These spreadsheets calculate and provide rod lengths and overall hanger assembly length. While these spreadsheets are generally considered to be proprietary, anyone proficient in the use of formulated spreadsheets and knowledgeable of hanger installation methods should be able to set one up.

[1] *Total station and GPS units are often confused, but they are not the same. While practical for many surveying operations, GPS is less accurate, inconsistent and often loses connectivity when used in building construction and is therefore not recommended.*

A hanger pre-fabrication and installation strategy should be part of project preplanning and deliverables related to that effort should be logged and scheduled. Timing is paramount in order for this technology to be successfully utilized. Hanger inserts and/or embedded strut accompanied by either dimensioned deck installation drawings or total station files must be ready for installation when the deck is released.

Hanger assemblies must be pre-fabricated and ready to go as soon as the GC releases an area. When pre-fabricating groups of hangers, tag and crate them so that they come out of the bin in the sequence in which they will be installed.

**Suspended Piping**

The same techniques and methods described above for underground piping can be applied to the suspended piping of gravity and pressurized systems. In this case, the biggest benefit accrues when it is used in conjunction with a comprehensive hanger plan. With both in place, installation can be accomplished by placing the precut pipe or prefabricated spools into the hangers and making the final connections. The piping self-aligns in the hangers and no additional layout, measuring or calculating is needed.

**Prefabricated Racks**

BIM can be used to consolidate and group piping runs to utilize common trapeze style piping supports. This strategy is particularly helpful if the plumbing contractor is also the mechanical contractor on a project.

*A pre-fabricated rack arriving on a jobsite.*

For example, domestic water lines can be grouped together with hydronic lines to save space and hangers. In this case, pre-fabricated racks can be used and both the trapeze supports and piping runs can be pre-fabricated in the shop.

The piping lengths are determined either based on standard lengths of pipe or in lengths that will be manageable as determined by field logistics. Pipe, fittings, valves, support steel, hanger rods, hardware, insulation inserts and shields are assembled in the shop and all hanger clamps, nuts and bolts are fastened in place.

Completely detailed fabrication drawings can be created from the BIM model. Current software functionality does not automatically number these racks, so detailers will need to work with the field to number and tag these racks in a logical manner so that field logistics to proceed smoothly. Close coordination and planning among detailers, fabrication shop, and field are essential for this type of prefabrication.

Installation plans also should be communicated, sequenced and coordinated with the GC and other trades to ensure transport and erection can proceed without hindrance.

*Coordination with the entire design team in a virtual meeting. Photo courtesy of University Mechanical.*

## Ongoing Communication and Teamwork

The time and effort put into formulating a comprehensive pre-fabrication plan will be for naught if it is not followed up on a regular basis. Without constant evaluation and feedback, the system can become stagnant and lose productivity potential.

Plumbing contractors that utilize BIM successfully have a process in place to regularly update the status of their project and provide adequate look-aheads. This ensures that material is procured, fabrication is on schedule and deliverables are generated and transmitted as needed. Hiccups and problems must be addressed as they develop, before they become major obstacles that negatively affect cost and schedule.

## Status Meetings

Regular mandatory weekly status meetings are one way to accomplish these tasks and promote clear communication and teamwork among CAD, project management, fabrication shop and the field. These meetings generally can be conducted online using web-conferencing software on the same day and at the same time each week. Using this format, any participant can share electronic copies of agendas, schedules, material lists, submittals, drawings, sketches, RFIs and/or BIM models to be reviewed and discussed.

To be successful, the meetings should last no more than an hour. They should be preceded by a written agenda and meeting reminder, with meeting minutes to follow. These minutes should place a ***strong emphasis*** on action items and tasks to be performed with due dates and responsible parties for each.

***Status meetings can be used for the following:***

1. Keeping the project manager and the field fully apprised of the progress and any issues, changes, or problems that have the potential to impact cost and schedule.
2. Becoming a look-ahead for items or deliverables needed for upcoming fabrication or construction activities
3. A means for letting the project manager and field know which submittals, field dimensions or other information are needed by detailers for ongoing or upcoming coordination activities critical to keeping the prefabrication and installation plans on schedule

## Tools for Technology

BIM also allows for the use of a host of other new technological tools to increase productivity, improve communication and information exchange and subsequently reduce costs and risk. This process is constant evolving and contractors should make every effort to stay abreast of the changing technology. Some of these tools are highlighted below.

### Laser-Guided Robotic Total Stations

Using two or more established control points, these line-of-sight surveying units pair an on-board computer and a fully articulating laser-guided robotic head to transfer any given geometric location in the building model to the corresponding point on the building site quickly and accurately. Used by

Total stations are the technology bridge from the CAD drawing to the field.

plumbing contractors chiefly for underground and hanger layout, these units are an invaluable element in creating prefabrication and installation strategies. They can be operated by one person, do not require traditional surveying knowledge and skills and the computer-savvy tradesperson can learn how to operate and use these stations in one day or less.

Successful use of this tool can deliver the layout of between 400-600 points in a single 8-hour shift.

### Construction-Based Digital Tablets and Applications (Apps)

These tools bring CAD/BIM technology directly into the field with lightweight tablet computers that can be loaded with CAD apps, CAD drawings and/or 3D models. Construction-grade tablets that can withstand the abuse of a traditional construction site are available from specialty vendors. Functions traditionally

tethered to the workstation—such as extracting dimensions, component information or material lists—can be accomplished in the field. Markups and notations can be recorded directly onto the screen with a suitable stylus.

Construction or project management apps can be utilized to paperlessly transfer schedule updates, manpower reporting or other similar items back to the office or trailer via a Wi-Fi connection. Advanced tablets manufactured in conjunction with specific total station units can be linked directly to the total station units to allow transfer of any point directly from the on-screen model to the field or vice versa.

**Laser Scanners**
These units use automated total station layout technology in reverse to collect the surface as-built condition of any object, room or structure and assemble it as a 3D surface "point cloud" which can become the basis or background of a new building information model. This technology requires some basic surveying skills and is substantially more expensive than a total station unit. Some units can double as a total station unit and a laser scanner, and pricing has declined over the last few years. Several specialty contractors also provide laser-scanning services at reasonable rates.

**Laptops and Workstations**
Successful use of BIM technology strongly dictates the use of laptops or computer workstations in the construction trailer by field supervisors. Free apps and viewers are available that allow the field foreman to view and extract information from CAD drawings or building models.

**Wide-format Plotter/Printers**
Moderately priced plotter/printers can be located onsite in construction offices or trailers to allow for the immediate distribution of full-size plans and prints to field personnel. Prints can be plotted directly to networked field printers from the CAD office or PDF format files can be e-mailed to the field or retrieved from appropriate digital storage locations or networks to be printed locally in the trailer.

**Digital Storage**
Digital storage can be secured through broadband high-speed Internet access for direct links to company networks or FTP sites where digital information is stored and/or uploaded. This allows for a single master file storage location, eliminating the risk presented by having multiple copies of duplicate documents or files with different revision levels. In effect, this ensures that only the latest current documents or prints are utilized for construction.

### Cloud-Based Storage and Information Exchange

Several CAD and construction service providers now offer web-based "cloud" storage, retrieval and information exchange for managing digital information and building information models. Combined with information management software, these subscription services allow for real-time automatic updating of building information models from multiple users in multiple locations each time they save their work on their local workstation. This then allows all changes and updates to the model to be viewed in real time.

### Web-Based Online Conferencing

If the old saying "a picture is worth a thousand words" is true, it can certainly be said "a model is worth a thousand pictures." Web-based conferencing is a user-friendly, inexpensive way to communicate ideas, information, issues and updates by allowing team members to view one another's computer screens and utilize their mouse or stylus to indicate or markup items on the other users' screens. Drawings, models or documents can be brought up for all to view. This technology can be used one-on-one or for as many users as the subscription service allows. Voice communication can be conveyed either through accompanying teleconferencing or directly through the computer speaker and microphone.

### Pre-Printed Catalogs of Typical Prefabricated Components

This is perhaps the simplest technology of all and consists of creating a three-ring binder and/or digital catalogs to show generic drawings of successfully used prefabricated assemblies, hanger supports or modules that can be marked up by the field personnel with component sizes and dimensions and sent to the fabrication shop for fabrication.

## Summary

BIM is a complex process. Contrary to popular misconceptions, it does not run on autopilot and is not the proverbial "easy button." It must be diligently managed in order to be successful. It is continually changing and evolving, and successful users need to stay on top of current trends and requirements in order extract the benefits to which they have become accustomed while meeting the increasing needs and requirements of GCs and owners. W when utilized as part of a comprehensive strategy, BIM can lead to higher quality, increased efficiency, improved safety, improved schedules and lower costs by maximizing prefabrication opportunities.

## Prefabrication Limitations

Prefabrication has many inherent advantages, but there are limits. Transportation costs, distances and the availability to install prefabrication into areas outside the range of your collective bargaining agreement can all restrict your profitability. Size and weight limitations, route restrictions, permitting requirements and the need for lifting equipment on site are factors that all need to be planned and coordinated before construction begins.

Transportation and logistics plays a key role in determining the feasibility of using prefabrication or modularization. Fabricators emphasize the need to pay attention to transportation costs. Although money can be saved in productivity gains inside the fabrication shop, they can just as easily erode if transporting long distances. There are cases where miscalculations of transportation expenditures were made upfront which resulted in higher costs than estimated.

If the transportation costs start outweighing the advantages of prefabrication, consider an off-site fabrication facility closer to the jobsite. Although you will not have all the advantages of a permanent facility, an off site fabrication facility located close to the job site will still yield productivity gains over doing all the work onsite.

Another solution might be to lease warehousing space closer to the jobsite. If materials already need to be stored due to delays or scope of project, renting space closer to the jobsite might allow for smaller vehicles to be used for the transportation. Instead of trying to stage and perfectly time the delivery of materials a long distance away, completed components can be shipped to the warehouse and stored there until the delivery window opens up. Then a smaller vehicle could make the final delivery.

This solution won't work for every case, but the key is to start thinking outside the box, evaluating the assets you might already have and choosing options that best utilize those assets.

The geographical distance from the fabrication shop to the jobsite could be a long distance requiring a significant amount of planning for the shipments. Although a few short trips aren't a major cost consideration, the farther the jobsite is from the fabrication facility, the smaller the returns.

Shipping cost may also vary depending on whether you own or rent the trucks. On occasion there may be a need to contract your shipments to a third party trucking company if the pieces are too large or the jobsite is too far away.

If you are sending the fabrication three hours or more away there needs to be additional coordination. The load may have to be more secured and maximized to reduce the number of

trips. Longer distances also might require additional weather protection.

The farther away the jobsite is, the more difficult scheduling and timing become. If your driver does not arrive to the jobsite in time, you might miss your window for the crane. If the driver arrives too early, you will pay for the driver to simply sit and wait until they have access.

Even more important than the geographic limitations are the job site limitations. There must be adequate accessibly to the site and to the final location of the installation. There is no point in building large fabrication pieces if you cannot unload it, move it to the proper place and install it. Check access points in the delivery area as well as the path to the installation. Make sure doors are large enough to fit fabrication in or schedule installation before the walls go up.

Shipping methods could be costly and should be considered at the time the estimate is being made.

**Multiple Trailers Loaded and Ready for Saturday Delivery and Installation**

| **Some transportation items that need to be taken into consideration at bid time:** |
|---|
| • Travel time to and from the site |
| • Number of shipments that need to be made |
| • Type of truck/trailers required |
| • Do the assemblies need to be transported in a “container”? |
| • Do you rent/lease or buy the trailers or containers |
| • There may be a need for more than one trailer to be used for shipping the fabrication in cases where the assemblies need to be on site when the crane is available, this may result in waiting charges charges, but even so could be money well spent. |
| • Permitting cost |
| • Oversize load |
| • Route restrictions |

Even though it is important to include the cost of shipping the fabrication, those added costs seldom sway the decision whether or not to do prefabrication. They are important considerations to make when determining how much to fabricate in the shop. If an assembly is too big to be able to be installed in one piece, you might need to break it down into multiple components.

Deliveries from the shop to the jobsite should be scheduled according to the Field Supervisor's input and per the shop's production schedule. See the below suggested procedures:

| **Here are some suggested procedures regarding shipping:** |
|---|
| a) Shipping scheduling information should be communicated to the person in charge of deliveries for the company. |
| b) Deliveries are set up utilizing either your own trucks or a third party transport company. |
| c) Anything shipped is identified per your standard shop procedure or project specifications. |
| d) Pipe open ends should be capped or sealed for shipment. |
| e) When possible, employ one-point rigging to load and unload spools on the truck. The attachment points to the pieces should be clearly marked to enable the field personnel to identify the rigging point, so the field crews don't have to problem solve. |
| f) Spools are loaded on to the trailers according to the Field Supervisor's needs for ease of unloading per area and or sequence of installation. |
| g) A BOL (Bill Of Lading) is created containing all appropriate information and should accompany each shipment and you may want to send a copy to the field supervisor ahead of time. |

## Modularization

The concept of modularization brings opportunities and challenges. Instead of simply constructing plumbing batteries, some contractors are now able to construct bathrooms or entire hospital rooms in the fabrication shop. These modules can be installed directly into the building with minimal finishes applied afterwards. Connections are made and the onsite construction schedule is greatly condensed.

While most contractors understand the opportunity of selling entire bathrooms as opposed to just the plumbing, the challenges are much more complex. Subcontractors need to operate in your facility, extensive storage space is required, transportation is more complex, and installation requires cranes and special coordination with the general contractor.

Contractors that prefabricate modules essentially become general contractors. They have to maintain multiple trades, permits, designs, schedules and inspections. If you are hiring other trades to perform work on modules or any other prefabrication, be sure to check your local and national agreements to make sure you are in compliance. Some may require that all work being performed are done by union trades people.


Hospital Bathroom Modules Being Fabricated


Modules loaded on Truck for Shipment


Module Being Hoisted up for Installation

**Work Rules**

Shop prefabrication of plumbing systems under the terms of local collective bargaining agreements and national prefabrication agreements requires careful implementation to gain the advantages of each type of agreement.

In general, prefabrication with bargaining unit personnel of systems made for installation in the local area of operations of a specific collective bargaining agreement is unrestricted in that single jurisdiction using the proper worker classifications in the local CBA for journeymen and any local metal trades shop classifications in the prefab shop. Also, prefabrication employers will need to be aware of any job site work preservation clauses that may be applicable in the local bargaining agreement, and how to install fabrication in compliance with them.

Some exception might apply for use of journeyman labor in the shop to work on the fabrication for a particular project. Also, the effect of the terms of the National Prefabrication Agreement (Yellow Label agreement described below), which supersedes local agreements, will have to be assessed. Particular care assessing the local or national agreement rules on prefabrication installation must be taken in areas of the country where there are multiple local union jurisdictions in a single region or market area – use of the National Prefabrication Agreement in those cases can provide ready portability and consequent market advantages.

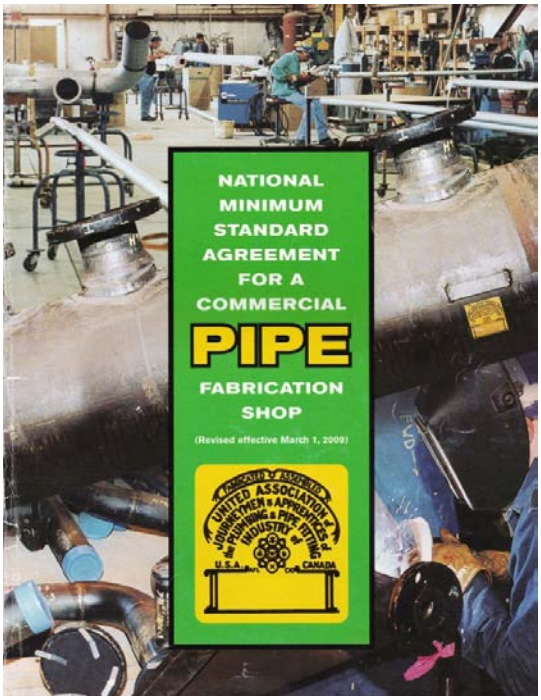
The National Minimum Standard Agreement for a Commercial Pipe Fabrication Shop (Revised October 1, 2013), is designed for use by employers that fabricate piping material in commercial use in the industry or employers that fabricate piping for sale to the industry as a commodity.

This agreement is known as the "Yellow Label" agreement, and it provides for the "bending and fabrication of welded pipe formations and pipe assemblies," as well as "the bending and fabrication of piping and/or domestic plumbing, comfort heating, air conditioning systems, and any related cast iron fabrication to be performed by the appropriate craft." The document also expressly includes "ammonia systems used for air conditioning and all skid-mounted and equipment related to such systems." The Yellow Label agreement also covers miscellaneous products, and all items "encompassed by the UA jurisdiction as set for in the UA Constitution." (The 50 points of jurisdiction.)

What does it all mean?

a. If you are not signatory to the Yellow Label agreement, and fabricate only for job site installation in your "home local" area, then the terms of the shop work and local project agreement are covered by the local agreement and any "metal trades' classification for shop employees that may be in the local CBA. Similarly, the use and installation of any local fabrication will be used in accord with the local CBA and any provision that may affect job site work preservation.

b. If you are signatory to the Yellow Label agreement, then the fabrication and shipping and installation of that piping assembly is governed by the terms of that national agreement. The Yellow Label agreement by its express terms permits the fabrication of covered work for installation on any project nationwide where the piping assembly carries the UA Yellow Label affixed the material. The Yellow Label agreement (Article 1, paragraph 2) expressly supersedes – any local CBA terms and conditions that would restrict the application of any of the terms of the national agreement.



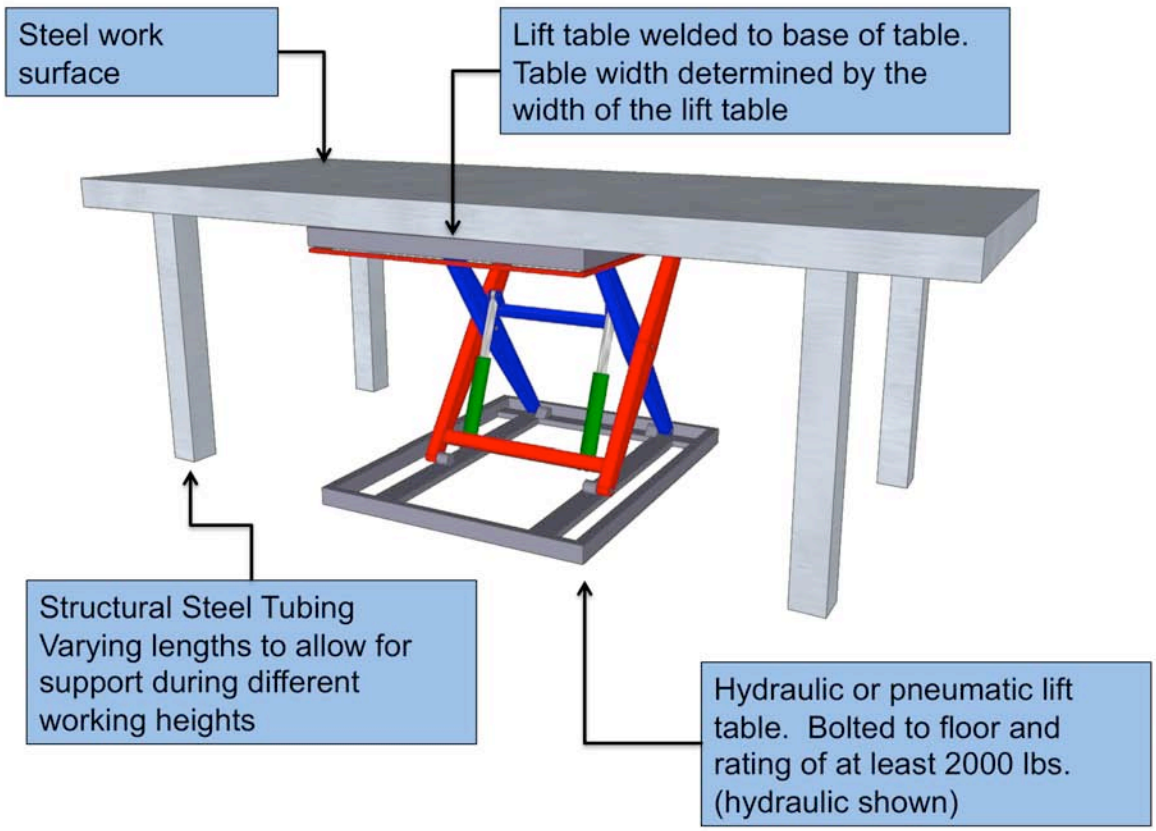
Employers can apply for use of the national Yellow Label agreement by contacting:
The Pipe Fabrication Institute
511 Avenue of the Americas
Suite 601, New York, NY 10001
514-634-3434
pfi@pfi-institute.org

Employers that intend to ship fabrication to a job site outside their home local area and install it there, and if the employer is not signatory to the Yellow Label agreement, then the employer would be well advised prior to bidding the job to contact the business manager in the job site's local to check on the local CBA's provisions regarding the use and installation of prefabrication on the project. Some typical material considerations on the question of importation of fabrication into the area without the Yellow Label agreement pertain to:

1. The presence of non-union competition for the project; and
2. The potential for using project area bargaining unit employees in the fab shop for that project fabrication.

# 2013 Supplemental Designs

## Adjustable Height Work Bench




In this design, the table needs to be braced each time it is adjusted with various sized legs.

While it does allow for varying heights, time is spent on resetting the legs each time the working height is adjusted.

New lifts, originally intended for motorcycles have automatic safety locks included each adjustable position.

This electric/hydraulic lift table, modified Neptune Plumbing, utilized a Titan 1500XLT-E.

They attached a layer of 1” plywood to the steel table surface so that channels for plumbing batteries could be mounted.


Once positioned at the required height, the table self-levels and rests in a safety lock for additional support.

This brand retails for around $1800.00, but with many of the pieces used for motorcycles unnecessary, try negotiating the price down with the dealer.

Photos courtesy of Neptune Plumbing.

# Tee Pulling Station

For areas that allow it, using a tee puller will save both time and money. Although engineers can be reluctant, the joint is as effective as using a copper fitting at a fraction of the price. Sometimes, submittal data will need to be sent to engineers, but the cost effectiveness of extracted tees is significant,

A variety of models that are built for various applications. Many contractors utilize a handheld portable model in the field to make extracted tees and modify a drill press set up in the fabrication shop for greater performance and efficiency. The reason being, industrial versions of the tee pulling station can cost up to $130,000.

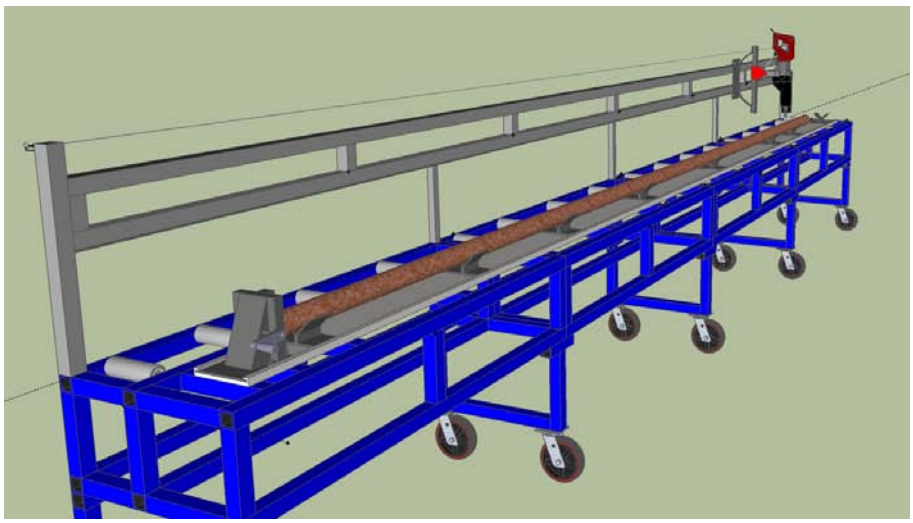
The T-60 (top) is the tool of choice in the field for contractors. Photo courtesy of T-Drill

Portable handheld units are not inexpensive in their own right, costing approximately $6800 for the drill and the specialized bits, but constructing a drill press using these handheld drills can be very cost effective.



SA Communale built this T-Drill press capable of handling 20' Lengths of copper in various sizes.

This tee pulling station was constructed of two inch square steel tubing. To better enhance the productivity, the contractor welded in a pipe vise, a manual tool drill press, pipe conveyers, casters, a wheeled drill and even a cord guide for the extension cord.



Based on this design, a 3D model was created in SketchUp. To see it, click on this link.

It contains a rough approximation of how the SA Communale design was constructed.

One drawback to this workstation will be the cost of materials and the time it takes to assemble them. Based on this design, approximately 3,700 inches of 2" square steel tubing was used that will roughly cost $2,000. That does not include the price of the casters, vise, press and conveyers and especially the labor to weld and assemble it. Assembly time for a workstation to be cut and welded could take a week or more of labor.



Contractors that perform a high volume of extracted tees have been known to purchase the Industrial models, geared towards the fabrication shop. The S-55 model above is the predecessor to the S-54 available now (Right). Photos courtesy of John J Kirlin and T-Drill

Having seen the way that contractors utilize their portable tee pulling drills in the fabrication shop, T-Drill developed a couple of options that some contractors use. The first is marketed for industrial purposes and is called the S-54. Having industrial equipment is not cheap though. The base price for the S-54 model is $95,000 and can run upwards of $130,000 - 160,000 with an optional base attachment.

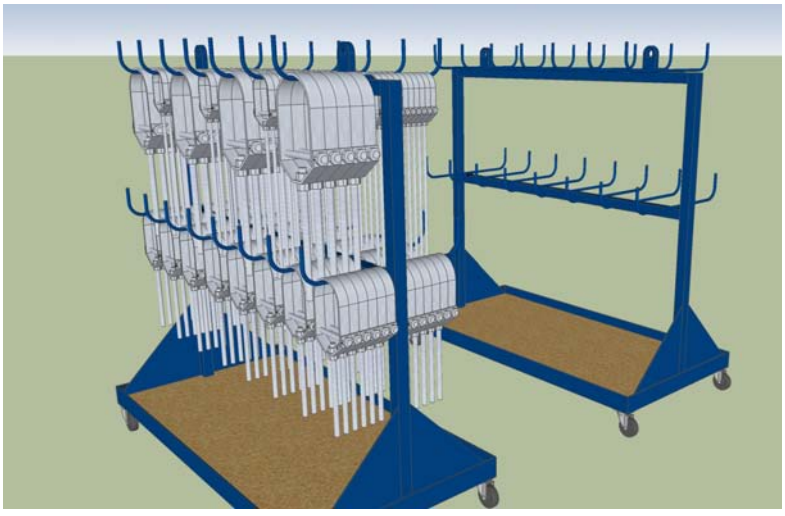
# Rolling Pipe Hanger Racks

Pipe hanger pre-fabrication can save an enormous amount of time and money for contractors. A common problem has always been how to deliver the fabricated pipe hangers to the jobsite in an organized manner. A solution that John J. Kirlin developed is to build a rolling pipe hanger rack.

This rack was built so that it could organize various sizes of pipe hangers and be transferred to the jobsite. The rack is set on 4" casters and not more than 3 feet wide to allow it to move easily in the shop, through doors on the jobsite. On its top, hang points are built in to allow it to be hoisted up with a crane.

This design uses a small amount of 2" square steel tubing for the vertical and horizontal frame. The floor of the rack has a plywood base so that additional materials needed for installation can be transported with the hangers to the jobsite.

Steel rings were attached to each side to be able to attach documents and drawings with the hangers as well.



Based on this design, a 3D model was created in SketchUp. To see it, click the following link.

## Nipple tightening Socket Wrench

This socket wrench has a nipple tightener that can fit into a closet carrier

*Photo courtesy of Neptune Plumbing*

## Carrier Bolt Bit for Power Drill

Getting that socket wrench deep into closet carriers is difficult enough, but this bit can attach to turn any power drill to speed the process and reach some difficult bolts.

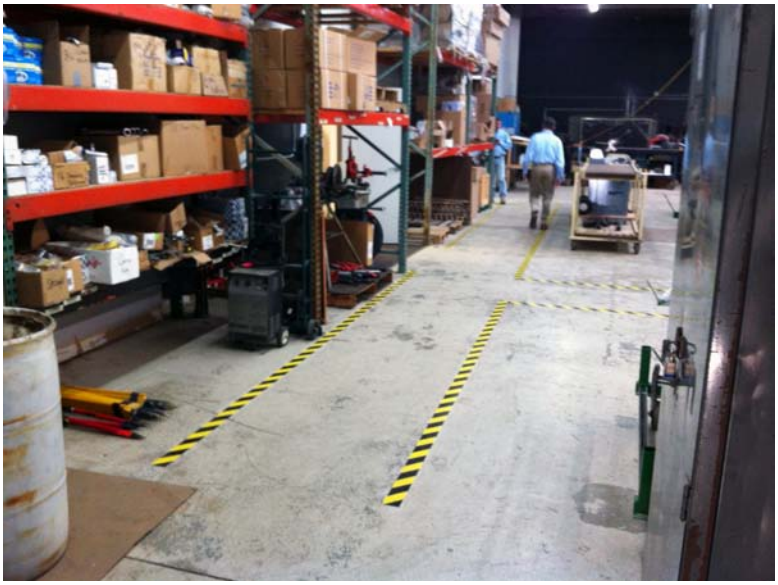

*Photo courtesy of Neptune Plumbing*

## Dunk Tank for Plumbing Batteries

When testing for leaks on large plumbing batteries, it is sometimes difficult to detect the location of pinhole leaks. SA Communale developed a dunk tank to drop plumbing batteries into if they fail air pressure tests.

With the dunk tank, the entire battery can be placed underwater. After pressurizing the system, multiple leaks can be identified immediately by looking for bubbles.

When constructing the dunk tank, verify that the tank itself is water tight before filling with water.



## Identifying Transit Paths

Although this seems a simple solution, but using warning tape to identify transit paths improves organization and material handling.

Items will be placed within their designated areas and as materials are moved from one station to the next, you are guaranteed a clear path. Less time will be spent clearing the way putting down and picking up items or reorganizing an area.