Chapter 1

Successful Estimating Principles

THE CRUX OF SUCCESSFUL CONTRACTING

Successful contracting is built on a foundation of complete and accurate estimates with valid markups for overhead and profit.

That means bids must cover the direct costs of labor, material, equipment and subcontractors, plus the indirect overhead costs of the company as well as providing some profit.

PRIMARY GOALS OF CONTRACTING AND BIDDING

The primary goal of an estimate is to cover all costs as they probably will occur when the job is completed, while still having a reasonable chance of getting the job and of being able to meet acceptable plan, spec and performance criteria.

The primary goal of a markup for overhead costs on bids is to cover the total of the overhead expenditures for the year, and that all the projects contribute their proportionate shares.

The primary goal of a markup for profit is to provide money for capital investments, a return on the corporate investments and as a reward for the hard work and risks. If you can't end up with sufficient earnings on investments commensurate with the burden of contracting, then it might be advisable to put the money into CD's or bonds and take it easy.

The primary goal of contracting is to make money, not lose it. It is not just to keep the company going some way or the other, or keep a lot of people employed.

Preparing complete and accurate bids is the first and most vital step in contracting and survival is predicated on it.

A Valid Estimate Leads to:

- A more positive approach to doing the job well and profitably with everything following more smoothly and positively from the beginning of the contract and on through the completion.
- Satisfied customers and repeat business.
- Fewer call backs.
- Easier to focus on the job, and on meeting plan, spec and performance requirements, rather than on how to skimp to make up for estimate shortcomings.
- Covering all overhead expenses such as rent, office salaries, machinery etc.
- Making a profit, a return on investment, money for capital investments.
- Personal satisfaction.

Poor Estimates Lead to:

- Losing money.
- Risky invalid cost cutting.
- Poorer job quality, loss of repeat business.
- Puts contractor behind the 8 ball before the job is even started.
- More call backs and less money available for them.
- A waste of time and energy business-wise leading to losses or maybe a breakeven situation.

A sale based on a deficient estimate is not a sale—it's a donation or a trade-off at best!

PROBLEMS AND CAUSES OF POOR ESTIMATING

Estimating sheet metal and piping construction projects can be a risky and error prone process and mistakes can and do happen.

The Problems

- Rushing, not allowing or having enough time to do a thorough and accurate job.
- Not all items included that should be.
- Not getting valid, acceptable, competitive equipment quotations.
- Not getting valid, acceptable, competitive sub-contractor quotations.

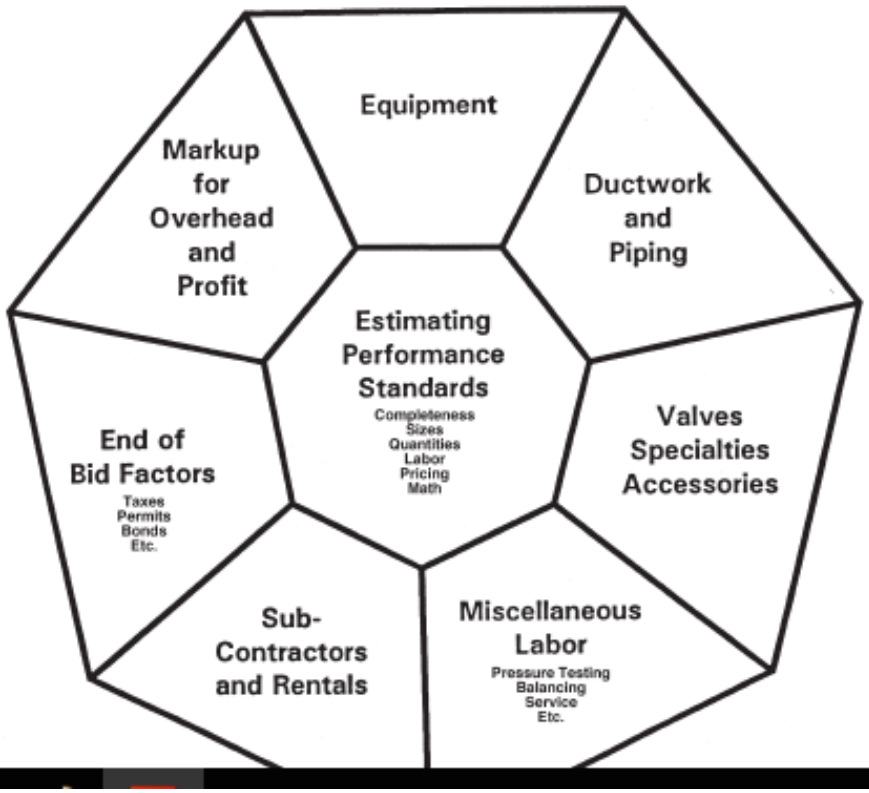
- Mistakes in math, extensions, summations, summaries, recaps, transferences.
- Wrong quantities of items.
- Missed taking off some ductwork or piping.
- Mistakes in labor calculations.
- Insufficient breakdown of the estimate for the particular project, for adequate estimating accuracy. Too much budgeting, rough pricing for expediency.
- Poor, inadequate overhead or profit markups.
- Not checking estimate thoroughly.
- Inadequate, unclear or incomplete information in plans, specifications, designs, bidding instructions.
- Unpredictable and uncontrollable job site conditions.
- Imperfect or incomplete labor or cost records for estimating purposes.
- Self delusions on prices, labor and markups.
- Incompetence or inexperience of the estimator.
- Negligence or indifference causing poor pricing or label selections.

ESTIMATING COMPETENCE REQUIRED

Hence estimating is a relatively difficult, complicated and judgmental type affair and must be handled with great care by competent, reliable and well trained personnel.

(See the beginning chapters on basics in the sheet metal and piping sections for the requirements of proficient sheet metal and piping estimators.)

Eight Facets of the Estimating Diamond
The Main Categories of an HVAC Estimate



The eight facet categories of estimating must be covered completely and accurately in order to produce valid estimates. Thinking in these terms and keeping them clearly in mind, aids greatly in planning, organizing and remembering everything in an estimate. It's a convenience technique which results in complete and accurate bids.

PERFORMANCE STANDARDS FOR COMPLETE AND ACCURATE ESTIMATES

There are six absolute performance criteria to be met in an estimate.

1. **Completeness**
   - The first and most important goal of a bid is that it is complete. All items must be included that should be and those that shouldn't -are not.
   - All implicit, related and accessory items, which are integral parts of a system or normally furnishes as industry practice must be included.
   - The major categories of an estimate must be completely covered.
   - Bastard items, which vary as to whether you are to furnish or not from job to job, must be thoroughly checked out on every project you bid to determine whether you are to include it or not.
   - Watch out for slippery end of bid factors which as permits, bonds, sales tax, items which like bastard items, may or may not be required and must be checked out each and every time.

2. **Based On Valid Sizes or Ranges**
   - Exact detailed sizes is the most accurate basis for labor and material.
   - When size ranges are used for estimating, this must be a valid correlation with the average size in the group. The broader the size group, the greater the risk of inaccuracy.

3. **Quantities Correct**

Another major goal of an estimate is correct quantities. Do you only have twenty grilles when there should be thirty, or do you only come up with 40,000 pounds or galvanized ductwork when there should be 50,000?

You only measured 800 linear feet of flexible tubing but there's really 1000 feet. You scaled the sheet metal housing as fifteen feet long and it really needs to be 20 feet long.

4. **Labor Hours Correct**

Labor is one of the toughest areas to get right and the greatest risk area. It is, however, absolutely necessary to be reasonably correct and to adequately cover the possible variances.

5. **Pricing Correct**

The pricing on your raw materials, equipment and subs all must be correct. Using $1.25 per pound for stainless steel when it really costs you $2.00 per pound later is a foolish donation to the customer and money lost out of your wallet.

Make sure you have the right price for the quantity you are working with, higher prices for small quantities and discounted prices for larger amounts.

Obtain a sufficient number of quotations on equipment and subs so that you know that the price is competitive and not too high or low. Check and compare them for performance and exclusions.

6. **Math Accurate**

All math operations must be correct, complete, and actually performed. Math errors are subtle and mischievous, and you are not generally aware of them as they occur. A disciplined check is required to ferret them out and to verify their validity.

Extensions and summations of columns on takeoff, extensions, summary and recap sheets must be correct and complete.

Adding up labor and material columns on summary sheets is a very vulnerable area. The most drastic errors can occur in the final addition on the recap sheet where can be in 5, 6, or 7 figures.

The transfer of figures, totals etc., from one sheet to another must be done carefully and to perfection. This is an area of frequent error and of cost.

FUNDAMENTAL BIDDING RULES

Allow Enough Time to Properly Prepare Your Estimate

Errors are made due to rushing, pressures, unforeseen interruptions, not making proper takeoffs, not making complete and thorough calculations, not having time to resolve plan and spec errors, omissions, contradictions and vagueness.

Errors are made due to not having time to evaluate equipment and sub prices and to detect and resolve quote problems.

Plan to be done sufficiently ahead of time so there is time for thorough checking, problems, interruptions, for proper digestion and a final realistic perspective view of the job.

Bid Selectively

Only bid on jobs you can do well on and get at a price you can make money on, or at worst, break even on, in rare critical situations.

- You will bid fewer jobs.
- You will get a higher percentage of the jobs you do bid.
- You will cover overhead better and make a profit on jobs.
- You will do better work.
- You will be better able to absorb some of the loses that occur on projects that inevitable occur on estimates or actually on the job.
- You will avoid trading dollars on jobs.

Only bid on projects which you:

- Can get at a price you can live with and that you can be truly competitive on.
- Have experience on or you can perform well on.
- Are adequately set up for in your shop, field, project management, etc.
- Mechanics are sufficiently versed in and perform well on.
- Can effectively work into your construction schedule.
- Have adequate cash flow and operational funds.
- Project within a reasonable geographical area.
- Size of project within your realm of handling.
- Have adequate cost and labor records for accurate estimating.
- Fits into estimating schedule priorities.

Avoid bidding projects with:

- Notoriously low bidders
- Too many bidders
- Where the odds of getting the job are astronomical.
- Against companies who have obvious advantages,

Use Uniform Company Estimating Standards

Work with written, substantiated, true company labor productivity rates and material, equipment and sub costs. Have a company estimating manual. Don't let every estimator or yourself pick out their own figures or vacillate with figures from job to job, etc.

Confident and accurate estimating is based on a constant accumulation of historical data market prices. "A price is either current or it is ancient history."

Last year you used $1.25 per pound for stainless steel. You can't assume the price is still the same this year, which may be $1.50

Follow Systematic and Efficient Estimating Procedures

The benefits of a time saving and efficient approach for controlling the preparation of bids are as follows.

- It promotes efficiency and gets bids done faster.
- Duplicating work unnecessarily is avoided.
- It provides time for proper checking of the bid and for solving of problems.
- It provides a frame work for planning and scheduling estimating work realistically and effectively.
- Promotes more complete and accurate bids, more thorough take-offs and more accurate extensions and reliable pricing.
- Through this systematic procedure you will produce more estimates, reduce errors and get more jobs.

Become Thoroughly Familiar with Job Before Bidding

Become Thoroughly Familiar With Job and of the Bidding Requirements, Before Deciding to Bid and Start a Takeoff

Study the plans and specs on a job thoroughly before you decide to bid or start your detailed takeoff.

Analyze the job, the market, your qualifications and ability to compete and make money before making a bidding decision.

Study the plans, specs, bidding instructions and other documents to become familiar with what's involved in the project, what the scope is, what's included and not. Determine what the approximate budget price is, the size of the building and what rough quantities of metal and equipment there are.

Determine if there are alternates or addendum's and what the bidding instructions are.

Become familiar with the areas, floors, systems, equipment, ductwork, conditions, specialties, subs, etc.

Evaluate the competition, architect engineers, generals, agencies, and inspectors involved, cash flow, your work load, the construction schedule, your ability and ex-

Breakdown Job Sufficiently

Suit the degree of breakdown of the estimate to the degree of estimating accuracy needed on the particular project being bid.

If you just need a rough price for budget purposes, a conceptual budget price with no breakdown at all is adequate. The new 5000 square foot office building will run approximately $40,000 at $8 per square foot. This gives you an accuracy of plus or minus 25%.

If you need more accuracy but not perfection use a semi-detailed budget estimate. Breakdown the system into major component parts and rough budget estimate each part: This increases your accuracy to a plus or minus 15%.

Fans	$0.25 per CFM
Air Handlers	$0.75 per CFM
Galvanized Ductwork	$3.40 per lb
Louvers	$20.00 per sq ft

For competitive, firm bidding, which is the bulk of the bidding done, you can't live with being off 10, 15, or 25%. Consequently you must break the job down extensively, not only into its major component parts, but into more specific types, sizes, individual labor operations, and job conditions.

The general rule here is the more you break down the estimate the greater the degree of estimating accuracy.

A corollary to this is the more unfamiliar you are with the item being estimated or the more complicated it is, the greater the need for break down is to minimize inaccuracy

Do Constant Systematic Checking

Human error, distractions, interruptions, lack of sufficient information, unforeseen problems, rushing, all contribute to potential errors as the estimate is being prepared. Systematic, thorough checking is a must.

Select Sub-Contractors Carefully

Subs can frequently make or break a job. You may request only one insulation quote, get a high price and find out after the bids are in that there were lower prices on the street. It is too late then because the job normally would have lost being too high.

Check Equipment Quotations Thoroughly

- Make sure everything is included.
- Know the quantities being quoted on.
- Make sure all components and accessories are included.
- Be aware of exclusions.
- Is the equipment acceptable to the plans and specs.
- Be sure the supplier is quoting a total price for his equipment and not just a unit price.
- Obtain a sufficient number of quotes on equipment and subcontracted work so that you know your price is competitive, neither too high or too low, and complete and accurate.
- Organize and compare the quotations and select the lowest acceptable ones.

Be Acutely Aware of the Right Price for Your Company

The right price for your company and for your level of competition for any job you bid is predetermined before you start your estimate. The right price for your company must truly reflect your operations and the particular job being bid. The price for your operations is a function of

- The productivity of your shop, field, engineering and overhead labor, and your efficiency, machines, tools, facilities, methods, expertise and controls.
- Ability to buy materials, equipment and subs well.
- Your experience and expertise on the particular type building, systems, equipment, ductwork, etc. effects your pricing in relationship to other bidders.
- Know realistically and objectively what overhead percentage you need. If your overhead calls for 30% of the direct costs on a job your bidding based on volume and properly covering indirect costs, and your competitor only needs 20%, you're obviously out of competition assuming your direct costs are about the same.
- The percentage profit desired or required as a return on investment.
- Cash flow available, your financial situation and the cost of money you may have to borrow to handle the project being bid.
- Location of project. The further away you are from the construction site the less control you exercise on it, the higher transportation, delivery, room and board costs are, and the weaker your knowledge and control is of local manpower.

HOW TO ESTIMATE LABOR ACCURATELY AND REALISTICALLY

There are a number of sources and techniques for deriving sound labor figures for estimating that you can draw from, such as job cost records, time studies, experience, previous estimates and de-tailed break down analysis, etc. as follows:

1. Know How Labor Varies

The factors that make labor vary are:

- Size
- Type
- Material
- Volume
- Duplications
- Number of Labor Operations
- Number of Component Parts
- Productivity of Man Power
- Building Conditions
- Assembled or Broken Down

A single large 50,000 CFM air conditioner broke down into many parts being installed in the penthouse of a forty story building takes a gross amount of labor compared to an assembled AC unit being installed on the first floor of an office building.

2. Cost Records

Labor on previous similar jobs, systems, equipment, ductwork, etc. completed in the past is one of the most valid sources of labor at your disposal.

Your labor record on the previous low rise office building shows you fabricated the low pressure galvanized ductwork at 45 lbs/hr and installed at 24 lbs/hr under normal building conditions. This is vital and usable cost data for your next office building estimate.

3. Time Studies

Time studies, rough spot checks on single items, or group of items is the second most valuable source of labor data. We are not talking about using a stop watch and measuring every motion to the "nth" degree, rather a more general and loose approach.

You ask your mechanic in the shop to keep separate time on a 36"x12" radius elbow he happens to be fabricating and he reports back it took 2-1/2 hours.

You note that a two man crew took 32 man hours to install 100 linear feet of 24 gauge ductwork weighing 730 pounds. This works out to be 26 lbs/hr.

You record the above times on your time study record sheets for future estimating reference. Repeated time studies may be needed of the same items to determine the true average and the range of variation.

4. Previous Estimates

Previous estimates which were prepared in detail and were found to be reasonably in the market range can be yardsticks as to what you subsequent estimating prices should be.

Your last two hospital bids may have run about $12 per square foot of building and the ductwork about $3.70 per pound. These figures can be your guide and comparison for the current hospital you are bidding.

5. Experience

Experience is a vital factor in determining labor not only for the labor times in an estimate but in knowing thoroughly all operations, tools and materials involved.

You recall it took about 24 man hours to install a fan on a previous job. Or you reconstruct in your mind the step-by-step process and approximately how long it took to install a built-up housing on another project.

A consensus of labor times and procedures to perform some work, from a number of people, can turn out to be a very valid source.

6. Detailed Breakdown and Analysis

A detailed breakdown and analysis of an item into all of its component parts and individual operations, for things you're not very familiar with and have no cost records on or which are very complicated, is effective in determining labor.

You break down a kitchen hood into all its parts, tops, sides, front, back, filter rack, and so on, You then calculate the material and labor for each part separately and as well as the assembly labor. In calculating the labor per part you may have to determine what all the sub operations are such as shearing, layout, forming, etc. Set up times may have to be taken into consideration.

7. Correlation and Curves

Make sure your labor times are based on valid correlations. That means that the unit labor used is a true function of whatever the labor is being related to.

The labor to install automatic and fire dampers relates very well to the linear feet of semi-perimeter while the cost of furnishing, the material and fabrication labor corresponds more reliably to square footage.

Round ductwork and flexible tubing correlates to the diameter for installation labor and to the circumference for furnishing costs.

Galvanized ductwork labor corresponds better to the piece of ductwork than to the pound or square foot.

Make quick calculations with curves and cover the entire spectrum of sizes. Cost and labor curves give you a feel as to how costs and labor vary with size etc., graphically portray relationships, help you become familiar with the nature of the cost variations and allow for interpolation and extrapolation.

Curves are relatively simple to work with. A four point plot with the points equally spaced going the entire span provides good accuracy, versatility and a tremendous savings in time. No need to make a time study for every point.

Man
Hours
of
Labor

SIZE:

8. Use Labor Correction Factors

Coming up with the correct labor on an estimate requires using correction factors to adjust labor up or down for various conditions and requirements.

You start with common denominators for standard conditions and add or subtract percentages for variations such as floors, duct heights, congestion, wide open areas, special spaces, temperatures, existing conditions, local labor and so on.

Ductwork on the 14th floor takes about 20% longer to install than on the first floor to compensate for additional vertical transportation of materials and men.

Thirty-foot-high ductwork requires a 1.3 factor over standard ten foot high ductwork.

Large open areas install faster and standard installation times can be reduced 15%.

9. Use Valid Labor Averages

Your final objective in estimating labor in a bid is that each component is based on valid labor averages corrected for variable conditions, and that the labor variances up and down will balance themselves out overall so that the total labor is correct in the end.

The range of potential labor variance from the average labor for each item used in the bid must be in a acceptable and reasonable range. The average labor used in a bid must be based on a truly average situation or on a sufficient number of labor studies to make it a valid arithmetical average.

you have your valid 32 hour average.

And finally, with all the minute variations in conditions, personnel, equipment and other unpredictable and uncontrollable things in the construction industry, realize that estimating labor is sometimes an approximation or judgment matter rather than an exact science.

DO YOUR HOMEWORK

Keep Cost Records

Keep sufficiently detailed separate cost records on the following items, as a minimum.

- Costs on equipment, raw materials and subs.
- Weights on galvanized ductwork, specialties, special metals.
- Shop labor on galvanized ductwork, specialties and special materials.
- Field labor on galvanized ductwork, equipment. Indicate productivity rates such as Lbs/Hr on galvanized in both shop and field. Monitor on a monthly basis comparing equipment, material, labor, sub costs, hours, weights and rates with estimate. Analyze final costs and adjust subsequent estimates accordingly.

Keep Up to Date with Your Market and Competitors

Know the approximate dollar volume of construction work in you geographical area of work, and what percentage market penetration you desire and are geared for.

Know how many contractors are competing with you, what their expertise is, the size of their operations, volume of work, bidding and markup strategies, etc.

Be Technically Competent,
Knowledgeable and Up to Date

Be knowledgeable about what you are estimating. Know your trade, systems and equipment, how the work is properly done, all the parts needed, what the components and accessories are, the operations involved and type of materials, tools and machinery needed. (See sections on proficient sheet metal and piping estimators.)

USE TIME SAVING ESTIMATING TECHNIQUES

Diagram color, write notes, mark whatever is needed on the plans, specs, forms you use.

Plans and specs are all too frequently hazy, incomplete, wordy and need clarification and amplification. Riser sections may be needed. Materials', lining, insulation should be marked on plans. Operations required and component parts not obvious on plans should be indicated. Indicate lengths, quantities, etc. if it aids in your quantity surveys, in your understanding, your memory and organization.

Use Forms

Forms are an indispensable aid and guide to organized, efficient and thorough estimating. They help control the proper sequence of estimating work, continually remind you of what information is needed, lead you logically through calculations and as a result, your bids will be more complete and accurate.

Use Short Cuts

Use short cuts where it is safe to. Reduce tedious takeoff time and excessive extension work, especially if preparing bids manually.

Use a Computer for Speed and Automatic Accuracy

Use a computer for takeoffs, extensions, summaries, recaps, reports, etc. and cut the estimating time on a bids in half or a third-while at the same time greatly increasing the accuracy of the calculations, lookups and generation of valuable information, etc.

Benefits

- Cut **estimating time** in half or a third.
- Perform **lookups** of labor, prices, data with electronic speed and perfect accuracy.
- Perform all the **calculations** for entire jobs automatically and in minutes.
- Make changes in estimates with automatic and instantaneously **recalculations**.
- Print extensive, readable estimating and management **reports** instantly.
- **Focus** on the project and the bidding requirements better.
- Use **formulas, standards, labor** and **price data** which are already built into the computerized estimating system.

Many Problems Disappear with Computer Estimating

Many of the problems that occur in manual estimating automatically disappear with a computerized estimating system, as follows:

- **Rushing** and the time pressure factor is reduced.
- Mistakes in **math**.
- Cumbersome, time consuming **pencil and paper takeoffs**.
- Slow, tedious, error prone manual **lookups** of labor, prices, technical data, etc.
- The messy mass of **manual calculations**.
- The error prone **transfers** of sub totals from sheet to sheet.
- The difficulty of making **changes and recalculations** in estimates.
- Not being able to **concentrate** on the job well enough when bidding manually because of the difficulty of the process.
- The need for extensive estimating reference manuals and **paperwork eliminated**.

Please refer to chapter 22 and computerized estimating for information on the Win-Duct and Win-Pipe estimating systems.

APPLY VALID OVERHEAD AND PROFIT MARKUPS FOR THE JOB AND YOUR COMPANY

Include Valid Overhead Markup

Every job must have a markup that is sufficient to provide it's proportionate share of overhead costs based on the type of job it is, volume of business you are doing and total overhead costs for the year.

Include Profit

- Profit must provide an adequate return or investment, commensurate with other available yields and the risk involved.
- Profit is necessary to buy new machinery, build facilities and other capital investments.
- Profit is necessary as an incentive and reward for hard work, accomplishment and personal satisfaction

Systematic, Efficient, Accurate Estimating Procedures

BENEFITS

The following is an efficient, systematic, organized, time saving procedure for controlling the preparation of your bids which provides the following benefits:

- It promotes more complete and accurate bids, thorough takeoffs, accurate extensions and reliable pricing.
- It promotes efficiency. You get your bids done faster. You avoid duplicating work unnecessarily. You can get certain things done at the same time following the critical path methodology, which leads to the ultimate shortest amount of time to complete the estimate.
- Bids are more likely to get done on time and thereby allow time for proper checking and solving of problems. Hectic 11th-hour scrambling is avoided.
- It provides a frame work for planning and scheduling estimating work realistically and effectively.
- Through this systematic procedure more estimates will be produced with fewer efforts and you will get the jobs you should and not the ones you shouldn't.

STEPS IN ESTIMATING PROCEDURE

1. Preliminaries

This first step of the procedure is a crucial one and it sets the ground work for a proper bid.

The preliminary survey is a systematic, highly organized approach to becoming thoroughly familiar with a job before preparing an estimate and getting into the quagmire of details.

- In the preliminary survey you study the plans, specs and other documents to become familiar with what is involved in the project, what the scope is, what is included and not, what the approximate budget price is, what the size of the building is and what rough quantities of metal and equipment there are.
- You determine if there are alternates or addenda and what the bidding instructions are.
- You become familiar with the areas, floors, systems, equipment, ductwork, conditions, specialties, subs, etc.
- You determine intelligently and realistically if you should bid the job or not by evaluating the competition, architect engineers, general contractors, agencies and inspectors involved, cash flow, your work load, the construction schedule, your ability and experience to do the job, your competitive stance and amount of time to bid the job.
- And lastly you use the preliminary survey as your note sheet and check-off list.

2. Notify Suppliers

Immediately after finishing the preliminary survey, notify sub-contractors and equipment suppliers that you will be needing a quotation from them, so they will have adequate time to prepare it, can do so simultaneously as you prepare your bid, and have it ready in time.

Also, make arrangements for any forms needed, pre-qualifications, written proposals, bid bonds, bid deposit checks, etc. so that they are ready at the bid time.

3. Perform Quantity Takeoffs and Extensions

Before beginning the takeoff of ductwork and equipment study the plans and specs thoroughly, mark and color the drawings. Highlight different types of duct runs, piping lines and insulated runs in color as required to distinguish one from the other. Locate and mark alternate and addendum areas and conditions that require labor adjustments. Take off major equipment first, then ductwork, piping and small equipment and then specialties.

List everything on the summary sheet, grouping items in the major categories; equipment to start with, then ductwork, piping, specialties, special labor and minor subs.

Price out raw materials, extend shop and field labor and total the labor columns.

4. **Calculate Miscellaneous Labor** based on quantity takeoffs and extensions, etc.

5. **Summarize**
Enter totals from takeoff extension sheets.

6. **Obtain Supplier Quotations**
Call for the quotations that have not come in yet. Make sure they have essential in formation on them such as quantities, types, manufacturers, accessories, exclusions, delivery, do they meet plans and specs, and are materials, sizes, performance correct, etc. Organize and compare the quotations and select the lowest acceptable ones. Plug numbers into summary sheet and total material column.

7. **Obtain Sub Contractor Quotations**
Check, compare and select sub-contractor quotations.

8. **Make Thorough Check**
Make a thorough check at this point of everything done to this point. Check all takeoffs, extensions, summations, transferences, pricing, labor, etc. Have someone else study project itself and review your estimate. Reread plan, specs, notes, quotes, etc. Have someone else check the math.

9. **Do Recap, Markups, Final Price**
Transfer correct totals from summary sheet to the recap sheet. Price out labor and summarize subs. Put in end of bid factors such as sides tax, performance bonds, material and labor increases, contingencies, etc.

Determine the proper markup for overhead and enter. Add everything together and add the desired profit to it. Recheck Recap.

10. **Submit Bid**
Submit a proper, qualified bid noting inclusions and exclusions and exceptions to plans and specs.

The above diagram shows a complete, fast and efficient procedure for preparing sheet metal and piping estimates. The diagram shows the correct sequence of operations and the main areas of work. It follows the critical path method showing the sheet metal and piping estimator, HVAC equipment supplier and sub-contractor within the bid time frame.

Avoid wasting time and money preparing estimates by locating, identifying and clarifying different duct runs, systems and special requirements before the takeoff is made.

Mark and color drawings before you make your takeoff so that you can easily follow the duct runs and systems for more efficiency, and to not accidentally miss or combine different type items.

Avoid taking off high priced stainless ductwork as much lower priced standard galvanized. Lined ductwork might accidentally be mixed in with the bare galvanized duct takeoff without being identified and then have to be re-taken off to separate it for correct pricing. Alternate areas and correction factor areas may be lumped in with the whole job and then have to be broken out later, doubling the estimating work required.

CHECKING ESTIMATES

Avoiding That Sunken Feeling In Your Stomach

There are many different types of errors that occur in estimating. They are generally made without realizing it at the time, they are made on a rather consistent basis, To avoid losing money and to survive in contracting, you must ferret out the errors and rectify them.

> $70,000 is incorrectly estimated for material and labor on a job, instead of $80,000 and $10,000 is lost. A $10,000 markup is put on a job for overhead when it should have been $20,000 and another $10,000 is lost.

Items are left out, counted wrong or added up wrong. It is very difficult to prevent errors 100 percent, but you can methodically and diligently catch them and correct them.

Page 15 shows an example of typical errors made in estimating.

Causes of Errors and Poor Pricing

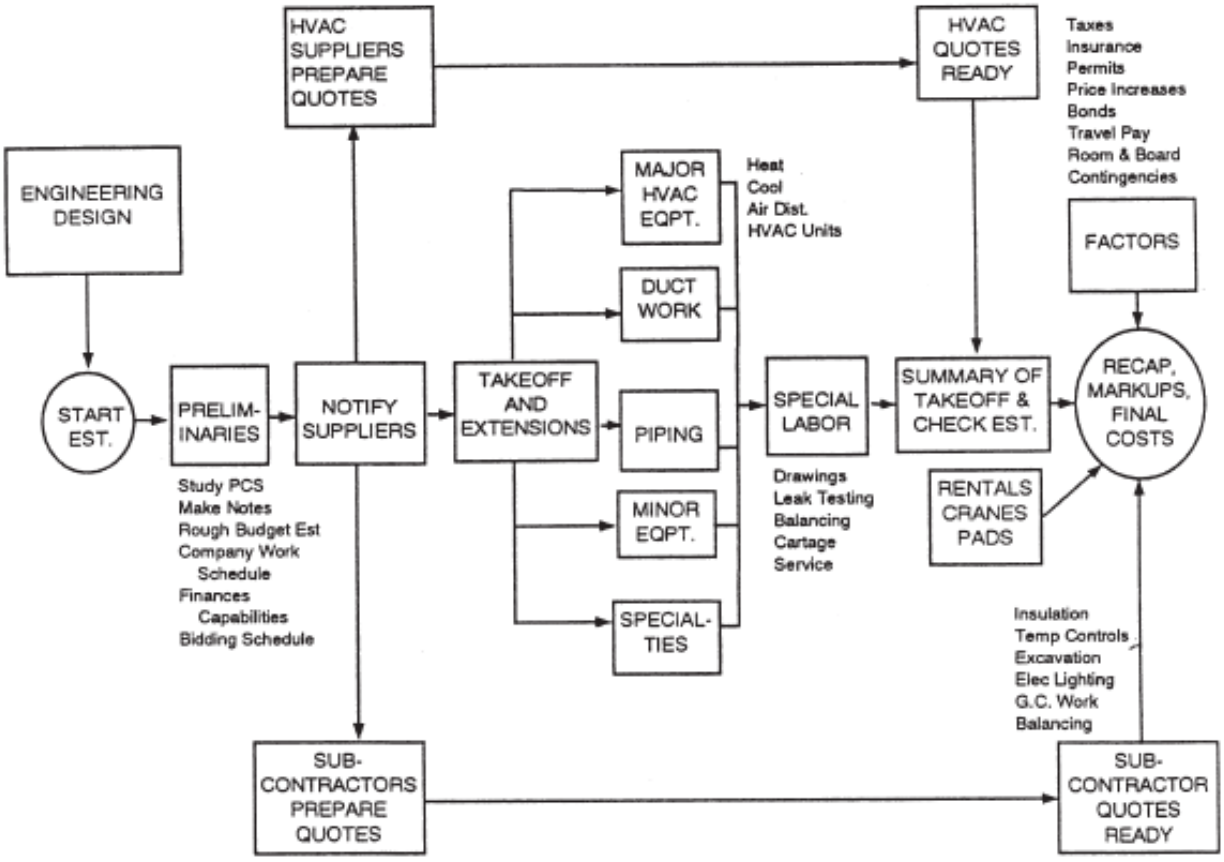
See Chapter One for the causes of errors and poor pricing in the "Problems of Estimating' section.

Procedure for Avoiding Errors

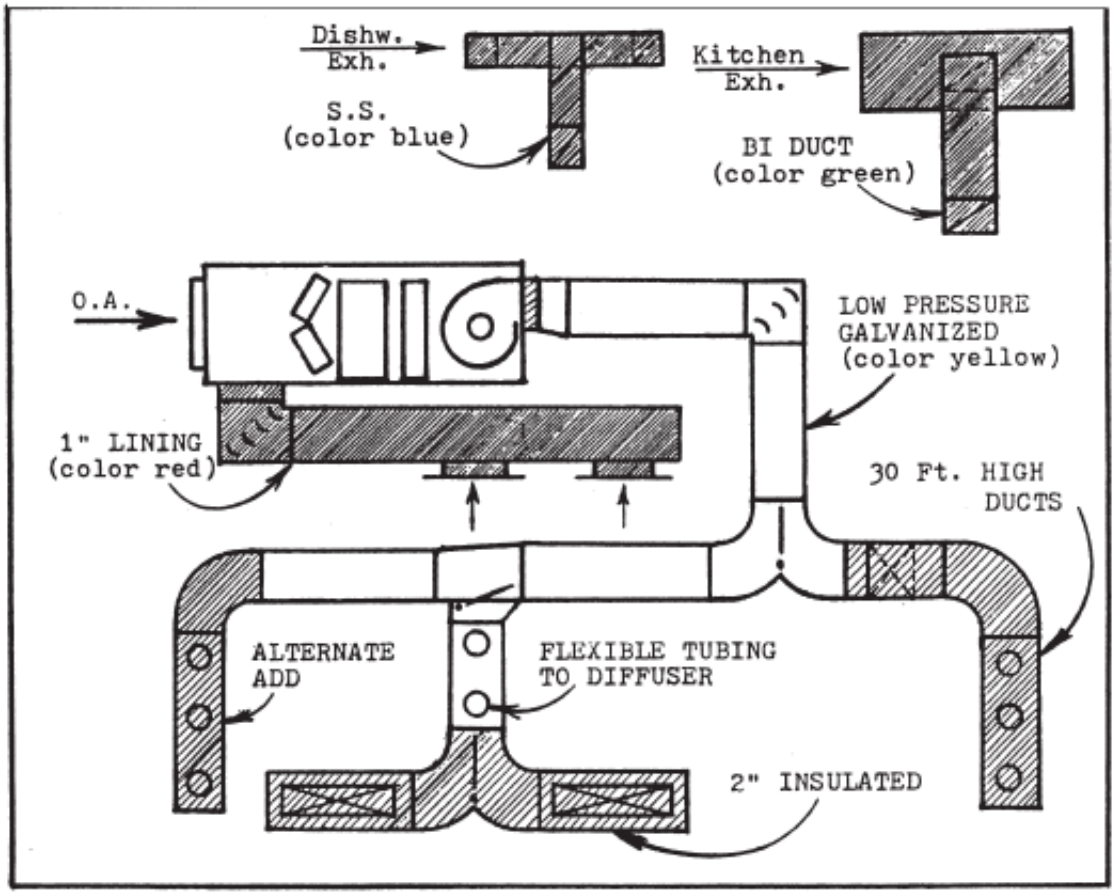
Avoid crippling loses on bids that are too low or wasting time on those that are too high due to errors by applying the following effective techniques:

1. The following aspects of an estimate must always be checked at the end of each bid.

Estimating Procedure Diagram
For Sheet Metal Work And Piping



Identify Different Items, Mark And Color Drawings Before Takeoff



Typical example showing location and identification of duct runs.

takeoff sheets. Compare the average weight per square foot of building with budget figures to see if they are reasonably close.

8. Check totals, unit prices and specific figures against **budget figures, past jobs, previous estimates** and cost records. How does the cost per pound, per ton or per square foot of building compare?

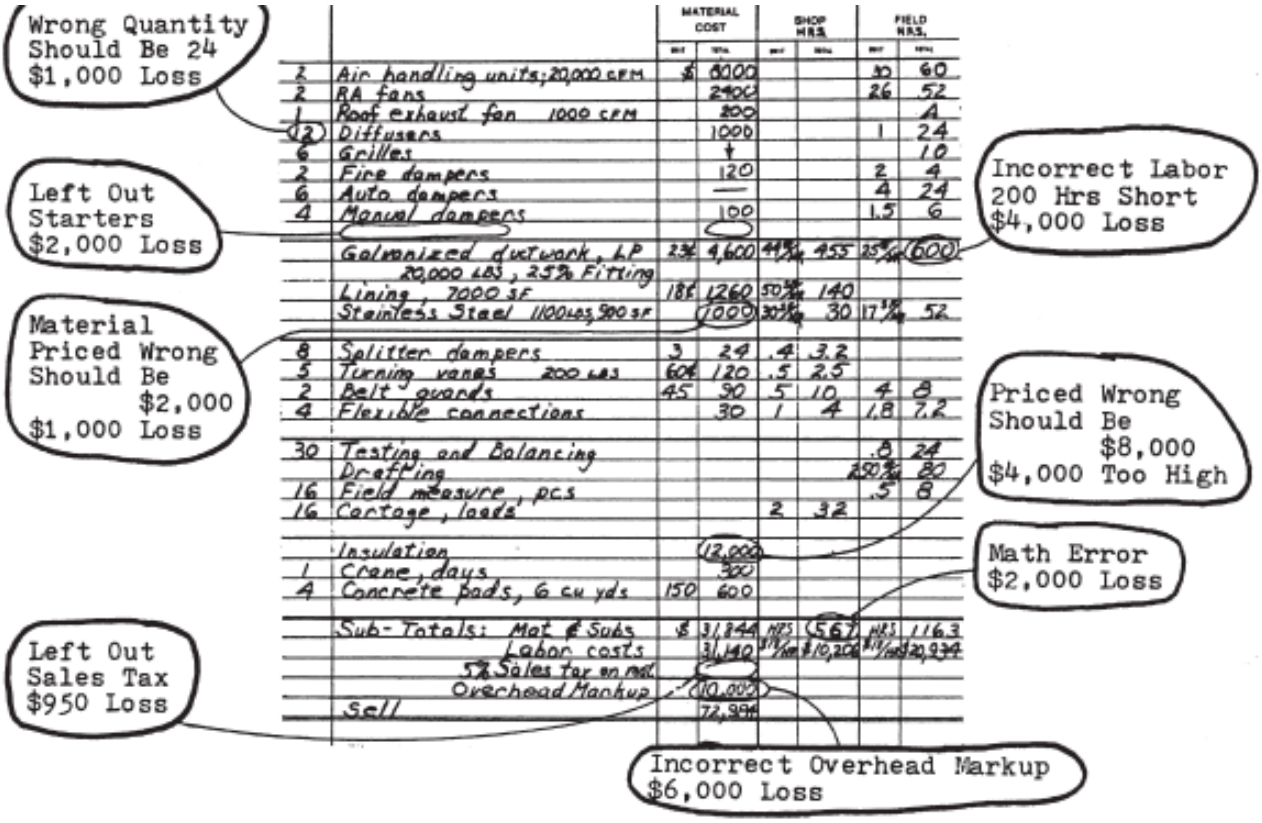
9. **Check your recap**, a horrendous place to make an error. Are the numbers transferred correctly, is the math right, are wage rates correct and are taxes, permits and bonds included. Are contingencies, risks and wage and material price increases covered?

10. Objectively **recheck your overhead markup**. What good is it if you get all your labor and material costs correct and blow it on the markup?
    What's your yearly overhead and what must this job contribute to it?
    Are you deluding yourself because you want this job badly?
    What's the material/labor ratio?
    What risks are involved?

11. Eleven can be your lucky number if you properly checked your bid... however, **if you are in doubt or the risks are very high** on a particular project, then consider not bidding. Why roll the dice and come up with a two or twelve and crap out? The risks outweigh the gain tenfold.

Check Quotations Thoroughly

- Make sure everything is included. Know exactly what is being quoted on and to what extent it is be-



ing covered. A supplier may be quoting all the steel fans but none of the PVC ones, and he may not state this.

- Know the **quantities** being quoted on. An air handling unit company may only be quoting seven units instead of the nine really required and not indicate so. This could cost an extra $4,000.

- Make sure all **components and accessories** are included. Don't find out after the bid has been accepted that the fan quote did not include $3,000 worth of inlet dampers that you are responsible for.

- If the fan wheels must be aluminum, be careful not to quote based on steel wheels. Make sure **materials** are per design.

- Note if the equipment being quoted on is to be **shipped assembled** or **knocked down**. The manufacturer may have a personal money saving plan to send the complex air handling units broken down into components for you to assemble on the job site causing many extra hours for you not covered in the bid.

- Be aware of **exclusions**.

- Is the equipment acceptable to the **plans and specs**?

- Be sure the supplier is quoting a **total price** for his equipment and not just a **unit price**.

- Obtain a sufficient **number of quotes** on equipment and subcontracted work so that you know your price is competitive, neither too low or too high, and complete and accurate.

- Organize and compare the quotation and select the **lowest acceptable** ones.

Scope of Complete Sheet Metal Estimate
Check-off List

AIR HAND. EQUIP.

HVAC Units
- ☐ Air Handling Units
- ☐ Coils, Filters, Dampers
- ☐ Roof Tops,Economizers
- ☐ Make Up Air
- ☐ Heat Recovery

Fans
- ☐ Centrifugal
- ☐ Vent Sets
- ☐ Tubular
- ☐ Industrial
- ☐ Propeller
- ☐ Isolators
- ☐ Inlet Vanes
- ☐ Drives, Motors
- ☐ Access Doors

Roof Equipment
- ☐ Roof Exhaust Fans
- ☐ Gravity Vents
- ☐ Louvered Vent Houses
- ☐ Roof Curbs

Filters
- ☐ FG Throw Away
- ☐ Washable Mesh
- ☐ Rollomatic
- ☐ Electro Static
- ☐ Bag
- ☐ Absolute
- ☐ Charcoal

Air Diffusion Equipment
- ☐ Grilles
- ☐ Diffusers
- ☐ Linears
- ☐ Troffers
- ☐ Extractors
- ☐ Slot Diffusers

Terminal Equipment
- ☐ VAV Boxes
- ☐ Dual Duct
- ☐ Reheat
- ☐ Induction

Industrial Exhaust
- ☐ Auto, Welding Exhausts
- ☐ Dust Collectors
- ☐ Scrubbers
- ☐ Paint Spray Booths

Dampers
- ☐ Manual
- ☐ Motorized
- ☐ Fire, Smoke

Electrical
- ☐ Starters
- ☐ Heating Coils

Factory Fab. Housings

Sound Attenuators

Thermometers

DUCTWORK

Galvanized
- ☐ Low,Medium,High Prs
- ☐ Spiral

Fiberglass

Round HVAC
- ☐ Flex Tubing
- ☐ Resid. Furnace Pipe
- ☐ Flues
- ☐ Collars

Industrial Exhaust
- ☐ Black Iron
- ☐ Stainless Steel
- ☐ Aluminum
- ☐ Blow Pipe
- ☐ FRP
- ☐ PVC
- ☐ PVC Coated Galvanized
- ☐ Transite
- ☐ Metal Flex. Tubing

Lining
- ☐ F.G. Flexible
- ☐ Hardboard
- ☐ Cement and Pins

SHT MTL SPECIALTIES

Duct Accessories
- ☐ Turning Vanes
- ☐ Splitter Dampers
- ☐ Bracing Angles
- ☐ Cleat, Hangers
- ☐ Trapeze Angles
- ☐ Spanning Angles
- ☐ Crossbreaking
- ☐ Seal Ducts
- ☐ Paint Ducts

Specialties
- ☐ Flexible Connections
- ☐ Belt Guards
- ☐ Hsg. Access Doors
- ☐ Exh Hoods-Kit, Lab,Shop
- ☐ Stands, Platforms
- ☐ Drain Pans
- ☐ Blankoffs, Safeoffs
- ☐ Roof Hoods
- ☐ Screens, Grating
- ☐ Expanded Metal
- ☐ Perforated Plates
- ☐ Water Eliminators
- ☐ Lead, Cork, Foam Glass

Sheet Metal Housings
- ☐ Panels
- ☐ Angles

SPECIAL LABOR
- ☐ Cartage
- ☐ Field Measuring
- ☐ Drafting
- ☐ Testing and Balancing
- ☐ Leak Testing
- ☐ Temporary Heat
- ☐ Set Up and Clean Up
- ☐ Chases and Sleeves
- ☐ Existing Buildings
- ☐ Removal
- ☐ Cut Openings, Patch
- ☐ Protection

SUB CONTRS, RENTALS
- ☐ Cranes, Hoists
- ☐ Concrete Pads
- ☐ Scaffolding
- ☐ Testing and Balancing
- ☐ Insulation
- ☐ Temperature Control
- ☐ Refrigeration, AC
- ☐ Heating
- ☐ Electrical
- ☐ Cut Openings, Patch
- ☐ Excavate, Backfill

END OF BID FACTORS
- ☐ Sales Tax
- ☐ Permits
- ☐ Travel Pay
- ☐ Room and Board
- ☐ Wage Increases
- ☐ Material Increases
- ☐ Premium Time
- ☐ Alternates
- ☐ Contingencies
- ☐ Clean Up Charges

MARKUPS
- ☐ Overhead
- ☐ Profit

Sample HVAC Estimate and Forms

OVERVIEW OF SAMPLE JOB

Sample HVAC Estimate The following sample estimate is of a small 6,800 sq ft office building with a low pressure, single zone galvanized duct system, an air handling unit and a split DX system. It includes most of the typical air distribution components in it involved in most projects such as rectangular and round galvanized ductwork, the air handling unit, the roof exhaust fan, dampers, louvers, grilles, registers and diffusers, duct wrap, acoustic liner, duct accessories, etc.

Treat as if you are the prime HVAC contractor, doing the air distribution portion while subbing out the refrigeration and heating pans.

PURPOSE OF FORMS

Forms are an indispensable aid and guide to organized, efficient and thorough estimating. They help control the proper sequence of estimating work, continually remind you of what information is needed, lead you logically through calculations and as a result your bids will be more complete and correct.

Job Description and Budget Costs Form

1. Budget estimate prices to determine if it should be bid or not, and as a check price against the detailed estimate after the bid is complete.

2. Approximate heating, cooling and CFM loads and rough out ductwork weight for check on detailed ductwork takeoff.

3. Record the key characteristics of the type of system involved.

Per Piece Duct Takeoff Sheet

Estimating ductwork labor by the piece is the most accurate and clearest method available for contractors. The takeoff involves listing the duct size, type, quantities on fittings and lengths on straight duct.

The extension of material involves totaling footages per line, entering the weight per running foot and multiplying for the total material weight on each line. The extension of labor involves totaling the quantity of pieces, looking up and entering labor hours per piece for the shop and field and multiplying out for the totals per fine. After the fines are extended the columns are totaled.

Quantity Takeoff Sheet and Extension Sheet

The quantity takeoff sheet is a general form for taking off and listing types, sizes, quantities, etc. of the various items required in a bid other than ductwork or piping, for extending the material amounts, labor, costs, etc. and summations.

Estimate Summary and Extension Sheet

The summary sheet is used as a fine item summary of all the major grouping of different items included in the estimate, from ductwork and other takeoff sheets, etc. It should be divided into the major divisions of a bid, quoted equipment, ductwork, piping, specialties and accessories, miscellaneous labor, etc.

The total amounts of material quantities, labor, etc. are transferred from duct and piping takeoff sheets, quantity takeoff sheets etc. to this summary sheet.

Bid Recap Sheet

1. Recap the job totals of direct costs on labor and prices on raw materials, equipment and sub contractors, and to total them.

2. Put markups on each group and total the overhead markup.

3. Put a profit markup on the labor, raw material, equipment and sub-contractor groups.

4. Total everything for a bottom line bidding price.

Calculating Labor Costs Per Hour

This form insures that all the components of the wage rate which include, base wage rate, normal union

fringe benefits, federal and state payroll taxes, insurance's and dues, are covered in the rate used in a bid.

Telephone Quotations Form

The telephone quotation form is for recording quotations which come over the phone, in an organized, complete and readable fashion. It includes a check-off list on the bottom of critical aspects of a quote such as, if they meet plans and specification requirements, addendum's, taxes, freight, lead times, etc. A box is provided for exceptions on what is not included.

Bidding Record Form

The purpose of the bidding record form is to have a written record of who the phone bid were given to, what the amount was, what the inclusions and exclusions were and what the plans, specifications and addenda of the bids were based on.

Specifications on Sample Job

IBM Sales Office

A. Related Documents

The general provisions of the contract, the general conditions and supplementary conditions of these specifications plus the A/A document A201-1976 "general conditions" apply to the work in this specification.

B. Scope of Work

Scope of work to include, but not be limited to the following:

Equipment

1. Air handling unit
2. Roof exhaust fans
3. Grilles and registers
4. Ceiling diffusers, lay in
5. Fire dampers with sleeves
6. Control dampers
7. Louvers

Ductwork

8. Galvanized ductwork, low pressure
9. Spiral
10. Flexible tubing
11. Flues

Sheet Metal Specialties

12. Turning Vanes
13. Splitter and manual volume dampers
14. Access Doors
15. Flexible Connections

Insulation

16. Liner, RA duct, 1," 2 lb density
17. Duct wrap, OA Duct, 1- 1/2," 3/4 lb density

Miscellaneous

18. Prepare blown up shop drawings
19. Test & balance air distribution system
20. Refrigeration piping, valves, condenser, insulation
21. Temperature Controls
22. Insulation

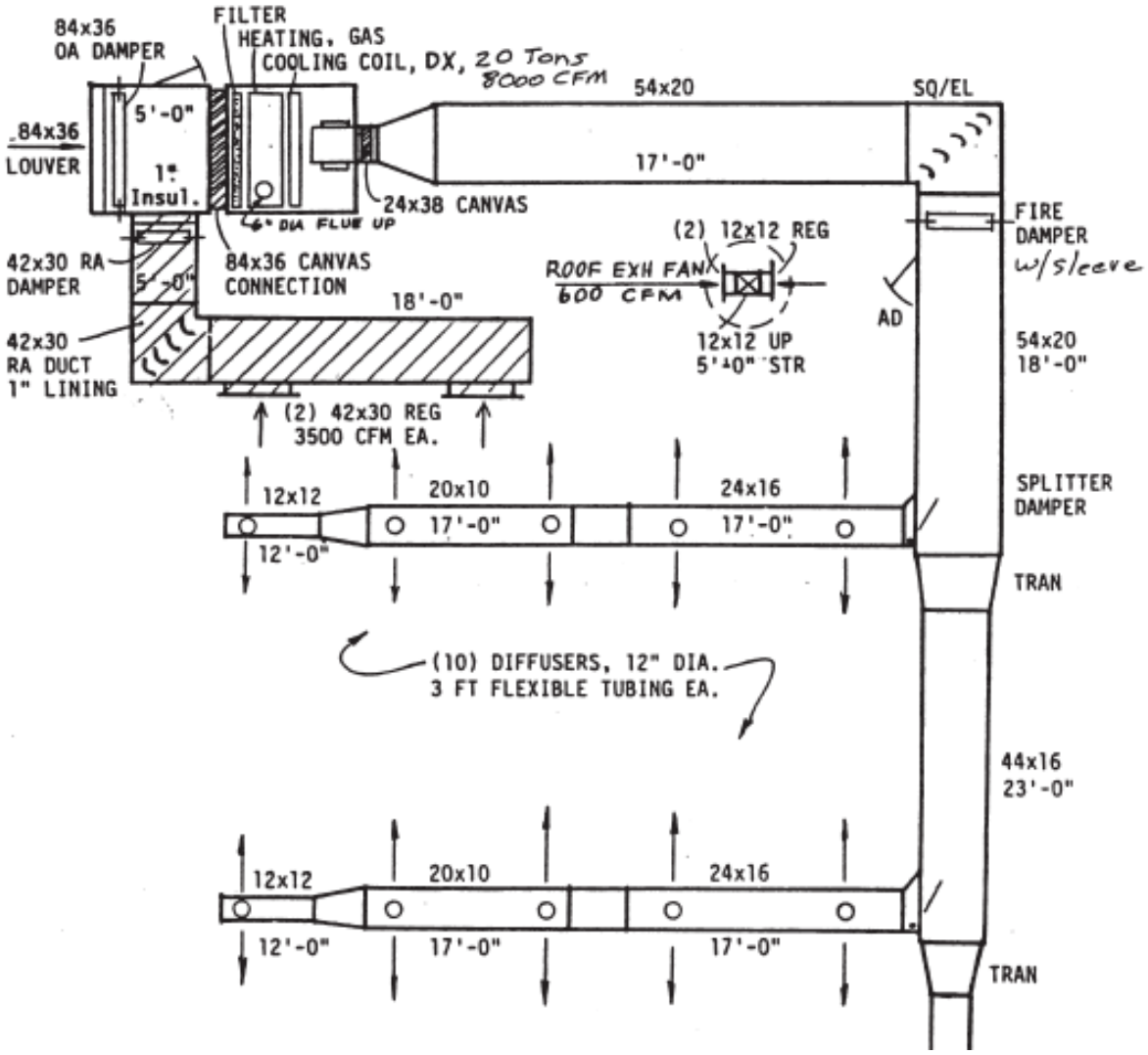
C. Work Not Included

1. Painting
2. Power wiring to mechanical equip.
3. Structural steel openings
4. Condensate piping
5. Gas Piping
6. Concrete Pads
7. Starter

IBM Offices, Drawing M-1

Low Pressure, Galvanized, Cleat Connections, SZ

Split DX System



Job Description and Budget Costs

Job IBM Offices (Low Rise) Date _____

Location _____ Distance 10 Miles

Total Project Costs $ _____ Volume of Building _____ Cu Ft

Total Area 6800 Sq Ft, Area$_1$ _____ Sq Ft Area$_2$ _____ Sq Ft

BUDGET COSTS

	COST/SQ FT BLDG	TOTAL	COST/TON	TOTAL
Total HVAC 6800 sq ft	$ 7.00	$ 47,600	$ 2,3.80	$ 47,600
Sheet Metal 3400 lbs	$ 3.50/lb	$ 11,900	$	$
Piping	$	$	$	$
Equipment	$	$	$	$
Insulation	$	$	$	$
Temperature Control	$	$	$	$
Electric	$	$	$	$

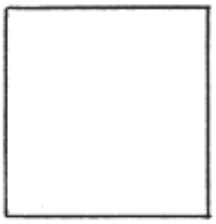
DESIGN LOADS

	Area$_1$		Area$_2$	
	Factor	Total	Factor	Total
Cooling	340 Sq Ft/Ton	20 Tons	Sq Ft/Ton	Tons
Cooling	35 BTU/Sq Ft	238,000 BTU	BTU/Sq Ft	BTU
Heating	35 BTU/Sq Ft	238,000 BTU	BTU/Sq Ft	BTU
Supply Air	1.1 CFM/Sq Ft	7,480 CFM	CFM/Sq Ft	CFM
Duct Weight	.5 LBS/Sq Ft	3,400 LBS	LBS/Sq Ft	LBS

SYSTEM DESCRIPTION

Heating Gas
Cooling Split DX
☒ SZ ☐ MZ ☒ Constant Volume ☐ VAV
Duct Pressure ☒ LP ☐ MP ☐ HP
Return Air Method ☒ Duct ☐ Ceil. Plenum
Type Outlets Diffusers
Type Perimeter Heat ☒ Air ☐ Baseboard
Temperature Control Electric

KEY PLAN



No. of Buildings Stories

CONSTRUCTION: Glass _____ Gross Area _____ Sq Ft; U _____

Exterior Walls _____ Gross Area _____ Sq Ft; U _____

Roof Gross Area Sq Ft; U

Per Piece Duct Takeoff Sheet

Galvanized

Job IBM Office Drawing _____ System S-1 ☐ Lining 1"

Type Duct: ☒ Galv, ☒ LP ☐ HP, ☐ Other Rectangular ☐ Insulation _____

DUCT SIZE	TYPE DUCT	EQUIVALENT LINEAR FEET PER PIECE	TOT LF	WEIGHT		QTY	SHOP LABOR		FIELD LABOR	
				LBS LF	Total		Hrs /Pc	Total	Hrs /Pc	Total
		STRAIGHT								
54 x 20	STR	17-18	35	21.0	735	8	.9	7.2	2.9	23.2
44 x 16	"	23	23	17.0	391	5	.8	4.0	2.3	11.5
24 x 18	"	18	18	9.8	176	4	.4	1.6	1.1	4.4
24 x 16	"	17-17	34	9.3	316	8	.4	3.2	1.1	8.8
20 x 10	"	17-17	34	7.0	238	8	.3	2.4	.9	7.2
12 x 12	"	12-12	24	4.4	106	6	.2	1.2	.5	3.0
84 x 36	"	5	5	40.0	200	1	1.3	1.3	4.4	4.4
44 x 32 L	"	5-18 (13 sq/ft)	23	21.5	495	4	.9	3.6	2.6	10.4
12 x 12	"	5	5	4.4	24	1	.2	.2	.5	.5
		STR TOTALS	201		2,681	lbs		24.7		73.4
		FITTINGS								
54 x 20	TRN	3-3 Supply	6	21.0	126	2	2.7	5.4	2.7	5.4
"	SQN	5	5	21.0	105	1	3.3	3.3	3.8	3.8
44 x 16	TRN	3	3	17.0	51	1	2.2	2.2	2.2	2.2
24 x 18	90L	6	6	9.8	59	1	1.5	1.5	1.3	1.3
"	SQRD	3	3	9.8	29	1	4.6	4.6	1.2	1.2
24 x 16	TRN	3-3	6	9.3	56	2	1.0	2.0	1.2	2.4
"	TAP	1-1	2	9.3	19	2	.6	1.2	1.2	2.4
20 x 10	TRN	3-3	6	7.0	42	2	.8	1.6	1.0	2.0
44 x 32 L	TAP	1-1-1 (13 sq/ft)	3	21.5	64	3	1.4	4.2	2.5	7.5
44 x 32 L	SQL	4 (13 sq/ft)	4	20.4	82	1	2.9	2.9	3.8	3.8
12 x 12	TAP	1-1	2	4.4	9	1	.4	.4	.5	.5
		FITTING TOTALS	56		670			32.9		32.5
		TOTAL STR & FITT.	257		3,343	lbs.		5 8	HR	106 HR

Quantity Takeoff Sheet

Job IBM Offices

DESCRIPTION: Small Equipment

Drwg Flr or Sys	Size	Description	Quantity	Total	LABOR HOURS		MATERIAL COSTS QUOTE			
M-1	84×36	Louver	1			5.0				
	56×20	Fire Damper	1			2.6				
	84×36	OA Damper	1			4.3				
	42×30	RA Damper	1			2.6				
	12" Ø	Diffusers	14		1	14.00				
	42×30	Registers	2		1	2.0				
	12×12	Registers	2		1	2.0				

Estimate Summary and Extension Sheet

Job IBM Offices
1 Story, 6,800 Soft

IBM OFFICES

	EQUIPMENT	MATERIAL COST		SHOP		FIELD	
		UNIT	TOTAL	UNIT	TOTAL	UNIT	TOTAL
1	AHU, 20 TONS, 8000 CFM, DX, GAS, 2 STAGE	$	9,953		---		18.0
1	ROOF EXH. FAN, 600 CFM		600		---		2.0
1	FIRE DAMPER, 56 x 20		110		---		2.6
1	LOUVER, ALUM. 84 x 36		465		---		5.0
1	OA DAMPER, 84 x 36		----		---		4.3
1	RA DAMPER, 42 x 30		----		---		2.6
14	DIFFUSERS, FIXED, 12"Ø, LAY IN, SQ.		340		---	1	14.0
4	REGISTERS (2) 42 x 30, (2) 12 x 12		400		---	1	4.0
	SUB TOTAL EQPT.	$	11,868				
	DUCTWORK						
	LP GALVANIZED 3330 LBS	$ .38	1,265		58.0		106.0
	LINING 447 SQ FT	.44	197	50	9.0		---
	SPIRAL 285 LBS	1.20	342		---		11.0
4	FLUES		100			.8	32.0
14 PCS	FLEXIBLE TUBING 12"Ø, 51 FT	2/FT	102		---	.7	9.8
10	COLLARS, CLAMPS, 12"Ø, $3 + $1	4	40		---	.5	5.0
	SHEET METAL SPECIALTIES						
2	TV, 56 x 20, 42 x 30 100 LBS	$ .75/LB	75		2.3		---
2	SPLITTER DAMPERS, 24 x 18, 14 LBS ea	6 ea	12	.5	1.0		---
2	REACH THRU ACC DOORS	15 ea	30		---	.5	1.0
2	FLEXIBLE CONN. 84 x 36, 24 x 38, 30ft	.80	24	1.0	1.9	1.6	4.2
	SUB TOTAL MATERIAL	$	2,187				
	SPECIAL LABOR						
	SHOP DRAWINGS, AND TICKETS		----	300/	12.0		
	FIELD MEASURING, 6 PCS		----		---	.75	12.0
	CARTAGE, 5 LOADS		----	2.5	13.0		
	BALANCING (18) OUTLETS, RTU, PRE		----				8.0
	JOB TOTALS	$	12,857		97.0		242.0
	SUB-CONTRACTORS				HR		HR
	REFRIGERATION PIPING, ETC.						
	TEMPERATURE CONTROL						
	INSULATION						

Bid Recap and Markup Sheet

Job IBM OFFICES Due Date

Location Estimator

	HOURS	WAGE RATE	COST			
Shop Labor	97	37.00	$ 3	589		
Field Labor	242	37.00	$ 8	954		
Wage Increase Shop	150	1.00	$	150		
Wage Increase Field			$			
Overtime			$			
Travel Costs			$			
			$			
			$			
TOTAL LABOR					$ 12	693
Raw Materials			$ 2	187		
Equipment			$ 11	868		
			$ 14	055		
Sales Tax 7%			$	790		
TOTAL MATERIAL AND EQUIPMENT					$ 14	854
Subcontracts Insulation, FAI, 200 SQ Ft, 1 1/2"			$	400		
Refrigeration, Condnr, Pipe insul.			$ 10	500		
Temp. Control			$ 1	500		
			$			
			$			
			$ 12	400		
TOTAL SUBCONTRACTS					$ 12	400
TOTAL DIRECT COSTS					$ 39	938

Calculating Labor Costs Per Hour

Location Typical U.S. _____ Date _____

☐Union; Local No. _____ Contract Expiration _____ Non Union _____

FRINGE BENEFITS PER HOUR

		Journeyman			Non Union
Base Rate		$26.00	$	$	$12.00
Welfare (Medical)	(%)	3.90			1.50
Pension	(%)	4.40			.35
Apprentice Fund		.55			---
National Training Fund		.13			---
Vacation Savings		1.00			.50
Industry Fund		.19			.50
TOTAL BENEFITS	%	$10.17	$	$	$ 2.85
TOTAL WITH BASE		$36.17	$	$	$14.85

PAYROLL TAXES AND INSURANCE*

F.I.C.A.	7.65 %	1.99			.91
Workman's Comp.	8.00 %	2.07			.96
Federal Unemployment	.60 %	.16			.07
State Unemployment	2.70 %	.70			.32
Liability Insurance	1.25 %	.33			.15
Property Insurance	1.00 %	.26			.12
Association Due	.60 %	.16			.07
TOTAL TAXES & INS.	21.80 %	5.67			2.60
TOTAL BASE, BENEFITS, TAXES, INS		41.84			17.45

*Percentage of Base Rate

COST PER POUND BREAKDOWN

	AT $41.84 Base, Union		AT $17.45 Base, Non	
	LBS/HR	COST/LB*	LBS/HR	COST/LB*
Material	44	.43		.43
Shop Labor	25	.95		.40
Field Labor	200	1.67		.70
Shop Drawings	800	.20		.09
Cartage		.05		.01
TOTAL DIRECT COSTS		$3.33		$1.63
Indirect Overhead %	30	1.00		1.00
TOTAL COSTS		4.33		2.63
Profit %	5	.22		.13
TOTAL SELL		$4.55		$2.76

Telephone Quotation

Job	IBM Offices
Supplier	Phone
	By

QTY	MFGR	DESCRIPTION	ACCESS-ORIES	AMOUNT Each	AMOUNT Total
1	Carrier	Air Handling Unit			$9,953
		20 Tons, 8000 CFM			
		DX, Gas, 2 Stage			
		Grand Total			

NOT INCLUDED					
		Vibration Isolators			

Meets plans and specs ☒	Taxes included ☐
Addendums included ☒	Freight included ☒
Type materials correct ☒	Lead time required 6 weeks
	Price good for 60 days

Bidding Record

Job IBM Office Building Due Date July 15, 1997

Location _____ Time 2 pm.

BID SUBMITTED TO:

Company	Name	Phone	Amount	Remarks
Kemper G.C.	T. Richman	981-2038	$48,272	
Cochran Builders	F. Andrew	439-9252	$48,272	
Quinn Contr's	R. Burke	870-8662	$47,050	Exclude Insul.

INCLUSIONS	EXCLUSIONS
Equipment	Power Wiring
Sheet Metal	Painting
Piping	Structural Steel Openings
Insulation	Plumbing
Temp. Control	

Budget Estimating

There Are Three Basic Types of Estimates

1. Conceptual or budget estimating
2. Semi-detailed budget estimating
3. Detailed estimating

BUDGET ESTIMATES

A conceptual budget estimate is a quick, approximate price without extensive quantity surveys or pricing calculations of the specific of items that comprise a bid.

Contractors use conceptual budget estimates in the following ways:

- To help determine if they should bid a job or not.
- To know approximately what the total price of a project should be before preparing a detailed estimate.
- Quick pricing for customer, general contractor or A/E.
- As a check of your estimate after you're done.
- For budgeting purposes, comparing design costs, feasibility studies.
- As a check on current market pricing.
- For negotiating.
- To check incoming bids and quotations.

There are two basic types of budget estimates, one for budgeting the overall price of the project or trade, and the other, the semi-detailed one, for budgeting individual component parts and totaling for the job.

The conceptual estimate issued for overall pricing, is a rough approximation based on some unit of measurement of the building or system:

- 10,000 sq ft Office Building @ $7.00/sq ft for HVAC = $70,000
- 100 Tons of Air Cond. in a Store @ $1500.00/Ton = $150,000
- 100,000 sq ft High School @ $9.00/sq ft for sheet metal = $900,000

Conceptual pricing should normally not be used for bidding with any firm commitment on the price. Your price may be reasonably accurate, even right on, but it also can be off the mark 20 to 25% one way or the other due to variations in design, scope, etc.

You may look at an office building, figure $7.00/sq ft, find out later, upon closer inspection or doing the job, that this particular office building runs $8.00/sq ft and you lose $20,000 on a 20,000 sq ft job.

SEMI-DETAILED SCOPE BUDGET ESTIMATES

Semi-detailed budget estimates, the second basic approach to pricing construction work is far more accurate than a conceptual one. It is "on" more frequently and only has a potential inaccuracy of 10 to 15% while still being a very speedy way to price without the tedious, length takeoffs and extensions.

In semi-detailed estimating you break the job down into component parts, as you would a fully detailed one, listing all the individual items on a summary and extension sheet. But instead of a long exact take off on each and extensive pricing, the quantities and the prices of the various components are budgeted; i.e., they are approximated in some expedient manner.

A thorough preliminary survey is made, again, as you would on a fully detailed bid, to insure covering and knowing the entire scope of the project and so that spec requirements are met.

Ductwork Budgeting

Ductwork weight is approximated by using an average weight per square foot of building, or by measuring the total linear footage with a measuring wheel, and multiplying it times the approximate average weight per linear foot.

Ductwork costs for the project are then found by multiplying the budget price per pound or per foot, based on inspection and judgment, times the approximate weight or linear footage.

Piping Budgeting

- Main Piping Runs Per Foot
- Piping Assembly Hookups To Equipment Per Assembly Price

Equipment Pricing

Equipment costs are determined in one of two ways. If the equipment has been sized and specified suppliers can furnish approximate pricing. The second pricing is budgeting by the cost per CFK square foot, linear foot, etc. or by the size. Equipment labor is determined either by the average size or the specific sizes.

Again, as with conceptual budget estimates, it is very risky business bidding firm quotes based on semi-detailed estimates. However, you can chance it, when the situation demands it by adding 10 or 15% on top to cover the possible range of error.

Budget Estimating HVAC Costs and Engineering Loads Per Square Foot of Building and Per Ton

TYPE BUILDING		HEATING COOLING LOAD		DUCT LOAD	SUPPLY	WEIGHT	TOTAL HVAC SELLING PRICE	
		Btu Per Sq Ft	Sq Ft Per Ton	Btu Per Sq Ft	CFM Per Sq Ft	lbs Per Sq Ft	Per Sq Ft	Per Ton
Apartments, condominiums		25	480	26	0.8	0.2	85.22	82,491
Auditoriums		40	300	40	1.3	0.8	13.56	4,066
Banks		48	250	26	1.6	1.2	14.71	3,672
Bowling Alleys		40	300	40	1.3	0.6	10.66	3,197
Churches		36	330	36	1.2	0.5	11.65	3,848
Clubhouses		50	240	40	1.6	1.0	10.39	2,491
Cocktail Lounges		70	170	30	1.3	1.2	14.71	2,497
Computer Rooms		140	85	20	4.5	1.5	30.67	2,602
Colleges:	Admin., Classrooms	44	270	42	1.5	1.3	21.50	5,810
	Dormitories	--	--	25	--	0.3	12.28	--
	Gyms, Fieldhouses	--	--	40	0.5	0.3	9.12	--
	Science Bldgs.	54	220	55	1.8	1.4	16.47	3,622
Court Houses		50	240	36	1.6	1.2	14.83	3,555
Fire Stations		--	--	35	--	0.7	9.12	--
Funeral Homes		30	400	32	0.9	0.8	10.36	3,522
Hospitals		44	170	28	1.4	1.5	28.76	4,885
Hotels		34	350	28	1.1	0.5	7.99	3,432
Housing for Elderly	--	--	28	--	0.2	7.84	--	
Jails		25	460	30	0.8	1.2	13.93	5,810
Laboratories		60	200	50	2.0	1.5	27.72	5,546
Libraries		46	260	37	1.5	1.3	15.95-	4,148
Manufacturing Plants		40	300	36	1.3	0.4	5.83	1,748
Medical Centers, Clinics		35	340	35	1.1	1.0	10.36	3,522
Motels		30	400	30	1.0	0.5	6.72	2,683
Municipal Bldgs., Town Halls		45	265	36	1.4	1.2	15.21	4,027
Museums		34	350	40	1.1	0.8	11.41	3,990
Nursing Homes		43	280	34	1.4	0.5	13.69	3,827
Office Bldgs:	Low Rise	35	340	35	1.1	.5 to .8	10.36	3,522
	High Rise	40	300	30	1.3	1.1	14.83	4,446
	Small Plant Off.	34	350	35	1.1	0.5	7.40	2,590
Police Stations		42	285	35	1.3	1.0	9.99	2,850
Post offices		44	270	40	1.4	1.2	15.21	4,103
Project Homes		--	--	28	--	0.1	3.64	--
Restaurants		60	150	35	2.0	1.0	16.34	2,224
Residences		25	500	30*	0.8	0.3	4.84	2,406
Schools:	Elementary	--	--	26	0.8	0.7	11.41	--
	Middle, Jr. Highs	36	333	26	1.0	1.1	14.56	4,409
	High schools	33	360	40	1.1	1.3	13.44	4,831
	Vocational	20	600	40	0.9	1.5	30-90	--
Stores:	Beauty Shops	63	190	30	2.0	1.3	16.47	3,127
	Department	34	350	30	1.1	0.7	9.26	3,235
	Discount	30	400	32	1.1	0.4	6.36	2,217
	Retail Shops	50	340	32	1.6	0.8	10.64	3,616
	Shopping Centers	30	400	30	1.1	0.4	5.22	2,076
	Supermarkets	30	400	32	1.0	0.4	5.45	2,179
Theaters		40	300	40	1.3	0.8	10.51	3,152
Warehouses		--	--	20	--	0.2	3.82	--

1. Cooling load based on is temp. differences, 50% RH, 400 CFM per ton.
2. Heating load based on 70 temp. differences and is the output Btu.
   Apply inefficiency factor to heating equipment for input Btu.
3. Price includes all HVAC material, labor and subs and overhead and profit.
   *R-11 wall and R-19 ceiling insulation

Budget Estimating Galvanized Ductwork Per Pound and Per Foot

Standard Low Pressure HVAC Rectangular Galvanized 25 Percent Fittings, New Construction, 10 Foot High, 1st Floor

SIZE	SEMI-PERIM Inches	GAUGE	LB/FT w/20% Waste	SQ FT/FT No Waste	SELLING PRICE * Furnished & Installed Per Lb.	Per Ft.
6x6	12	26 Ga.	2.8	2.0	$5.14	$14.39
12x6	18		3.3	3.0	4.96	16.34
12x12	24		4.4	4.0	4.77	22.07
18x6	24	24 Ga.	5.6	4.5	4.77	26.71
18x12	30		7.0	5.0	4.62	33.24
24x9	33		7.7	6.5	4.54	34.94
24x12	36		8.4	6.0	4.47	37.49
24x15	39		9.2	6.5	4.47	41.07
30x12	42		9.8	7.0	4.38	42.99
30x18	48		11.2	8.0	4.31	48.26
30x24	54		12.6	9.0	4.23	53.34
36x12	48	22 Ga.	13.6	8.0	4.23	57.57
36x18	54		15.3	9.0	4.13	63.11
36x24	60		17.0	10.0	4.00	68.04
42x12	54		15.3	9.0	4.13	63.11
42x18	60		17.0	10.0	4.00	68.04
42x24	66		18.7	11.0	3.97	74.27
48x12	60		17.0	10.0	4.00	68.04
48x18	66		18.7	11.0	3.97	74.27
48x24	72		10.4	12.0	3.94	80.41
54x24	78		22.1	13.0	3.91	86.40
54x30	84		23.8	14.0	3.88	92.32
54x36	90		25.5	15.0	3.85	98.12
60x15	78	20 Ga.	26.0	13.0	3.88	100.85
60x24	84		28.0	14.0	8.50	108.60
60x30	90		30.0	15.0	3.85	115.44
72x24	96		32.0	16.0	3.82	122.14
72x30	102		34.0	17.0	3.79	128.75
72x36	108		35.3	18.0	3.74	132.03
84x30	114		38.0	19.0	3.82	140.38
84x36	120		40.0	20.0	3.67	146.53
84x42	126		42.0	21.0	3.63	152.56
96x24	120	18 Ga.	52.6	21.0	3.60	189.44
96x36	132		57.2	22.0	3.57	204.25
96x48	144		62.4	24.0	3.54	220.90
96x72	168		72.8	28.0	3.51	255.51
96x96	192		83.2	32.0	3.48	289.37

*Selling price based on $.42 per pound for galvanized, $39.00 per hour for labor, a 30 percent markup on direct costs for overhead and a 5 percent markup for profit. The price includes material and all labor for the fabrication, installation, drafting and shipping.

CORRECTION FACTORS ON SELLING PRICE OF GALVANIZED DUCTWORK

1. Percent fittings by weight,

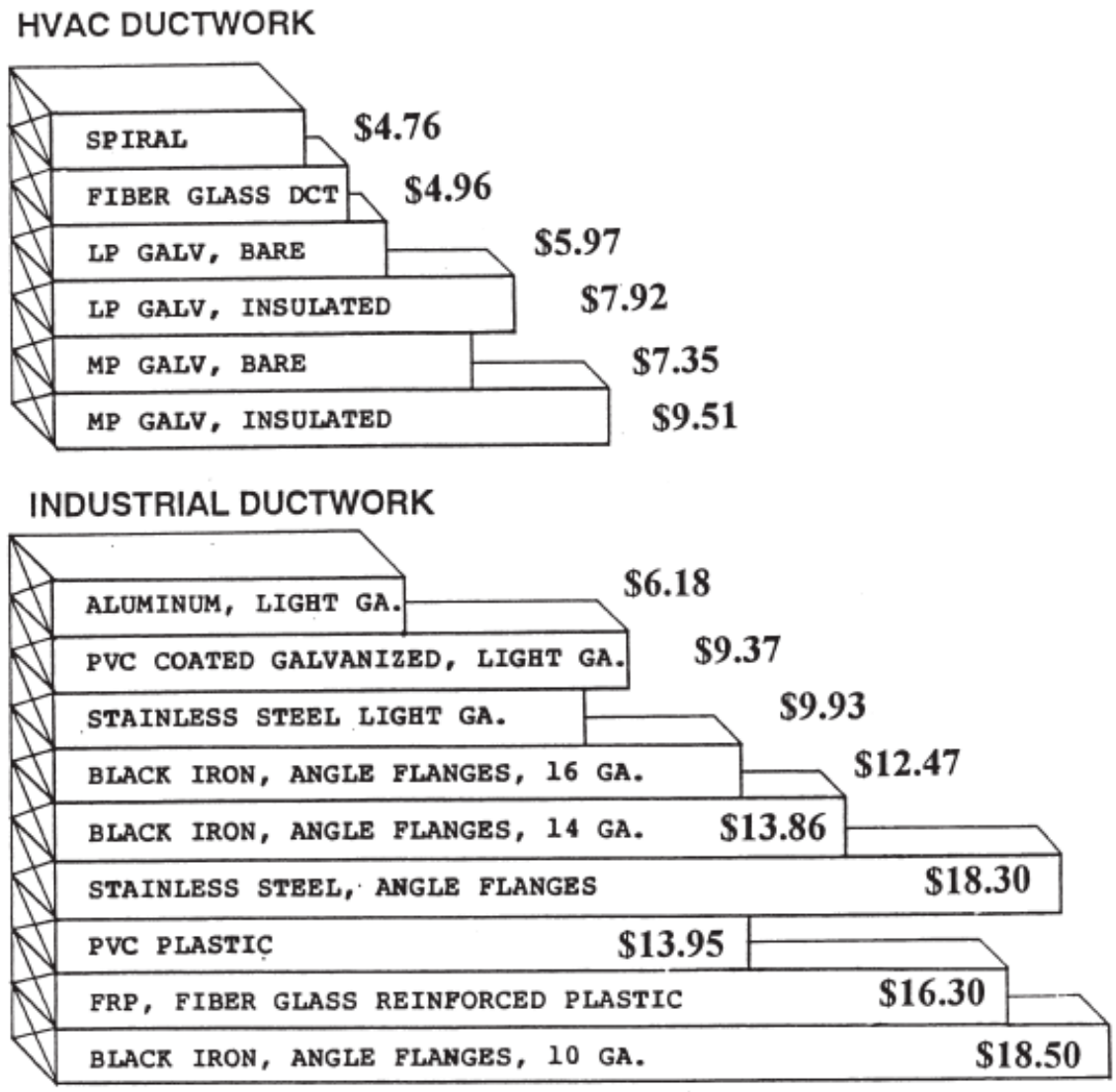
15%	0.09	25%	1.00
35%	1.08	45%	1.15

2. Different wage rates (incl. base pay, fringes, payroll taxes, ins.)

$12.00	(per hour) 0.66	$22.00	0.89
15.00	0.77	26.50	1.00
18.00	0.80	30.00	1.08

Installed Price Per Square Foot for Different Types of Ductwork

Average Size 24″x12″ in a Typical Mix
25 Percent Fittings by Square Feet



Installed price per square foot includes material, shop labor, field labor, shop drawings, shipping and a 35 percent markup on costs for overhead and profit. Labor is based on $39.00 per hour.

See the others

Chapter 5

Heating and Cooling Equipment

The equipment tables in Section III of this manual are designed to maximize the accuracy of the selections from the tables.

- The left columns in the tables show the size or capacity of the particular piece of equipment, alternate units of measurements if required and sometimes secondary factors-which altogether make selections more specific and realistic.

  Column one might be the capacity of the equipment in typical units such as GPM, BtuK KWs, watts, MBH, tons of cooling, CFM of air, etc. The size might also be denoted in actual dimensional units such as 24" x 24."

  The second factor in the sizing and capacity columns might involve a condition such as feet of head along with gpm as with pumps.

  In some cases, there may be another condition listed long with gpm and feet of head; such as the horsepower of a motor for a particular unit.

- The middle columns involve the direct material costs for each size plus a unit cost based on the units of measurement being used for the size category. For example, a certain GPM pump might have a unit material cost of $41.00 per gallon.

- The right columns show the labor in man hours, the total direct costs of labor and material together and the installed selling price with overhead and profit included.

Read all equipment estimates on this page

Chapter 6

HVAC Units and Air Distribution Equipment

The equipment tables in section III of this manual are designed to maximize the accuracy of the selections from the tables.

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- The right columns show the labor in man hours, the total direct costs of labor and material together and the installed selling price with overhead and profit included.

Chapter 7

Plumbing Fixtures and Specialties

This chapter contains labor tables for plumbing fixtures such as:

- Lavatories and Sinks
- Toilets and Urinals
- Drinking Fountains
- Tubs and Showers
- Kitchen Products
- Fire Protection Equipment
- Water Meters
- Carriers and Supports

In addition, this chapter covers labor tables for plumbing specialties such as:

- Drains: Floor, Roof, Scupper and Gutter types, Floor Cleanouts
- Back Flow Preventers

Current and local prices for bidding purposes are to be gotten through quotations from suppliers or from a suppliers pricing manual.

Plumbing Fixtures
Labor Only

	Labor
Lavatories	
Wall Hung	3.26
Comer	4.15
Counter Top	3.05
Sinks	
Counter Top	4.46
Floor	5.95
All Purpose	5.28
Instrument	6.75
Toilets	
One Piece Toilet	3.05
Two Piece Toilet	4.00
Wall Hung	4.76
Bidet	3.05
Urinals	
Wall Hung	4.76
Floor Mounted	5.95
Trough	6.75
Women's w/FV	5.35

Plumbing Fixtures
Labor Only

Drinking Fountains	Labor
Wall Hung	2.96
Wall Recessed	3.27
Freeze Proof	3.78
Free Standing	4.47
Tubs	
Cast Iron Corner	7.48
Cast Iron Recessed	7.48
Cast Iron Square	7.48
Showers	
One Piece Fiberglass Shower and Tub	8.94
32" Square Shower Stall	7.35
36" Square Shower Stall	7.48
36" Corner Shower Stall	7.48
Kitchen Products	
Dishwashing Machine, 45 inch	23.95
Dishwashing Machine, 54 inch	27.90
Dishwashing Machine, 64 inch	32.50
Dishwashing Machine, 80 inch	35.50
Garbage Disposal, 1-1/2 BP	5.95
Garbage Disposal, 5 Bp	9.95
Ice Maker, 225 lbs, 24 hours, Air Cooled	5.95
Ice Maker, 225 lbs, 24 hours, Water Cooled	5.95

Plumbing Fixtures
Labor Only

Fire Protection Equipment	Labor
Fire Hose Cabinet w/Valve & 75' Hose	3.00
Hose Valve with Cap & Chain	2.80
Fire Pump	
500 GPM	50.80
750 GPM	53.35
1000 GPM	62.20
1500 GPM	69.00
2000 GPM	95.00
2500 GPM	104.80
3000 GPM	131.50
3500 GPM	140.00
Fire Extinguishers	
Manual Pull Station	1.25
CO_2 High Pressure System	
75 Lb Cylinder	2.45
100 Lb	2.95
FM200 System	
25 Lb Container	1.85
45 Lb	2.15
65 Lb	2.45

Plumbing Fixtures
Labor Only

Water Meters	Labor
Commercial / Residential—Bronze	
1/2" to 1"	0.55
1-1/4" to 2"	1.08
3"	5.00
4"	9.80
6"	15.05
8"	18.60
Carriers / Supports	
Adjustable Siphon Jet Single Water Closet	
4"-5"	1.80
Adjustable Siphon Jet Double Water Closet	
4"-6"	3.20
Offset Single Blowout Water Closet	
4"	1.80
Offset Double Blowout Water Closet	
4"	3.20
Floor/Wall Mount Urinal	1.80
Lavatory	1.55
Sink	1.55
Drinking Fountain	1.55
Water Coolers	1.55

Plumbing Specialties
Labor Only

Drains	Labor
Floor Drain—Standard	
2" Dia	1.32
3" Dia	1.42
4" Dia	1.58
5" Dia	1.79
6" Dia	2.00
Roof Drain—Standard	
2" Dia	1.58
3" Dia	1.68
4" Dia	1.84
5" Dia	2.10
6" Dia	2.37
Scupper Drain—Standard	
2" - 4" Dia	0.95
5" - 6" Dia	1.10
Gutter Drain—Standard	
2" Dia	1.32
3" Dia	1.42
4" Dia	1.58
5" Dia	1.79
6" Dia	2.00

Plumbing Specialties
Labor Only

Cleanouts	Labor
Floor Cleanout	
2" Dia	0.86
3" Dia	0.92
4" Dia	1.09
5" Dia	1.51
6" Dia	1.70
8" Dia	1.89
Wall Cleanout	
2" Dia	0.50
3" Dia	0.53
4" Dia	0.56
5" Dia	0.59
6" Dia	0.61
8" Dia	0.65
Backflow Preventers	
Threaded Bronze	
3/4"	1.23
1"	1.46
1-1/4"	1.93
1-1/2"	2.16
2"	2.84
Flanged Iron	
2-1/2"	4.00
3"	4.39
4"	5.80
6"	8.52
8"	10.33
10"	12.35

Plumbing Specialties
Labor Only

Backflow Preventers	Labor
Union Bronze	
3/4"	1.23
1"	1.46
Double Check Valve Threaded	
3/4"	0.78
1"	0.95
1-1/2"	1.14
2"	1.39
Double Check Valve Flanged	
2-1/2"	2.41
3"	4.02
4"	5.55
6"	8.07
8"	9.99
1001	12.16

Chapter 8

Air Pollution and Heat Recovery Equipment

AIR POLLUTION EQUIPMENT

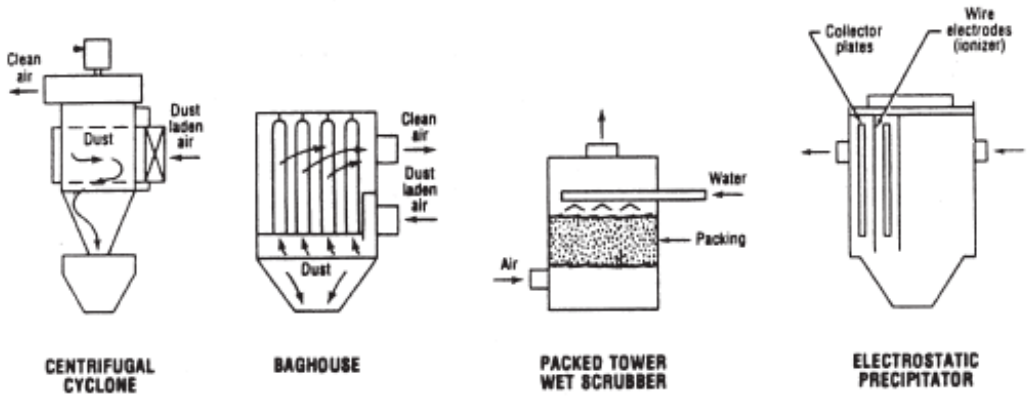
There are four basic types of collectors, each with its own variations. These are: centrifugal cyclones, baghouses, scrubbers, and electrostatic precipitators. Collectors are rated by the size of particles they can remove, by percentage efficiency of removal of different size particles, and by permissible temperature ranges, pressure drops, air volumes, and water usage.

Cyclones are dry centrifugal collectors that remove particles down to approximately 10 microns at efficiencies in the 80 to 90 percent region. Particles are removed by centrifugal force and drop down into a hopper while the cleaned air goes out the top of the unit. There are three variations of cyclones. The first is the large diameter, low resistance type, which is most efficient in the 40 to 60 micron particle size range. The second is the medium efficiency cyclone, which has a smaller diameter housing and is generally used for 20 to 30 micron sized particles. The third cyclone is the high efficiency, small diameter model, which is very efficient in the 10 to 15 micron range.

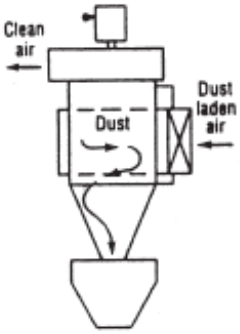
Baghouses are dry collectors that clean like a vacuum cleaner, incorporating a number of tubular, stocking-like fabric filter bags. They can collect dry particulates such as dust and fumes only and cannot be used for gases or liquids. They are highly efficient, reaching a 99.9 percent level on 1 micron size particles, and operate best in the 0.25 micron size range. Pressure losses are higher, around 3 to 8 inch WG, and are dependent on the air-to-cloth ratios involved. There are two basic types of fabric collectors, distinguished by the method of bag cleaning and direction or air flow. The mechanical baghouse has motorized shakers to remove dust from the insides of the vertical tubes. The dust laden air flows up and into the tubes, then out through the fabric. The other type of baghouse is pneumatically cleaned-air is used to clean the bags rather then mechanical shakers-and there are three variations: reverse air flow, reverse jet, and pulse jet.

Wet scrubbers can be used for particulates, gases, and liquids. Liquid droplets in a scrubber capture particulates mechanically while gases are removed through absorption. There are a number of different types of scrubbers such as packed towers, venturi, wet centrifugal, wet dynamic, orifice types, and fog towers. Efficiencies range from 90 to 99 percent for particles in the 1 to 5 micron range. Mgh energy scrubbers remove particles in the 0.25 to 1 micron range. Wet scrubbers are often divided into three groups according to pressure losses, theses being 4 to 8, 8 to 25, and 25 to 60 inch WG, respectively.

Electrostatic precipitators are used primarily to collect particulates such as welding fumes and some mists. Efficiencies are in the 98 to 99 percent range for 0.25 to 1 micron particles. A precipitator employs an ionization process whereby incoming particles are made negative and then collected on a positive plate through magnetic attraction. The collector plate is periodically cleaned by rapping, causing the particles to fall away by gravity.



Four basic types of collectors



High Efficiency Centrifugal Cyclone Collectors

Includes Fan

CFM	DIRECT MATERIAL COST		LABOR	TOTAL MATERIAL & LABOR	
	Each	Per CFM	Man Hours	Direct Cost	with 30% O&P
1,000	$2,605	$2.60	8	$2,917	$3,792
3,000	6,216	2.07	10	6,606	8,588
5,000	8,658	1.73	15	9,243	12,016
8,000	11,248	1.41	20	12,028	15,636
10,000	12,876	1.29	25	13,851	18,006
15,000	18,870	1.26	32	20,118	26,153
20,000	24,272	1.21	38	25,754	33,480
25,000	28,860	1.15	44	30,576	39,749
30,000	33,744	1.12	50	35,694	46,402
40,000	43,216	1.08	58	45,478	59,121
50,000	-----	-----	---	-------	-------
60,000	-----	-----	---	-------	-------

CORRECTION FACTORS	MATERIAL	LABOR
1. Medium efficiency cyclone		
2. Low efficiency cyclone		
3. Wet centrifugal cyclone		1.25

Chapter 9

Sheet Metal Estimating Basics

REQUIREMENTS OF A PROFICIENT SHEET METAL ESTIMATOR

The crux of successful contracting is built on a foundation of complete and accurate estimates with proper markups.

Solid estimates are produced by competent and reliable estimators. Good sheet metal estimators are developed through the following background of knowledge, procedures, skills and abilities:

ESTIMATING PRINCIPLES AND PROCEDURES

1. They must follow sound efficient procedures for preparing estimates, such as:

- Become thoroughly familiar with the project, the types of systems and ductwork involved, in the scope of work, etc. before starting detailed takeoffs.
- Be Familiar with budget estimating; HVAC costs for different buildings based on cost per square foot of building or cost per ton of air conditioning, amount of ductwork per square foot of building or by the average size, cost of ductwork per linear foot, per pound or per square foot.
- Know the major categories of an estimate:
  - Equipment
  - Ductwork
  - Piping
  - Duct Accessories and Sheet Metal Specialties
  - Special Labor
  - Sub-Contractors
  - End of Bid Factors (such as sales tax)
  - Markups for Overhead and Profit
- Must be familiar with detailed scope of what is required in a sheet metal estimate.
- Highlight drawings before doing the takeoff.
- Follow systematic overall procedure.
  - Study the plans and specs
  - Send out quotation requests
  - Highlight Drawings
  - Make Takeoff; and Extensions
  - Summarize
  - Recap and markups
- Do constant systematic checking on each part as you go along and overall at the end. Double check everything.

2. They must have the ability to read blue prints, recognize symbols, types of ductwork, equipment and systems, etc.

Air Distribution Systems

3. They must be familiar with the different types of HVAC systems such as:
   - Low pressure constant volume systems
     - Single zone, reheat coils, multi-zone
   - High pressure constant volume systems
     - Dual duct, induction, reheat terminals
   - Variable air volume
     - Cooling only, cooling / reheat terminals
     - Fan powered, dual duct
     - Induction, multi-zone
     - System powered, riding fan curve
     - Damper terminal by-pass
   - Exhaust systems
     - Return air, toilet exhaust
     - Kitchen, lab, industrial

They must not only recognize the various types of systems on plans, but they must know all of the components required in them, whether shown on plans or not.

4. They must know duct pressure and velocity ranges:
   - Duct Pressure Ranges:
     - 1/2 inch, 1 inch, 2 inch static pressure
     - 3, 4, 5 inch static pressure
     - 6 inch static pressure and up
   - Velocities: 0 to 2,000 fpm
     - 2,000 fpm and up, etc.

5. They must know about different ductwork system configurations such as:
   - Single Duct

Dual Duct
Multi-Zone
Loops
Plenum Ceilings

6. They must have some familiarity with air distribution system design, know the recommended air speeds, pressure drops and duct sizing and selection of equipment.

Types of Ductwork

7. A sheet metal estimator must be familiar of the different types of ductwork and their correct construction.
Rectangular galvanized: Low, medium and high pressure
Low pressure round ductwork; flues, flexible tubing
Spiral pipe and fittings
Light gauge aluminum, stainless, PVC with cleats, pittsburghs
Heavy gauge metals; black iron, stainless, aluminum, galvanized, corton, etc.
PVC, FRP, Sundstrand

8. They must know the correct applications of different types of ductwork materials to various systems:
Low, medium, high pressure HVAC systems
General exhausts
Fume exhausts
Heat exhaust systems
Chemical exhaust systems
Abrasive material systems

Ductwork Construction

9. They must be familiar with the different type of connections for each type of ductwork and their correct application to different types of systems.
Cleats; drive, flat S, standing S, bar, reinforced bar
Transverse; TDC, TDF
4 bolt connections
Angle flange, vane stone
Bent angle flange
Butt welded
Slip, couplings

10. They must be familiar with different types of seams used for constructing ductwork.
Pittsburgh
Snaplock, lockseam
Welded

11. They must be familiar with the different gauges used for ductwork and specialties.
Commercial galvanized 26 through 16 gauge
Residential galvanized 3 0 through 18 gauge
Heavy gauge industrial 18 gauge through 1/2 inch thick plates
Fiberglass ductboard, 1 inch thick
PVC, 1/4, 3/16 inch thick

12. They must be familiar with the different types of reinforcing used on ductwork.
Angles
Channels
Cross breaking
Tie rods

13. They must be familiar with all the different types of fittings used in air distribution systems and of their correct application.
Elbows; 90°, 45°, 22-1/2°, etc.
Radius throat, square throat
Transitions; equal taper, ROT, ROB, square side, etc.
Offsets; Ogee, square
Wye fittings
Tap in tees

Estimating Materials and Labor

14. They must know the various methods of estimating ductwork.

15. A good sheet metal estimator must know how to estimate ductwork materials.
Takeoff and calculate surface square footage of material based on size, length, etc.
Add waste and seam factors
Multiply by weight per square foot

16. They must be familiar with different waste and allowance factors for seams, cleats, hangers, hardware, etc.

17. They must know the methods of estimating ductwork labor such as:
Per Piece — Per Breakdown of component parts
Per Pound
Per Square Foot — Per Linear Foot
Per Batch

They must know sources of labor such as the Wendes Mechanical Estimating Manual, cost records, etc.

Correction Factors

18. They must apply labor multipliers with reasonable accuracy whenever needed to adjust for conditions, such as:
    - 5th floor takes 10 percent longer
    - 30 foot high ductwork takes 20 percent longer
    - Duplicate fittings go 33 percent faster

Accessories

19. They must be familiar with the various duct accessories and sheet metal specialties.
    - Turning vane's air foil, single skin
    - Splitter dampers
    - Canvas or flex connections
    - Single and multiblade dampers
    - Access doors

Fabrication and Installation Procedures

20. They must be familiar with fabrication procedures and machinery and how they affect labor and overhead margins. They must be familiar with plasma cutters, coil lines, seam machines, press breaks, rollers, etc.
    - Plasma cutters cut overall fitting labor in half
    - Duct coil lines reduce straight duct labor by about 70 percent

21. A Sheet metal estimator must be well versed in ductwork installation procedures, in the operations involved in installations, with hand tools, scaffolding, vermets, scissor hoists, etc.

Pricing Equipment

22. They must know sources of pricing on accessories and equipment, suppliers, price catalogues, suppliers for quotations, etc.

23. They have to know about small ventilation equipment.
    - Grilles, registers, diffusers
    - Multiblade dampers, back draft dampers
    - Fire dampers, access doors

24. They must know about sheet metal specialties such as:
    - Sheet metal housings, walk through doors
    - Belt guards, drain pans, coil stands
    - Coil blank offs

25. They must know about major HVAC equipment.
    - Roof top units, air handling units
    - Fans, filters, louvers

Wage Rates, Unions, Jurisdictions

26. They must know about wage rates, union fringe benefits, federal, state and local taxes, insurance's, etc.

27. They must be knowledgeable about union, trade and local labor jurisdictions.

28. They must be familiar with building codes.

Other Trades, Types of Buildings

29. They have to be familiar with other trades such as piping, insulation, temperature control, electrical and excavation.

30. They must be familiar with all types of buildings, commercial, institutional, their general sizes, layout, etc. and with the sequence of general construction work.

Markups

31. A good sheet metal estimator must be generally familiar with financial statements such as profit loss and balance sheets. They must be able to determine the correct markup for overhead and profit for their company and for the particular job they are bidding.

    They should understand how overhead costs are pro-rated onto direct material and labor costs for different projects, for different levels of sales and overhead costs, for different ratios of material to labor, etc.

Skills, Traits Required

32. Estimating requires a host of skills, mathematical, mechanical, reading, writing, visualizing and drawing. It requires being methodical, analytical, strategically and realistic.

33. It absolutely demands that the estimator be reliable, that they be thorough in their understanding of the project, of it's scope, in takeoffs, interpretations, extensions, summaries and recaps.

    Thus, the knowledgeable, proficient and reliable estimator as described above will be able to produce complete and accurate estimates, which in turn become the required foundation blocks of successful contracting.

TYPES OF DUCTWORK

HVAC Rectangular

1. Low pressure galvanized ductwork comprises the

Types of Ductwork Connections

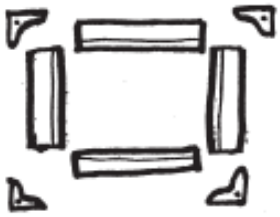
Flat and Standing Drives Cleats

Flat S Cleats

Standing S or Bar Cleats

Reinforced Bar Cleats

Purchased 4 Bolt Connectors



TDC/TDF

Angle Flanges

Bent Metal Flange

Slip Connection (Round)

Companion Angle

Van Stone

Coupling

prefer this approach for all jobs whether small with one drawing, or very large with many drawings.

The other general procedure is to takeoff everything "system by system," both the galvanized and the special round ducts. This is helpful when there is a great deal of congestion on the plans which can cause errors. Each system is taken off completely from beginning to end regardless of how many drawings it spans.

4. The general sequence for taking off the different types of ductwork, whether you do so drawing by drawing, or system by system, is as follows:

   - Make sure you have all the lined ducts, alternate areas and correction factor areas taken off first or clearly marked.
   - Follow up with the bare galvanized.
   - Do the low pressure runs first.
   - Then the high pressure ductwork.
   - Follow up with heavy gauge industrial ductwork
   - Lastly take off the round ductwork.

5. Takeoff ductwork segment by duct segment picking up all connecting branches as you go along, and complete each segment before going to the next.

6. Another approach on complicated duct runs is to take off fittings first to get familiar with the duct runs and to identify accessories etc. within the duct runs so as they are not missed. Then takeoff straight pipe.

7. Identify takeoff sheets with drawing numbers, systems, floors, type of ductwork, connection type, etc. such as "M1, S2, LP Galvanized, Lined" etc. and check off or draw a line through ducts on the drawings as they are taken off.

METHODS OF FIGURING DUCTWORK WEIGHT

1. **Weight Per Running Foot**

This is the traditional way of arriving at material weight for HVAC galvanized and other types of metal ductwork.

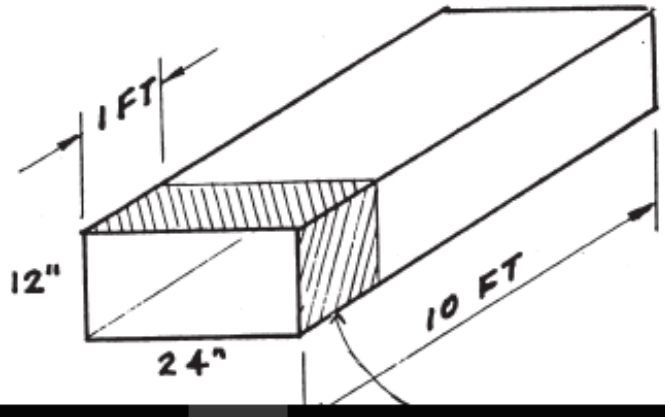
Long Hand Method

The sq ft/ft of ductwork if multiplied times the linear feet involved, then multiplied by the weight per sq ft of metal for that gauge, and finally a 20% allowance is added for waste, hangers, cleats, seams, etc.

Combining Pound Per Sq Ft and Allowance into One Factor

The factors 1. 156 lbs/SF and 1.2 allowance can be combined into a single multiplying factor of 1. 156 x 1.2 = 1.4. Hence 60 SF x 1.4 = 84 lbs.

Duct Size	Sq Ft/Ft	Length	Square Feet
24 x 12	6	10 Ft	60 SF Total
			x 1.156 Lbs/Sq Ft
			69.4 Lbs Raw
			x 1.2 + 20% allow
			84 Lbs total



Using Chart to Read Pounds Per Foot Directly

Using precalculated Lbs/Ft from chart eliminates a great deal of wasted repetitious math, calculations and writing.

When using the chart you simply determine and locate the semi-perimeter of the duct, read the weight per foot on the chart according to the gauge (which already has the 20% allowance built into it) and multiply it times the length of duct.

Duct Size	Length	From Chart Lbs/Ft w/20% Waste Built In	Total Weight
24 x 12	10 Ft	8.4	84 lbs

This is a much faster and simpler method for calculating duct weight per foot than the long hand method, converting to sq ft for lined and insulated ductwork. If the duct run happens to be lined or insulated you simply divide the total weight by whatever lbs/ft of metal you used to start with, and you will be converted to square feet.

Example: 84 lbs of 24 gauge—1.4 lbs/sq ft = 60 sq ft

2. **Square Feet Per Foot**

For non-metallic ducts such as fiberglass ductboard, plastic PVC, fiberglass reinforced plastic FRP, lining and insulation, the traditional method for determining the material required for ductwork is similar to the pounds per foot for metal ducts, except that one factor is left out, the weight per sq ft.

Example:
Using the same duct as in example from above:

Duct Size	Sq Ft/Ft	Length	Square Feet
24 x 12	6	10 Ft	6.0
			x 1.2 Waste Factor
			7.2 Sq Ft Gross

3. **Weight Per Piece**

Actual weight per piece is used based on prior weighing, or from the actual recorded amount of material used for the particular item.

* 42 x 18 transition, 3 foot long weighs 51 lbs
* 18 x 9 joint of pie, 5 foot long weighs 32 lbs

4. **Actual Sheets Needed**

Material is determined by actual sheets of metal needed to fabricate the ductwork. This is normally done for special, more expensive materials, for odd configurations, or for smaller projects.

METHODS OF CALCULATING DUCTWORK LABOR

1. **Hours Per Piece**

The actual amount of labor to fabricate or install each specific piece is predetermined and applied to the various sizes and types of ductwork to arrive at the number of hours needed. (See figure on following page.)

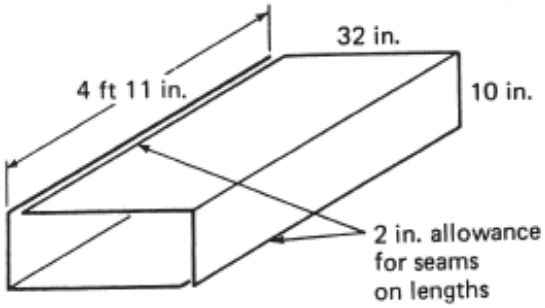
2. **Pounds Per Hour** (or hours per pound)

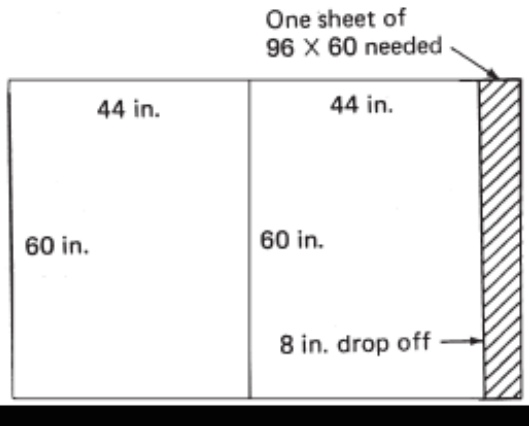
A pounds per hour productivity measurement is used to determine labor.

Shop rate for typical LP galvanized is about 44 lbs/hr

Installation rate about 25 lbs/hr

Or lbs/hr can be converted to "hours per pound."





← LP Galvanized

Shop labor 2.3 hours
Field labor 1.4 hours

30x12

44 lbs/hr divided into 1 = .023 hrs/lb
25 lbs/hr is the same as .04 hrs/lb

3. **Square Foot Per Hour**
Many special material ducts are calculated on a "SF/W" basis for labor, fiberglass, PVC, and FRP being some.

Square feet per hour is an excellent way to compare costs of different gauges of ductwork and of different types of ductwork. It does away with many of the confusing variables involved with weight and gives you a more direct comparison.

Fiberglass ducts fabricate at a rate of 55 SF/hr and install at 30 SF/hr

If you converted typical 24 gauge LP galvanized ductwork productivity rates into square feet you would get:

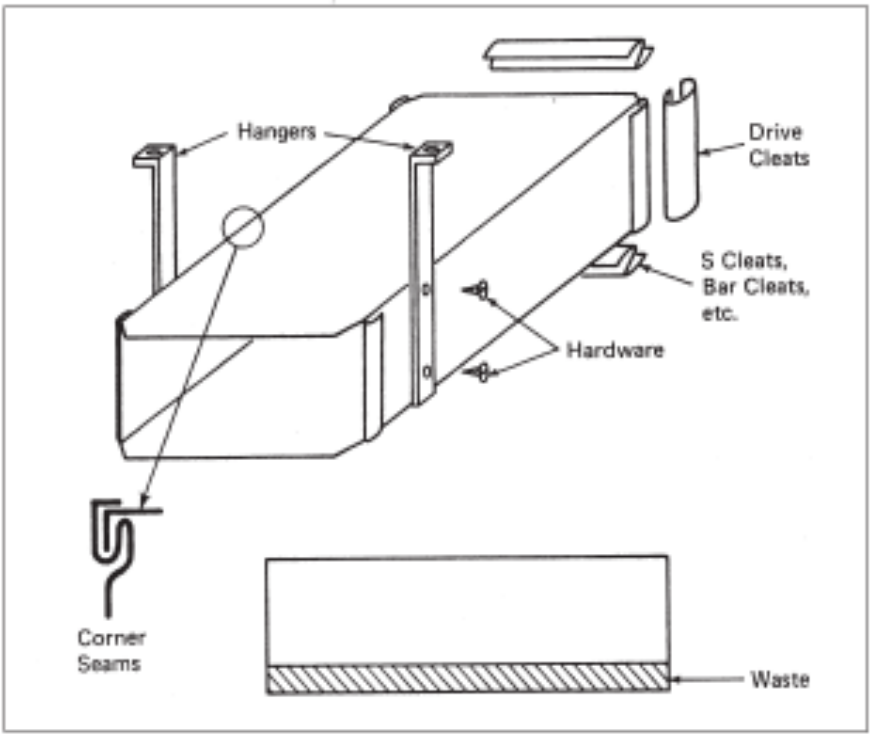
$$\frac{44\ \text{lbs/hr}}{1.150} = 38\ \text{SF/hr} \qquad \frac{25\ \text{lbs/hr}}{1.150} = 22\ \text{SF/hr}$$

4. **Man Days**
The time needed to fabricate or install ductwork or equipment is calculated in terms of days it would take one man or a crew to perform the work.

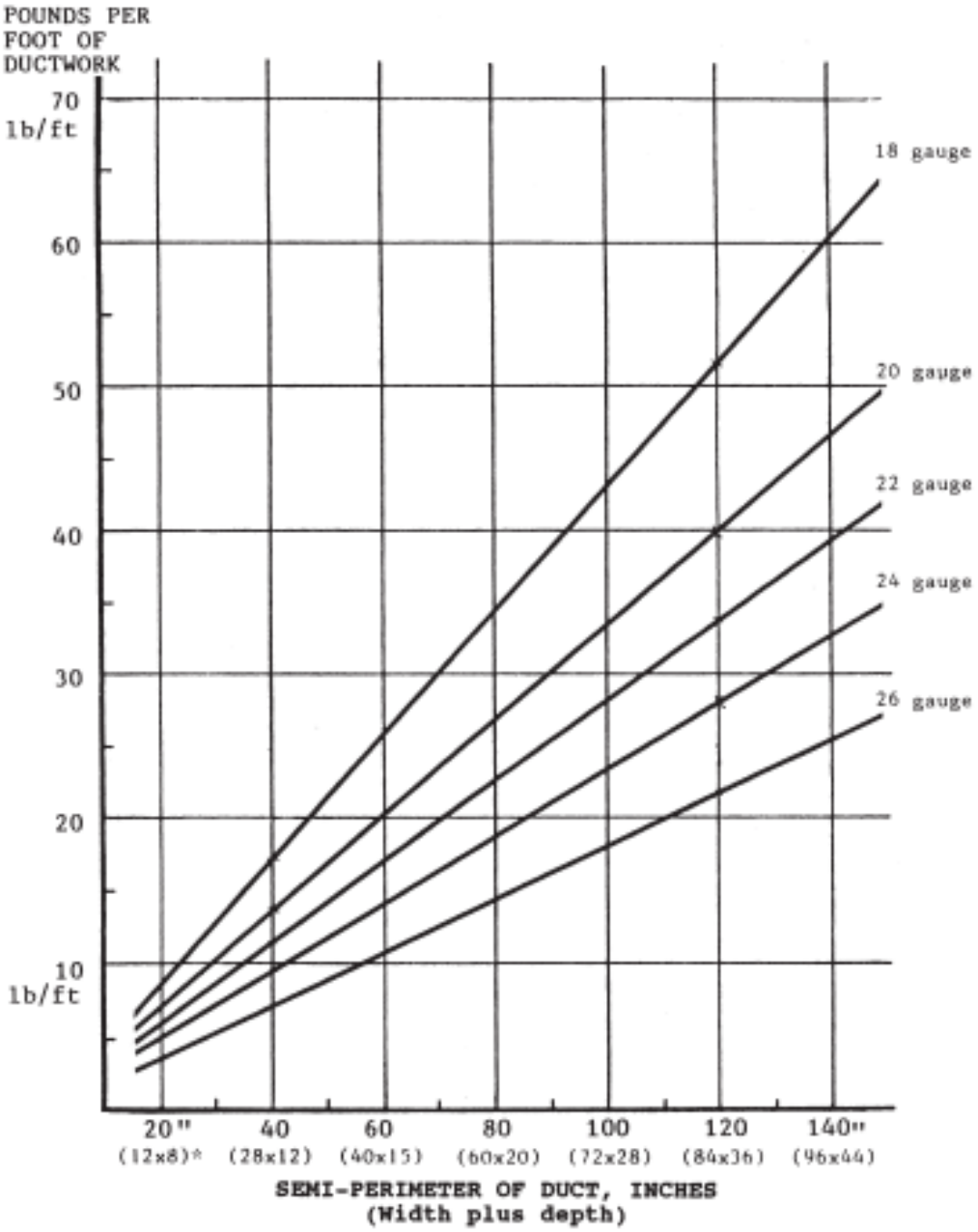
5. **Per Operation**
The time needed to perform each operation, such as layout, cutting, bending, assembly, etc., is calculated separately and then added together.

20% Allowance Factor for Galvanized Ductwork

A 20% allowance must be added to the surface area of ductwork to cover hangers, cleats, hardware, waste and seams.



Weight of Galvanized Ductwork Per Linear Foot
With 20% Allowance



* Sample size

Weight of Galvanized Ductwork Per Linear Foot
With 20% Allowance

SEMI-PERIM	0-12	13-30	31-54	55-84	85 up	Square Feet per LF (no allow.)
Width + Depth	26 ga	24 ga	22 ga	20 ga	18 ga	
	.91 lbs/SF 1.10 W/20%	1.16 1.40	1.41 1.70	1.66 2.00	2.16 2.60	
12	2.20	2.80	3.40	4.00	5.2	2.00
14	2.56	3.26	3.96	4.66	6.06	2.34
16	2.94	3.74	4.54	5.34	6.93	2.67
18	3.30	4.20	5.2	6.10	8.00	3.00
20	3.66	4.66	5.66	6.66	8.66	3.34
22	4.04	5.14	6.24	7.34	9.55	3.67
24	4.40	5.60	6.80	8.00	10.4	4.00
26		6.06	7.36	8.66	11.29	4.34
28		6.54	7.94	9.34	12.15	4.67
30		7.02	8.50	10.00	13.00	5.00
32		7.46	9.06	10.66	13.85	5.34
34		7.94	9.66	11.34	14.75	5.67
36		8.40	10.10	12.00	15.6	6.00
38		8.88	10.86	12.66	16.45	6.34
40		9.34	11.32	13.34	17.34	6.67
42		9.8	11.90	14.00	18.20	7.00
44		10.26	12.46	14.66	19.24	7.34
46		10.74	13.00	15.34	20.00	7.67
48		11.20	13.60	16.00	20.80	8.00
50		11.66	14.27	16.66	21.69	8.34
52		12.14	14.93	17.34	22.55	8.67
54		12.6	15.30	18.00	23.40	9.00
56		13.00	15.87	18.66	24.29	9.34
58		13.54	16.43	19.34	25.15	9.67
60		14.00	17.00	20.00	26.00	10.00
62			17.37	20.66	26.87	10.34
64			18.13	21.34	27.73	10.67
66			18.70	22.00	28.6	11.00
68			19.27	22.66	29.47	11.34
70			19.83	23.34	30.33	11.67
72			20.40	24.00	31.20	12.00
74			20.96	24.66	32.07	12.34
76			21.53	25.34	32.93	12.67
78			22.10	26.00	33.80	13.00
80			22.67	26.66	34.67	13.34
82			23.23	27.34	35.53	13.67
84			23.80	28.00	36.40	14.00
86			24.37	28.66	37.27	14.34
88			24.93	29.34	38.13	14.67
90			25.50	30.00	39.00	15.00
92			26.07	30.66	40.00	15.34
94			26.63	31.34	40.87	14.67
96			27.20	32.00	41.60	16.00
98			27.77	32.66	42.47	16.34
100			28.33	33.34	43.34	16.67
102			28.90	34.00	44.20	17.00
104			29.47	34.66	45.09	17.34
106			30.03	35.34	46.96	17.67
108			30.60	36.00	46.80	18.00
110				36.66	47.67	18.34
112				37.34	48.53	18.67
114				38.00	49.40	19.00
116				38.66	50.27	19.34
118				39.34	51.13	19.67
120				40.00	52.00	20.00

CORRECTION FACTORS

Correction factors save time, increase the accuracy of bidding, reduce the bulk of bidding data needed, simplify the whole estimating process and point the way for understanding and controlling costs.

Correction factors are multipliers used to adjust labor and costs of common standard items and conditions. Correction factors show the percentage increase or decrease needed.

Instead of keeping complex bulky data on an infinite number of items and variable conditions, only a few are kept, while other similar items and different conditions are simply related with the multipliers.

The most common standard in the sheet metal industry, the bench mark, is low pressure galvanized ductwork, 24 gauge average, 25% fittings by weight, unlined, installed on lower floors at about 10 foot high in reasonably clear ceiling spaces. Most other ductwork and conditions are related to this situation.

For example, if it takes 10 hours to install the following low pressure, bare galvanized duct run under standard conditions, the following labor adjustments would have to be made for other conditions and hence more money be included in the bid.

	Labor 10 hrs x Correction Factor	=	Adjusted Hours
10th Floor	1.16		11.6
25 ft High Duct	1.30		13.0
Congested Ceiling Space	1.15		11.5
Area 300 ft. from Unloading	1.05		10.5
35°C days	1.15		11.5
Existing Office Buildings	1.35		13.5
All Piping Installed	1.12		12.5

If the sell price (material, labor, overhead and profits) for the above standard low pressure galvanized duct run is $ 1000, the sell price for other type ducts would be:

	$1000 x Correction Factor	Adjusted Price
Lined 1" 1-1/2 lb	1.4	$1,400
Insulated 1-1/2", 3/4 lb	1.4	$1,400
Fiberglass Ductboard	.9	900
Automatic Duct Coil	.8	800
High Pressure with Cleats	1.35	1,350

Field Labor Correction Factors
for HVAC Equipment, Ductwork and Piping
Use as Multipliers Against Labor Hours

Floors	
Bsmt, Ground, 1st	1.00
2nd & 3rd	1.04
4th, 5th, 6th	1.08
7th, 8th, 9th	1.12
10th, 11th, 12th	1.16
13th, 14th, 15th	1.21
16th, 17th, 18th	1.26
19th, 20th, 21st	1.31
Duct Heights	
10 ft	1.00
15 ft	1.10
20 ft	1.20
25 ft	1.30
30 ft	1.40
35 ft	1.50
40 ft	1.60
Correction for Size of Job	
0-24 hours	1.12
25-48 hours	1.08
49-96 hours	1.04
96 hours and up	none
Special Areas	
Open areas, no partitions	.85
Congested ceiling space	1.15
Equipment room	1.20
Kitchen	1.10
Auditorium; pool w/ sloped floor	1.25
Attic space	1.50
Attic space	1.50
Crawl space	1.20
Cramped shaft	1.30
One or two continuous risers	.80
Distance from Unloading Point	
100 ft	1.00
200 ft	1.03
300 ft	1.05

Existing Buildings	
Typical existing office bldg, hospital, school, etc.	1.35
Existing factory, warehouse, gym, hall, garage, no ceilings	1.15
100% gutted area	1.10
Work around, over, machinery, furnit.	1.10
Protect machinery, floor furniture	1.05
Quiet Job	1.05
Occupied areas	1.05
Remove items and reinstall same	1.50
Remove and replace equipment	2.00
Cost Control	
Piping or ductwork installed	1.10
Electrical conduit installed	1.05
Partitions & door frames erected	1.10
Ceiling grid installed	1.05
Overmanning job, crashing	1.20
Company overloaded with work	1.20
Not being on top of job	1.20
On top of job continually	.90
Go back to put something in	1.15
Out of phase work	1.15
Move stock pile about	1.05
Delays of deliveries, shop drawings, approvals, purch., fab., tools	1.15
Poor shop drawings	1.15
Poor foreman	1.20
Delay in fixing prob. decision	1.15
Cluttered floors	1.15
Trades working on top of each other	1.10
No service roads, muddy	1.10
Congested traffic, poor unloading	1.10
Overtime	
Overtime 40 to 50 hours	1.10
50 to 60 hours	1.15
Night work 4 to 12 midnight	1.20
12 to 8 am	1.20
Correction For Temperature	
Under 20%	1.15
Over 90%	1.15

Ductwork Correction Factors

Multipliers Applied on Standard Low Pressure Galvanized Ductwork For Material, Connection, Automated Fabrication Variations

	MULTIPLIER ON: Total Price Furnished and Installed	FACTORS ON: Shop Labor	Field Labor
Low Pressure Rectangular Galvanized	1.00	1.00	1.00
Lined Low Pressure: 1" thick, 1-1/2 lb	1.40	—	1.03
1/2" thick, 1-1/2 lb	1.34	—	1.01
Insulated Duct: 1" thick, 1-1/2 lb	1.35	—	1.00
1-1/2" thick, 1-1/2 1	1.40	—	1.00
Medium Pressure: Cleat Connections	1.25	1.25	1.25
Angle Flanges	1.30	1.30	1.30
High Pressure: Cleat Connections	1.35	1.35	1.35
Angle Flanges	1.40	1.40	1.40
Coil Line Ductwork, Bare (shop factor, straight)			
Shop Assembled	.80	.30	1.00
Field Assembled	.80	.25	1.05
Plasma Arc Fitting Cutting Machine	.60	.30	1.00
Computerized Blank Out Program	.98	.95	1.00
Spiral: Low Pressure	.70	—	.80
High Pressure	.80	—	.90
Fab Only, low & high pressure	—	.25	—
Pipe Fittings	—	.80	—
Fiberglass Ductboard	.90	.70	.70
Aluminum, Light Gauges, Cleats	1.20	1.20	1.20
Stainless Steel, Light Gauges, Cleats	2.00	1.25	1.25
PVS, Light Gauges, Cleats	1.70	1.25	1.30
Angle Flange Connections versus Cleats	—	1.60	1.10
Bent Metal Flanges versus Cleats	—	1.10	1.05
Welded Connections versus: Cleats	—	.75	1.05
Ductmate versus: Cleats, (shop installed)	—	1.05	1.03
Angle Flanges (shop installed)	—	.75	.94
TDC Connections versus: Cleats	—	1.08	1.05
Angle Flanges	—	.68	.95
Cementing Seams and Connections	—	1.05	1.10
Taping Seams and Connections	—	1.05	1.05
Duplications: of Duct Sections, Shop	—	.66	—
of Field Areas	—	—	.80
Connect Two Duct Sections on Floor in Field	—	—	.75

Chapter 10

Galvanized Duckwork

This section of the manual covers pricing of low, medium and high pressure rectangular galvanized ductwork as used in HVAC systems in commercial, institutional and industrial buildings.

1. Low pressure galvanized ductwork comprises the bulk of HVAC ductwork used in buildings. It is used for system pressures between 0-2" S.P. and air velocities between 0-2500 FPM. Generally, connections are with cleats and the seams are snaplock or pittsburgh. Reinforcing is either crossbreaking, beading, reinforced cleats or structural angles.

2. Medium pressure galvanized ductwork is used for pressures from 2-6" S.P. and velocities from 2000 to 4000 within the S.P. range. High pressure galvanized ductwork is used in systems where the S.P. is over 6" and the velocities are over 2000 FPM.

Both medium and high pressure ductwork must be sealed to maintain pressures within 1 or 1/2% of design CFM. Both are constructed with pittsburgh seams and the connections are with cleats which you can seal, or are gasket companion angles. Reinforcing is with angles, either backup near the connection and/or at prescribed intervals.

ASHRAE/SMACNA Standards

All ductwork weights, labor productivity rates and construction is based on SMACNA and ASHRAE criteria and on the traditional gauge breakdown. For example, low pressure galvanized 0-12" wide 26 gauge, 13"-30" 24 gauge, 31"-54" 22 gauge. 55"-84" 20 gauge and over 85" wide 18 gauge.

Methods of Estimating

This chapter covers estimating rectangular galvanized for HVAC systems both by the piece and by the pound. To estimate per linear foot, all per pound figures can be converted into linear foot rates.

All labor productivity rates and figures are based on standard conditions, lower floors, ten foot high duct runs, new construction and average space conditions.

ESTIMATING GALVANIZED DUCTWORK BY THE PIECE

Benefits

1. The major benefit of estimating galvanized ductwork by the piece is supreme labor accuracy. You use the actual labor time normally expended for that specific type duct and for that size.

   Sheet metal contractors are sometimes off a plus or minus 25% in attempting to use the cost per pound method because of the variety of gauge mixtures, the different pipe and fitting combinations, which both radically effect the cost per pound and causes it to go up and down dependent on many variable factors.

   Where as labor per piece has the most valid correlation between the unit of measurement and the actual labor. It is the most direct, logical connector between a particular duct and its intrinsic labor. It automatically compensates for all mixtures of fittings and pipe, all duct sizes and gauges, for the various types of fittings. The inherent fallacy and confusion and uncertainty in per pound pricing is sidestepped. You don't care if there are 10% or 45% fittings by weight or if the average gauge is 24-1/2 or 22 1/4. You can ignore this criteria, and avoid possible erroneous guesses on labor.

   Pricing by the piece keeps your fingers on the real labor pulse automatically. If the end price should sell for 3.95/lb that is what you will end up with, if it should be $2.50, again that is what you are programmed to get.

2. Another advantage of per piece estimating is that it promotes clarity, simplicity, better understanding of duct runs and of the different pieces involved. The per piece method is a clear, simple counting of things, as one would grilles or dampers. It deals with quantities of things and understandable sizes and labor entities.

Per piece takeoff and extension clears the estimators mind and permits him to concentrate on including all items in a bid and on pricing them correctly. He feels more aware of what the job entails, offsets, risers, drops, complicated ducts, the function of the duct run, etc. It cultivates confidence and skill in him.

The per piece labor approach is something your sheet metal men in both the shop and field, your supervisors, foremen, production schedulers can relate to. It is an understandable, usable, practical, concrete unit of measurement. You can talk "pieces" with people, the hours per piece, you can count them easily, and you can relate sizes to labor accurately. This is very difficult to do, however, with pounds per hour estimating.

Per piece estimating will help you get the jobs you should get and keep you from getting those you should not!

BASIS OF PER PIECE LABOR AND MATERIAL

What's Included and Not

1. Per piece labor is based on the actual labor required to fabricate or install a certain type duct in a certain size range, by an average sheet metal mechanic journeyman; what he should be able to do under normal, typical conditions with standard tools and erection equipment, under normal supervision. It is the mix of the fast and the slow worker, the competent and the less skillful man, the well run job and the poorly run one.

2. Labor includes all production operations:
   a. Shop labor includes unloading raw materials, sheets, listing, blanking, layout and cutting, seaming, forming, assembling, reinforcing angles, cleats, hangers and the final loading of the assembled items on the truck for shipment to the job site.
   b. Field labor includes all operations from the tailgate of the truck to final cleanup, distribution of the ductwork, set up of scaffolding, tools, layout of the duct runs, cutting hangers and cleats, the actual hanging and finally the tear down of erection equipment and clean up.
   c. Both material handling and supervision are also included in the shop and field labor figures in per piece pricing.

3. Non-production operations such as drafting, truck driving, and field measuring are not included in the per piece unit hours.

4. Installation unit hours are based on the time it takes to erect complete duct runs as a batch and not as single pieces.

5. The material for reinforcing angles are not included in the unit weights and must be calculated separately, but the labor time, as stated above, to fabricate and attach them to the ducts is included.

6. Per piece labor and material is based on SMACNA specifications for gauges and construction.

TAKEOFF AND EXTENSION PROCEDURES FOR ESTIMATING DUCTWORK BY THE PIECE

A. **Takeoffs**

1. Use the Per Piece Duct Takeoff Sheet for listing sizes, lengths, wt per ft, shop labor, field labor, etc.

2. List each duct size, as you do in per pound estimating, indicate the type duct, write in the equivalent length for fittings and the measured length for pipe for each piece required.

B. **Extension for Per Piece Estimating**

1. The material weight is calculated by adding up the lineal footages on each line, inserting the lb/lf from the lb/lf chart, which has a 20% allowance included in it already, and then the two are multiplied and the lbs are written in the weight column.

2. Labor is determined by adding up the number of pieces on each line and inserting the total in the "qty" of pieces column. The unit labor per piece for the various types of ducts and size categories is taken from the galvanized labor charts and written in the unit labor columns for the shop and field and multiplied time the quantity of pieces for the total labor for both the shop and the field.

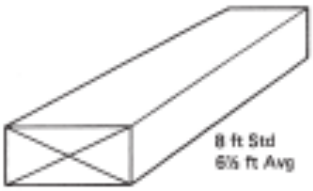
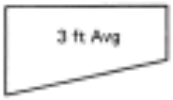
3. After all labor and material are extended the columns are added up for the grand totals of each and transferred to the summary sheet.

C. **Calculate reinforcing angles as needed.**

D. **Calculate the turning vanes and splitter dampers as needed.**

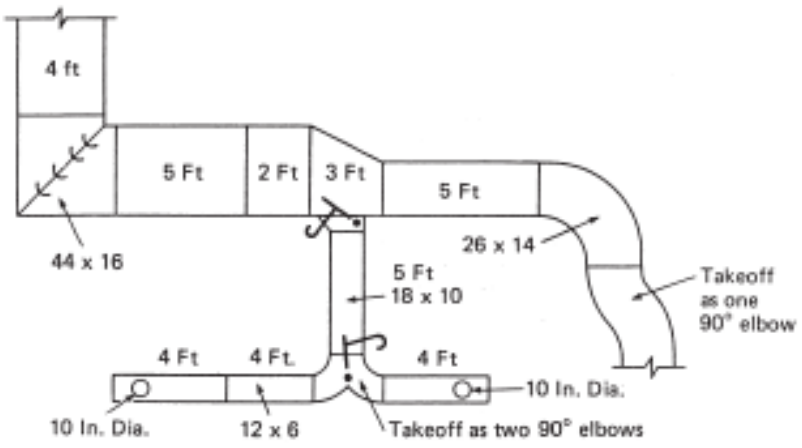
E. **Check work by measuring total linear feet of ducts on drawings with measuring wheel and compare with total linear feet from takeoff sheets.**

Per Piece Takeoffs and Equivalent Lengths

	Equivalent Length
Straight Duct (STR)  0 to 48 in. 8 ft Standard Length  49 in. and up — or all sizes 4 or 5 ft Standard Lengths	Measure
 Transitions (TR)	3 ft
 (Converting Radius Ell to Sq) Weight = 0.5 X 90° Ell Labor = 0.75 X 90° Ell 0-36 in. Wide 90° Radius Elbows (RE)	3 W*
 Over 36 in. Wide Square Elbows (SE)	W + 6"
 Tap in Tees (T)  Drops (T) (add 50 percent for material and labor for splitters)	1 ft
 30, 45, 60° Elbows (45° RE) (Shop labor = 0.75 X 90°)	1½ W
 Take off as two 90° elbows 3W ea Y Fittings (Y)  Take off as one 90° elbow 3W Offsets (OFF)	

*W: width of duct

Example Per Piece Takeoff and Extension
Listing Duct Sizes and Lengths



Per Piece Duct Takeoff Sheet

Job 1st NATIONAL BANK Mat'l Galv. Duct Elev 10'
Dwg/Flr M-1 Sys S-1 Pres LOW Lin/Insul 1"

QTY	DUCT SIZE	TYPE DUCT	Equivalent LINEAL FEET Per Piece	TOT LF	WEIGHT		SHOP		FIELD	
					LBS /LF	Total	Hrs /Pc	Total	Hrs /Pc	Total
3	44x16	STR	4-5-2	11	17	187	.8	2.4	2.3	6.9
1	"	SE	4	4	17	68	2.8	2.8	3.3	3.3
1	"	TR	3	3	17	51	2.2	2.2	2.2	2.2
1	26x14	STR	5	5	9.4	47	.55	.55	1.6	1.6
1	"	RE	6	6	9.4	56	2.4	2.4	2.2	2.2
1	"	RE	6 (offset)	6	9.4	57	2.4	2.4	2.2	2.2
1	18x10	TEE	1	1	6.6	7	.6	.6	.6	.6
1	"	STR	5	5	6.6	33	.3	.3	.9	.9
2	12x6	RE	3-3 ("Y" Fitt.)	6	3.3	19	.8	1.6	.6	1.2
3	"	STR	4-4-4	12	3.3	40	.2	.4	.5	1.0
2	10"ϕ	TEE	1-1	2	3.3	7	.4	.8	.5	1.0
17	pcs			61'		572 LBS		16.4 HRS		23.1 HRS

USING MULTIPLIERS FOR DUCTWORK

This chapter contains correction factors for using a plasma cutter for galvanized ductwork versus manual fabrication, x 0.50.

This factor is applied to the total labor to fabricate galvanized ductwork. For per piece labor use this factor as a multiplier. For example, if it takes a total of 2 hours to fabricate a 24x12 elbow by hand, it only takes 0.50 times 2 which equals 0.50 hours with a plasma cutter.

If you are using lbs per hour use 0.50 as a divisor. For example, 4 lbs per hr divided by 0.50 equals 88 lbs per hr. If you are using hours per lb units, then.024 hrs per lb divided by 0. 50 equals .0 12 hrs per lb.

ESTIMATING GALVANIZED DUCTWORK BY THE POUND

Galvanized ductwork on a particular project can run anywhere from $1.50 to $4.50 per pound installed depending on the mixture of straight duct and fittings and on the average size.

> Yet too many contractors use the ground beef approach for estimating galvanized ductwork by the pound. They throw all different grades of beef into the meat grinder whether $2.00 or $4.00 / lb, crank it through, come up with one big pile and have no real idea of what the correct mixed price per pound is.
>
> When ductwork is all humped together into one heap contractors have great difficulties determining what the correct labor productivity rates are on a per pound basis. Hence he bids roughly the same price per pound regardless of fitting ratio or the average duct size, or makes a wild guess, and then either loses money or doesn't get the job.

Methods of Estimating Galvanized Ductwork

There are three basic approaches to estimating galvanized ductwork by the pound to resolve this problem.

1. *The traditional lump method.* In this approach straight and fittings are taken off together and everything is lumped together into one weight as described above. Then a judgment is made as to what the percentage fittings and average size are for the project, and a combined labor productivity rate is selected from the chart on page 140.

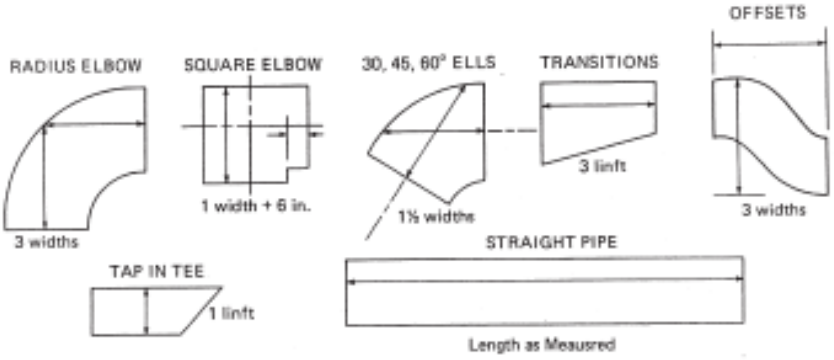
   This approach can work reasonably well if you have actual cost records from similar installations, or if it is obviously typical standard ductwork. But if it's not, and costs should be 20% more or less, a great risk is taken in guessing.

2. *Labor based on percentage fittings and average size.* In this approach fittings and straight are taken off separately, the percentage fittings calculated, the weights for each gauge totaled, and a judgment made by inspection as tot he average gauge. Then everything is lumped into one weight and a combined productivity labor rate is taken from the chart, based on the percentage fittings and average size.

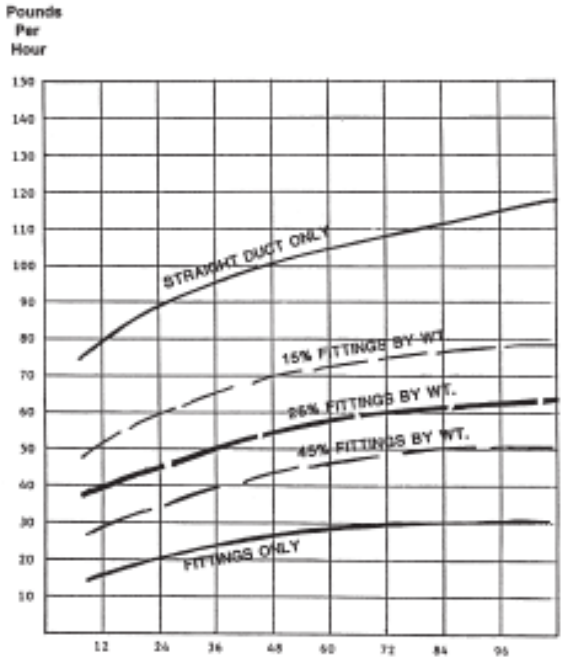
3. *Separate labor productivity rates for each gauge of fillings and of straight.* In this method the fittings and straight are taken off separately and the weights per gauge are kept separate. Then separate labor productivity rates for each gauge for fittings and for straight are applied.

   This approach is the most accurate, but it is cumbersome and time consuming, if done manually. It lends itself well to computer operations.

Measuring Ductwork for Pounds Per Hour Pricing
Equivalent Lengths



Pounds Per Hour Fabrication Labor for Low Pressure Galvanized Ductwork

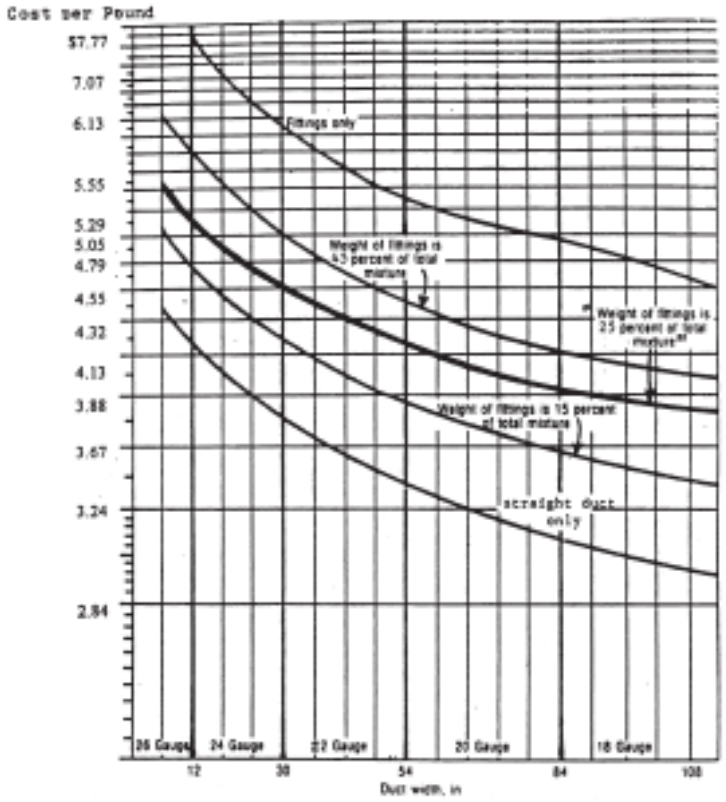


system:
- 50% tees
- 25% elbows
- 12% transitions
- 12% offsets, wyes, etc.

5. Average length of straight pipe
6. Average length of transitions
7. The floor the ductwork is being installed on
8. Height of ductwork
9. Type connection, cleats, flange, ductmate, TDC, etc.
10. Ceiling space conditions

Per piece laboring for galvanized ductwork automatically adjusts these hours per lb according to the average size, percentage, fittings, type fittings, average lengths, type connections, etc.

Installed Cost Per Pound For Galvanized Ductwork
Budget Pricing

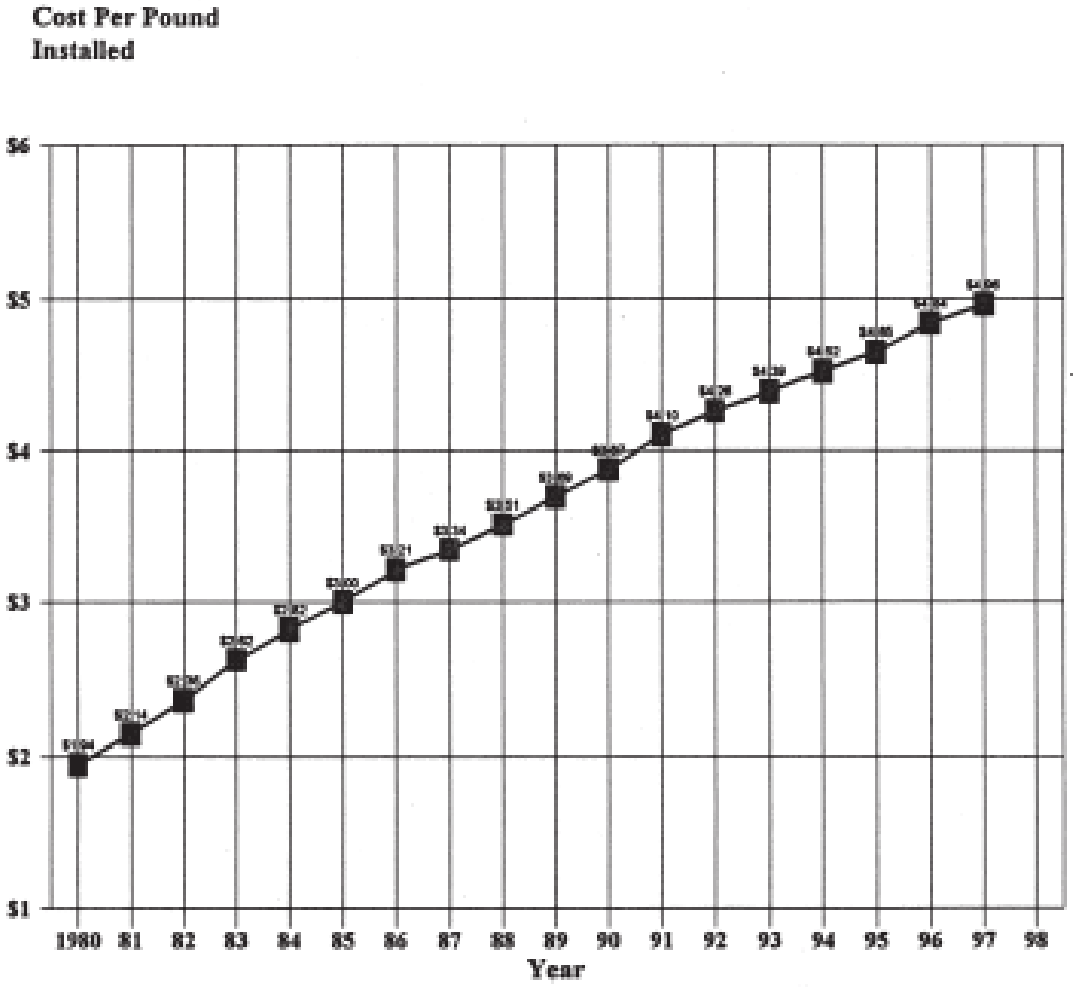


Curves for cost per pound of bare low pressure galvanized ductwork for new construction, 2000 lbs and up, standard installation conditions and conventional duct fabrication (not coil line).

Prices include material, shop and field labor, shop drawings, shipping and a 30 percent markup for overhead and profit on both material and labor.

Costs are based on galvanized material at $.40 per pound and direct labor wage rates of $39.00 per hour which includes base pay, fringes, insurance and payroll taxes.

The Ever Increasing Cost of Standard Low Pressure Galvanized Ductwork Installed



MEDIUM AND HIGH PRESSURE DUCTWORK

Pressure Classification

Medium pressure	2000 fpm and up	2 to 6 inches S.P.
High pressure	2000 fpm and up	6 to 10 inches S.P.

Construction

About 2 gauges heavier than low pressure galvanized

More reinforcing angles required combined with alternate tie rods.

Angle reinforced double S cleats, welded flanges or companion angles are used at connections.

Seams and connections are sealed to withstand pressures 25% over design S.P.

Correction Factors

(On the totally installed cost of low pressure if figured as the identical duct system.)

Medium pressure cleat connections	1.25
Medium pressure companion angles	1.30
High pressure cleat connections	1.35
High pressure companion angles	1.40

Take Off Procedure

Take off the same as low pressure ductwork, either by the piece or per pound.

Methods of Pricing

Completely price all labor and material as low pressure and apply a correction factor from above onto the total price.

Example:

As Low Pressure	As Medium Pressure Cleats
$30,000	1.25 x $30,000 = $37,500

Or apply factors to the low pressure material and labor separately:

As Low Pressure	As Medium Pressure Angles
1500 lbs	1.30 x 1500 = 1950 lbs
35 hrs shop	1.30 x 35 = 46 hrs
60 hrs field	1.30 x 60 = 78 hrs,

Budget Pricing

(Based on 10,000 lb job, 25% fittings by weight, standard conditions)

Medium pressure cleat connections $4.93
Medium pressure companion angles 5.11
High pressure cleat connections.....5.33
High pressure companion angles.....5.54

Galv. 0.41/lb, Labor $39.00/hr. Includes material, all labor, cartage, drafting, overhead and profit.

Included in the above labor figures are:

1. Switching from one gauge coil to another
2. Duct size changes
3. Replacing coils in cradle
4. Labor to remove stacks of L's on tables or skids from machine
5. Banding stacks of L's and loading on truck
6. Loading assembled duct sections on truck
7. Daily maintenance and breakdowns
8. Operator idle time
9. Supervision time
10. Machine running speeds of 25 to 30 fpm

Automatic Duct Coil Line Fabrication

Operations Performed by Coil Line

Uncoil & Straighten | Shear | Notch | Bead | Seam | Drives | Bend

Fabricated Labor

Gauge	Width Range of Duct	Straight Duct LBS/HR		Straight & Fittings Combined LBS/HR			
				Percent Fittings by Weigh of Tot.			
		Fab. L's Only	Fab L's & Assem in Shop	10-20%	20-30%	30-40%	40-50%
26	0-12	860	230	72	50	38	31
24	13-30	1100	300	95	66	51	41
22	31-54	1300	350	116	79	61	49
20	55-84	1500	420	135	93	71	58
18	85 up	1900	560	153	103	78	63

Correction Factors

1. Assemble L's in field versus in the shop 1.07

Waste Allowance

There is little or no waste in fabrication straight duct on a coil line. However, a 10% allowance must be added to the raw duct weight for corner seams, cleat edges and hangers.

Budget Figures

Typical, commercial type ductwork, average mix of gauges and sizes, installed.

$3.00/lb	11 lbs/hr	9000 lbs/day	2-1/2 Mills lbs/yr

Chapter 11

Spiral and Light Gauge Round Duckwork

TYPES OF ROUND HVAC DUCTWORK

Spiral Pipe and Welded Fittings

Spiral pipe and welded fittings are primarily used for medium pressure HVAC systems but they are also used to some degree in general and industrial exhaust systems.

Connections are generally the slip type but companion angles can also be used. Slip connections are cemented or taped in high pressure or industrial exhaust systems. Heat shrink bands may also be used.

Spiral comes in round and oval configurations and can be either single or double skin.

Flexible Tubing

Flexible tubing for HVAC systems is constructed of helical wire or bands covered with different types of fabrics depending on usage. Special fabrics may be fire, moisture or corrosion resistant.

Flexible tubing may be single skin or factory wrapped with insulation.

Connections are the slip type and are fastened with draw bands.

Residential Furnace Pipe and Fittings

Residential furnace pipe is used for residential, apartment and light commercial HVAC work. It can also be used as a smoke flue.

Pipe is constructed with length wise snaplock seams and elbows are generally the adjustable type.

Residential furnace pipe is generally constructed of galvanized material but it is also available in stainless steel, aluminum and in a blue or walnut finish.

Connections are crimped on one end, slipped together and screwed or taped.

Flues

Flues are used for venting fumes from smaller HVAC heating equipment. It comes in either single or double skin and in round or oval.

Round Duct Gauge Data

RECOMMENDED GAUGES FOR GALVANIZED ROUND DUCTS

DUCT DIAMETER, INCHES	LOW PRESSURE DUCTS AND FITTINGS	MEDIUM AND HIGH PRESSURE DUCTS		
		SPIRAL PIPE	LONGITUDINAL SEAM DUCT	WELDED FITTINGS
Up thru 8"	26 Ga.	26 Ga.	24 Ga.	22 Ga.
9-13	26	24	22	20
14-22	24	24	22	20
23-36	22	22	20	20
37-50	20	20	20	18
51-60	18	18	18	18
61-84	16	—	16	16

RECOMMENDED GAUGES FOR OVAL GALVANIZED OR B.I. DUCT

DIMENSION OF MAJOR AXIS, INCHES	SPIRAL	LONGITUDINAL SEAM SUCT	WELDED FITTINGS
Up thru 24"	24 Ga.	20 Ga.	20 Ga.
25 to 36	22	20	20
37 to 48	22	18	18
49 to 50	20	18	18
51 to 70	20	16	16
71 and Over	18	16	16

Labor to Install Furnace Pipe, Flexible Tubing and Flues

HOURS PER PIECE, PIPE AND FITTINGS MIXED

AVG FURN. DIA.	FLEX. 5F/LF	FLUE PIPE 5 ft.	TUBING 5-6 ft.	DOUB. WALL
4"	1.1	.4	.3	.7
6	1.6	.5	.4	.8
8	2.1	.6	.5	1.0
10	2.6	.8	.6	1.2
12	3.2	.9	.7	1.4
18	4.2	1.1	.9	—
15	4.7	1.2	1.0	—
22	5.8	1.5	1.2	—
24	6.3	—	—	—
30	7.9	—	—	—
36	9.4	—	—	—
42	11.0	—	—	—
48	12.5	—	—	—

(Labor based on ratio of 1 joint of pipe to 1 fitting)

Chapter 12

Estimating Fiberglass Ductwork

INTRODUCTION

Fiberglass ductwork has the following advantages over sheet metal:

- It costs less than conventionally fabricated steel ductwork: 5% less than bare galvanized 30% less than insulated sheet metal 3 5% less than lined sheet metal
- It costs less than galvanized ductwork fabricated on a coil line if insulated or lined: 20% less than insulated 35% less than fined
- However, fiberglass costs 15% more than bare galvanized off of a coil line.
- It requires very little machinery and tools to fabricate, minimal floor space and consequently overhead costs are far less than a sheet metal shop.
- It's more flexible than sheet metal, easier to revise and manipulate at the job site in order to fit into diverse, unpredictable field conditions and to meet precise outlet locations.
- It can be fabricated either in the shop or at the job site.
- It's lightweight. Shipping, material handling and hoisting are far easier than with sheet metal.
- It has built in thermal insulation and acoustical absorption.
- It has built in built in a vapor barrier.
- And lastly, it's an automatic energy saver over bare steel because it's self insulating and virtually leak proof.

Takeoff Procedures

1. Use duct take off sheet and fill out heading.
2. List inside dimensions of duct.
3. Write down type of duct. Use abbreviation.
4. Measure off pipe in 4 foot lengths and list each length.
5. Put down equivalent lengths for each fitting.
6. List sheet metal components separately on bottom of duct take off sheet or on separate sheet, as you go along.

Material Extension

1. Total the linear footage on each line and enter total in total linear foot column.
2. Enter the sq ft/lin ft from the chart which includes the allowance for the 8" corner overlap and a 5% waste factor.
3. Multiply the length times the sq/lin ft and enter in the square feet column.
4. Add up the total square feet.

Material Costs

Typical current prices:

			Square Feet Ordered Over 10,000
Type Board	0-2400	2400-10,000	Truckload
475	$0.96	$0.87	$0.79
800	$1.06	$0.10	$0.96
1400	$1.32	$1.28	$1.15

Budget Figures

The budget cost of a 1000 square foot or larger batch of typical fiberglass duct work, under standard conditions, including a markup of 30% for overhead and profit, based on union wages, is about $4.41 per square foot of duct.

Non union cost is about 33% less, roughly $3.04 per square foot.

Square Foot Per Linear Foot of Fiberglass Ductwork

Semi-Perim I.D. Width plus Depth	SF/LF Includes allowances, 8" corner overlap 5% waste	SF/LF No Allowance Included
12	2.8	2.00
14	3.1	2.34
16	3.5	2.67
18	3.9	3.00
20	4.2	3.34
22	4.6	3.67
24	4.9	4.00
26	5.2	4.34
28	5.6	4.67
30	5.9	5.00
32	6.5	5.34
34	6.7	5.67
36	7.0	6.00
38	7.3	6.34
40	7.7	6.67
42	8.0	7.00
44	8.4	7.34
46	8.8	7.67
48	9.1	8.00
50	9.5	8.34
52	9.8	8.67
54	10.1	9.00
56	10.5	9.34
58	10.9	9.67
60	11.2	10.00
62	11.6	10.34
64	11.9	10.67
66	12.3	11.00
68	12.6	11.34
70	12.9	11.67
72	13.3	12.00
74	13.7	12.34
76	14.0	12.67
78	14.4	13.00
80	14.7	13.34
82	15.1	13.67
84	15.4	14.00
86	15.8	14.34
88	16.1	14.67
90	16.5	15.00
92	16.8	15.34
94	17.2	15.67
96	17.5	16.00
98	17.9	16.34
100	18.2	16.67

Calculating Labor

Following labor productivity rates are based on:

1. Volume of 1000 SF and up
2. 800 Board
3. Average duct size of 18" x 12", or equivalent 24 gauge galv.
4. Tie rod reinforcing.
5. Rates based on gross square footage including 8" overlap and 5% waste.
6. Using standard grooving machine.

(See **Fabrication Labor** at the top of the following page.)

Installation Labor

Neither the duct size nor the percentage of fittings affects the installation productivity rate appreciably.

Consequently the erection rate remains relatively constant at 30 sf/hr.

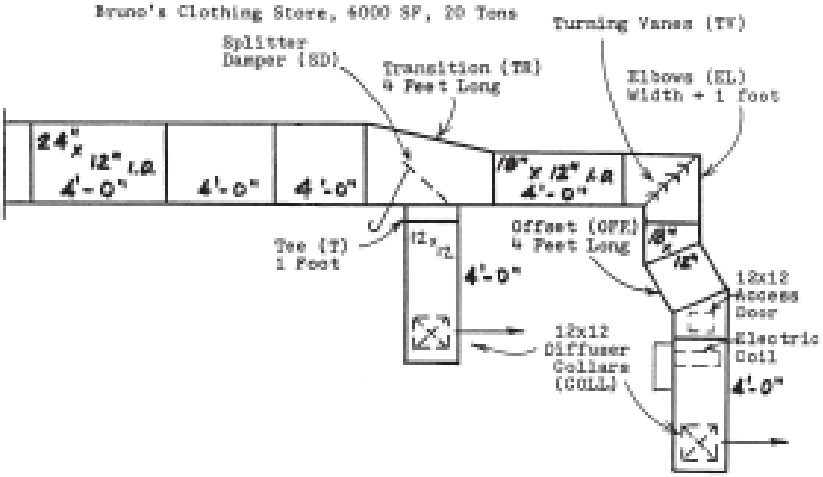
Correction Factors

1. Shop labor
   - a. Hand grooving machine versus grooving machine 1.50
   - b. Auto grooving machine versus manual machine ..... .90
   - c. Auto closer versus manual ..... .70
   - d. Auto groover and closer ..... .60
   - e. Exhaust and return ducts with tie rods in conduits 1.33
   - f. Fittings versus straight duct 1.50
   - g. "V" groove versus shiplap 1.05
2. Channel or "T" bar reinforcing versus tie rods
   - Shop 1.20
   - Field 1.10
3. 475 Board versus 800, Material costs ..... .90
   - Shop and Field labor ..... .95
4. 1400 Board versus 800, Material costs 1.20
   - Shop and Field labor 1.05
5. Material quantity discounts 0-2400 SF 1.05
   - 2400-20,000 SF 1.00
   - Factory, truck load ..... .94
   - Factory, car load ..... .90

FABRICATION LABOR

	Size Ranges									
Percentage	0.12"		13.30"		31.54"		55.84"		85.96"	
Fittings	SF/ MH.	MH./ SF	SF/ MH.	MH./ SF	SF/ MH.	MH./ SF	SF/ MH.	MH./ SF	SF/ MH.	MH./ SF
Str. Duct. Only	59	.0169	62	.0161	56	.0179	53	.0189	38	.0263
10-20%	55	.0183	58	.0174	52	.0191	49	.0202	35	.0284
20-30%	52	.0191	55	.0182	50	.0200	47	.0211	34	.0297
30-40%	50	.0200	53	.0190	48	.0208	45	.0220	32	.0311
Fittings Only	39	.0256	41	.0244	38	.0263	36	.0278	25	.0400

Example of Fiberglass Ductwork Takeoff and Extension



TYPICAL AREA
(Represents 1/10th of job)

DUCT TAKE OFF

Qty Pcs	DUCT SIZE I.D.	TYPE DUCT	Equivalent LINEAR FEET Per Piece	Total LF	SF/LF* Raw	Total SF
3	24 x 12	STR	4-4-4	12	6	72
1	"	TR	4	4	6	24
2	18 x 12	STR	4-4	8	5	40
1	"	EL	2½	2½	5	12½
1	"	OFF	4	4	5	20
1	12 x 12	T	1	1	4	4
1	"	STR	4	4	4	16
10 Pcs		Totals				188.5 SF Raw

ALLOWANCES: Add 8" per linear foot for overlap $\frac{24}{12} \times .66 \times 35.5 LF$ = 195

Add 5% for waste 14

Gross total for 1 area 209.5 SF

Times 10 areas x 10

Job total 2095 SF

*Can also use SF/LF from chart which has the 8" corner allowance and 5" waste built in already.

Pricing Sheet Metal Components
Fiberglass Ductboard

ITEM	SIZE	DIRECT MATERIAL & LABOR
Turning Vanes	12x6	$24.24
	18x12	30.10
	24x12	36.18
	36x12	82.42
	42x12	111.50
	48x24	153.34
	60x24	205.25
Splitter Dampers	0x0	$30.71
	18x12	35.35
	30x12	43.63
	42x18	54.95
Round Diffuser Collar	8" dia	$54.95
	12	71.11
	18	82.42
Rectangular Diffuser Collar	12x12	$60.50
	24x12	82.42
	48x24	187.47
Fire Damper Sleeves 18 Gauge	24x12	$143.84
	36x18	190.71
	48x12	200.20
Electric Coil Sleeves	12x12	$74.34
	24x12	108.28
	36x12	143.84
	48x12	205.25
Access Doors	12x12	$72.73
	24x12	87.28
Reinforcing Channels and formed "T" Bars	—Material Labor-Fab &	$0.20LF Install
	24" long	.10 Mrs ea
	36"	.14
	48"	.18
	60"	.22
	72"	.26

Estimate Summary and Extension Sheet

Job Bruno's Clothing Store — FIBER GLASS DUCTWORK TYPE 800

		MATERIAL COST UNIT	MATERIAL COST TOTAL	SHOP HRS UNIT	SHOP HRS TOTAL	FIELD HRS UNIT	FIELD HRS TOTAL
	Fiber Glass Ductboard, 2090 Sq Ft	$.95/SF	$1,986	1 HR/50 SF	38	1 HR/30 SF	70
	Accessories, Tape, Hangers, etc. 2090 sq ft	$.16/SF	334				
	Shop Drawings "			1 HR/400 SF	5		—
	Cartage "			1 HR/1000 SF	2		—
		Ea.					
10	Splitter Dampers, 12x12	$25	$ 250	(Labor Included)			
10	Turning Vanes, 18x12	45	450				
20	Diffuser Collars, 12x12	59	1,180				
10	Electric Coil Sleeves, 18x12	75	750				
10	Access Doors, 12x12	60	600				
			$5,320		45 HRS		70 HRS
					70		
			+ $3,795	←	115 HRS	@ $	33.00
	Total Direct Costs		9,115				
	30% O+P		+ 2,735				
	Total Sell		$ 11,850				
	Cost Per Square Foot Breakdown	Union $33/hr.		Non Union @ $24/hr.			
	F.G. Board #800		$ .84/ SF		.84/ SF		
	Accessories		.20		.20		
	Shop Labor, 55 SF/HR		.60		.44		
	Field Labor, 30 SF/HR		1.10		.80		
	Shop Drawings, 400 SF/HR		.08		.06		
	Cartage, 1000 SF/HR		.03		.03		
	Direct Costs		2.85		2.37		
	30% O. + P.		.86		.71		
			$ 3.71	Sq ft	3.08	Sq ft	

Chapter 13

Heavy Gauge Ductwork

TYPES OF INDUSTRIAL EXHAUST DUCTWORK

There are four basic categories of materials used for ductwork in air pollution control and, industrial and commercial exhaust systems.

1. **Galvanized** ductwork, either round or rectangular, is used in many applications for heat, moisture and dust removal when corrosion and abrasion do not present problems.

2. **Black iron** ductwork, hot or cold rolled, round or rectangular is used in many applications for heat, moisture and dust removal when corrosion and abrasion do not present problems.

3. **Corrosion and moisture resistant** ductwork round or rectangular, is fabricated from the following materials:

PVC	Stainless Steel
FRP	PVC Coated Galvanized
Aluminum	Transite

4. **High temperature** ductwork is generally stainless steel.

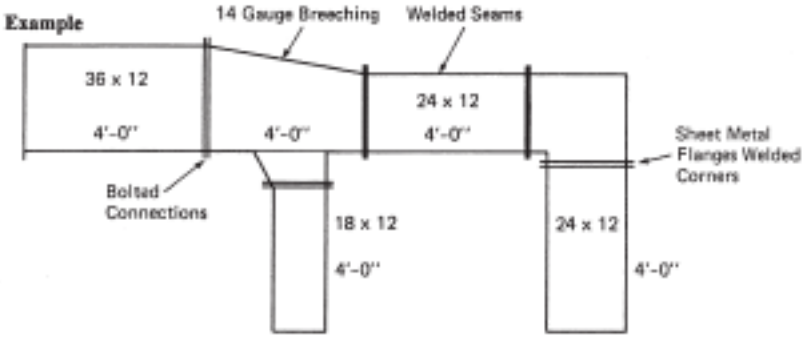
Round ductwork is used more commonly than rectangular in air pollution control and material conveying work. Connections may be cleated, slip, sheet metal flanged or companion angle flanged and bolted, welded, soldered, cemented, gasketed, sleeved, coupled, or riveted.

Budget Estimating
Rectangular Black Iron Ductwork
Metal Flanges
Per Pound and Per Square Foot

Average Lb/Hr, Sf/Hr Labor Productivity Rates and Budget Prices

Gauge	Fabrication		Installation		Budget Price	W/O & P
	Lb/Hr	Sf/Hr	Lb/Hr	Sf/Hr	Per/Lb	Per/Sf
18	28	14	34	17.0	$4.73	$ 9.44
16	31	12.5	39	15.5	4.32	10.60
14	35	11	45	14.2	3.57	11.52
12	44	10	50	11.5	3.43	15.13
10	52	9	55	10.0	3.05	16.73
3/16"	53	7.0	41	5.4	3.30	25.45

Based on $0.40 per pound for hot rolled steel and $39.00 for labor. Labor productivity based on average 6 foot perimeter (24x12 plus or minus) and 25 percent fittings by weight or square footage.



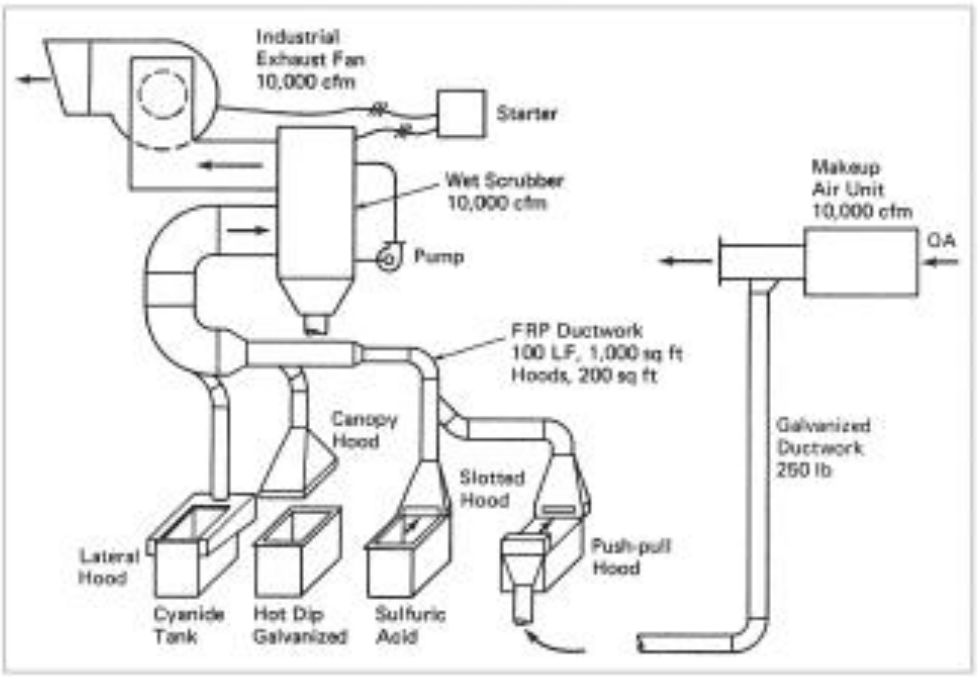
	Size	SF/LF	Linear Feet	Total LF	Square Feet	
2	36x12	8	4-4	8	64	
3	24x12	6	4-3-4	11	66	
2	18x12	5	1-4	5	25	
7 pcs			Totals	24 LF	155 SF	
			@ 3.125 LBS/SF		485 LBS	
			Waste 30%		145	
					630 LBS	
			Material @ 31¢/LB		$195.30	
			Shop @ 35 LBS/HR		18 HRS	
			Field @ 45 LBS/HR		14 HRS	

Heavy Gauge Ductwork Labor Factors

Showing Relationship Between Different Materials, Gauges and Connections

TYPE OF MATERIAL	LABOR FACTOR Multipliers: SHOP	FIELD
Black Iron, (Base)	1.00	1.00
Stainless Steel	1.25	1.25
Galvanized	1.10	1.06
Aluminum	.75	.75
PVC 1/4", 3/16"	.43	.82
FRP 1/4", 3/16"	.83	.87
Aluminized Steel	1.00	1.00
Cor-Ten	1.00	1.00

Smyth Lighting Fixture Plant
Sample Estimate



Open Surface Tank Exhaust System

Estimate Summary and Extension Sheet

Job SMYTH LIGHTING FIXTURE PLANT

Open Surface Tank Exhaust Estimate

		MATERIAL COST		SHOP		FIELD	
		UNIT	TOTAL	UNIT	TOTAL	UNIT	TOTAL
1	Wet Scrubber, 10,000 CFM	$ 10% /unit	$9,700		—		45
1	Pump		700		—		—
1	Makeup Air Unit, Direct Fired	5% /unit	8,177		—		24
1	Industrial Fan, 10,000 CFM, 25 HP	5% /unit	6,567		—		21
2	Starters		1,700		—	2	4
	FRP Ductwork, 1000 SF		3,000	15 LBS/SF	83	10 LBS/SF	67
	Galv. Ductwork, 250 LBS	50 LBS/LB	104	50 LBS/HR	7	50 LBS/HR	13
4	Hoods, FRP, 200 SF		600	7	28	4	16
	Field Measure				—		8
	Testing and Balancing; Svc.				—		4
	Cartage, 4 Loads			3	12		—
	Total Eqpt. Mat.		$40,548	Man Hrs	130 Hrs		202 Hrs.
Subs	Wiring 150ft, 54 amps	$ 10%	1,551				
	Crane ½ day		400				
	Water Piping Valves		700				
	Total Subs		$2,497				
	RECAP						
•	Equipment, Materials		$ 40,548				
	Markup on Eqpt. 30% Ovhd.		12,164				
•	Labor, 332 Hrs. @ $33.00		10,956				
	Markup on Labor, 36% Ovhd.		3,947				
•	Subs		2,497				
	Markup on Subs, 10%		249				
•	Total Costs with Ovhd. Mu		$ 69,681				
	Profit 5%		3,403				
	Sales Tax on Mat., 7%		2,838				
•	Total Sell Price		$ 75,922				

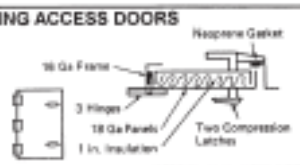
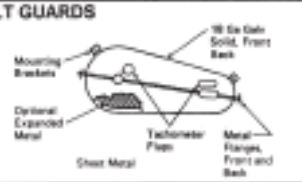
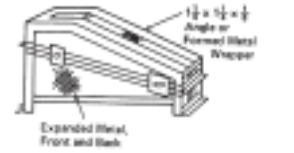
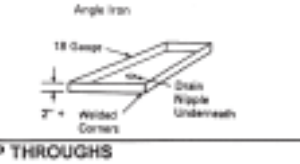
Chapter 14

Sheet Metal Specialties and Acoustical Lining

This chapter covers estimating sheet metal specialties, acoustical lining for ductwork and other fabricated items, but are not ductwork per se, and are as follows:

- Dust Turning Vanes for Ductwork
- Splitter Dampers
- Flexible Connectors to Equipment
- Belt Guards
- Exhaust Hoods
- Equipment Platforms
- Fabricated Roof Hoods
- Sheet Metal Housings
- Housing Access Doors
- Blank Offs in Housings
- Coil Drain Pans

Access Doors, Belt Guards, Drain Pans

	SIZE	MATERIAL WEIGHT	MATERIAL COST	LABOR HOURS SHOP	LABOR HOURS FIELD	DIRECT MATL & LABR COST
CASING ACCESS DOORS 	36x20	38 Lb	$43	3	3	$277
	48x20	50 Lb	$54	4	3	$327
	60x20	70 Lb	$80	4	3	$333
BELT GUARDS 	3 ft	80 Lb	$54	3	2	$249
	5 ft	130 Lb	$83	4	3	$356
	7 ft	180 Lb	$124	5	4	$475
	10 ft	260 Lb	$182	6	5	$611
ANGLE IRON 	5 ft	125 Lb	$117	6	3	$548
	7 ft	175 Lb	$155	9	4	$862
DRAIN PANS UNDER COILS 	10' x 4' Galv	110 Lb	$78	3	1	$234
	10' x 4' S.S.	110 Lb	$389	4	3	$672
DRIP THROUGHS 	10' x 1' Galv	30 Lb	$25	2	2	$161
	10' x 1' S.S.	30 Lb	$106	3	2	$303

SHEET METAL HOUSINGS

Built up sheet metal housings are field assembled casings used to enclose HVAC component equipment such as filters, coils, fans, water eliminators, dampers, etc.

Construction

Casings are built in panels with standing seams or channel flanges, 20", 26", 32" or 44" wide by lengths of anywhere between 5 and 10 feet and are normally 18 gauge. (See figure below.)

Material Calculations

1. Measure size of housing and calculate square footage.
2. Add 30% for waste, seams and hardware.
3. Measure required angles and add 15% waste.

A typical full size panel is 32" wide seam to seam, 8 feet long, requires an 18 gauge 36x96 sheet which weighs 32 pounds and costs $23.34 per sheet at $.42/lb.

Labor Single Skin Panels

Fabrication	1/2 hr/panel	36 sf/hr	64 lbs/hr
Installation	2 hr/panel	9 sf/hr	20 lbs/hr

Includes angle and caulking labor.

Budget Figures

Single skin	$160/panel	$9.42/SF	$4.10/lb
Double skin	$314/panel	$17.41/SF	$8.71/lb

Labor and budget figures are based on an average 32" wide by 6 foot long panel, which is a typical size in a mix, single skin, 18 gauge galvanized, 39 lbs per panel, $39.00/hr, $.40/lb, 30% waste allowance and a 30% markup for overhead and profit.

Correction Factors

Double skin, 2" thick, 2" internal insulation, and perforated inner panel.

Material costs	3.0
Shop labor	3.0
Field labor	1.5

ACOUSTIC LINING

The main purpose of internal lining is to absorb sound, but it can also function simultaneously as a thermal insulator when needed. Sometimes it is simply used in place of insulation for economic or other reasons.

Uses

Lining is used in auditoriums, libraries, in outside ductwork, in high pressure ductwork off of a fan, on the low pressure side of high pressure terminal units.

Lining is not used in fume or partial exhaust industrial exhaust systems, in hot systems such as kitchen exhaust, in wet or moist situations such as with dishwashers, showers and pool exhausts.

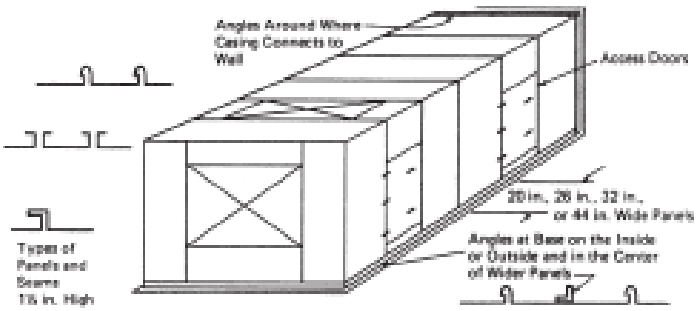
Description

Fiberglass lining comes in 2 basic types blanket and rigid board. (See figure on following page.)

Calculating Material

1. If you have the square footages just add 15% for waste and corner overlaps.

2. If you only have poundage figures you have to convert them back to square feet by dividing the weight per square foot for each gauge into the poundage to get back to the square footage.



Chapter 15

Miscellaneous Labor Operations

DRAFTING AND SKETCHING LABOR

Miscellaneous labor covers additional operations which are not directly installation work. This may include shop drawings, sketching, cartage, testing and balancing, operation and maintenance manuals, sleeves and chases, excavating and backfilling, removal work, cutting and patching openings, etc.

Fully detailed, 1/4 inch scale, office prepared shop drawings with locations, elevations, outlet locations, fitting details, pipe and fitting lengths, walls, partitions, and reflected lights and beams all shown.

Labor

Labor includes the preparation of the shop drawings, revisions, field checks, making out shop fabrication tickets, and listing blankouts.

It is a function of the quantity of pieces of ductwork rather than the weight, fittings taking twice the total amount of time than straight pipe sections. It is also dependent on congestion in the ceiling space of all the mechanical, electrical work, on the complexity of the duct runs, and the extent of the architectural, structural complexity in the particular area.

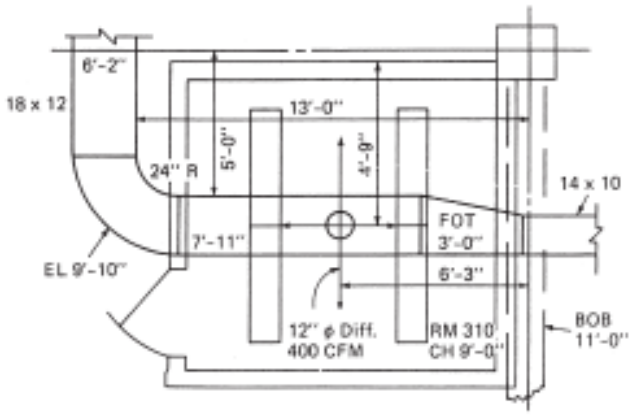
Straight pipe	.10 hr/pc
Fittings	.20 hr/pc
Typical 50/50 mix, straight duct and fittings, by quantity pieces	.15 hr/pc

On a *pounds per hour* basis for an average mix of gauges:

Mix 10-20% fittings by weight 23 5 lbs/hr
Mix 20-30% fittings by weight 200 lbs/hr
Mix 3040% fittings by weight 185 lbs/hr
Mix 40-50% fittings by weight 175 lb/hr
Pipe only 350 lbs/hr
Fittings only 100 lb/hr

Correction Factors

Clear, open areas or straight runs	0.7
Congested ceiling spaces	1.2
Equipment room	1.2
Heavy duplications	0.8
Complete duplication of area	0.6



Budget Figures

Galvanized ductwork:

230 per pound

260 per square foot of ductwork

FIELD MEASURING AND SKETCHING LABOR

Final Duct Connections

Final duct and flexible connections to units, fans, louvers, etc.: 120lbs/hr or 30hr/pc, based on size of 48"x24".

Complete Duct Runs

Measure area, obstructions, sketch run, figure lengths, elevations, draw fittings—30% fittings by weight.

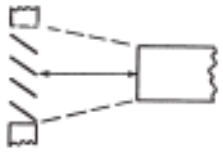
0-800 lbs	24 gauge avg 22 gauge avg	120 lbs/hr 200 lbs/hr	.25 hr/pc .25 hr/pc
800 lbs up	24 gauge avg 22 gauge avg	150 lbs/hr 300 lbs/hr	.2 hr/pc .2 hr/pc

Budget Figures for New Projects

Use 5% of total metal weight for finals and for measuring sheet metal specialties.

Ex. 50,000 lb job x 5% = 2500 lbs divided by 120 lbs/hr = 21 hrs total

Hence field measuring averages out to about 2000 lbs/hr or 2.50/lb based on total weight of job.



SERVICE

Two methods of calculating service and punch list work:

1. 2 hours per piece of equipment
2. 5% of the cost of heating, refrigeration, air handling equipment

ESTIMATING AIR TESTING AND BALANCING

Balancing Procedures

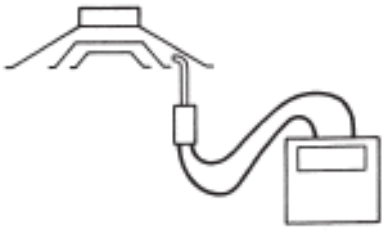
The labor figures in this section are based on the following air testing and balancing procedures.

1. **Prepare test reports**
   - Assemble plans, specs, equipment cuts, A_k factors.
   - Survey and plan balancing.
   - Determine instruments to use.
   - Draw schematics.
   - List outlets on outlet sheet.
   - Determine A_k factors and calculate required velocities.
2. **Start up**
   - Check motor name plates, starter overload, heater size, fan, type wheel, rotation, drives, bearings, filters, etc.
   - Check and set automatic dampers.
   - Checkout dampers in duct runs, and at outlets and inlets. Check terminal units.
   - Clean up debris.
   - Turn fan on and take start up readings: amp, volts, fan rpm, total, CFM fan static pressure.
3. **Balance duct runs and outlets** proportionately.
4. **Reread equipment** and adjust as required.
5. **Finalize reports.**

Instruments

The labor figures are also based on using the following instruments:

Volt-Ammeter	Pitot Tube
RPM Counter	Inclined Draft Gauges
Rotating Vane Anemometer	Magnehelic Gauges
Alnor Velometer	Thermometers



Start Up Labor

Includes checkout of equipment, setting automatic dampers, reading amps, volts, fan rpm, fan static pressure and total CFM.

Hours	
Supply units	4.0
Multi-zone units (plus .5 hours per zone)	3.0
Centrifugal exhaust fans	3.0
Roof exhaust fans	2.0
Fan coil units	2.0
Dust collectors	3.0

Correction Factors on start up labor	Multipliers
1. If no S.P. or total CFM readings are taken on supply units	0.70
2. Typical units	0.90

Balancing Outlets and Inlets

Based on 8 to 12 foot high ceilings, 2 to 3 passes, 3 to 4 readings each, using flow hood.

	Smaller Simpler Systems	Larger Complicated Systems
Diffusers		
6"-24"	0.35	0.50
26" up	0.50	0.70
Linear diffusers, per 5 foot length	0.40	0.60
Light troffers, per slot	0.30	0.40
Grilles, registers		
0-4 SF	0.35	0.50
4-8 SF	0.40	0.60
8 up SF	0.50	0.70
Exhaust hoods	0.40	0.60

Terminal Units

High pressure boxes:	access through ceiling	0.50
	access by crawling in ceiling	0.80
Induction units:	under windows	0.50
	in ceiling	1.00

Test Reports

Fill out equipment sheets, each system	0.20
Fill out and finalize outlet sheets, per outlet	0.12
Draw schematic layout, per outlet	0.05

Rule of thumb: all test reports, 10% of all field balancing work.

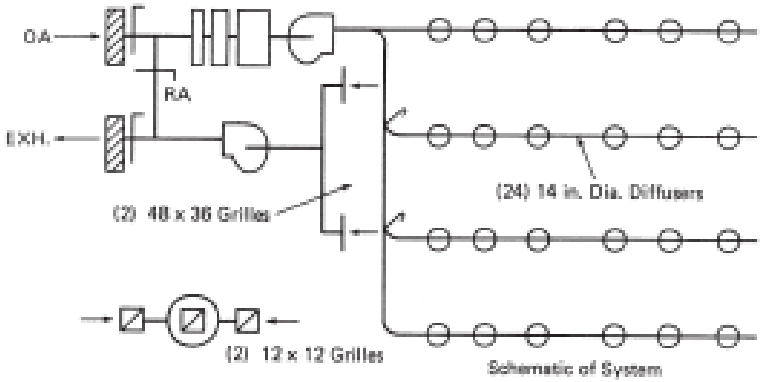
Correction Factors		Multipliers
1. Ceiling height;	8 to 12 feet	1.00
	13 to 18 feet	1.15
	19 feet and up	1.25
2. Floor	1-5	1.00
	6-15	1.10
	16-30	1.20
	31 and up	1.25
3. Occupied areas		1.15
4. Hazardous industrial exhaust areas		1.25

Budget Figures

Includes all operations from preparing reports through startup, balancing and finalizing reports. Figures are based on low pressure systems, single zone, low rise building, 8 to 12 foot high ceilings, 1 to 2 outlets per room, a typical mixture of outlet sizes and CFMs and that there are several systems on the job.

	PER OUTLET	
	Average Hours	Budget Each
Smaller, simpler systems:	0.75	$40
Larger, complicated systems:	1.00	$47

Example Testing and Balancing Estimate

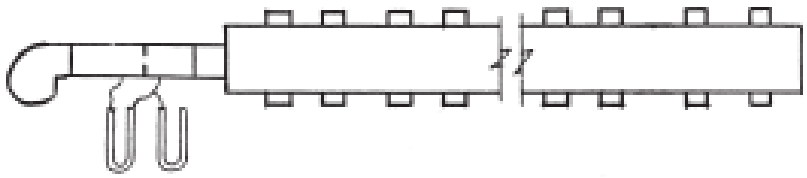


Schematic of System

Qty.	Item		Hours Each	Total
1	Supply unit	Start Up		4.0
1	Return air fan			3.0
1	Roof exhaust fan			2.0
24	Diffusers (typical .9 x .5 = .45)	Bal.	.45	10.8
2	12x12 grilles		.5	1.0
2	48x36 grilles		0.7	1.4
2	Pitot tube traverse in branch duct		.6	1.2
3	Equipment sheets	Test Reports	.2	.6
28	Outlet sheets		.12	3.4
28	Schematic drawing		.05	1.4
1	Change RPM			.75
		Gross total		29.55
Small simple job .9 x 29.55		= Net total		26.6
Average per outlet 26.6 ÷ 28 =			.95hrs	

Estimating Ductwork Leak Testing
Medium or High Pressure Duct Runs

LABOR FOR TYPICAL DUCT RUN



1. Set up leak testing rig	1.0 hr
2. Cap and seal ends of duct run, 1/2 hr each	1.0 hr
3. Cap and seal branch collars, 16 at .2 hrs each	3.2 hr
4. Check leakage with fan, walk run, seal	2.0 hr
5. Retest	1.0 hr
Total time for segment	8.2 hrs

ESTIMATING HYDRONIC BALANCING

Check Out Equipment	Hours
Pumps: Check out pump itself, motor, starter, adjacent valves; read pressures, gpm, amps volts; adjust.	1.5 to 2.5
Chillers, Absorption Units:	2.0 to 3.0
Cooling Tower	3.0 to 10.0
Central Cooling and Heating Coils	2.0 to 4.0
Balancing Terminals	
Reheat Coils, Radiation Units:	.75 to 1.25
Induction Units, Fan Coil Units:	.75 to 1.25

Miscellaneous Labor Operations
Check Off List

DRAWING, CARTAGE
- ❒ Cartage
- ❒ Shop Drawings
- ❒ Field Sketching

TESTING, BALANCING, SERVICE
- ❒ Testing and Balancing
- ❒ Pressure Testing
- ❒ Monitoring
- ❒ Service
- ❒ Operation and Maintenance Manuals

MISCELLANEOUS
- ❒ Initial Set Up of Job
- ❒ Clean Up of Job

GENERAL CONSTRUCTION WORK
- ❒ Sleeves
- ❒ Chases
- ❒ Excavate
- ❒ Backfill

REMOVAL WORK
- ❒ HVAC Equipment
- ❒ Ductwork
- ❒ Piping
- ❒ Electrical
- ❒ Remove and Replace Partitions
- ❒ Ceilings
- ❒ Remove and Replace Doors
- ❒ Remove and Replace Windows
- ❒ Cut Openings
- ❒ Patch Openings
- ❒ Remove and Replace Ceilings
- ❒ Paint
- ❒ Protect Furnishings and Equipment
- ❒ Scrap items
- ❒ Clean Up

Chapter 16

Piping Estimating Basics

REQUIREMENTS OF A PROFICIENT ESTIMATOR

A proficient and reliable piping estimator must possess the following background knowledge, skills and abilities:

Estimating Principles and Procedures

He must follow sound efficient procedures for preparing estimates, such as:

- Become thoroughly familiar with the project, the types of systems and piping, valves etc., involved in the scope of work, etc. before starting a detailed takeoff.
- Be familiar with budget estimating piping systems, costs for different type buildings and systems based on: Cost per square foot of building or cost per ton of air conditioning, Amount of piping per square foot of building, The average size of piping on a job, Cost of piping per linear foot, Cost per square foot of building of piping.
- Know the major divisions of an estimate as described in "8 Facets of the Estimating Diamond" in Chapter 1:
  - Equipment
  - Piping, Valves
  - Accessories, Specialties
  - Special Labor
  - Sub-Contractors End of Bid Factors (such as sales tax)
  - Markups for Overhead and Profit
- Must be familiar with detailed scope of what is required in a piping estimate.
- Identify and highlight various types of pipe, fittings, valves, etc. on drawings before the takeoff.
- Follow systematic overall procedures as described in chapter 2.
  - Study the plans and specs.
  - Send out quotation requests
  - Make Takeoffs and Extensions
  - Summarize
  - Recap and Markups
- Do constant systematic checking on each part as you go along and overall at the end. Double check everything.

Blue Print Readings

Must have the ability to read blue prints, recognize symbols, types of pipe lines, types of equipment and systems, etc.

Types of Piping Systems

Must be knowledgeable of the types of piping systems there are such as:

- Low, medium and high temperature **hot water** systems.
- Low, medium and high pressure steam systems.
- **Chilled water** cooling systems
- **Refrigeration** systems.
- **Hot** and **cold** water systems.
- **Oil** and gas piping.

He must not only recognize the various types of systems on plans, but he must know all of the components required in them, whether shown on plans or not.

They must know about different types of **piping system configurations** such as:

- 1,2,3 and 4 pipe systems
- Reverse and direct return
- Constant and variable volume
- Closed and open systems

Piping and Fitting Materials

A piping estimator must know about different types of pipe and fitting materials, manufacturing methods, types of fittings in each category and applications to systems.

Black Steel Pipe: Sch 20, 40 and 80, A53, A120, A106, Seam and Seamless Pipe, TC and PE ends

Black Fittings: Malleable, Butt Weld, Forged and Black Cast Iron Fittings

Copper Tubing: L, K, KACR, Soft and Hard Tubing, plus DWV

Copper Fittings: Wrought and Cast Fittings
Pressure PVC: Sch 40, 80, Socket and Threaded Pipe and Fittings
Galvanized Pipe: Sch 40 and 80
Galvanized Fittings: Malleable
Cast Iron Soil Pipe: Hub and Spigot, No Hub

Material Applications

He must know the applications of different types of pipe and fitting materials to various systems:

Recirculating Water, 2500°F
For 2" diameter and under
Black Steel A53 Seam, Sch 40 Threaded Pipe
Malleable Threaded Fittings
For 2-1/2" to 12" diameter
Black Steel A53 ERW Welded Pipe
Butt Weld Fittings

Steam and Condensate
For 2" diameter and under, 90 lb
Black Steel A53 Seam, Sch 40 Threaded Pipe
Cast Iron Threaded Fittings
For 2-1/2" to 12", 250 lb
Black Steel Standard Welded Pipe
Wrought Steel Welded Fittings

Refrigerant
Copper L, Y, ACR Hard Tubing, Brazed
Wrought Copper Pressure Fittings, Brazed

Underground Water
Through 12" diameter, 350 lb
Copper Y, Hard Tubing, Soldered
Wrought Copper Pressure Fittings, Soldered

Portable Water Inside Building, 350 lb
Copper & Hard Tubing, Soldered
Wrought Copper Pressure Fittings, Soldered

Fittings

He must be familiar with different types of fittings and those available with all the different types of materials:

Long and Short Radius 90° and 45° **Elbows**
Straight and Reducing **Tees**
Concentric and Eccentric **Reducers**
Straight and Reducing 45° **Laterals**
Caps, Plugs, Unions, Adapters and Couplings
Weldolets, Threadolets and Sockolets
Threaded, Slip on and Welded Neck **Flanges**
Straight and reducing **Wye** Fittings, DW
Combination Fittings, DW
Bends, 1/8, 1/4, 1/6, etc., DAW
Straight, Reducing Taps, **Sanitary Crosses**, DWV
Traps, Cleanouts, DWV

Connections

He must have thorough knowledge of the different types of piping connections.

Steel:	Threaded
	Butt Weld
	Flanged
	Grooved
	Socket Weld
Copper:	95/5
	Brazed
PVC:	Solvent
	Heat Fusion
	Threaded
Cast Iron:	Soil Pipe
	Hub and Spigot
	No Hub

Hangers

He must be familiar with various types of hangers and supports such as:

Clevis
Roller
Spring
Riser
Clamps

Labor

- He must know sources of labor such as MCA and NAPHCC association labor tables, other manuals available, cost records, etc.
- He must know the methods of estimating piping labor such as pipe per foot and fittings per piece or pure per joint labor method.
- He must apply labor multipliers when ever needed and do so with reasonable accuracy.

Piping Pricing

He must know sources of pricing such as piping supply houses, list pricing services such as Harrison, Allprizer, Trade Services, etc. He must be able to use quotations, pricing estimating manuals, etc.

Valves

He has to know about valves:

Standard Valves:
- Bronze, Iron, Steel, Plastic, etc.
- Gate, Ball, Globe, Butterfly, Check, Angle

Specialty Valves:

- Strainer
- Steam Traps
- Pressure Control
- Temperature Control
- Balancing
- Gas Valves
- Refrigeration
- Three or Four Way Combo check, gate and balancing

Specialties

He must know about specialties such as:

- Hot and Chilled Water
- Refrigeration
- Steam
- Plumbing
- Air Separators, Air Vents, Bleeders
- Roloirtrols (Combo air separator and strainer)
- Receivers, Sight Glasses, Dryers, Filters
- Vacuum Breakers, Drip Legs, Converters

Equipment

He must know about Equipment

- Pumps: Centrifugal, Inline, Single and Double Suction
- Boilers
- Unit Heaters
- Baseboard Heaters
- Chillers
- Compressors
- Condensers
- Cooling Towers
- Terminal Equipment
- Tanks

Gages

A piping estimator has to know about gages for temperature, pressure and flow readings.

Types of Insulation

He must be familiar with different types of insulation

- Fiberglass Per-form and Blanket
- Foam Plastic
- Calcium Silicate
- Eurethene Rigid
- Rubber Tubing, Foam

Wage Rates, Unions, Jurisdictions

He must know about wage rates, fringe benefits, federal, state and local taxes, insurance, etc.

He must be knowledgeable about union, trade and local labor jurisdictions and they must know about building codes.

Design

A piping estimator must have some familiarity with piping system design, such as typical flow rates, different systems, pressures and typical sizing for common parameters. He must be generally familiar with the selection of proper equipment.

Other Trades, Types of Buildings

They have to be familiar with other trades such as:

- Insulation
- Temperature Control
- Trenching
- Electrical

He must be familiar with all types of buildings, commercial, institutional, industrial, their general sizes, layout, etc. and with the sequence of general construction work.

Markups

A good piping estimator must be generally familiar with financial statements such as profit loss and balance sheets. He must be able to determine the correct markup for overhead and profit for their company and for the particular job he is bidding.

He should understand how overhead costs are pro-rated onto direct material and labor costs for different projects, for different levels of sales and overhead costs, for different ratios of material to labor, etc.

Skills, Traits Required

Estimating requires a host of skills, mathematical, mechanical, reading, writing, visualizing and drawing. It requires being methodical, analytical, strategical and realistic.

It absolutely demands that the estimator be reliable, that he be thorough in their understanding of the project, of its scope, in takeoffs, interpretations, extensions, summaries and recaps.

Thus, the knowledgeable, proficient and reliable piping estimator as described above will be able to produce complete and accurate estimates, which in turn becomes the required foundation blocks of successful contracting.

HOW TO ESTIMATE PIPING SYSTEMS

This section of piping basics will cover how to takeoff and extend the various piping components in a piping estimate, piping, fittings, accessories (flanges, hangers, connection materials, etc.) valves, specialties and equipment. It win cover what forms to use for larger projects and small jobs.

General Basis of Piping labor and Material Pricing

The installation labor and material pricing for piping, fittings, valves and specialties is a function of the following characteristics:

	Examples
Type Material:	(Black, copper, etc.)
Type Item:	(pipe, 90 Elbow, etc.)
Size:	(1/2", 3" diameter)
Type Connection:	(threaded, welded, flanged, etc.)
Type Hangers:	(band, ring, clevis, etc.)

Hence the labor and pricing tables, takeoff and extension sheet divisions are mostly divided up in the above manner. Hangers usually are not a fundamental category and standard lengths of pipe may be a factor with certain materials.

General Takeoff Approach and Job Breakdown

In making the takeoff, separate the job into different categories so that correction multipliers can be applied as required.

- Standard Floor Plans
- Congested Areas
- Crawl Space
- High Piping Runs
- Equipment Rooms
- Higher Floors

The takeoff should be separated into different materials and type systems.

e.g. Hot water heating, Black steel, Schedule 40, AW53
System P 1

Refrigeration System, Copper Tubing, Type L.
System P2

Separate the takeoff into alternates so that alternate prices can be computed separately.

Equipment Hookups

Stop or start takeoffs at the equipment before taking off risers going up or down and hooking up to the piece of equipment. The hookups should be taken off separately and duplications should be treated as an assembly times the number pieces of equipment connected to. Then estimate the hookups separately.

Labor

The labor factors in the tables are based on normal working conditions.

- Non-productive supervision is not included.
- For Job Conditions correction multipliers should be applied.
- Normal Material Handling is included.

Taking off Piping

- Piping is taken off in footage and is listed separately.
- It is taken off per system, per material, type connection and diameter.
- Labor and pricing are computed on a per foot basis
- Piping comes in various lengths, e.g. Black A53 is 21 feet long in the smaller size range.
- Cuts are figured for pieces that are less than the standard length.
- Connection materials such as weld, solder, etc. or flanges, coupling are needed between pipe to pipe connections and must be counted and priced.
- Hanger sets are based on the footage of pipe and average spacing between sets, and must be counted and priced.
- The labor tables are generally based on an average of one piping connection for every five feet of pipe.
- Certain piping, such as cast iron hub and spigot may be labored and priced per standard length, for example, per two or five foot long standard section etc.

Taking off Fittings

- Fittings are taken on an "each" basis and listed separately from pipe on the takeoff sheets.
- They are taken off per system, per material, type connection and by diameter.
- Connections materials such as weld, solder, putty, etc. may be required at joints and need to be taken off, priced and labored.
- If the fitting is a flanged piping system or a connection to a piece of equipment with a flange, and the fittings are not flanged, then separate flanges that need to be taken off, price and labor them.

Large Projects; Takeoff Method and Extensions

On large projects where numerous takeoff sheets are required, separate piping takeoff and extension sheets

should be used as opposed to a combination takeoff and extension sheet.

1. Piping takeoff sheets are used for taking off piping, fittings, valves, etc. Each column is headed with the particular diameter, except the left hand column which is used for listing different type of fittings, valves, etc.
2. After the takeoff is complete the footages of pipe for each diameter are totaled, as well as the total quantities of fittings, valves, etc. for each diameter being totaled.
3. The totals per type piece and diameter etc. are transferred to a piping extension sheet and summarized.
4. Unit labor and pricing are looked up in the tables in this manual and extended for a total labor and price for each type and size.
5. The columns are then totaled on the extension sheet and transferred to a piping recap sheet for the totals per type of material and connection.
6. The totals of each category are then transferred from the piping recap sheet to the estimate summary sheet for the job.

Small Job Takeoff and Extension Method

1. On small projects where maybe only one or a few takeoff and extension sheets are needed, the piping extension sheet is used for both the takeoff and extension of the piping, fittings, valves, etc.
2. In this case, sizes are simply listed in the left hand column, the type of item in the second column on the same line and the footages or quantities in the third column over.
3. After the takeoff is completed the footages and quantities are totaled in the middle column.
4. Unit material costs and erection labor hours are looked up, entered in the unit columns on the right hand side of the form and extended in the total columns.
5. The material and labor totals are then added up for either each category or for the entire sheet, and the numbers transferred to a job summary sheet accordingly.

SAMPLE ESTIMATE
Hot Water Heating System

Overview of Sample Piping Estimate

The sample piping system covers a hot water heating system for an office building with hot water heating coils in three air handling units, black steel threaded and welded piping, malleable threaded and butt welded fittings, bronze and iron body valves, control and balancing valves. It contains a hot water boiler, compression tank, pump, three way valve, rolairtrol air eliminator, thermometers and pressure gauges, plus other miscellaneous items.

Purpose of Forms

Purpose of Forms

Forms are an indispensable aid and guide to organized, efficient and thorough estimating. They help control the proper sequence of estimating work, continually remind you of what information is needed, lead you logically through calculations and as a result your bids will be more complete and correct.

Job Description and Budget Costs Form (See form samples in chapter 3)

1. Budget estimate prices to determine if it should be bid or not, and as a check price against the detailed estimate after the bid is complete.

2. Approximate heating and cooling loads and rough out total piping linear footage for check of detailed piping takeoff.

3. Record the key characteristics of the type of system involved.

Piping Takeoff Sheet

The piping takeoff sheet can be used for piping, fittings, valves, gages, strainers, etc on larger type projects. Estimating piping labor by the hours per foot, and estimating fitting, valve, gage, strainer, etc. labor by the piece, is the most accurate and clearest method available for contractors. The takeoff involves listing the diameter, type, quantities on fittings, valves, etc. and lengths on pipe.

Piping Extension Sheet

The extension of material involves totaling piping footages per line, entering the labor per foot and extending totals. The extension of fitting, valve, etc. labor involves totaling the quantity of pieces, looking up and entering labor hours per piece and multiplying out for the totals per line. The same procedure is followed for pricing. After the lines are extended the columns are totaled.

Combined Piping Takeoff and Extension Sheet

The combined piping and takeoff sheet is more practical for smaller projects involving fewer items and one or a few sheets. Sizes are listed horizontally in the left hand column, rather than in the column headings.

Equipment Takeoff and Extension Sheet

List all equipment, quantities, sizes, capacity, description on this combined sheet and enter purchase costs from quotations, pricing sheets if available. Enter labor to install equipment using labor tables in this manual or other sources.

Quantity Takeoff and Extension Sheet (See form samples in chapter 3)

The quantity takeoff sheet is a general form for taking off and listing types, sizes, quantities, etc. of the various items required in a bid other than ductwork or piping, for extending the material amounts, labor, costs, etc. and summations.

Estimate Summary and Extension Sheet (See form samples in chapter 3)

The summary sheet is used as a line item summary of all the major grouping of different items included in the estimate, from ductwork and other takeoff sheets, etc. It should be divided into the major divisions of a bid, quoted equipment, ductwork, piping, specialties and accessories, miscellaneous labor, etc.

The total amounts of material quantities, labor, etc. are transferred from duct and piping takeoff sheets, piping extension sheets, quantity takeoff sheets etc. to this summary sheet.

Bid Recap Sheet (See form samples in chapter 3)

1. Recap the job totals of direct costs on labor and prices on raw materials, equipment and sub contractors, and to total them.
2. Put markups on each group and total the overhead markup.
3. Put a profit markup on the labor, raw material, equipment and sub-contractor groups.
4. Total everything for a bottom line bidding price.

Calculating Labor Costs Per Hour Form (See form samples in chapter 3)

This form insures that all the components of the wage rate which include, base wage rate, normal union fringe benefits, federal and state payroll taxes, insurance's and dues, are covered in the rate used in a bid.

Telephone Quotations Form (See form samples in chapter 3)

The telephone quotation form is for recording quotations which come over the phone, in an organized, complete and readable fashion. It includes a check off list on the bottom of critical aspects of a quote such as, if they meet plans and specification requirements, addendum's, taxes, freight, lead times, etc. A box is provided for exceptions on what is not included.

Bidding Record Form (See form samples in chapter 3)

The purpose of the bidding record form is to have a written record of to whom the phone bids were given, what the amount was, what the inclusions and exclusions were and what the plans, specifications and addenda of the bids were based on.

Specifications on Sample Job

IBM Sales Office

A. **Related Documents**

The general provisions of the contract, the general conditions and supplementary conditions of these specifications plus the A/A document A201-1976 "general conditions" apply to the work in this specification.

B. **Scope of Work**

Scope of work to include, but not be limited to the following:

Equipment

1. Boiler
2. Roloirtrol
3. Centrifugal Pump
4. Hot Water Coils
5. Chemical Pot Feeder
6. Compression Tank
7. Control Dampers

Piping

8. Black Steel, Sch 40, A53, Threaded
9. Black Steel, Sch 40, A53, Welded

Fittings

10. Black Malleable Threaded
11. Black Steel Butt Welded

Valves

12. Bronze, Threaded
13. Iron Body

Specialties Valves

14. Control Balancing

Specialties

15. Strainers
16. Drains

Gauges

17. Thermometers
18. Pressure

Miscellaneous

19. Test piping systems

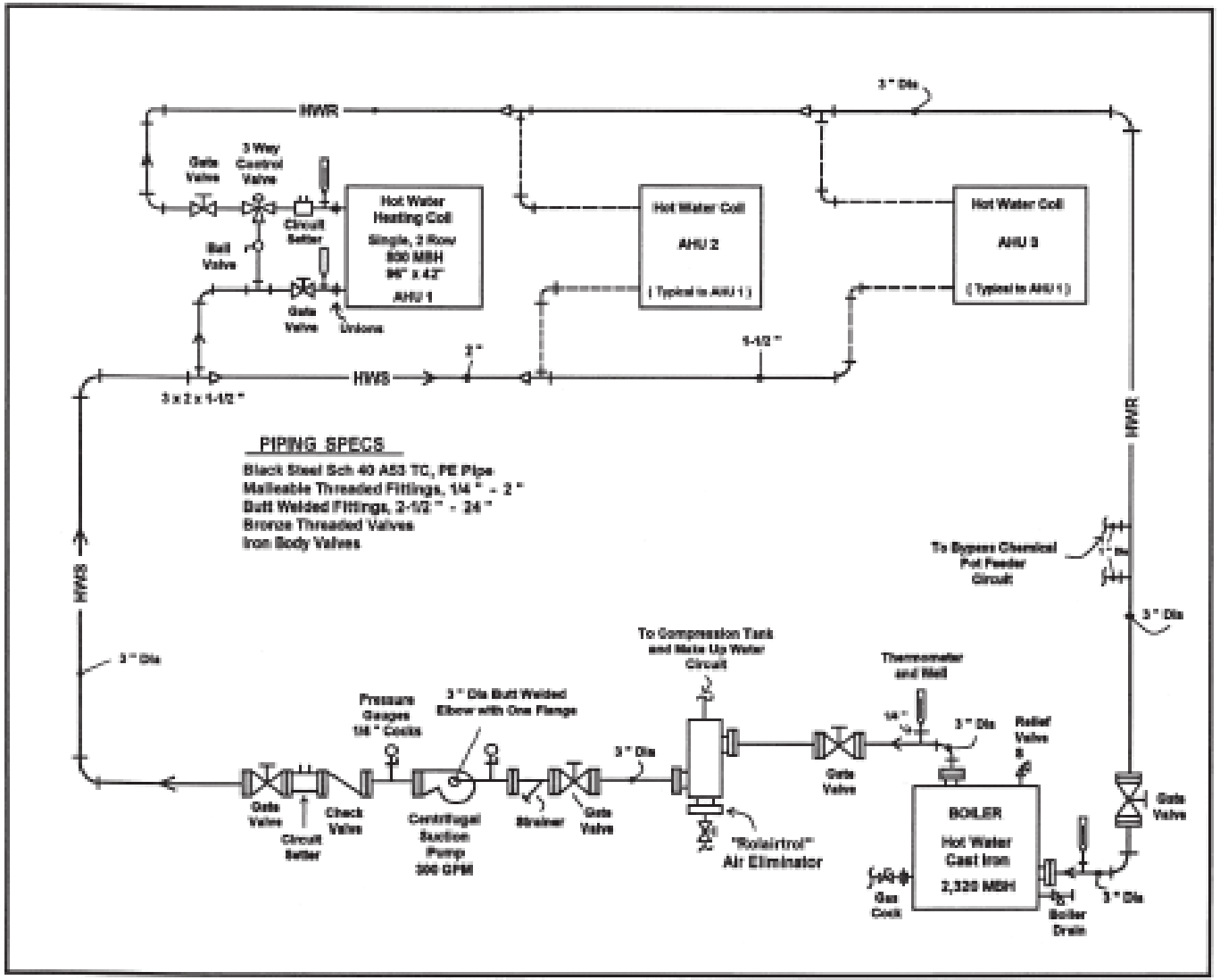
Sub Contractors

20. Temperature Controls
21. Insulation

C. **Work Not Included**

1. Painting
2. Power wiring to mechanical equip.
3. Structural steel openings
4. Concrete Pads
5. Starters

Sample Hot Water Heating System



Chapter 17

Pressure Pipe, Fittings and Insulation

This chapter covers pressure pipe and fittings used for the following type systems:

- Hot Water
- Chilled Water
- Refrigeration
- Steam and Condensate
- Oil and Gas
- Hot and Cold Potable Water

This chapter further covers all types of the following pressure pipe and fitting materials:

- Black Steel
- Galvanized
- Carbon Steel
- Malleable
- Copper
- Pvc

These tables in this chapter also covers all the normal type **fittings** involved in pressure type systems such as radius elbows, street elbows, tees, laterals, crosses, caps, plugs, unions, couplings, weldolets, etc.

Standard type **connections** are covered, such as threaded, welded, grooved, soldered, solvent, etc.

Flanges such as threaded, slip on and welded neck are also covered.

Pricing for different types of **pipe hangers** such as band, clevis, roller, and riser clamps are included, plus standard hanger spacing, rod diameter tables, concrete inserts and anchors.

Piping sleeves and cutting round openings are covered.

At the end of this chapter are tables on **insulation** as follows:

Fiberglass Blanket
Fiberglass Preformed
Foam Plastic
Calcium Silicate
Rigid Eurethene
Foam Rubber Tubing

Units

All **diameters** are in inches.

Labor

The labor productivity rates in the tables are what the average mechanic under average conditions can erect on lower floors of construction projects. However, they may require the application of **labor correction** factors for variable conditions such as upper floors, higher piping runs, congested spaces, etc.

The labor in the tables are in hours per piece and hours per foot for pipe.

Pricing and Discounts

The pricing in the tables are based on the typical manufacturers list prices and the contractor's supplier discounts must be applied.

Appropriate price discounts can range from roughly 10 percent to 80 percent dependent on the following:

- Supplier discount structure
- Who manufacturer is
- Size of batch involved
- Availability
- Shipping distance, costs

Not All List Prices Are Publicly Available

Where there are no prices listed in tables, they are not usually publicly available from the manufacturer. If there is neither labor nor prices listed for a particular diameter in the tables, the particular item may not be available or it may not be a commonly used item.

Caution With List Prices

Pricing can sometimes vary significantly because of changes in commodity material pricing such as copper, etc. Periodic checks of current list prices should be made.

If in doubt about your discounts from list prices, *check with your supplier* as to what they are for the various categories of items—or request a *quotation*.

Automatic Updating
Available in Wendes Computer System

Automatic updating of list pricing is available in the *Wendes Computerized Piping Estimating System*. Call (847) 808-8371 for more information.

Terminology Abbreviations

TC pipe:	Cut and threaded.
PE pipe:	Plain end.
Thrd:	Threaded connections.
Weld:	Welded connections.
Grvd:	Grooved connections.

Black BW A53 Schedule 40 Pipe
Labor

	Hours per Foot		
	TC Pipe	PE Pipe	
Dia	Thrd	Weld	Grvd
1/8	0.04	0.05	—
1/4	0.05	0.06	—
3/8	0.05	0.06	—
1/2	0.06	0.06	—
3/4	0.06	0.06	0.06
1	0.08	0.08	0.08
1-1/4	0.08	0.08	0.07
1-1/2	0.08	0.10	0.08
2	0.10	0.13	0.09
2-1/2	0.13	0.15	0.10
3	0.16	0.17	0.12
3-1/2	0.18	0.19	0.14
4	0.20	0.23	0.16
5	—	0.28	0.20
6	—	0.32	0.25
8	—	0.38	0.30
10	—	0.45	0.35
12	—	0.50	0.40
14	—	—	0.42
16	—	—	0.45
18	—	—	0.48
20	—	—	0.50
24	—	—	0.57

	Labor Factor
Black BW A53 Schedule 80 Pipe:	
Threaded TC Pipe over 2" Dia.	1.15
Welded PE Pipe all Diameters	1.20

Black Malleable Standard Fittings
Threaded Connection Labor

	Threaded Labor Hours Each							
Dia	90 Elbow	45 Elbow	Tee	Wye	Cross	Cap	Coupling	Brass Union
1/8	0.14	0.09	0.16		0.25	0.13	0.15	0.23
1/4	0.21	0.10	0.25	—	0.31	0.14	0.16	0.27
3/8	0.28	0.22	0.38	0.45	0.45	0.15	0.21	0.31
1/2	0.35	0.35	0.51	0.51	0.66	0.20	0.35	0.35
3/4	0.46	0.46	0.70	0.70	0.95	0.25	0.46	0.50
1	0.60	0.60	0.87	0.87	1.13	0.30	0.60	0.56
1-1/4	0.70	0.70	1.00	1.00	1.32	0.36	0.70	0.63
1-1/2	0.75	0.75	1.10	1.10	1.45	0.40	0.75	0.70
2	0.90	0.90	1.35	1.35	1.75	0.46	0.90	0.95
2-1/2	1.47	1.47	2.18	2.18	2.88	0.75	1.46	1.47
3	1.76	1.76	2.62	2.62	3.46	0.90	1.74	1.76
3-1/2	2.06	2.06	3.06	—	—	1.04	—	—
4	2.37	2.37	3.53	3.53	4.64	1.19	2.32	—
5	3.84	3.84	5.70	—	—	1.93	—	—
6	4.65	4.65	6.89	—	—	2.32	—	—

	Labor Factor
Black malleable standard fitting threaded XH	1.03

Black Malleable Standard Fittings
Grooved Connection Labor

	Grooved Labor Hours Each									
22-1/2 Dia	90 Elbow	45 Elbow	Lateral Elbow	Tee	Female Wye	Cross	Std Flex Adapter	Cap	#150 Coupling	Flange
3/4	0.35	0.35	0.42	0.50	0.88	0.98	0.18	0.18	0.03	—
10.42	0.42	0.45	0.60	0.88	0.98	0.22	0.22	0.04	—	
1-1/4	0.45	0.45	0.50	0.68	0.88	0.99	0.25	0.24	0.05	—
1-1/2	0.50	0.50	0.60	0.70	0.89	1.00	0.27	0.25	0.05	—
20.60	0.60	0.58	0.90	0.89	1.15	0.32	0.30	0.06	0.05	—
2-1/2	0.65	0.65	0.70	0.90	0.87	1.10	0.30	0.31	0.08	0.07
3	0.70	0.70	0.80	1.05	1.05	1.40	0.35	0.35	0.09	0.08
4	0.95	0.95	0.93	1.45	1.42	1.85	0.50	0.47	0.10	0.10
5	1.45	1.40	1.40	2.15	2.12	2.75	—	0.70	0.12	0.12
6	1.75	1.70	1.70	2.62	2.60	3.35	—	0.85	0.20	0.15
8	2.45	2.30	2.28	3.60	3.55	4.45	—	1.18	0.25	0.20
10	3.30	3.00	2.90	4.85	4.55	5.75	—	1.53	0.35	0.20
12	4.00	3.30	3.00	5.30	4.75	5.95	—	1.67	0.45	0.50
14	4.35	3.73	—	5.70	5.45	6.35	—	—	0.70	0.70
16	5.05	4.10	—	6.14	5.80	6.55	—	—	0.82	0.85
18	5.30	4.55	—	7.38	7.02	8.65	—	—	0.84	0.90
20	6.15	5.30	—	8.25	8.05	9.95	—	—	1.6	1.12
24	6.95	6.80	—	9.90	9.35	10.93	—	—	1.62	1.53

Chapter 19

DWV Pipe and Fittings

This chapter covers labor and price tables for DW (drain, waste and vent) piping and fittings as follows:

DWV Pipe and Fittings:

- Copper DVVV Pipe and Wrot Copper DWV Fittings
- PVC DWV Schedule 40
- ABS DWV Schedule 40
- Cast Iron Hub and Spigot
- Cast Iron No Hub

Units

All diameters are in inches.

Refer to chapter 17 for hangers.

Labor

The labor productivity rates in the tables are what the average mechanic under average conditions can erect on lower floors of construction projects. However, they may require the application of labor correction factors for variable conditions such as upper floors, higher piping runs, congested spaces, etc.

The labor in the tables are in hours per piece and hours per foot for pipe.

Pricing and Discounts

The pricing in the tables are based on the typical manufacturers list prices and the contractor's supplier discounts must be applied.

Appropriate price discounts can range from roughly 10 percent to 80 percent dependent on the following:

- Supplier discount structure
- Who manufacturer is
- Size of batch involved
- Availability
- Shipping distance, costs

Not All List Prices Are Publicly Available

Where there are no prices listed in tables, they are not usually publicly available from the manufacturer. If there is neither labor nor prices listed for a particular diameter in the tables, the particular item may not be available or it may not be a commonly used item.

Caution With List Prices

Pricing can sometimes vary significantly because of changes in commodity material pricing such as copper, etc. Periodic checks of current list prices should be made.

If in doubt about your discounts from list prices, *check with your supplier* as to what they are for the various categories of items - or request a *quotation*.

Automatic Updating Available in Wendes Computer System

Automatic updating of list pricing is available in the *Wendes Computerized Piping Estimating System*. Call (847) 808-8371 for more information.

Copper DWV Pipe and Fittings
Soldered Connections

Dia.	Pipe		1/4 Bend		1/8 Bend		1/16 Bend	
	Labor	Price	Labor	Price	Labor	Price	Labor	Price
1-1/4	0.06	$2.34	0.50	$3.53	0.50	$3.23	0.50	$5.80
1-1/2	0.06	2.95	0.52	4.73	0.52	2.69	0.52	7.62
2	0.06	3.90	0.60	6.87	0.60	6.16	0.60	9.87
3	0.08	6.16	1.15	16.98	1.15	13.04	1.15	16.69
4	0.10	11.10	1.53	80.13	1.53	55.12	1.53	68.00
5	0.15	34.38	—	—	—	—	—	—
6	0.18	47.55	—	—	—	—	—	—
8	0.22	86.42	—	—	—	—	—	—

Dia.	Double		Sanitary Tee		Dbl Sanitary Tee		Wye	
	Labor	Price	Labor	Price	Labor	Price	Labor	Price
1-1/4	0.71	$14.45	0.71	$6.94	1.03	$17.73	0.71	$13.24
1-1/2	0.76	21.39	0.76	8.64	1.09	15.42	0.76	14.41
2	0.88	33.97	0.88	10.08	1.29	37.42	0.88	19.79
3	—	—	1.70	35.96	2.50	54.50	1.70	45.28
4	—	2.29	91.24	3.39	253.00	2.29	91.24	—
5	—	—	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—

Chapter 20

Markups for Overhead and Profit

UNDERSTANDING AND APPLYING CORRECT OVERHEAD AND PROFIT FACTORS

Most of the manual to this point has been spent on emphasizing the necessity for making sure direct material and labor costs are covered fully and accurately. However, you may cover direct costs correctly, and still may be short many thousands of dollars on your bid by putting an inadequate markup on the job for overhead and profit thus despite your success in the first part, you are really no where in the end.

Hence, not only must you make sure that the estimate of labor and materials is complete and accurate-but also that the profit and overhead markups on each job bid correspond accurately to the actual finances of the company.

Hence, the following concepts and definitions must be thoroughly understood in the preparation of bids:

DIRECT COSTS

Direct costs are the costs for material, labor, and subcontractors needed for a job. They are charged directly to the particular project.

Labor covers fabrication, installation, drafting, balancing, etc.; materials include raw material and equipment; sub-contractors include rentals and these are all normally direct costs. Also, sales tax, permits, bonds, travel costs, room and board are direct type costs which can be attributed directly to a project.

Total direct costs for the year for the $2 million dollar sales contractor in the sample illustration are $1,500,000, which is 75 percent of sales.

OVERHEAD COSTS

Overhead costs however, are those costs you cannot charge directly to each specific project. They are fixed and semi-variable costs that continue on, either 100 percent of the time or to some degree, whether you have work or not. Overhead costs are prorated in varying degrees to all projects. Some of the main ones are:

Office Salaries	Interest
Rent or Owning Costs	Depreciation
Utilities	Insurance
Real Estate Taxes	Boats, Lear Jets
Auto and Truck Costs	Trips to Disney World

Labor draws about two to three times as much indirect cost as equipment, materials and sub-contractors do.

Total overhead costs for the year in the sample illustration are $400,000, which is 20 percent of sales.

PROFIT

Profit is the amount of money you have left over at the end of the year and at the completion of the projects after you have paid out all your direct and overhead costs. Net profits are after corporate income taxes are taken out.

Honest profit is not a dirty word, but rather a necessity for successful business operation in a free functioning economy:

- Profit pays a return on investment for stockholders
- It provides money for capital investments, machinery, buildings, etc.
- It provides for replacement, improvements and growth.
- It provides for increases in wages and more fringe benefits for employees
- Profit provides more jobs through expansion
- Profit is the incentive needed to take the risks of a business, and is the reward for the hard work and risk.
- Profits are necessary for a healthy economy.

- Profits pay taxes to the government

A business cannot survive long without profits, and the if the business fails, many parties are hurt, not only the owners, but also employees, creditors, customers, etc.

A company is in business to make money not lose it. Its primary goal is to earn a sufficient amount of profit to cover the items listed above.

However, just because someone is in business and must make money to survive, it also doesn't justify, on the other hand, a carte blanche approach. A business must run responsibly in the context of the overall good of the community, etc. and must meet the following criteria:

- The products and services of a company must meet acceptable standards and satisfy needs.
- The business cannot break the law.
- It must meet common morality standards
- It must provide healthy and safe working conditions for its employees.
- It should not adversely effect the environment
- It cannot adversely effect other peoples property
- It cannot adversely effect the health or safety of the public in general.

Profit for the year in the sample illustration is $100,000, which is 5 percent of sales.

RETURN ON INVESTMENT

Given a ¢2 million sales and a ¢500,000 capital investment in a company:

- If a 20% return on investment is required, (which is ¢100,000 based on the ¢500,000 capital investment), there must be a 5% profit of ¢ 100,000 on the sales of ¢2 million.
- A corporate tax of 25% reduces the profit to ¢75,000.
- If ¢50,000 is spent on new machinery etc. it reduces the net profit to ¢25,000 or earnings of 2-1/2% for stockholders.

MARKUP FOR OVERHEAD

Markup for overhead is the amount of money added to direct costs on an estimate to cover overhead costs. The markup percentage is the ratio to direct costs.

Average percentage markup required on jobs during the year:

$400,000 (yearly overhead costs)/$1,500,000 (yearly direct costs) 27% average (rounded out).

The goal of an overhead markup on the various projects is to recuperate all the actual overhead costs incurred for the year. Each job must make its proportionate contribution to overhead and plus contribute proportionately to the profit.

MARGIN, GROSS PROFITS

Margin, which is also called gross profit, is the difference between sales and direct costs,and is equal to the overhead and profit together.

The margin percentage is the ratio to total sales, as differentiated from markup, which is the ratio to total direct costs. However, they are both the same thing money wise, but just have different names and different ratio references.

Margin works from the top down from total sales, as an accountant does, rather than from direct costs up as the estimator does. Margin, obviously then, is always a lower percentage than markup since it is a ratio to a higher base. Hence:

The margin in the illustration is $500,000 and includes the overhead and profit for the year.

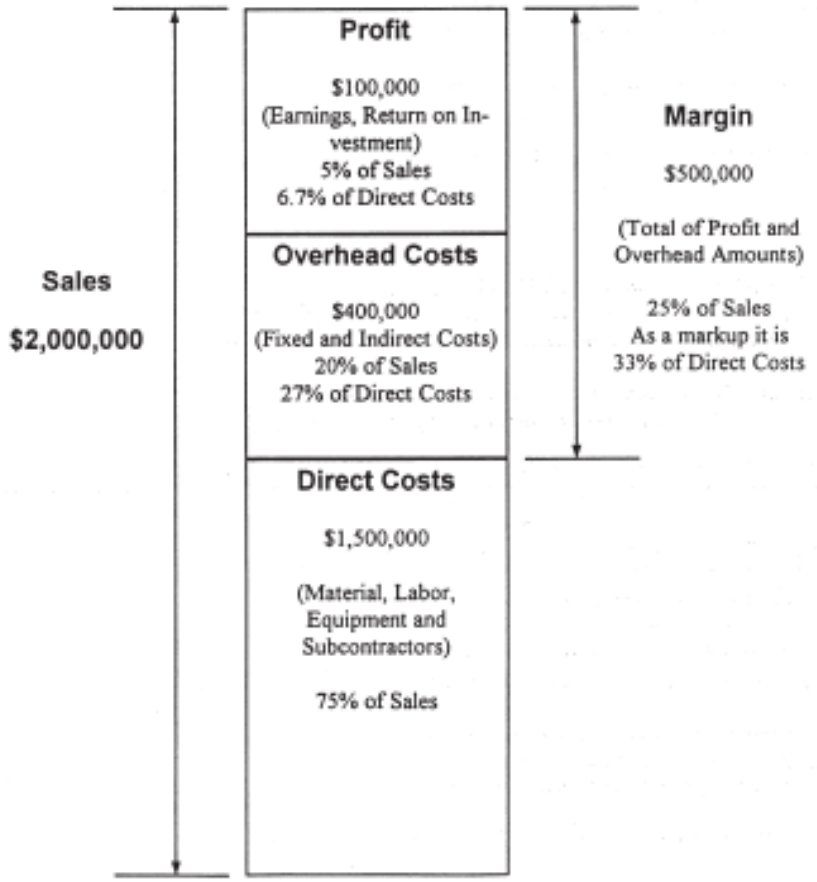
The $500,000, as a ratio to $2 million sales, is 25%.

The $500,000, as a ratio to direct costs to $1,500,000, is 33 %.

METHODS OF DETERMINING PERCENTAGE MARKUPS ON COSTS

Single Markup On Labor and Materials for Overhead

A single markup for overhead, which is a percentage of the combined total of direct labor and material costs, is the basic and clearest approach in marking up jobs. Whether estimating or monitoring jobs, when you have them, you should always know what the average percentage should be. It is a starting and reference point and gives you a vital overall view.



An estimator, when preparing a bid, works up the direct costs on the project first and then "markups" to cover overhead and profit as a ratio to direct costs. The accountant, in his financial statements, deals with the percentage overhead and profit as a ratio to the total sales figure.

$$\frac{\$400{,}000 \text{ overhead}}{\$1{,}500{,}000 \text{ direct costs}} = 27\% \text{ average markup required on direct costs}$$

$$\frac{\$500{,}000 \text{ overhead and profit}}{\$1{,}5000{,}000} = 33\% \text{ average markup required on direct costs}$$

PROFIT MARKUPS

The markup for profit should generally be kept separate from the overhead markup so that overhead can be covered more accurately and distinctly in the bid. Then, when it is necessary to trim the price on a bid to be more competitive, it is easier to only focus on reducing the profit, rather than the overhead.

MULTIPLE MARKUPS

The multiple markup method puts a different percentage markups on labor and material. Even though a single markup on material and labor is easy to apply and correlates well to financial statements, it frequently is not a competitive approach to bidding because it may not place the bulk of the overhead on where it properly belongs, which is on labor. As stated previously, since labor generally draws more overhead than equipment and materials, it must contribute a larger portion to it.

Consequently when applying a multiple markup, a lower percentage is applied on equipment, and a higher one on labor. This more properly and competitively covers the variations in material/labor ratios and is more realistic. The approach here is to select an appropriately lower percentage markup on equipment and subs first, according to your market conditions and material/labor ratios of the project being bid. Then put the balance of the overhead burden on labor.

For example:

Given: Labor Costs $750,000
Equipment and Subs $750,000

A 10% markup on equipment and subs for overhead is $75,000,

$400,000	Total overhead
– 75,000	Less equipment/subs overhead markup
$325,000	Overhead left for labor to cover

Markup percentage needed on labor

$325,000 (Labor Overhead Burden)
$750,000 (Labor Costs) *Equals a 50% markup needed on labor for overhead*

MARKUPS ON LABOR HOURS ONLY

Just adding a markup to direct labor costs, to cover overhead and profit, can be a simpler, more convenient approach for change orders, time and material orders and possibly for certain type operations according to the preference of the contractor or customer.

For example:

Given: 9 mechanics employed in company = 17,857 man hours/year

If all overhead is covered by labor:

$400,000 Total Overhead / 17,857 Hours = $22.40 which must be added onto direct labor costs

$100,000 Total Profit / 17,857 Hours = $5.60 which must be added on also

Direct labor costs with fringes, pay roll taxes, etc.	$42.00 per hr
Overhead costs	$22.40
Plus 5% Profit	$ 5.60
Total required selling price per hr for labor	$70.00

BIDDING STRATEGY REGARDING MARKUPS

You must know what average percentage markup is needed on direct costs during the course of the year to properly cover the actual overhead and profit final amount at year end. It must be based on anticipated sales, overhead costs and desired profit and be monitored monthly and adjusted if need be.

Even though you may have to vary your percentages at times for various type projects, bidding situations and material labor ratios, the overall average must come out to the percentage determined by yearly sales and overhead.

Overhead must be totally covered for the year no matter what variation in percentages are applied on the estimates.

Each job must make its proper proportionate contribution to both overhead and profit and the total must equal the years total overhead costs and meet the anticipated profit.

Situations where You May Vary Your Standard Markup

- The markup for overhead might be varied where the number of bidders is considerably more or less than usual, or where the competitors may change the bidding strategy.
- Jobs which are considerably larger or smaller than your average.
- Where the ratio of materials and subcontractors to labor is greater or less than normal.
- For low risk or higher risk projects than the normal, or those with considerable capital involved.

Markup Calculation Sheet

COMPANY MARKUP CALCULATION SHEET

Date November 1, 1997

Company Northwest Mechanical — Period Nov. 1997 to Nov. 1998

			Percent of Sales
1. Anticipated Sales for a Year	$ 2,000,000		
2. Total Indirect Overhead and Administration Costs for the Year		$ 400,000	20%
Profit Desired 5 %		$ 100,000	5%
Total Anticipated Direct Costs for the Year (Material and Labor)		$ 1,500,000	75%
Breakdown: Labor (Includes fringes, payroll taxes, insur.)	$ 750,000		
Material and Equipment	$ 750,000		
Subs	$		

3. SINGLE MARKUP NEEDED ON TOTAL DIRECT COSTS

Percent For Ovhd Only:	$ Overhead Costs / $ Direct Costs	$ 400,000 / $ 1,500,000	=	27	%
Percent For Overhead & Profit Together	$ Overhead & Profit / $ Direct Costs	$ 500,000 / $ 1,500,000	=	33	%

4. SIMPLIFIED DUAL MARKUP FOR OVERHEAD

			Amount of Markup For Year
Markup on Materials and Equip	10 % x $ 750,000	=	$ 75,000
Markup on Subs	% x $	=	$
Total Overhead on Mat. & Subs			$ 75,000

Percent Markup on Labor for Overhead = ($ Total Ovhd) - ($ Matl. & Sub Ovhd) / ($ Labor Costs)

$(400,000) - $(75,000) / $(750,000) = $ 325,000 / $ 750,000 = (43)%

5. TOTAL SELLING COST OF LABOR PER HR COVERING OVERHEAD AND PROFIT

Wages per hr (incl. fringes, insr., & taxes)	$ 42.00	
$ Wages x percent overhead markup on labor	$ 22.40	(17.857 hr)
Profit 5 % (on total sales)	$ 5.60	
TOTAL		$ 70.00

The above markup calculation sheet can be used for determining the required level of markups needed for overhead and profit for a company using the three methods described in this chapter: 1) a single markup applied to total direct costs either for overhead alone or for the combination of overhead and profit as one markup factor. 2) individual, multiple markups for labor, materials and subcontractors. 3) selling cost of labor.

Single Markup Factors On Direct Costs
To Cover Both Overhead and Desired Profit
As Percent of Sales

Overhead Margin as Percent of Sales	DESIRED NET PROFIT								
	4%	5%	6%	7%	8%	9%	10%	15%	20%
10%	1.16	1.18	1.19	1.20	1.22	1.23	1.25	1.33	1.43
11%	1.18	1.19	1.20	1.22	1.23	1.25	1.27	1.35	1.45
12%	1.19	1.20	1.22	1.23	1.25	1.27	1.28	1.37	1.47
13%	1.20	1.22	1.23	1.25	1.27	1.28	1.30	1.39	1.49
14%	1.22	1.23	1.25	1.27	1.28	1.30	1.32	1.41	1.52
15%	1.23	1.25	1.27	1.28	1.30	1.32	1.33	1.43	1.54
16%	1.25	1.27	1.28	1.30	1.32	1.33	1.35	1.45	1.56
17%	1.27	1.28	1.30	1.32	1.33	1.35	1.37	1.47	1.59
18%	1.28	1.30	1.32	1.33	1.35	1.37	1.39	1.49	1.61
19%	1.30	1.32	1.33	1.35	1.37	1.39	1.41	1.52	1.64
20%	1.32	1.33	1.35	1.37	1.39	1.41	1.43	1.54	1.67
21%	1.33	1.35	1.37	1.39	1.41	1.43	1.45	1.56	1.69
22%	1.35	1.37	1.39	1.41	1.43	1.45	1.47	1.59	1.72
23%	1.37	1.39	1.41	1.43	1.45	1.47	1.49	1.61	1.75
24%	1.39	1.41	1.43	1.45	1.47	1.49	1.52	1.64	1.79
25%	1.41	1.43	1.45	1.47	1.49	1.52	1.54	1.67	1.82
26%	1.43	1.45	1.47	1.49	1.52	1.54	1.56	1.69	1.85
27%	1.45	1.47	1.49	1.52	1.54	1.56	1.59	1.72	1.89
28%	1.47	1.49	1.52	1.54	1.56	1.59	1.61	1.75	1.92
29%	1.49	1.52	1.54	1.56	1.59	1.61	1.64	1.79	1.96
30%	1.52	1.54	1.56	1.59	1.61	1.64	1.67	1.82	2.00

Example: If overhead is 20% of sales and you are shooting for a net profit of 5% before taxes, use 1.33 as a single markup on direct costs.

- Where you find you will be closing more work during the year than you had anticipated; and where overhead will be greater than anticipated; where gross margins on projects are greater than calculated for the year, and you find you have overhead covered ahead of time.
- Potential extras, tenant areas, additions, which produce higher gross margins may influence your markup.
- Fast moving, quick completion projects may reduce overhead costs somewhat.
- Quick paying jobs.
- Anticipated buyouts on equipment and sub-contractors may reduce the percentage markup required.
- Large contracts where the cost of money may increase the markup percentage needed.
- The markup may be adjusted according to the estimators general accuracy. His estimates may be generally higher or lower than actual direct costs.

ODDS OF GETTING JOB

The odds of being low on a bid and getting the contract are contingent on the following factors:

- Number of bidders.
- Whether being bid as a prime contractor or sub-contractor.
- Bidding to owner, architect/engineer or general contractor.
- The efficiency and productivity of your company compared to competitors.

- Percentage markup you require for overhead and profit compared to competitors.
- How badly you are in need of work compared to competitors.
- The general accuracy of estimating of the other contractors.
- How rationally the competitors normally bid.

Income Statement
12 Months Ending December 31, 1997
(Typical $2 Million Mechanical Contractor)

	Amount	Percent of Sales
Sales	$2,000,000	100.00
Direct Costs (variable with volume of work)		
Material	700,000	35.00
Sub Contracts	100,000	5.00
Labor	500,000	25.00
Fringes, Insurance, Taxes	200,000	
Total Direct Costs	1,500,000	75.00
Gross Margin	500,000	25.00
Overhead Expenses (fixed and semi fixed costs)		
Salaries Officers	120,000	6.00
Office	60,000	3.00
Fringe, Insurance, Taxes	40,000	2.00
Rent, 6000 square feet	30,000	1.50
Utilities	10,000	0.50
Insurance - Fire and Theft	20,000	1.00
Taxes - Real Estate	8,000	0.40
Interest	16,000	0.80
Bad Debts	4,000	0.20
Maintenance	8,000	0.40
Expendable Tools	6,000	0.30
Office Supplies	8,000	0.40
Dues	1,000	0.05
Donations	1,000	0.05
Advertising	2,000	0.10
Professional Expenses	4,000	0.20
Auto and Truck, Owning & Operating	20,000	1.00
Sales Expenses	4,000	0.20
Travel and Entertainment	2,000	0.10
Depreciation - Auto and Trucks	20,000	1.00
Depreciation - Machinery and Equipment	10,000	0.50
Depreciation - Building	6,000	0.30
Total Overhead	$400,000	20.00
Net Income Before Income Taxes	$100,000	5.00

Typical Income Statement

Chapter 21

Contracting for Profit

WHAT DETERMINES YOUR PROFITABILITY AN OVERALL VIEW

Productivity

The number one major factor that determines your profitability is your productivity rate. For sheet metal contractors the rate of fabrication and installation, what machinery, tools and equipment are owned, the methods used to operate and your quality of manpower are primary factors. Do you fabricate at 22 pounds per hour or 28, or at the average 25? Do you have a duct coil line or a hand break? Productivity between companies can vary 30 or 40 percent. For piping contractors, the rate of erection, field efficiency and quality of the manpower are primary productivity factors.

Being On Top of the Job

Avoiding costly delays, goof-ups, miscoordination, out of sequence work, over manning, waste; the control of all the operations, of timing, being on top of costs, confronting problems as they come up, is the 2nd major factor that controls your profitability. The ductwork or piping for the 2nd floor is two weeks late and it costs an extra $1,000 to install because the other trades got in first. Or some equipment doesn't fit and it costs you $2,000 to rectify the problem.

Complete and Accurate Estimating

You can be off 10 to 20 percent without batting an eye lid. The accuracy of your estimate is a major, constant factor in determining the profitability of your company. Treat each bid like a new born baby, give it the time and attention it must have to survive.

Correct Markups

Hand in hand with estimating direct costs is the proper evaluation of overhead costs, setting of profit goals, and the adequate application to each bid. The markup money which isn't covered for overhead comes off the top, which is the profit layer.

Buyout and Good Purchasing

The fifth most important factor which determines your profitability is buyout and frugal purchasing. If you bid a job with no commitments to equipment suppliers or to subcontractors, you just accept their bids as received, make no deals, you can well buyout with a 3, 5 or even 10 percent pickup, with a more thorough evaluation after you receive the contract, than is possible at bid time.

Many equipment and sub quotes are too high going in, not really competitive and some have contingencies. If you allow your suppliers and subs to reevaluate their pricing, recheck their take-offs and extensions before purchasing from them, you frequently uncover errors and inflated pricing. You may develop cost saving ideas with the additional time and the second look, which can reduce costs. Two suppliers may have bid $22,000 and $24,000 and later found they could trim and polish their bids for something under $20,000. You get several prices on 30,000 pounds of galvanized ductwork and you find some one who can sell it for less per pound.

Selective Bidding

Another factor that has a major influence on how well you operate, and consequently how you fare economically, is selective bidding: choosing those jobs you can do well; volume you can handle; projects where you have a history of experience and pricing on; jobs that suit your operations in terms of facilities, machinery, manpower, and management.

Do you do well with smaller, shorter simpler projects with multi-skilled tradesmen, and with service operations, or is your expertise with large and medium size projects that span 1, 2 or 3 years and which involve highly sophisticated production equipment in your shop, aggressive foremen on the job site, and a wide range of special skills.

Selective bidding involves being correctly capitalized for a project and not having to go out and borrow $100,000 or $200,000 at 12% to run a job. The amount of money you must or must not borrow effects your profitability potential.

Timely Payments

Timely payments for work you have completed on projects is another factor in your profit making picture. If you have to wait 6 months, or a year for $20,000 or $50,000 and it's worth 8 or 10 percent per year, you are hurting money wise and cash flow wise. Waiting 60 or 90 days or more for monthly progress payments are damaging to your financial situation. Cash flow control is an absolute determinant on your profitability, and prompt invoicing, follow up and demand of payment within a reasonable time span is a necessity.

Controlling Overhead

Overhead can effect you astronomically if left to its own meandering. A $500,000 overhead can jump to $600,000 or $700,000 in a year or two without any increase in business or work load.

Job Costing

Job costing and time studies provide the factual figures for estimates, for production scheduling, progress billing and valid financial reports and can indirectly effect efficiency and accuracy.

Inventory Control

Not having $40,000 worth of uninstalled fans on the job site 6 months, where you have to pay the manufacturer, but you can't collect from the owner; or an over abundant supply of galvanized material in the shop, can chew away the dollars that should be profit in the end.

Bidding and Pricing Strategically

Bidding strategy can often provide many extra thousands of dollars by not leaving too much on the table, by properly sensing the market and the competition.

Being On Top of Finances

Job costing reports and control, regular financial statements and managing cash flow effectively are all essential for bottom line profits.

HOW TO LEGITIMATELY REDUCE COSTS ON A BID

To Be More Competitive

System and Design

1. **Redesign**

   An intelligent redesign or change in specifications while still giving the customer the same performance at a substantially lower price can open many doors for you. Redesign should always be a consideration when looking for ways to reduce costs.

2. **Lower Priced Systems**
   - A roof top or split DX system might handle the customers needs just as well as a chilled water system and costs considerably less.
   - Combining a number of small systems together into a larger one can often reduce costs.
   - Using a 2 pipe system versus a 3 or 4 pipe can save if feasible.
   - Eliminate or minimize return air ductwork if possible.

3. **Check for Over-Design**

   A system may be over designed, too full of design safety fudge factors, excessive capacity, larger sizes than need be, and can be reduced to just what is really needed providing substantial cost reductions.
   - Where 40 tons of cooling will do the job on a project instead of an excessive 50 tons, costs can possibly be reduced 10 or 20 thousand dollars.

Ductwork and Piping

4. Reduce Ductwork and Piping Costs Through "STAR" Method of Streamlining
   - Straighten out ductwork and piping routings.
   - Maximize duplications of runs and fittings.
   - Optimize arrangement of straight and fittings in runs.
   - Simplify and standardize fittings.

   Five hundred feet of ductwork might be cut down to four hundred with more direct and efficient routing, outlet placement and so on. This can well reduce costs on a $100,000 project to $86,000, a sure winner to get you a job once substantiated.

5. **Lower Priced Ductwork or Piping Materials**

   Different materials which work equally as well as those specified, but cost less, might be offered as a substitution on a bid.
   - 24 gauge cleated stainless steel ductwork may be equally resistant to the fumes in a system as PVC ductwork, and costs 20% less.
   - Threaded black steel pipe and fittings may be 25 to 30 percent less than copper to purchase, and still work equally well in certain applications.

Equipment

6. **Lower End Standard Equipment and Systems Versus Deluxe**

Deluxe equipment, materials, control systems, construction, accessories, options, etc. may be as extravagant as a Mercedes, whereas standard features and design may be more than satisfactory at a much lower cost.

- Use XYZ equipment at $9,000 instead of ABC equipment at $12,000.
- Use an electric control system versus a deluxe pneumatic.

7. **Substitute Lower Price Non-Specified Equipment**
Substitute non-specified equipment manufacturers with a lower priced manufacturer who can meet the performance and construction of the specified equipment. This can make the difference in the final low bid price.

8. **Pre-Negotiated Equipment and Sub-Contractor Prices**
Equipment and sub contractor prices can be negotiated at the time of bidding. Agreements can be made and prices might be considerably lower than street prices. This frequently provides a competitive edge.

9. **Package Buy at a Discount**
You may have several projects that will be going at the same time and can package buy equipment and materials at a volume discount, thereby edging under competitors who are pricing the same items in the bid at the street quotations.

Grilles and diffusers for three projects all bought simultaneously from the same supplier might be five or ten percent cheaper.

Labor

10. **Use Lower Priced Labor**
Where *conditions permit* you might use helpers, stockmen, truck drivers, draftsmen, etc. at lower wage rates which may tilt the scales in your favor when bidding.

Machinery and Methods of Operation

11. **More Efficient Productive Machinery or Methods**
You may plan to buy a high speed forming machine, coil line, plasma cutter, heavy duty power shear or press break or some other equipment which will increase efficiency. This can be factored into your bid to lower the price and help you be more competitive.

Estimates

12. **Recheck Estimate for Overage Errors**
Errors in estimates are made in both directions. You may have $5,000 too much in your bid as well as too little due to math or takeoff errors or poor pricing. This throws you out of the running and you don't get the job. Recheck estimates thoroughly, not only for loss errors but for overage also.

STAR METHOD OF REDUCING DUCTWORK AND PIPING COSTS

Standardize and Simplify Ductwork and Piping Designs
Create Duplications
Arrange Pieces More Economically
Route Runs More Efficiently
Optimize Ductwork and Pipe Sizing

You design and lay out an air distribution system and find that there are 300 pieces of ductwork in it. The current market price for the average size duct section in this design, let's say, is approximately $150 each. This brings the total price for 300 pieces to $45,000.

Now you take the initial layout and apply the principle rules of STAR to it for reducing costs. You then recount the pieces and discover that you've reduced the number from 300 to 250. You also re-evaluated the cost of each piece and determined that the average price is reduced 10 percent also, from $150 to $135. Consequently, you have slashed the total installed cost of the ductwork 25 percent, a $15,000 saving, from $45,000 to $30,000.

Can this be true, you wonder? So you check whether the calculated performance has been affected and find it unchanged. If anything, the total static pressure drop is lower, the noise level unaltered, air distribution in the spaces still as intended, and anticipated air volume delivery still on target.

How can you do this with the same ductwork materials, the same designer, the same contractors and sheet metal men, and the same architectural design?

STAR is the answer, a value analysis approach for reducing total costs while still maintaining function and performance in building piping and ductwork systems. The mnemonic acronym is derived from the four basic elements of the method: S for standardization, simplification and sizing, T for typicals, A for arrangement, and R for routing. But more on these later.

STAR is a method of vigilant search for, and extermination of, costs that do not contribute to a system's objectives and to the user's needs. Its principles are aimed at

maximum compatibility between performance and cost efficiency in any pipe or duct conveying system, whether air, liquid, steam, electricity, or otherwise. Its specific goals are fewer joints of pipe and fittings, more standardized economical ones, more direct routing, and fewer connections, so that labor time is reduced. Material is generally considered secondary in this approach.

STAR is a process of revising and polishing, of editing, of whittling away at what is unnecessary and creating more economical alternatives.

STAR helps contractors to meet their estimates and to avoid losing money in a hotly competitive market with pricing so low that firms cannot afford to manage as they should. The design engineer benefits from STAR in that he can get more work through lower cost systems, and he derives the professional satisfaction of designing more efficient systems.

The owner has the most to gain from STAR, however, he gets more for his construction dollar; it's easier for him to meet budget allocations; there is generally a reduction in operating costs; his building gets constructed quicker because of the reduced labor hours; and his initial outlay is less. And if he chooses, he can get additional features in his systems with the money saved through STAR. In some cases, it might enable those who could not otherwise afford to build a chance to do so.

Why Extra Costs Are Built In

Why aren't all duct and pipe systems designed, fabricated, and installed in the most economical and efficient way? There are at least three basic reasons:

1. The first is a lack of detailed cost knowledge by the designers and even by contractors themselves.
2. The second is that designs are assumed to be the most economical when they're taken off the boards and sent out for bidding.
3. And third, repeated and objective checking of completed designs to ferret out and eliminate unnecessary costs that have been built in isn't done often enough if at all.

Design is a complicated, creative process, involving many engineering considerations and calculations. Detailed cost reduction can be done more effectively after the design is completed by looking at the entire layout. The consideration and creation of alternate options become more concrete when you have a layout in front of you.

There are additional reasons why duct and pipe systems aren't put in at optimum cost: projects are rushed; experienced and qualified personnel aren't available; and the additional man-hours of engineering required to trim costs are not always in the interest of those working on a percent of construction fee basis.

Another major reason is that designers do not work closely enough with contractors in the design stage. Contractors can provide needed information on detailed costs, results of installation, performance of systems, and problems encountered and solved along the way.

The last category of causes for excessive costs includes "shooting from the hip," "budget load calculation" designs, fudge factors, and contingencies in lieu of precise, thorough, and complete design calculations.

What is Value Analysis?

What is value analysis really all about? Here's an example of one aspect of it. Max Smart, an accountant, wants to buy a car. He's married, has one child, and doesn't plan to have any more. His objective is to get reasonably comfortable, dependable, quality transportation for three persons for short distance driving.

> Max looks at a $40,000 Cadillac first, and this is what he'd love to have most. But he sees there are many unnecessary costs built into this luxurious, powerful, and spacious automobile that he just doesn't need. So next he looks at an Oldsmobile. It's sure nice, too, Max thinks, but it's the same situation: he just doesn't need high horsepower, power windows, etc. How about a full size Ford or Chevrolet? Naw, he'd still be paying for more pounds of steel and more cubic feet of space than he needs.
>
> Compacts—they're better, and why not go all the way and get a car that efficiently uses the energy put into it, has no wasted internal space, is highly reliable, and will have no unused horsepower. A Toyota sub-compact fits the criteria, he decides, and that's what this objective, analytical gentleman buys, for $12,000. This is $28,000 less than the Cadillac, and Max gets all the satisfactory performance he needs without spending money unnecessarily.

The point here is not to recommend the purchase of an economical foreign car. Rather, it's that unnecessary luxuries, over seeing, inefficient usage, conspicuous waste, and complexity of products that frequently confront us in our lives can double, triple, and quadruple the costs of things without giving us the returns we need or want for the extra costs.

Extra Costs: Where to Look

There are many categories of unnecessary costs, in addition to those just mentioned, that STAR methodically

maximum compatibility between performance and cost efficiency in any pipe or duct conveying system, whether air, liquid, steam, electricity, or otherwise. Its specific goals are fewer joints of pipe and fittings, more standardized economical ones, more direct routing, and fewer connections, so that labor time is reduced. Material is generally considered secondary in this approach.
STAR is a process of revising and polishing, of editing, of whittling away at what is unnecessary and creating more economical alternatives.

STAR helps contractors to meet their estimates and to avoid losing money in a hotly competitive market with pricing so low that firms cannot afford to manage as they should. The design engineer benefits from STAR in that he can get more work through lower cost systems, and he derives the professional satisfaction of designing more efficient systems.

The owner has the most to gain from STAR, however, he gets more for his construction dollar; it's easier for him to meet budget allocations; there is generally a reduction in operating costs; his building gets constructed quicker because of the reduced labor hours; and his initial outlay is less. And if he chooses, he can get additional features in his systems with the money saved through STAR. In some cases, it might enable those who could not otherwise afford to build a chance to do so.

Why Extra Costs Are Built In

Why aren't all duct and pipe systems designed, fabricated, and installed in the most economical and efficient way? There are at least three basic reasons:

1. The first is a lack of detailed cost knowledge by the designers and even by contractors themselves.
2. The second is that designs are assumed to be the most economical when they're taken off the boards and sent out for bidding.
3. And third, repeated and objective checking of completed designs to ferret out and eliminate unnecessary costs that have been built in isn't done often enough if at all.

Design is a complicated, creative process, involving many engineering considerations and calculations. Detailed cost reduction can be done more effectively after the design is completed by looking at the entire layout. The consideration and creation of alternate options become more concrete when you have a layout in front of you.

There are additional reasons why duct and pipe systems aren't put in at optimum cost: projects are rushed; experienced and qualified personnel aren't available; and the additional man-hours of engineering required to trim costs are not always in the interest of those working on a percent of construction fee basis.

Another major reason is that designers do not work closely enough with contractors in the design stage. Contractors can provide needed information on detailed costs, results of installation, performance of systems, and problems encountered and solved along the way.

The last category of causes for excessive costs includes "shooting from the hip," "budget load calculation" designs, fudge factors, and contingencies in lieu of precise, thorough, and complete design calculations.

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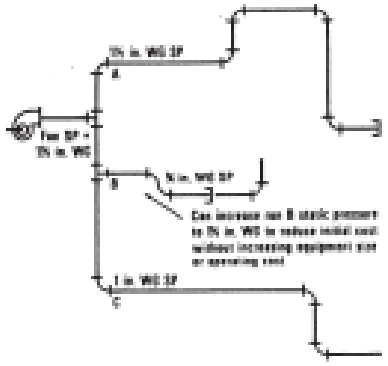
- System balance, within 5 percent of design.

Acceptable Duct Static Pressure Increases

The static pressure drop of a trunk or branch duct run can be increased, if need be for initial cost economy, to match that of the run with the highest static pressure drop in the system (provided, of course, that the run so handled is not part of the run with the highest static pressure drop). It is the same as a critical path schedule. You can increase the time for any activity that is not on the critical path, up to the point where the time for its path equals the critical path's.



Increasing static pressure drop of a duct run, up to that of the run having the highest static pressure drop in the system, can lead to initial cost savings

This can vary with whatever safety factor the designer adds to his static pressure calculation, with difference between brake horsepower and actual horsepower of the motor selected, and with the actual performance of the equipment. Keep in mind that an increase of 15 or 20 percent in system static pressure drop—with no change in fan size, drive speed, or horsepower—may not change the air volume more than 6 or 7 percent. And a 1°F increase in air temperature will overcome this airflow decrease.

Critical Times to STAR, Definitions

As you design and lay out ductwork and piping systems, you will, of course, use all your knowledge of cost saving techniques without letting this distract you from effective engineering. There are four critical times, however, when you should concentrate your attention and efforts to the costs of the system without design thoughts prevailing.

These are:

- After your rough schematic design is completed.
- After the 1/8 inch scale design drawing is laid out.
- After the contractor's 1/4 inch scale background drawing is completed.

As indicated previously, the S in STAR stands for standardization, simplification and sizing. Look for opportunities to standardize the design, sizes, lengths, and component parts of the ductwork. Simplify areas, runs and designs.

The T stands for typicals. Compare runs, pipe sections, and fittings for duplications, either in their entirety or in their component parts. Compare parts of a run itself for typicals, runs with other runs, areas of a building with other areas, and one project with other projects.

The A stands for arrangement. Look for improvements in the arrangement of pieces in runs, which might include different lengths, different combination of pieces, and elimination of fittings.

The R stands for routing. Check each trunk run, branch, and riser for routing improvements that may lead to more direct routing and more efficient equipment locations.

These are the STAR procedures. Following is a more detailed guide to their implementation.

DETAILED APPLICATION

Standardization, Simplification and Sizing

The more variations one has in dimensions, design, configuration, and performance, the more labor time, complications, errors, lack of control, and confusion one will encounter, all of which lead to higher total cost. Standardization leads to simplification, efficiency, cost reduction, interchangeability of parts, and mass production.

Standards are not haphazard or arbitrary. They are established to make sure things fit together, to assure they perform as expected, to avoid confusion, and to prevent recurrence of past errors.

The following methods can be used to standardize and simplify duct runs and consequently reduce costs without impairing system performance:

1. Make taps in tees one length and one configuration.
2. Standardize elbow radii to size ranges.
3. Use a single section offset rather than two elbows and pipe.
4. Standardize the length of straight duct sections.
5. Make change fittings constant in depth so they can

be fabricated from two pieces instead of four.

6. Reduce the number of different duct sizes; stay away from odd and excessively large sizes.
7. Use standard size panels in built-up housings.
8. Avoid seaming on flat sides of ducts wherever possible.
9. Avoid double curved offsets.
10. Avoid changes in depth at elbows.
11. Avoid changes in depth at divided flow wye fittings.
12. Design for mass production runs.
13. Use duct sizes that come from standard sheet sizes.
14. Avoid cramped, messy criss-crossings.
15. Minimize the use of fittings; shoot for as much straight duct as possible.

Convert Rectangular Ductwork to Round Ductwork

Round ductwork is the most efficient ductwork in regard to performance such as maximum air flows per surface square feet and per the least amount of resistance per running foot. Flat rectangular ductwork with width to depth aspect rations of 2, 3, or 4, restrict air flow and can develop pressure drops that are twice that of round duct. Hence, converting rectangular ductwork to equal friction round, can save 20 to 30 percent in square foot of ductwork materials required per the same amount of air delivery.

This application works best with duct branches and small main runs. Larger rectangular main duct runs generally become too large in round sizes to fit into ceiling spaces, etc.

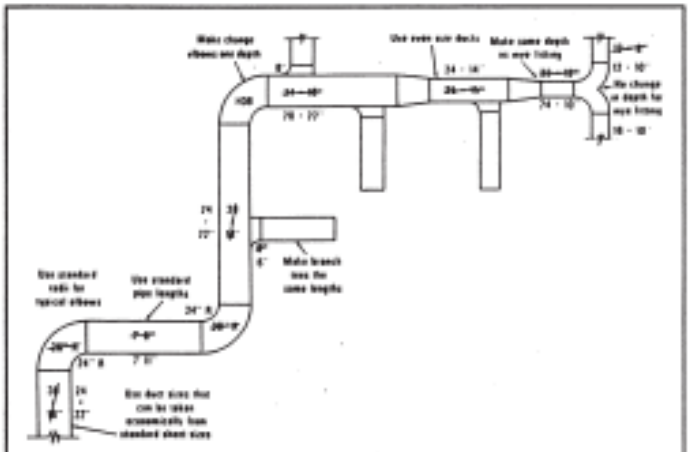
The method of determining the equal fiction round sizes in lieu of the given rectangular size is based on:

- Determining the actual friction factor per 100 feet for the rectangular size per ASHRAE manuals first.
- Then working backwards from the friction factor to the equivalent round diameter. The following are some examples.

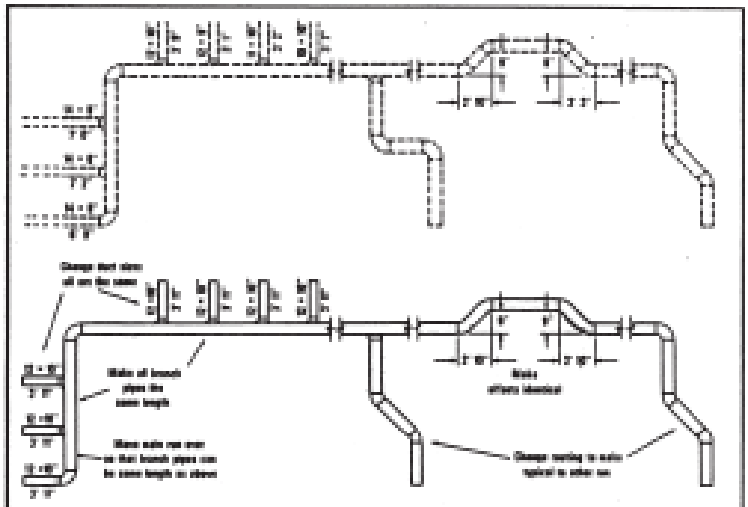
Rectangular Size	Equal Friction Round Diameter
12 x 6	9
18 x 6	11
24 x 6	12
24 x 12	18
36 x 12	22
48 x 12	25

WinDuct Estimating System Does Automatically

However, there is no need to do this by hand. The WinDuct Wendes estimating systems performs the rectangular to round calculations and selection of optimal rectangular sizes automatically.



Standardization and simplification are important procedures in STAR value analysis. Study of the changes in this air distribution system reveals specific methods of standardization, which leads to simplification.



Typicals in STAR analysis refers to the duplication of dimensions and runs wherever possible to promote mass production and interchangeability of parts. Comparison of original and revised systems here shows specific methods.

Typicals or Duplicate Fittings

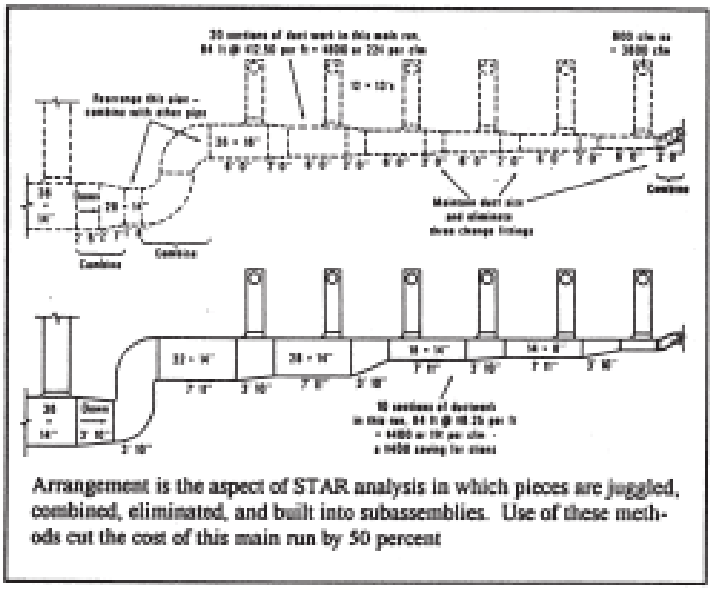
This involves duplications, interchangeable component parts, and mass production runs for both fabrication and installation. Here are some methods of eliminating unnecessary costs in the typicals department:

1. Make a series of branch ducts typical in size and length.
2. Reroute a duct or pipe run to make it typical with one or more other runs.
3. Make duct section lengths the same.
4. If you have two offsets or two change fittings with the same dimensional changes, make them the same length.
5. Move a trunk run to make the branch-offs typical with a series of branch-offs on another run.
6. Change duct sizes, within the limits of design criteria tolerances, to make them typical with sizes in other runs.
7. Make size changes also to create interchangeable parts.
8. Make divided flow wye fittings typical.
9. Elbows and tees offer marvelous opportunities for duplication.
10. Search for and create typical pieces, runs and areas.

Arrangement

You can juggle pieces in a duct or pipe run, alter lengths, combine pieces, eliminate them and build subassemblies without adversely affecting system performance. In fact, it is more likely that performance will benefit from these measures. Here are some specific methods:

1. Combine an offset and a change fitting into one piece.
2. Combine short pieces of duct.
3. Combine a size change fitting with an elbow if there is no depth change.
4. Combine two 90° Elbows into one offset.
5. Combine two elbows and the piece of pipe between into one offset.
6. Eliminate change fittings and maintain the larger duct size as long as possible.
7. Alter lengths of pieces and juggle their locations back and forth until you have the fewest pieces and connections possible in a run.
8. Assemble duct sections in the shop whenever practical.
9. Substitute a shop welded connection for a field companion angle one.
10. Make as many connections as possible on the floor at the job site before hanging.



Arrangement is the aspect of STAR analysis in which pieces are juggled, combined, eliminated, and built into subassemblies. Use of these methods cut the cost of this main run by 50 percent

Routing

Direct routing and strategic placement and orientation of equipment can be one of the major areas of cost reduction, not only for air distribution systems but piping and wiring systems as well.

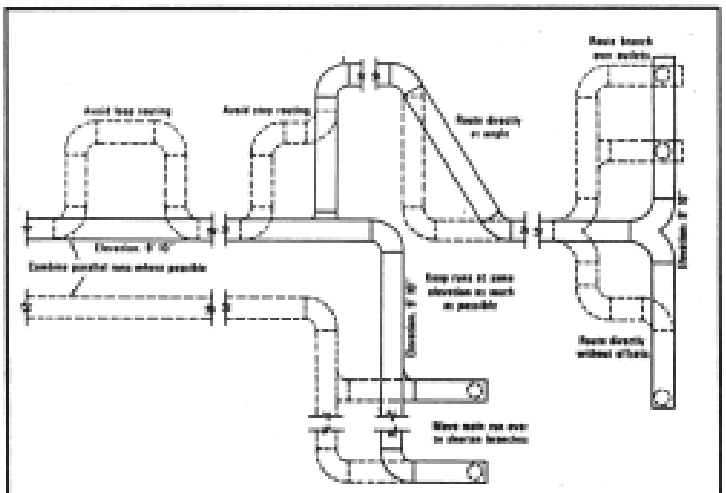
> The ultimate in efficiency of routing, air distribution, and equipment location is found in large single story discount stores with exposed duct runs. The air handling units are at the back of the store, their discharges facing the front. Ductwork is routed straight out of the units, directly across the store, with straight duct sections and only one or two change fittings. There are no turns or offsets. There is a grille at the end of the run to blow air on the front windows and a few grilles flush on both sides of the ductwork between there and the unit.

Skeptical though some may be, if the engineering is done correctly, the system achieves and maintains the objectives we are committed to. Physical comfort is provided for customers and employees, air conditions are healthy and people can function as required.

The cost of the ductwork in this case is approximately 10 percent of the ventilation cost pie, not 30 or 40 percent as is the normal range.

Here are specific methods and things to watch for in routing distribution and locating equipment:

1. Avoid loop routing wherever possible.
2. Avoid step routing.
3. Route directly at an angle instead of making turns.
4. Combine parallel runs if possible.
5. Move a main run over ceiling outlets and eliminate branches.
6. Move a main run closer to outlets to shorten branches.
7. Route branches directly to outlets or terminals.
8. Route runs directly without offsets wherever possible.
9. Raise or lower criss-crossing ducts or reduce duct depth to eliminate multiple offsets and elbows.
10. Avoid cramped or unnecessary criss-crossing by rerouting.
11. Keep runs at the same elevation as much as possible.
12. Place mixing boxes between hot and cold trunk runs to avoid criss-crossing branches and trunk runs.
13. Turn equipment so that duct or pipe connections are perpendicular to the runs they attach to, thereby eliminating turns. Provide straight shot orientation.
14. Locate equipment at the same elevation as the duct or pipe runs, if possible, to avoid risers, offsets, turns, etc.



Proper routing of distribution system and proper orientation of equipment can lead to significant cost reductions in STAR analysis.

Implement STAR as a Standard Procedure

STAR can be implemented over and over. You will continually find more and more unnecessary costs built into mechanical systems. The reasons for them are immaterial; they're there. And you'll find yourself and others through your effort-through using your imagination and creative abilities and through the valuable technique of simply looking.

ASHRAE Incorporates STAR Techniques

Since these STAR techniques and principles were developed by Herb Wendes, and this article was originally published in HPAC magazine in 1979, ASHRAE has incorporated many of the methods of cost reduction into their manuals.

Chapter 22

Computerized Estimating Principles

Wendes Systems, Inc. is pleased to announce two new powerful Windows based estimating systems that incorporate the principles and methodology described in this manual in an easy-to-use computerized software program. The systems are easy to learn and are ready to use with preloaded materials and labor.

The WenDuct sheet metal estimating system is fast, accurate and easy-to-use with pre-loaded price and labor tables. A customizable database allows for maximum flexibility. Computerized Takeoff incorporates fast digitizer technology, electronic pen, material templates and mouse driven point and click menus. The accurate Wendes method of estimating produces extensive reports and a bottom-line bid directly from the takeoff. The system is flexible with user-definable square footage equations, customizable reports, tables and specifications for material and labor. Choose between a variety of duct types within a takeoff by selecting galvanized, spiral, industrial and fiberglass systems.

After a takeoff is completed a system may be "value engineered" by comparing alternate duct types and materials. The software will automatically re-calculate an entire system based on alternate duct types and materials calculating new material and labor. The calculations for ductwork and fitting are converted based on the aspect ratio of the original takeoff.

WenDuct will automatically produce a detailed estimate by accepting the transfer of data from a wide range of Computer Aided Drafting and Detailing Systems. An estimate may be easily produced based on the as drawn system vs. an original bid. Changes in job scope may be more accurately tracked and change orders produced. Data is available for viewing real time during takeoff, per selected item or system.

The new WenPipe piping and plumbing estimating system includes an extensive 60,000 item database covering a wide range of HVAC, plumbing, piping, process and industrial materials. Computerized takeoff incorporates fast digitizer technology, electronic pen, material templates and mouse driven point and click menus. Accurate Labor is based on national labor or MCA labor available to registered MCA members. Extensive labor and material reports are produced directly from the takeoff. Harrison Pricing Services and Wendes Systems provide a seamless interface that links the estimating material database with updated Harrison pricing. Ferguson Enterprises, Inc. and Wendes Systems, Inc. have partnered to make Ferguson Commodity Pricing available to Ferguson customers. Ferguson Commodity Pricing is available directly through Ferguson Enterprises. Other pricing services are available for all North American Regions.

For detailed information or to view the capability of computerized estimating contact the Wendes Systems, Inc. technical and training staff at 1-847-808-8371. Software is available on a free 30-day evaluation basis. On-line training is provided with evaluation software. Additional information is available on the Wendes Systems, Inc. web site: *www.wendes.com*.