How to estimate the cost of new air conditioning system to an existing storage warehouse.

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Section 1 Introduction

The use of many storage warehouses in city centers is being adapted to office or manufacturing

use. There is a high demand for office space and many industrial areas near downtown are being

transformed to office space. This paper provides the understanding of the challenges on adding an air-

conditioning system to single story ambient warehouse storage to be used as an occupied space. This

adaptive reuse has many factors to be considered for construction estimators and developers. Existing

roof conditions, insulation, optimum air-conditioning system selection, available electrical power, are all

factors that need to be addressed by the estimator along with the design team.

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Brief Description

In this paper the writer will describe the all factors that will need to be considered when preparing an estimate for new air conditioning system. The estimator should examine existing site conditions, review as-built drawings, review new plans and specifications, complete quantity takeoffs for materials, and accommodate all factors to finish a complete cost estimate. The estimate is for a general contractor who is preparing a competitive proposal for a private client, usually a developer, investor or a property manager who owns a single story warehouse facility with ambient temperature – not controlled temperature interior space. The general contractors will be using his/her own forces in addition to hiring subcontractors for specialty trades. It is assumed that the construction documents will be prepared by a designer working with the owner. It is also assumed that this scope is for the landlord responsibility for changing the space use to an occupied facility. Additional work will need to be done by the future tenant of the building or suite for a complete build out. Finish carpentry, doors and windows, glass and glazing, interior partitions, painting, finishes, plumbing, mechanical distribution, light fixtures, and electrical power distribution will not be part of this project.

Although the contractor will provides a lump sum proposal based on construction documents, he/she should have full understanding for the basic estimating knowledge for all sub trades used to double check their quotes, complete scope reviews, and prepare budget estimates before receiving actual bids from subcontractors. The contractor should also be prepared to provide preliminary budgets for his clients before they hire a design team to complete the construction documents.

Section 2 Types of Methods of Measurements

Quantity takeoffs for interior improvements are measured in several ways including; air conditioning units by Each (EA.), roof deck insulation by Square Feet (SF), wall insulation, by SF, roof structure supports by EA., roof patching by EA., metal studs and drywall by SF, condensate drains by Linear Feet (LF), electrical circuits by EA, and subcontractors pricing by Lump Sum (LS).

There are many takeoffs tools to be used, from the traditional drawing takeoffs, two dimensional takeoffs (2-D) software, or three dimensional takeoffs (3-D) also known as Building Information Modeling (BIM). With the advances in computer technologies, estimating software is very common in the market. One of the leading software in 2-D is On-Screen Takeoff (OST) by On-Center Software. BIM estimating is used on larger and more complex projects throughout the lifecycle of the project. Whatever tool is used, the role of the estimator is still very important when transferring data on his estimate sheet as estimating is both an art and a science.

Items that are measured by EA, should be separated by types. If the air conditioning units (AC Units) are different in size, each size should have a separate condition. Wall insulation should be separated from deck insulation, and wall types should have separate conditions considering types and heights. Waste factors should be considered by the estimators for materials when finishing his takeoffs or assigning unit costs. An insulated wall with many bends, corners and varying heights will have more waste compared to a straight full height separation wall. For deck insulation, the existing roof structure will affect the amount of cutting and waste to make sure all areas between purlins and trusses are being filled with insulation.

Electrical circuits could be measured by EA to simplify the average cost of each circuit including conduit, wiring, breakers, disconnects and electrical hook-up. A subcontractor will breakdown the cost of the circuit to more details for exact takeoffs of the wiring and conduits in LF including horizontal and vertical runs, quantities by EA for breakers, disconnects and all fittings.

Contractor general conditions and supervision will be time driven, and will be measured by Weeks (WKS) or Month (MO.)

Section 3 Project Specific Factors to Consider in Takeoff and Pricing

Small Quantities vs. Large Quantities

A larger warehouse will help reduce the unit costs assigned to the unit measure. For the mechanical scope, the cost of the installation crane is a fixed cost and will usually be a minimum trip charge of one day regardless of the number of AC units being installed. Scissor lifts and other equipment will also have fixed delivery and pick up charges that would be spread over many units to reduce the cost per unit. The learning curve for labor will improve as they do more of the same task.

Geographic Location

Location of the project will have a significant impact on the project cost. Union labor rates vs non union labor rates is a major cost factor. In downtown areas, many metropolitan city centers have regulations and agreements with certain labor union groups especially for carpentry, plumbing, mechanical and electrical.

The AC units will have the longest lead time for order, fabrication and delivery. The location of the project site in relationship to the AC unit manufacturer factory location will affect delivery time and should be incorporated into the project schedule.

Seasonal Effect on Work

Cost of labor and materials is affected by the season the projected is being constructed. In the summer, many schools have major projects during school recess and this will result in labor shortage. The contractor should understand the current market conditions to forecast availability of materials and labor. A boom in residential construction or multi family projects will affect commercial construction. AC unit delivery and fabrication times will also be affected due to higher demand, and manufacturers will have bigger backlog for orders.

Installation of new AC units will require new penetrations on the roof deck. Rain days will affect the time of making these penetrations. The contractor may expedite the installation of the roof curbs for the mechanical units and provide the proper seal to prevent any roof leaks.

Special Conditions Affecting Installation of New Air Conditioning System to an Existing Warehouse

Improvements in an existing building require special attention to many factors. Older buildings may contain asbestos, and getting an environmental testing and investigation report is important before starting construction. Roof penetrations for the new AC units will require partial tear of the existing roofing materials, and in many old buildings the roof mastic material was found to be hot (containing asbestos). The testing is recommended to have as many samples for any areas that are going to be disturbed during construction including but not limited to: drywall, flooring, ceiling tiles, and exterior walls. The contractor should schedule a job walk to review existing conditions along with his subcontractors. Many field conditions are not shown on the drawings and visiting the site prior to preparing a bid is very important. The mechanical contractor will review access for his crane and insure he has enough clearances. The insulation subcontractor will need to check the roof structure and decide how the insulation boards will be attached to the deck.

The design team should also arrange for a site visit before finishing the construction documents as the building as-built drawings may not be accurate due to undocumented remodels. Current building codes will be different from the codes when the existing building was constructed. Modifications to the roof structure to accept new loads for the AC units will be a challenge. In addition to the additional roof supports, the existing roof structure may not be up to the current codes. The city code review and field inspectors might require the contractor and owner to bring the structure up to the current codes since modifications are be done. This could be a significant cost impact to the construction budget. Changing the building occupancy and use from industrial to office use will require many modifications and new calculations to be done to obtain occupancy change and a building permit. Since office use will have more occupancy, the drawings should show that the; fire exits, number of restrooms, number of parking spaces are all adequate for the new occupancy. Suite accessibility should also be reviewed by the design team. Current building codes and ADA (American with Disabilities Act) requirements will trigger additional improvements.

Another building code that the team will need to satisfy, is the mechanical energy codes. New mechanical units should be energy efficient, and provide for outside air. The building envelope that the

air conditioning system is to be installed, should have the proper thermal insulation to prevent energy loss. Insulation of roof deck and exterior walls are always associated with new mechanical system installation. R-Value for roof deck insulation should be a minimum of R-38 and exterior walls should be R-19. Existing roofing system might have an insulation value that would help reduce the R-Value for the new deck insulation. The mechanical engineer will run his calculations to determine if the existing exterior wall system has an established R-Value to reduce the insulation requirement for the exterior walls.

Although contractors are not responsible for the design, they should be aware of the current building codes and bring any potential issues to the owner and design team to help avoid any surprises during construction. After reviewing the existing site conditions with subcontractors, the contractors should provide the owner and design team all his concerns and questions to be addressed before the start of the construction. Any stoppage by the building officials and city inspectors during construction, will cause delays and increase the project cost for all parties. Contractors are now being used in many projects in a design assist role and their professional knowledge is a key factor to the success of every project.

Section 4

Overview of Labor, Material, Equipment, and Indirect Costs and Approach to Markups

The contractor will start the estimate by calculating his/her site supervision and general conditions cost. The project team usually consists of a project superintendent, project manager and project engineer. This team will be responsible for the delivery and execution of the project in a timely matter, within the budget, per the drawings and specifications and in a safe work environment. The number of the project team and the percentage of their time assigned to the project will also need to be decided. The project superintendent will be assigned fulltime to the project from start to finish to insure safety of all personnel at the job site, manage the schedule, monitor quality of the work, meet with building officials, represent the contractor and protect the owner's interests at all time. The percentage of the project manager and project engineer will depend on the complexity of the project and other projects they are managing. A project manager will have an average of four projects running at the same time, so 25% of his/her time will be assigned to this project. The same applies to the project engineer. A labor burden will be added to the weekly rates of project team. The burden is an added percentage of the employee's salary to cover the payroll taxes, insurances, vacation, company truck, gas, phone, and fringes. The percentage is based on historical accounting data of the company and the benefits provided by the company to it's employees. For this project 40% will be added to the project team weekly rates.

The project duration is a key factor for calculating site supervision, project management, and general conditions. The estimator, with the help of the subcontractors, will need to come up with the optimum project duration taking into considerations material delivery, lead time, field installation, and proper inspections. Since the AC units have the longest lead time for fabrication, the mechanical work will be part of the critical path when developing the project schedule. The estimator will calculate the durations for activities before and after the installation of the AC units to come up with the project overall duration. Average lead time for fabrication and delivery of AC units is 6 weeks. The estimated project duration for this installation is 8 weeks.

Job site general conditions will be included to cover safety supplies and signage, progress clean up, final clean-up, temporary toilets, dumpsters/trash removal, and small tools. The extent of general conditions

for an interior improvement project is much less compared to a new ground up construction. For this project the estimated supervision and general conditions are per Table 1.

Table 1

	QTY.	Unit	Labor		Materials/Equipment		Labor Burden 40%		Grand
Description			Unit Cost	Total	Unit Cost	Total	Unit Cost	Total	Total
		104					#700.00	05 700 00	000 400 00
Project Manager	ð	VVKS	\$1,800.00	\$14,400.00			\$720.00	\$5,760.00	\$20,160.00
Superintendent	8	Wks	\$540.00	\$4,320.00			\$216.00	\$1,728.00	\$6,048.00
Project Engineer	8	Wks	\$450.00	\$3,600.00			\$180.00	\$1,440.00	\$5,040.00
Blueprinting & Copies	2	Мо			\$110.00	\$220.00			\$220.00
Safety Supplies & Signage	2	Мо			\$80.00	\$160.00			\$160.00
Cleanup Materials	2	Мо			\$60.00	\$120.00			\$120.00
Final Clean-Up	1	LS			\$1,200.00	\$1,200.00			\$1,200.00
Trash Disposal	2	Мо			\$450.00	\$900.00			\$900.00
Temporary Toilets	2	Мо			\$110.00	\$220.00			\$220.00
Misc. Small Tools	2	Мо			\$200.00	\$400.00			\$400.00
Total General Conditions Estimate :							\$34,468.00		

General Conditions And Supervision Estimate

Direct costs from subcontractors will be requested via bid solicitation from multiple subcontractors. After the initial review of the construction documents by the estimator, he/she will make a list of trades that will be required to complete the project. For this project we will need mechanical, electrical, drywall, insulation, rough carpentry, and roofing subcontractors. Since the mechanical scope is the biggest line item in the project, it is recommended to send bid solicitations to more than five mechanical subcontractors. All subcontractor will provide lump sum proposals and the estimator will review their bids to verify they are complete and per plans and specifications.

Once all direct costs are calculated, the estimator will finalize indirect expenses including insurances, overhead, profit and taxes. Contractor liability insurance is required and the estimator will confirm if him current liability coverage is adequate for the project or if should buy additional coverage for the project. Builder's risk insurance will also need to be addressed if it is provided by the owner or contractor. The estimator should be aware of the tax laws for the project location to confirm if he is responsible for the taxes as the prime contractor, or material taxes are to be paid at the point of sale for all materials purchased for the project. If the subcontractors are responsible for the taxes, this should be reviewed when doing scope reviews for all subcontractors' bid proposals.

Section 5 Special Risk Considerations

Older warehouses that are used for storage have relatively higher roof clearances to allow for storage racking and forklift operations. Installation of rooftop mounted heat pump package units on high roofs will expose workers to the risk of fall injuries due to the roof penetrations. According to OSHA, falling is the most prevalent cause of fatal accidents in construction. Anyone working on the roof should be tied off and access to the roof should be limited to construction workers. Many older buildings have no parapets and that will increase the fall hazards. Contractors should anticipate and inforce the use of proper personal protection equipment (PPE).

In some cases these remodels will be done in an occupied space that is expanding its office area. Doing construction in occupied spaces will be very challenging to insure the public protection. Barricades and signage should be provided and continuous communications about the project progress and areas of construction should be conducted on daily basis with the tenants. Electrical shut downs will need to be scheduled off-hours to avoid business interruptions.

Section 6 Ratios and Analysis – Testing the Bid

Although the subcontractors will provide bids for their specialty trades, the estimator should understand the basis for the subcontractors' estimate calculations and how they are developed to enable him/her to review and ask questions. The estimator should actually complete his own estimate before receiving subcontractor bids and compare both estimates to insure complete scope. For the mechanical scope, the mechanical subcontractor will solicit supplier's quotes for the AC units, provide installation labor, fabricate duct drops with sheet metal, purchase copper piping for the condensate drains, and use rental equipment rates for cranes and scissor lifts. For this project there are total of eleven (11) 6.5-ton AC units. There are no registers, diffusers, main ducts or any ductwork distribution as this project doesn't include the tenant built-out package. The general contractor preliminary estimate for the mechanical scope is per Table 2. A similar exercise will be done for other sub trades to come up with unit rates. The estimator will develop unit cost rates for each sub trade to complete the overall project cost.

Table 2

QTY. Unit Description Unit Cost Total \$ 4,150 45,650.00 Mechanical AC units (FOB) EA. \$ 11 AC roof curbs \$ 5,940.00 11 EA. 540 \$ Duct Drops EA. \$ 450 \$ 4,950.00 11 \$ 7,150.00 **Condensate Drains** 11 EA. 650 \$ \$ 12,672.00 Labor 264 HR. 48 \$ Scissor Lift \$ \$ 1,500.00 2 MO. 750 1,100 1 \$ \$ 1,100.00 Crane LS. Subtotal \$ 78,962.00 Overhead at 10% \$ 7.896.20 Profit at 8% \$ 6,316.96 **Total Mechanical Estimate :** 93,175.16 \$ 8,470.47

Mechanical Scope Estimate

Unit cost for Each AC unit delivered and installed. \$

Another calculation that will be helpful on future projects, is to get the ratio of air-conditioning tonnage in relationship with the warehouse square footage. In this project there are 11x6.5-ton AC units for a total of 71.5 tons of cooling. The warehouse area is approximately 18,260 SF, and this will make the ratio approximately 255 SF per ton of cooling. If the estimator is doing a budget for a similar project, this ratio will help in calculating how many AC units are required for cooling an existing warehouse

Section 7 Other Pertinent Information

The general contractor estimator must think about the constructability of the project and all the means and methods for execution of the work. Installing new AC units might require the demolition and restoration of an existing ceiling. New interior drywall furring might affect existing electrical outlets that would need to be adjusted. Documenting all existing site conditions during a pre-bid job walk will help resolve future claims and disputes. The roofing system in an older building might have leaks that had not been noticed. The roofing subcontractor should make a quick survey of the existing roof conditions to insure there are not leaks or unacceptable roof patches from previous improvements. If the roofing

system is still under warranty from the manufacturer, then an approved applicator by the roofing manufacture should be used to perform the new roof patches and to maintain the long term warranty. The estimator should also be aware of mechanical screening requirements in the jurisdiction of the project. Some municipalities require mechanical units on the roof to be screened by a parapet or new mechanical screens. Low profile AC units may also be used.

The estimator must send bid solicitations to multiple subcontractors. Due to construction industry market conditions, certain subcontractors might get very busy and would not have enough manpower to perform all their projects on time. A low subcontractor on one project doesn't mean they would be low on another project. Having at least three subcontractors' bids will make the general contractor estimate very competitive.



Section 8 Sample plan for an Existing Industrial Warehouse.

Figure 1

As-Built drawing for an existing warehouse in a distribution center. The suite is empty and the owner of the property would like to change the use of the warehouse from storage to office space. There is a high demand for office spaces near the city center and once the space occupancy is changed by adding air conditioning and insulation, the owner will find a tenant to lease the space.

Section 9 Sample New Floor Plan



Figure 2

Floor plan of the construction drawings showing new insulated full height separation wall, insulated drywall furring, and 11 new 6.5-ton rooftop package AC units.

Section 10 Sample Estimate – Takeoff and Pricing Sheets



Takeoff Tab

ASPE - Sample Project

Bid No. 516	
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No.	Name	Height	Area Quantity1 UOM1	Quantity2UOM2	Quantity3 UOM3
01 Are	a				
Ⅲ 3	Total Warehouse SF	0"	18,260 SF	0	0
09a Fr	aming & Drywall				
26	6 24' Interior Wall Furring & R-11 Insulation	24' 0"	321 LF	7,694 SF	0
28	3 Full Height Stud Wall & R-19 Insulation	24' 0"	164 LF	3,932 SF	0
23 Me	chanical				
1 1	6.5-Ton Heat Pump Mechanical Package Unit	0"	11 EA	0	0

Figure 4

The takeoff plan and table developed by On Screen Takeoff (OST) will help he estimator get quantities for materials and measurements needed. Based on the table the following quantities/measurements will be used in the estimate:

06 10 00 Rough Carpentry

11 EA Roof framing for 11 AC Units.

07 21 00 Thermal Insulation

18,260 SF Insulate Underside Deck - R-38 Wired w/Scrim

7,694 SF Insulate In Walls - R-11 - Exterior Wall Furring

3,932 SF Insulate In Walls - R-19 - Full Height Separation Wall

07 50 00 Membrane Roofing

11 EA Roof patches for 11 new AC units.

09 20 00 Plaster and Gypsum Board

3,932 SF Full Height separation wall 6" 20ga 16" oc 5/8 drywall 2 side 24'

7,694 SF Full Height drywall furring 24'

23 74 00 Packaged Outdoor HVAC Equipment

11 EA 6.5 Ton Package RTU's AC Unit

Detailed Estimate page 1

Detailed Estimate page 2

Summary Estimate page 1

Section 11 Glossary/Terminology

MasterFormat

MasterFormat is a standard for organizing specifications and other written information for commercial and institutional building projects in the U.S. The purpose of this format is to assist the user to organize information into distinct groups when creating contract documents, and to assist the user searching for specific information in consistent locations. Information contained in MasterFormat is organized in a standardized outline format within 50 Divisions (16 Divisions pre-2004). Each Division is subdivided into a number of Sections.

R-Value: An R-value is a unit of thermal resistance for a particular material or assembly of materials (such as an insulation panel). The term is used in the building and construction industry. The R-value depends on a solid material's resistance to conductive heat transfer. The higher the value of R, the better the building insulation's theoretical effectiveness.

Drywall Furring:

Furring are thin strips of Metal to level or raise surfaces of another material to make space for insulation, or to level and resurface ceilings or walls. Metal furring strips can be used for commercial projects. Often called "hat channels" to describe the profile (cross section), they consist of two flanges on each side of a trapezoid shape, 7/8" thick.