SEABEE
PLANNER'S AND ESTIMATOR'S HANDBOOK

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SEABEE PLANNER'S AND ESTIMATOR'S HANDBOOK

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FOREWORD

The *Seabee Planner's and Estimator's Handbook* is a technical *GUIDE* for planning and estimating construction projects undertaken by the Naval Construction Force (NCF). The handbook provides information on estimating construction work elements and material quantities, including equipment and manpower requirements.

Prepared by Seabees for Seabees, the handbook is specifically for use in typical Seabee construction projects, and is designed for flexible application to projects of varying size, scope, and conditions. Tables for estimating labor have been provided to show the number of man-hours required for each work function. Diagrams illustrate the functions of planning and estimating. Both tables and illustrations have been made as useful, accurate, and comprehensive as possible.

Abbreviations for measurements and quantities have been changed to conform to Supply Department ordering requirements (not commercial abbreviations) to facilitate the ordering process. A glossary of abbreviations used, standard drawing symbols, and other professional information needed by the planner or estimator are provided in the back of the handbook.

The addition to the P-405 HANDBOOK are work element code numbers. The code number is always **bold** and in the parenthesis, either to the right or directly below man-hour per unit. The unit is always **ONE**. This codes are used in the CBCM planning and estimating software.

This publication cancels and supersedes the *Seabee Planner's and Estimator's Handbook, NAVFAC P-405*, dated October 1994 and subsequent changes. Recommendations for revisions for improvement should be specific and forwarded to the Director, Civil Engineer Support Office, Naval Construction Battalion Center, 1000 23rd Avenue, Port Hueneme, California 93043-4301. This publication has been reviewed and approved in accordance with SECNAVINST 5600.16A.

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CHAPTER 1. INTRODUCTION TO PLANNING AND ESTIMATING

1. **INTRODUCTION**. Good construction planning and estimating procedures are essential to the ability of the Naval Construction Force (NCF) to accomplish quality construction that is responsive to Fleet operational requirements. This handbook contains information which can be used to plan and estimate construction projects normally undertaken by Seabees; **it is designed to be a helpful reference, not to establish procedures.** The procedures described herein are suggested methods that have been proven with use, and can result in effective planning and estimating. How and when these procedures are applied is left to the discretion of the user. **The tables are helpful references and are not intended to establish production standards.** The tables must be used with sound judgment and modified as the user's experience suggests. Man-hour tables are based upon direct labor and do not include allowances for indirect or overhead labor.

2. **DEFINITIONS**. Users of this handbook should be familiar with the definitions and their usage that follow.

a. **Planning** is the process to determine requirements and to devise and develop methods and schemes of action for construction of a project. A good construction plan is a combination of the activity, material, equipment and manpower estimates, plant layout, material delivery and storage, work schedules, quality control, specialty tools, environment protection, safety, and progress control.

b. **Estimating** is the process to determine the amount and type of work to be performed and the quantities of material, labor, and equipment needed. The lists of these quantities are called estimates.

c. **Preliminary estimates** are made from limited information, such as general descriptions of projects, or preliminary plans and specifications with little or no detail. Preliminary estimates are usually prepared to establish costs for budget purposes and to program manpower requirements.

d. **Detailed estimates** are precise statements of quantities of materials, equipment, and manpower required to construct a given project. Underestimation of quantities can cause serious delays in construction or result in unfinished projects. A detailed estimate must be accurate and be at the smallest level of detail to correctly quantify the requirements.

e. **Activity estimates** consist of a list of all the steps required to construct a given project, and includes specific, descriptive information as to the limits of each clearly definable quantity of work (activity). Activity quantities provide the basis to prepare the material, equipment, and manpower estimates. Activities are used in the scheduling process to provide the basis to schedule material deliveries, equipment, and manpower. Errors in activity estimates can multiply many times through their use in the preparation of other estimates and schedules.

f. **Material estimates** consist of a list and description of various materials and the

quantities required to construct a given project. Information to prepare material estimates is obtained from the activity estimates, drawings, and specifications. A material estimate is sometimes referred to as a Bill of Material (BM) or a Material Take Off (MTO).

g. **Equipment estimates** consist of a list of the various types of equipment, the amount of time, and the number of pieces required to construct a given project. Information from activity estimates, drawings, specifications, and information obtained from inspection of the site provide the basis to prepare the equipment estimates.

h. **Manpower estimates** consist of a list of the number of direct labor man-days required to complete the various activities of a specific project. These estimates may show only the man-days for each activity, or they may be in sufficient detail to list the number of man-days of each rating (Builder, Construction Electrician, Equipment Operator, Steelworker, and Utilities man) for each activity. Man-day estimates are used to determine the number of men and ratings required on a deployment, and provide the basis to schedule manpower in relation to construction progress. **A man-day** is a unit of work performed by one man in 8 hours.

I. **Direct labor** includes all labor expended directly on assigned construction tasks, either in the field or in the shop, which contributes directly to the completion of the end product. Direct labor must be reported separately for each assigned construction task.

j. **Indirect labor** is labor required to support construction operations, but does not produce and end product itself.

k. **Overhead labor** is not considered to be productive labor because it does not contribute directly or indirectly to the end product. It includes all labor that must be performed, regardless of the assigned mission.

l. **An estimator** is one who evaluates the requirements to do a task. A construction estimator must be able to mentally picture the separate operations of the job as the work would progress through the various stages of construction. The estimator must be able to read and obtain measurements from drawings. The estimator must also possess a knowledge of mathematics, have previous construction experience and a working knowledge of all branches of construction. The estimator should have good judgment when determining what effect numerous factors and conditions will have on construction of the project and what allowances should be made for each of them, and be able to do accurate work. A Seabee estimator must have access to information about materials, equipment, and labor that is required to perform various types of work under conditions encountered in Seabee deployments. The collection of such information on construction performance is part of the job of estimating. Reference information of this kind may change from time to time and, therefore, should be reviewed frequently.

m. **Scheduling** is the process to determine when an action must be taken, and when materials, equipment, and manpower will be required. A progress schedule coordinates all

projects of a Seabee deployment, or all activities of a single project. It shows the sequence, the time for starting, the time required for performance, and the time for completion. Material schedules show when materials are needed on the job and may show the order in which they should be delivered. An equipment schedule coordinates all equipment to be used on a project and shows when, and the amount of time, each type of equipment is required to perform the work. A manpower schedule coordinates the manpower requirements of a project and shows the number of men required for each activity for each period of time. The number of each rating (Builder, Construction Electrician, Equipment Operator, Steelworker, and Utilities man) required for each activity for each period of time may also be shown. The selected unit of time to be shown in a schedule should be some convenient interval such as a day, week, or month.

n. **Network analysis** is a method to plan and control projects by recording their interdependence in a diagrammatic form that enables each fundamental problem involved to be undertaken separately. The diagrammatic form, known as a "network diagram," is drawn so that each task is represented by a "box" on the diagram. The boxes are linked with lines which indicate the dependencies of the tasks to each other.

o. **Progress control** is the comparison of actual progress with scheduled progress, and the steps necessary to correct deficiencies and to balance activities to meet overall objectives.

3. **DATA REQUIRED FOR ESTIMATING.** In order for the estimator to prepare a detailed and accurate estimate, information must be available about various conditions that affect construction of the project. The drawings should be detailed and complete. The specifications should be exact and leave no doubt as to their intent. Information should be available about local materials, quarries, gravel pits, borrow pits, spoil areas, types of soil, haul roads and distances, foundation conditions, weather conditions to be expected during construction, and time allotted for completion. The amount and types of construction equipment available for use should be known. Other items and conditions which might affect production or progress of construction should also be considered.

4. **TABLES AND DIAGRAMS.** Tables and diagrams save time in the preparation of estimates and, when understood and used properly, give accurate results. The tables and diagrams in this handbook are based on Seabee experience whenever possible. Where suitable information was not available, construction industry experience was adjusted to represent production under the range of conditions encountered in Seabee construction. In the **Man Hour/Unit** columns there are two numbers, first is the man hour/unit and the second one, in parenthesis, is the work element code number. Work element number is used with CBCM planning and estimating program.

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CHAPTER 2. ACTIVITY AND QUANTITY ESTIMATES OF MATERIALS

1. ACCURACY. The estimator needs a thorough knowledge of the project drawings and specifications, and be alert to the various areas where estimating errors may occur.

a. Examination of Drawings. Accurate estimating requires a thorough examination of the drawings. Information found on drawings is the main basis to define the required activities and to measure quantities. All notes and references should be carefully read and all detail and reference drawings examined. Dimensions shown or drawn should be used in preference to scaling. If it is necessary to scale dimensions, a scale rule should be used and the graphic scale on the drawings should be checked for expansion or shrinkage of the drawing. When there is disagreement between the plans, elevations, and details, the detail drawing normally is followed. When there is disagreement between the specifications and the drawings, the specifications normally are followed.

b. Examination of Specifications. Specifications must be used with the drawings to prepare the estimates for activity, equipment, and quantity. The estimator must be familiar with all the requirements contained in specifications, such as unfamiliar work procedures or materials, and the specific requirements concerned with testing. The estimator may find it necessary to read the specifications several times to fix these requirements in mind. Notes made while reading the specifications prove helpful when the drawings are examined. Specifications often contain information required to prepare purchase requisitions and this should be used to prepare material lists. Wrong interpretation of a section of the specifications can cause errors in the estimate. If there is any doubt about the meaning of any portion of the specifications, the estimator should request an explanation.

c. Need for Accuracy. Quantity estimates are used to purchase materials and to determine equipment and manpower requirements. The use of quantity estimates in the scheduling process provides the basis for material deliveries, equipment, and manpower use. Because of the widespread use of quantity estimates, accuracy during preparation is very important, since errors tend to become larger. For instance, if the estimator misread a dimension for one side of a concrete slab as 30 feet instead of 300 feet and the other dimensions was 100 feet, the quantity estimate would show 3,000 square feet instead of the actual 30,000. This quantity would then be used to order the required construction materials such as cement, sand, and reinforcing steel, and as the basis for equipment and manpower requirements. This one error would be the source of short estimates and future problems.

d. Checking Estimates. The need for accuracy in quantity estimates requires that they be checked to eliminate as many errors as possible. One of the best ways to check, is to have another person make an independent estimate and then compare the estimates after completion. Any differences should be checked and corrected.

e. **Sources of Errors.** The most common source of errors follow:

(1) Failure to read all notes and references on a drawing results in incomplete estimates. For example, an estimator may overlook a note "Symmetrical about 0" and thus compute only one-half the quantity.

(2) Errors in scaling drawings mean wrong quantities. Be sure that the correct measurements are recorded. Common errors are: using the wrong scale; reading the wrong side of a scale; and failure to note that the detail being scaled is drawn to a different scale than the rest of the drawing. Some drawings are not drawn to scale and may have the note "NTS" (not to scale), and the estimator must then obtain his measurements elsewhere.

(3) Omissions are usually the result of a careless examination of the drawings. Thoroughness in examining drawings and specifications eliminates omissions. A checklist must be used to ensure that all work elements or materials have been included. Drawings frequently are revised after the Material Take Off (MTO). The estimate must be updated to reflect the revisions.

(4) Failure to make the proper allowance for waste and loss of construction materials results in wrong estimates.

2. **ACTIVITY ESTIMATES.** Activity estimates provide a basis to prepare estimates of material, equipment, and manpower requirements.

a. **Application.** The activity estimate, for example, might call for an 8-inch concrete masonry unit (CMU) wall to be constructed. In the materials estimate, this would be converted into required quantities of sand, cement, lime, and 8-inch CMU block. In the equipment estimate it would be converted into mixer time required to mix the mortar. In the manpower estimate the activity quantity would be converted into the number of man-days required to perform the work. The quantity of CMU, together with information on work sheets (such as length and height of wall) would be used to estimate the number of scaffold frames and scaffold boards required, together with requirements of special tools. Information shown in activity estimates is used to schedule material deliveries, equipment and manpower, and is also used to schedule progress.

b. **Suggested Procedure.** The following procedures have been proven with use, and the estimator will find that it will produce satisfactory results.

(1) A general knowledge of the project is obtained by studying the drawings, reading the specifications, and examining all available information that concerns site and local conditions. The estimator is ready to identify individual activities only offer first becoming familiar with the project.

(2) After becoming familiar with the project and defining its scope, the estimator proceeds to identify individual activities required to construct the project. To identify

activities, ensure that each activity description indicates a specific quantity of work, with clear definite limitations or cut-off points that can be readily understood by everyone concerned with the project. A list of these activities is prepared in a logical sequence to check for completeness.

(3) The estimator must first define activities. An activity is a clearly definable quantity of work. For estimating and scheduling purposes, an activity should be a specific task or work element accomplished by a single trade.

3. **MATERIAL ESTIMATES**. Material estimates are used as for construction material procurement, and as a check to determine if sufficient materials are available to construct or complete a project.

a. **Application**. The Operations Officer, for example, may have some doubts about the availability of materials and request than an estimate be prepared that lists material quantities required to complete the project. This estimate is then compared with the stock of materials on hand to determine any shortages.

b. **Typical Estimating Forms**. The sample forms shown in *figures 2-1, 2-2, 2-3*, and 2-4 may be used to prepare material estimates. The forms are presented as one method to record the various steps taken to prepare a material estimate. Each step can readily be understood by others when reading the work sheets. A work sheet must have a heading that shows the project title, project location, drawing number, project section, prepared by, checked by, and date. Forms for reproductions are in appendix H.

(1) Estimating work sheet *(figure 2-1)* shows the various individual activities for a project with a list of the required materials. When materials are scheduled for several activities or uses, show it in the remarks section. The work sheet should show activity description, item number, material description, unit of issue, waste factors, total quantities, and remarks. Retain the estimating work sheets for use by the field supervisor when construction is underway to ensure use of materials as planned.

(2) Bill of Material (BM) sheet *(figure 2-2)* contains information presented in a format suitable for data processing. Requests for supply status, issue, or location of materials use this form. Bill of Material sheets are used to prepare purchase documents, and when funding data have been added, to draw from existing supply stocks.

(3) BM/MTO comparison work sheet *(figure 2-3)* is used to compare the independent Material Take Off (MTO) with the BM. It should contain activity number,

material description, unit of issue (UI), BM line item number (BMLI), BM quantity, MTO quantity, difference between the two (BM/MTO), and remarks. If differences exist they should be reconciled.

(4) Add-on BM *(figure 2-4)* is used to reconcile differences found in the BM/MTO comparison. It should be used for both add-ons or reorders. If it is a reorder state so on the form.

c. Waste and Loss Factors. Between the procurement of construction materials and final installation, materials are subject to loss and waste. This loss may occur during shipping, handling, or storage. Waste is inevitable where materials are subject to cutting or final fitting prior to installation. Frequently, materials such as lumber, conduit, or pipe have a standard issue length, which is longer than required. More often than not, the excess is too short for use and end as waste. Waste and loss factors vary, depending on the individual item, and must be checked against the conversion and waste factors *(see appendix C)*.

d. Checklist. Checklists are used to eliminate omissions from material estimates. The estimators should prepare a list for each individual project when examining the drawings, specifications, and activity estimates. This is the practical way to prepare a list of the variety of materials used in a project. The list applies only to the project for which it has been prepared. If no mistakes or omissions have been made in the checklist or estimate, the material estimate will contain a quantity for each item on the list.

e. Long Lead Items. Long lead items are those which are not readily available through the normal supply system, and require special attention by the estimator to ensure delivery at the required time. Items that require long lead time are those which are not shelf items such as steam boilers, special door and window frames, items larger than the standard issue, and electrical transformers for power distribution systems. It is recommended that these items be identified and ordered early. Periodic checks must be made about the status of the order to avoid delays in completion of the project.

f. **Suggested Procedure.** The suggested procedure for the preparation of a Material Estimate is to use the activity description together with the detailed information given in or on the drawings to provide a quantity of work. This quantity is then converted to materials required. Next, the conversion should be on a work sheet to show how each quantity was obtained *(figure 2-1)*. Work sheets need to be sufficiently detailed to be self-explanatory. Allowances for waste and loss are added after the total requirement is determined. All computations should appear on the estimate work sheet, as must all notes relative to the reuse of materials. Material quantities for similar items of a project are entered on the Bill of Material *(figure 2-2)* and becomes the Material Estimate for the project.

ESTIMATOR WORK SHEET

PROJECT LOCATION	PROJECT TITLE	PROJECT NUMBER	BM NUMBER	DATE PREPARED

PROJECT SECTION	ACTIVITY NUMBER	DRAWING NUMBER	PREPARED BY:	CHECKED BY:

DESCRIPTION							BM LINE ITEM	UNIT OF ISSUE	TOTAL QTY	REMARKS

FIGURE 2-1. Estimating Work Sheet

BILL OF MATERIAL

PROJECT	PROJECT TITLE	AUTHORITY/ORIGINATOR	BM NO.	SECTION

M&S	SERV & REQNR	DEM	SERV & SUPP ADD	SIG	FUND	DIS	PRJ	PRI	JON	ROS	ACCOUNTING DATA
7	30-35	44	45-50	51	53-53	54	57-59	60-61	62-64	72-77	

COG	NSN	UNIT OF ISSUE	QTY	DOCUMENT NUMBER	ADV	LI	DESCRIPTION VENDOR/SOURCE INTENDED USE	UNIT PRICE	TOTAL COST
55-56	8-20	23-24	25-26	36-43	65-66				

BM SUBMITTED BY/DATE	BM APPROVED BY/DATE	TARGET APPROVED/DATE	PAGE TOTAL	BM TOTAL	PAGE OF

FIGURE 2-2. **Bill of Material**

BM/MTO COMPARISON WORK SHEET

ACTIVITY NO.	MATERIAL DESCRIPTION	U/I	BM LI NO.	BM QTY	MTO QTY	DIFF	REMARKS

FIGURE 2-3. BM/MTO Comparison Work Sheet

ADD-ON BM

PROJECT NUMBER	PROJECT TITLE	DATE	MLO USE ONLY

BM NUMBER	MASTER ACTIVITY NUMBER	DRAWING NO.	PREPARED BY:	UNIT PRICE	TOTAL COST	REQUESITION NUMBER

BM ITEM NO.	UNIT OF ISSUE	QTY	DESCRIPTION	JUSTIFICATION			

1. CREW LEADER	DATE	5. OPS	DATE	MLO NOTES & REMARKS
2. PROJECT SUP.		6. MLO CHIEF		
3. PROJECT MGR.		7. MLO SK		
4. QC REP.		8. PROCUREMENT APPROVAL		

FIGURE 2-4. Add-On BM Work Sheet

CHAPTER 3. EQUIPMENT ESTIMATES

1. **APPLICATION**. Equipment estimates are used with project schedules to determine the construction equipment requirements and constraints for a Seabee deployment.

2. **FACTORS AFFECTING PRODUCTION**. Equipment estimators must be familiar with the following definitions and how they affect production.

a. Permissible speeds are established either by a governing authority, as in a highway or street speed limit, or by a command, such as in an operating limit on the equipment. In either case, the speed limits must be considered when estimating the average hauling speed which, in turn, determines the amount of material the equipment will move in one day. The estimator should not make the mistake of using the speed limit as the average speed at which equipment will be operated. Equipment speed usually averages 40 to 65 percent of speed limits, depending upon factors such as the condition of the road, number of intersections to be crossed, amount of traffic, and length of haul. Long hauls usually result in higher average speeds, other conditions being equal.

b. The type of material to be handled has a definite effect on the amount of time required. For example, wet, sticky clay is slower to handle because it sticks to the bucket, pan, or truck bed and requires jarring and shaking to loosen and dump the load. On the other hand, damp, sandy loam does not stick to equipment as readily and requires little or no jarring or shaking; therefore, the time required for this extra effort is saved. Sand handles easier and quicker with a clamshell bucket than does gravel or crushed rock. When lifting with a crane, bulky, hard-to-rig material and equipment require more time to load and unload. Several trial lifts usually are required, moving the slings after each lift before the equipment is balanced for safe lifting.

c. Safety factors limit the amount of work which can be produced with a machine and, therefore, they must be considered as a production factor. Although the manufacturer's crane rating may show it to be capable of lifting 40 tons with a 70-foot boom at a 45-degree angle, for reasons of safety the maximum lifting capacity of that particular crane may have been limited to 85 percent of the okay rating. The crane can then only be used to lift 34 tons with a 70-foot boom at a 45-degree angle. Certain pieces of equipment which may have the speed limited because of safety reasons will reduce the rate of production.

d. Operator experience must be considered when estimating equipment production. An experienced operator spreads a load of dirt with less passes than an inexperienced operator, and does a better job of spreading. Also, inexperienced operators are more inclined to forget some of the required maintenance operations and tend to cause more equipment downtime.

e. Age and condition of equipment must be considered in estimating the number of days required to perform work. Old or poorly maintained equipment has more downtime than new equipment or equipment in good operating condition. Also, worn equipment responds more slowly to the operator, has less power, and is generally less efficient. Downtime of equipment sometimes affects more than just its own operation. For example, if one of five trucks hauling dirt broke down, it would affect only its own operation, but, if the equipment loading those five trucks broke down, it would stop all of the trucks plus the equipment spreading and compacting the dirt being hauled.

f. Completion time affects production if crews must work long hours daily, or if the work must be performed under crowded conditions in order to complete the project within the allotted time. More efficient operation and better production is usually obtained by working two or more shifts per day.

g. Climate has a considerable effect on production of equipment working outside. Rain slows down the work, and frequently stops it for the remainder of the day, and sometimes for several days. In climates with considerable rainfall, equipment does not produce as much per hour or per week as in dry climates. Extremely cold weather slows down the operator and lowers the efficiency of the equipment, thus lowering production.

3. **EQUIPMENT PRODUCTION DETERMINATION**. Production rates are usually available for equipment assigned. It is not practical to draw up a production table to consider the particular combination of factors that affect production on a given project. Production rates in the tables of this handbook must be adjusted to fit the conditions expected on each project. In order to make this adjustment the estimator should know on what basis the rate in the table was established. The production rates found in the tables are an average of commercial manufacturers and government planning sources combined with, and adjusted to, the Naval Construction Force (NCF) productivity.

4. **EQUIPMENT ESTIMATES**. It is not practical to use a form with columns for work quantities, equipment quantities, and operator days when preparing the equipment estimate. However, forms with certain information in the heading will save the estimator time. The heading should show that it is an equipment estimate with the following information: sheet number, estimator's name, date estimated, the checker's name, date checked, battalion and detachment number, location of deployment, year of deployment, project number, project title and activity description. Examples of such a form to estimate equipment required for "cut and fill" operations are shown in *figure 3-1*.

The activity estimate must be examined and all activities that require equipment listed. Each activity on this list should be treated in the following manner.

a. The type of equipment and method of performing the work should be selected.

b. The production rate per day should be estimated for each piece of equipment, considering all factors discussed in paragraph 2, and using information obtained from sources mentioned in paragraph 3, or based on the estimator's experience.

c. To find out how many days of equipment operation are required to perform the work, the quantity of work is divided by the production per day. Some elements of work require several items of equipment to be used as a group, rather than individually, and in these cases, the days of operation should be shown as days of group operation.

If one end loader and five trucks are to be used for 10 days loading and hauling earth fill, they would be shown as one end loader and five trucks for 10 days, not as 10 days of end loading time and 50 days of truck time.

d. The project schedule should be consulted to find the time allotted for completion of the activity after determination of the number of days of equipment operation required. In order to complete the work within the time scheduled, it may be necessary to work several pieces or groups of equipment at the same time. The result is a more efficient operation.

e. An equipment schedule should be prepared for the total deployment using the project schedule to determine when the work will be performed. The schedule will indicate the peak loads for each equipment type. A study of the peak loads may show that it is desirable to revise the project schedule to more evenly distribute the equipment work load and thereby reduce the amount of equipment required for deployment. For example, an equipment schedule shows 80 dump trucks required during May and 20 dump trucks required during June and July. It may be possible to revise the project schedule to evenly distribute the work for these dump trucks over the three months so that 40 dump trucks are required during May, June, and July. This would mean a reduction of 40 dump trucks needed for the total deployment.

f. A list of the equipment requirements for the deployment can be prepared following a review of the equipment and project schedules, and making all possible adjustments to them. In preparing this list, downtime should be anticipated and sufficient equipment added so that when equipment is out of service awaiting repairs, a reserve piece is available for use. The number of pieces of equipment required for a deployment is obtained by adding the required reserve equipment of each type to the peak figures indicated by the equipment schedule.

SHEET 1 of 2

ESTIMATED BY Brown **DATE** 6/13/95

CHECKED BY Greene **DATE** 6/23/95

EQUIPMENT ESTIMATE

NMCB _____ **LOCATION** Guam **YEAR** 1995

PROJECT No. 013 **PROJECT TITLE** CONSTRUCT BLDG 101 **DESCRIPTION** Site Preparation

Earth Fill 36,000 CD loose measurement required.
Haul one way 2-1/2 miles.
Use 2-1/2 CD end loader and 10 CD dump trucks.

End loader capacity 100 CD/hour

$\frac{36,000}{100}$ = 360 hours or 45 eight-hour days.

$\frac{100}{10}$ = 10 trucks loaded per hour.

Average hauling speed estimated at 15 MPH.
2 X 2.5 = 5 miles round trip.

$\frac{5}{15} \times 60$ = 20 minutes hauling time.

$\frac{60}{10}$ = 6 minutes loading time.

Estimated dumping time 4 minutes.
30 minutes total time per truck load.

$\frac{60}{30}$ = Two loads per hour per truck.

$\frac{10}{2}$ = Five trucks required to keep end loader working at capacity.

100 X 8 = 800 CD hauled per 8-hour day.

Need one bulldozer (can spread 1,400 CD daily).
Need one grader to keep haul road in shape.

One tractor and tandem sheepfoot roller (can compact 1,200 CD daily).

One water truck with sprinkler for moisture control.

One rubber-tired wobbly wheel roller on standby for compaction and sealing fill when rain is expected (can be towed by above bulldozer or tractor).

FIGURE 3-1. Equipment Estimate Sample (Sheet 1 of 2)

ESTIMATED BY Brown **DATE** 6/13/95

CHECKED BY Greene **DATE** 6/23/95

EQUIPMENT ESTIMATE

NMCB _____ **LOCATION** Guam **YEAR** 1995

PROJECT No. 013 **PROJECT TITLE** CONSTRUCT BLDG 101 **DESCRIPTION** Site Preparation

NOTE: The preceding example is not very efficient , as spreading equipment is not used to full capacity. Suppose that when the work scheduled is prepared, completion of fill will be required in 18 days. Assume that the climate is that 3 days in every 17 working days will be lost due to rain. Therefore, 15 working days would be available in an 18-day schedule.

3,600
15 = 2,400 CD must be hauled daily to complete the work on schedule.

2,400
800 = Three times the output of loading and hauling spread shown previously.

Equipment required to load and haul:

Three	2-1/2 CD end loaders
One	Bulldozer to keep pit in shape
one	Grader to keep haul road in shape
Fifteen	10-ton trucks hauling (one or two extra trucks should be added to assure that a truck will always be waiting to be loaded so that end loader will work at full capacity).

2,400 CD will be hauled each day

2,400
1,200 = Two tractors and tandem sheepfoot roller for compaction
Two bulldozers to spread earth

2,400
1,400 = One water truck with sprinkler

One wobbly-wheel roller (standby for sealing of fill before rains).

NOTE: This is a more efficient operation, because production has been tripled but equipment has not, and total equipment working at or as close to capacity as can be expected.

FIGURE 3-1. Equipment Estimate Sample (Sheet 2 of 2)

5. **TABLE OF ALLOWANCE.** The Naval Mobile Construction Battalion (NMCB) Table of Allowance (TOA) contains specific information on the quantities and characteristics of the construction equipment available for NMCBs. Table 3-1 contains an abbreviated list of such construction equipment.

TABLE 3-1. NMCB TA-01 Construction Equipment Characteristics

Qty	EC	Description
16	0355-01	TRK, Pickup, 4X4, 4 Dr, 9200 GVW
4	0360-41	TRK, Util Cargo, 4X4, DED, HMMWV XM998
8	0360-51	TRK, Armament Carrier, 4X4, HMMWV M1043
2	0361-41	TRK, AMB, 2 Litter, 4X4, DED, HMMWV XM1035
16	0587-51	TRK, Dump, 5T Mil, 6X6, FMTV M1090
14	0588-51	TRK, Cargo, %T Mil, 6X6, FMTV M1083
10	0607-51	TRK, Trac, 5T, 6X6, FMTV M1088
4	0645-21	TRK, Trac, 6X6, DED, 600000 GVW
2	0709-51	TRK, Lube, Servicing, 6X6, Auto Trans., FMTV M1092
4	0722-21	TRK, Maint/Util, 4X4, DED, 8500 GVW
2	0730-21	TRK, Wrecker, 25T, 6X6, Commercial, 46000 GVW
2	0746-01	TRK, Truck TNK Fuel, 4X2, DED, 1500 Gal
84	Subtotal	
10	0816-11	Semi, Stake, 34X, 34T, 40 FT Mil
13	0825-11	Semi, Lowbed, 34X, 35T
5	0829-02	Dolly, TRLR Conv, 9T Commercial
1	0842-01	TRLR, BOLST, Pipe/Pole, 13T payload
10	0880-02	TRLR, TNK 400G, Potable water M149A2
39	Subtotal	
2	1820-00	TRFK, 4k-20k lb CAP, Rough, DED
5	1820-04	TRFK, 4000 lb CAP, Rough, DED
7	1820-12	TRFK, 12000 lb CAP, Rough, DED
14	Subtotal	
2	2433-01	MXR, CONC, Wheel, MTD, 11 CF, DED
1	2520-12	Distributor Asphalt, TRK MTD, 6X6, 2000 gal
2	2521-05	Distributor Water, TRK MTD, 6X6, 2000 gal
2	2521-22	Distributor Water, Off Hwy, 7000 gal, DED
7	Subtotal	

TABLE 3-1. NMCB TA-01 Construction Equipment Characteristics (Continued)

Qty	EC	Description
4	3135-02	COMPRES, WHEEL MTD, DED, 250 CFM
1	3165-02	COMPRES, WHEEL MTD, DED, 750 CFM
1	3165-11	COMPRES, WHEEL MTD, DED, 750 CFM 300 PSI
1	3630-32	HAMMER PILE, 1600 FT LBS, W/LEADS
1	3635-01	EXTRACTOR PILE, AIR, 100T LINK PULL
2	3710-11	AUGER, EARTH, TRK MTD, DED, 24 INCH X 10 FT
1	3720-02	DRILL WELL, WATER ROT/PER, 1500 FT, DED ETWD
1	3720-51	DRILL, SUPPORT ULH, DED, 6X6,FRONTV M1086
12	Subtotal	
1	4310-01	DITCHING MACH, LDDR TYPE,DED, CRAWLER MTD
1	4310-02	DITCHING MACH, WHL TYPE, DED, 6 FT DEPTH
2	4350-01	EXCAVATOR, CRWLR MTD, W/BKTS, PAV BRKR
6	4420-21	GRADER, ROAD, MOTORIZED,DED,6X4,OPEN ROPS
4	4530-41	LOADER,SCOOP,FULL-TRKED, 2-1/2 CY W/ROPS
3	4531-10	LOADER,SCP,WHL,2 CY,MP,BKT,BHOE,FRKS,ROPS
3	4531-30	LOADER,SCP,WHL, 2-1/2CY, MP, BKT, BHOE,FRKS,BOOM,ROPS
2	4615-01	ROLLER, MOTORIZED, COMPACTOR, 9 WHLD
3	4635-20	ROLLER, ROAD, VIBRATORY, 1 DRUM, FRONT, ROPS
6	4750-20	SCRAPER TRACTOR, DED,4X2,14-18 CY, ROPS
2	4830-10	TRACTOR CRAWLER, DED, 105HP, STRGHT BLD, ROPS
3	4850-12	TRACTOR CRWLR, DED, 195 HP, A-BLD, WNCH, CAB
3	4850-21	TRACTOR CRAWLER, DED 195 HP, SEMI-V BLD
1	4875-04	TRC WHL, END, 4X2, 60HP, LDR, ICY, BKT, BHOE, EC
2	4875-10	TRK WHL, END, 4X2, 60HP, LDR, ICY, BKT, BHOE, ROP
42	Subtotal	
10	5110-22	FLDLT SET, TRLR MTD, DED, 5KW W/4 1KW LUM
2	5121-10	GENERATOR SLT, SKID MTD, DED, 10KW, MRP 803A
4	5121-15	GENERATOR SLT, SKID MTD, DED 15KW, MRP 004A
3	5122-30	GENERATOR SLT, SKID MTD ,DED 30KW, MRP 805A
6	5124-60	GENERATOR SLT, SKID MTD, DED 60KW, MRP 806A
1	5160-01	LUBRICATION/SERVICING CMT, SKID MTD
7	5170-71	WELDER, ARC, WHL MTD, DED, 3-- AMP, TIG
2	5210-11	PUMP, DIAPHRAGM, RECIPROCATING, DED, 100GPM
2	5220-19	PUMP, CENTRIFUGAL, SLTWTR, SKID, GED, 500 GPM
8	5220-21	PUMP, CENTRIFUGAL, TRASH, WHL, GED, 400GPM
1	5220-31	PUMP, CENTRIFUGAL, TRASH, TRLR MTD, 1000 GPM

TABLE 3-1. NMCB TA-01 Construction Equipment Characteristics (Continued)

Qty	EC	Description
2	5420-01	SPRAYER, DECONTM, MIL, 50 GPM W/SHOWER, SKID
2	5710-21	SWEEPER, PERM, MAGNET, TOWED, 8 FT, SWATH
4	5900-01	SAW, RADIAL ARM, WOOD, 16 INCH BLADE, DED, GED
1	5910-11	SHOP MACHINE, MOBILE SEMITRLR MTD
30	Subtotal	
2	8215-01	CRANE, TRUCK MTD, 2 ENG, PRT, 35T
2	8254-25	CRANE, WHL MTD, 4X4, CONTAINER HANDLING
4	Subtotal	
263	TOTAL	

a. **Functions and Use of Common NMCB Construction Equipment.** The following information about the functions and uses of common construction equipment is basic and not meant to replace the knowledge and skills gained from practical experience. It is offered to assist planners who are not themselves equipment operators, and to supplement the information in *table 3-1* and the TOA. The following descriptions cover only that equipment listed in the TOA for an NMCB. Planners should recognize that there may be additional (augment) equipment available at a construction site, and that such equipment must be taken into consideration when making job estimates.

(1) Graders are designed for finish grade work but can be used in a variety of grading and ditching jobs. Most motor graders are equipped with scarifier teeth for breaking up "hard pan" and asphalt paving.

(2) Loaders have two general classifications: track or crawler tractor mounted; and wheel or pneumatic tire tractor mounted. The primary job of the loader is to load common earth materials into dump trucks or other earth hauling equipment. Most NCF loaders are equipped with a "4-in-1" bucket which can be used as a loader, scraper, dozer, or clamshell. Loaders come with a variety of attachments, such as rear-mounted backhoe and lifting forks interchangeable with the front-end loader bucket. The loader is a versatile piece of construction equipment capable of digging above or below ground level, dozing, and rough grading.

(3) Rollers are classified by the job they are intended to do, and by their weight. They may be either self-propelled or drawn. Weight varies with make, model, and type of roller. In order to increase compaction capabilities, vibratory rollers have been developed in both the towed and self-propelled types. Some later model rollers have articulated-type steering. The basic types and their purposes are as follows:

Type Roller	Purpose
Sheep foot	Tamp and compact fill material
Grid	Break and crush rocks and pavement
Three wheel	Breakdown and roll subsurface
Tandem	Finish roll asphalt paving
Rubber tire	Knead action subsurface compaction
Vibratory	Deeper penetration and vibration force

(4) Scrapers have two general classifications: drawn or towed; and motorized or self-propelled. Scrapers towed by track-laying tractors have self-loading capabilities beyond those of motorized scrapers, but are restricted in their efficient hauling distance, ranging from 300 to 1,500 feet. The struck capacity for scrapers most frequently used by the Seabees ranges from 14 to 18 cubic yards. Generally, scrapers are used where large volumes of material are to be hauled in "cut and fill" operations.

(5) Tractors have two general classifications used in earth moving: wheel or pneumatic tire tractors; and track or crawler types. Both types are used to pull scrapers, rollers, and other earth moving or compacting equipment, and may be fitted with a dozer blade, loader, backhoe, and a variety of other attachments.

(6) Cranes have three general types of land cranes, plus floating or barge-mounted cranes. The three types of land cranes are: track mounted or crawler cranes; truck mounted; and self-propelled rubber tired (single engine), sometimes called "maxi-mount." Capacities of cranes are usually rated in two ways: safe-load lifting capacity; and cubic yards struck bucket capacity. There is a variety of attachments that is standard with the basic crane machine. The following is a list of crane attachments and their characteristics.

Attachment	Characteristics
Lattice-type Boom	Hook block for general lifting jobs.
	Clamshell bucket for vertical digging below ground level; ideal for digging manholes, charging aggregate hoppers, where vertical height and depth is needed.
	Dragline for below ground level digging of trenches or culverts; well suited for bank sloping, with horizontal digging action as the bucket is drawn toward the machine.
	Pile driver leads. Orange peel for handling large boulders. Headache ball for demolition work. Magnet.
	Assorted specialized hooks and lifting devices.

Attachment	Characteristics
Backhoe, or Pull Shovel	Used for below ground-level digging. The digging action is similar to a dragline in that the bucket is drawn toward the machine. Positive digging action due to its rigid construction, which makes it ideally suited to work in hard material. It is limited in reach, however. Not well suited to bank sloping.

(7) Multi-purpose excavator, sometimes referred to as a "grade all," is an all-hydraulic-control machine with a pivoting telescoping arm or boom which comes with a variety of quick change attachments for a large number of jobs. It is ideal for trenching, digging footings, digging manholes, and bank sloping.

6. MATERIAL WEIGHTS AND PERCENT OF SWELL. Data that pertain to the weight and percentage of swelling of various construction materials are presented in *chapter 4, table 4-18*. These data are helpful to the estimator to prepare quantity estimates.

CHAPTER 4. LABOR ESTIMATES

1. TYPES OF LABOR ESTIMATES. There are two types of labor estimates: preliminary manpower estimates, and detailed manpower estimates.

a. Preliminary manpower estimates are used to establish costs for budget purposes and to project manpower requirements for succeeding projects and deployments. The estimates are prepared from limited information: general descriptions or preliminary plans and specifications that contain little or no detailed information; for example, on the basis of area, length, or other suitable measurement. In some cases, a comparison may be made with similar facilities of the same basic design, size, and type of construction. A good preliminary estimate should vary less than 15 percent from the detailed estimate.

The NAVFAC P-437, *Facilities Planning Guide*, Volume 1(drawings), and Volume 2 (materials list) is an excellent source for preliminary estimates which can be used to find estimates for a wide range of facilities and assemblies commonly constructed. The NAVFAC P-437 not only gives the man-hours required, but also gives a breakdown of the construction effort by rating (BU, CE, UT, and so forth), as well as construction duration estimates.

b. Detailed manpower estimates are used to determine the manpower requirements for the construction of a given project and the local direct labor requirements of a deployment. Detailed estimates are prepared using the individual activity quantities taken from the activity work sheet. Then, selecting from the appropriate table the man-hours per unit figure, and multiplying by the quantity, the total man-hours required is obtained. When the activity estimates are prepared in the format as discussed in chapter 2, a copy of the estimate may be used as a manpower estimate work sheet by adding columns with the headings of Activity Quantity, Man-Hours/Unit, and Man-Days Required. Work sheets, whether prepared using the Activity work sheet, or another format, should be prepared in sufficient detail to provide the degree of progress control desired. For example, if the work sheets show the following:

Work Sheet

Description	Quantity	Man-Hours Per Unit	Total Man-Days
Exterior spray painting, flat metal	6,000SF	.007mhrs/SF	5.25 mds
Exterior brush painting, wood siding	10,000 SF	.012 mhrs/SF	15.00 mds
Exterior roller painting, masonry	100,000 SF	.01 mhrs/SF	125.00 mds
TOTAL	**116,00 SF**		**145.25 mds**

If the control is to be exercised only on exterior painting without regard to detail, the Manpower Estimate would show the following on the work sheet.

WORK SHEET

Description	Quantity	Man-Hours Per Unit	Total Man-Days
Exterior Painting	116,000 SF	0.01 mhrs/SF	145 mds

2. **CHECKLISTS.** Manpower estimates should be checked against the activity estimate to assure that no activities have been omitted. The tables included in the chapters concerned with manpower estimates may serve as a checklist for omissions. In addition, a work element (or activity) checklist is included as *appendix A*, and an equipment and tool checklist is included as appendix B.

3. **FACTORS AFFECTING PRODUCTION.** In preparing manpower estimates various factors which affect the amount of labor required to construct a project must be weighed and considered. These factors are: weather conditions during the construction period; the skill and experience of the men who will perform the work; the time allotted for completion of the job; the size of the crew to be used; the accessibility of the site; and the types of material and equipment to be used. The following guidance is presented to aid the estimator in evaluating and applying these factors to his estimates.

a. **Workload.** The time allotted for construction of the project has a definite bearing on the number of workers assigned to do the work. Rush jobs may require a crew to work long hours and 7 days a week. A worker's production per hour decreases sharply under these conditions. Sometimes it is better to increase the number of workers in a crew or work several crafts at the same time in one location in order to complete a job quickly. When work area is crowded, workers are likely to get into each other's way, or distract others in the area. The results are reduction in efficiency so that more man-days are being used to accomplish the same amount of work. The size of the crew can affect production in another way. Crews are made up of workers with the various skills required to do a certain job and are assigned to jobs as a crew. They vary in size. When a crew is assigned to a job which will not take quite all day, there is tendency to slow down and make the work last out the day.

For example, electricians and utilities men have to work at the same time in the same area, working 12-14 hour days, the efficiency factor can be as low as .30; on the other extreme, if each craft can work independently in different areas of the project, then the efficiency factor can be as high as .85.

b. **Site Area.** The space for equipment maneuverability, storage of materials, and job layout, have significant impact on the productivity of the crew. Site accessibility can affect labor

requirements for a project. A hard-to-reach site may cause irregular delivery of materials and time consuming delays, which use man-hours without producing results. These factors must be considered when estimating manpower requirements for a project. Conditions may vary, cramped working area, no material storage, may reduce productivity to .25 -.30 efficiency. An example of ideal working conditions, large work area, no restrictions on use or equipment maneuverability, all materials stored at the site with easy access, will rate high .80's as productivity efficiency in that area.

c. Labor. The skill and experience of the workers who are assigned to the work should be considered when deciding the man-hour range to use. The production rate of experienced workers is better than that of a workers with little or no experience. If a crew consists of a few experienced workers and many inexperienced workers, the experience workers will use part of their time instructing and training the inexperienced workers. If a deployment consists of essentially the same type of construction on all its projects, inexperienced workers will increase their skill before the deployment is completed. Jobs performed towards the end of the deployment, after many months of similar work are done quicker, and with less effort. For example, a person with no training or experience will rate .25 -.30, "A" school graduate may raise factor to .35 -.40, a 3rd class petty officer will average .50 -.65, a journeyman with long experience at task ma rate .80 -.85 in efficiency.

The physical abilities of a person dictates how much can be accomplished in a given time period. Someone with limited physical power to lift or with no endurance will slow down progress of the project significantly, compared to a person with great physical power, agility and endurance. Efficiency will vary from .25 -.30 for weak to .65 -.75 for someone who is strong.

General health will affect performance of the crew; the "flu season" will slow down even strongest person. High sick call may rate .25 -.30 and sporadic sick call will rate .70 -.80 in efficiency.

The morale of the crew will dictate how quickly the job will progress. Hardships in getting to and from the job, or meals which are delayed or serve cold, extended working hours, and poor living conditions tend to lower morale and reduce production.

d. Supervision. The skill and experience of the crew leader has a definitive bearing on how the crew performs. A 3rd class petty officer with little training and experience may achieve .30 -.40 efficiency factor; a 2nd class petty officer with repetitive projects, and leadership training will perform an average range, for the Seabees, of .60 -.70; an experienced 1st class petty officer may have .70 -.85 efficiency rating.

e. Job Conditions. Conditions that a worker faces on the job effects productivity. Low quality work requirements such as rough surfaces, inexact cuts, where visibility is not

important may have a .70 -.75 efficiency rating. Median quality requirements such as temporary construction may have an average efficiency rating. High visibility projects where highest quality and workmanship are required may have an efficiency rating of .25 -.30. The types of material used may slow down job progress significantly. Heavy wet clay is much more difficult to excavate than sandy loam or sand. Bulky or heavy materials will require more time and equipment than light, prepackaged, easy to handle materials. The efficiency factor may range from .25 -.35 for heavy clays to .75 -.80 for pelletized tiles. Time allocated for operations will give .30 -.40 for "short fuse" or short duration projects to .65 -.80 for projects with adequate time. Insect annoyance has to be taken under consideration. A site with great number of mosquitos, gnats, or other insects will have a .30 -.40 efficiency factor, where a site with no insects may rate .65 -.80.

f. **Weather conditions**. Weather conditions have an effect on the number of man-hours required to do a job. Cold, damp climates, as well as hot, humid climates, reduce a worker's daily production and affect the output of construction equipment. Although time lost due to rain is not normally charged against a project, rain in the midst of a construction operation slows production and sometimes causes additional work which increases the number of man-hours required to repair damages, and to remove water from work areas before construction can resume.

In colder climates it is usually necessary to provide heat and protection for some parts of a project. Allowances must be made in the estimate for weather conditions either by selecting a man-hours per unit, which will provide some labor for these possibilities, or by directly adding man-hours to provide for them. *Appendix E* lists the average monthly temperature, average monthly rainfall, and average monthly days of rain for the various Seabee deployment locations. This table will assist in selecting a more accurate percentage for weather conditions. As an example, a summer deployment to Guam, with temperatures in upper 80's, high humidity, and frequent intermittent rain rates .25 -.35 in efficiency. A home port project in Port Hueneme in late August with pleasant weather, low humidity, no rain fall, an ideal construction weather will rate .65 -.75 in efficiency. A project on Adak during winter months will be affected significantly by cold winds, snow and rain and miserable weather. This will slow the project to .25 -.30 efficiency rating.

g. **Equipment**. The type of equipment available has considerable effect on the amount of labor required to perform a certain task. It is, therefore, necessary for the estimator to know what equipment will be used on a project before he can make an accurate estimate of manpower requirements. For instance, he needs to know whether soil is to be hauled in trucks or scrapers and the equipment size (it will take twice as many drivers and trucks if 5 cubic yard trucks are used instead of 10 cubic yard trucks). The estimator needs to know if concrete is to be placed by cranes and concrete buckets or with wheelbarrows, and if piles are to be driven with a diesel hammer or a drop hammer. The conditions of the equipment will dictate how often a piece has to go for repairs. Frequent breakdowns and maintenance requirements will have efficiency as low as .30 -.40 for a given task to high .60 -.75 for a new piece that stays on the job site and is always operational and requires minimal maintenance.

h. Tactics and Logistics. Location of a job site will have tremendous impact on the progress of the project; remote location, slow supply delivery, frequent tactical delays will rate . 25 -.35 in efficiency factor. Project near the main camp, prompt deliveries, no tactical delay will rate .70 -.80 in efficiency factor. As an examples, a DFT project in South America, distant from a supply point, with special ordering requirements will rate .25; a project near CampMitchell, where there are no problems with supply and delivery will rate .65; and a home port project in Gulfport where materials can be delivered at a moment's notice will rate .75 -.80 in efficiency.

4. **PRODUCTION EFFICIENCY GUIDE CHART AND GRAPH.** The **chart** (*table 4-1*) lists eight production elements that directly affect production. Each element is subdivided into three areas for evaluation, each of which contains two or more foreseen conditions from which to select as applicable to the job in question. The estimator evaluates each production element at some specific percentage between .25 and 1.00, according to the estimator's analysis of the foreseen conditions. The average of the eight evaluations is the overall production efficiency percentage. The percentage is then converted to a delay factor by using the **graph** (*figure 4-1*), or by dividing the average Seabee production (67 percent) by the average of the eight production elements. It is strongly recommended that field or project supervisors, once on site, reevaluate the various production elements and make the necessary adjustment to man-day figures, based on the actual conditions as found at the job site prior to the 45-day review. **It is very easy to over rate the capabilities of the crew, and other factors. This will give a higher than actual efficiency factor which, in turn, will give less man-days than needed to complete the project.**

The estimate of average Seabee production in this manual falls at 67 percent on the bottom of the graph (*figure 4-1*), which in turn will be a delay factor of 1.00 on the right. A delay factor of 0.67 represents peak production. The delay factor is used only to determine man-day estimates. Use the formula that follows to determine a man-day estimate.

Man-Day Estimate: MD = (QTY / UNIT SIZE) x (MHRS / UNIT) / 8 x DF

MD	=	Man-Day Estimate
QTY	=	Material quantity from material take off (MTO)
UNIT SIZE	=	Obtained from labor estimating tables
MHRS/UNIT	=	Obtained from labor estimating tables
8	=	8 hours per one man-day
DF	=	Delay Factor obtained from production efficiency chart

a. How to Use the Chart and Graph. Assume that from the tables in this handbook you extract an estimate of 6 man-hours for a given unit of a work element. To adjust this figure to the conditions evaluated on your job, assume that the average of foreseen conditions rated by you is 87 percent. The corresponding delay factor read off *figure 4-1* is 0.80 or .67 / .87 = .77. The adjusted man-hour estimate is found by multiplying this factor by the man-hours from the estimating tables, shown in the computation: 6MHRS x 0.80MHRS = 4.8MHRS or 6MHRS x .77 = 4.6MHRS

TABLE 4-1. Production Efficiency Guide Chart

	LOW PRODUCTION	AVERAGE PRODUCTION	HIGH PRODUCTION
PERCENTAGE	25 35 45	55 65 75	85 95
1. WORKLOAD	Construction req't high Misc. overhead high	Construction req't avg. Misc. overhead avg.	Construction req't low Misc. overhead low
2. SITE AREA	Cramped work area Poor laydown/access	Work area limited Avg. laydown/access	Large work area Good laydown/access
3. LABOR	Poorly trained/motivated or inexperienced	Adequately trained/motivated crew	Highly trained/motivated crew
4. SUPERVISION	Poorly trained/motivated or inexperienced	Adequately trained/motivated/experienced	Highly trained/motivated/ experienced
5. JOB CONDITION	High quality work req'd/short fuse	Avg. quality work req'd/adequate time	Rough/unfinished work req'd/well planned
6. WEATHER	Abnormal heat, rain, cold	Moderate rain, heat, cold	Favorable rain, heat, cold
7. EQUIPMENT	Poor cond., maint., repair, application	Fair cond., maint., repair, application	Good cond., maint., repair, application
8. TACTICAL/LOGISTICAL	Slow supply, frequent tactical delays	Normal supply, few tactical delays	Good supply, no tactical delays

Table Notes: *1. The weights of the elements can be adjusted if known facts so indicate.*

2. Rainfall is normally treated separately in the area of calendar day scheduling. Predictions of lost construction days are based on geographic rainfall charts. Typhoon and hurricane seasons can cause considerable lost time in securing job sites for alerts and warnings, even if work areas are not directly in the path of the storm.

3. The tactical delay area of consideration should include: night travel restrictions; mine sweeps on roads into the work area; preparation of zig-zag trenches or individual protective measure; sabotage of equipment or materials left on the job site; and any additional security requirements which detract from the assigned work force.

4. The continual theft of tools and materials can affect production and is very common in some areas of the world. This condition requires abnormal controls and security, which in turn slows production.

5. The man-hour estimates contained in this manual are based on the average Seabee Production Efficiency which is 67 percent.

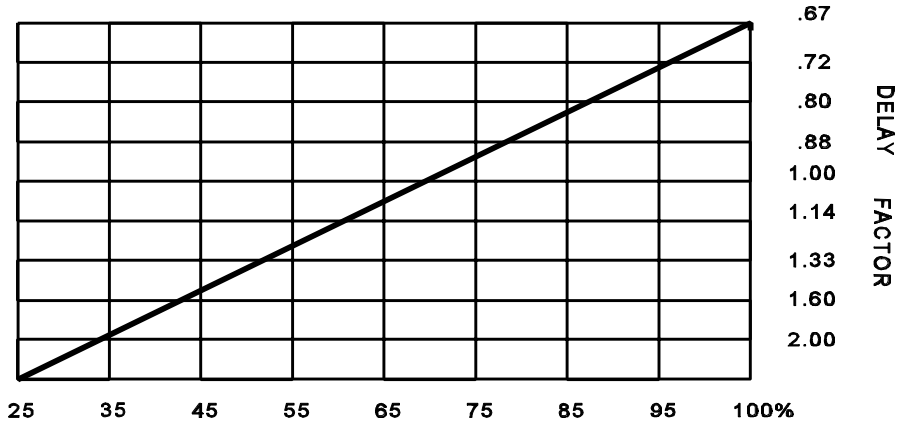

FIGURE 4-1. Production Efficiency Graph

5. **LABOR ESTIMATING TABLES.** The man-hour labor estimating tables contained in this chapter are arranged and grouped together into the 17 major divisions of work. This is the same system used in the preparation of government construction specifications established by the Construction Specifications Institute (CSI). The 17 major divisions of work are presented in the following list, together with the labor estimating tables associated with that division.

SEVENTEEN MAJOR DIVISIONS OF WORK

Divisions	Tables	Divisions	Tables
1. GENERAL	4-2 through 4-5	9. FINISHES	4-102 through 4-117
2. SITEWORK	4-6 through 4-38	10. SPECIALTIES	4-118 through 4-120
3. CONCRETE	4-39 through 4-55	11. Architectural Equipment	Not used
4. MASONRY	4-56 through 4-63	12. Furnishings	Not used
5. METAL	4-64 through 4-79	13. Special Construction (ABFC)	Not used
6. CARPENTRY	4-80 through 4-93	14. Conveying System	Not used
7. MOISTURE PROTECTION	4-94 through 4-98	15.MECHANICAL	4-121 through 4-136
8. DOORS, WINDOWS, GLASS	4-99 through 4-101	16.ELECTRICAL	4-137 through 4-153
		17. EXPEDITIONARY STRUCTURES	4 - 154 through 4 - 155

a. **How to Use the Labor Estimating Tables.** The activities in the various labor estimating tables are divided into units which are always **ONE not** measurement commonly associated with each craft and material take-off quantities. There is only one amount of man-hours effort per unit of work. This number represents normal Seabee production under average conditions. As used here, one man-day equals eight man-hours of direct labor. Man-day figures do not include overhead items such as dental or personnel visits, transportation to and from the job site, or inclement weather.

No two jobs will be exactly alike and have exactly the same conditions; therefore, the estimator must exercise some judgment about the project that is being planned. The production efficiency guide and graph *(table 4-1, figure 4-1)* are provided to assist the estimator to weigh the many factors that contribute to varying production, and eventual completion of a project. The estimator can then translate what is known, and can predict a more accurate quantity from the average figures given on the labor estimating tables.

b. Efficiency Factor. There are three types of efficiency factors that impact on manpower resources. The definitions of these three types should assist the estimator to decide when to apply each towards the manpower availability equations.

(1) Direct Labor Efficiency factor is used to determine how much construction type production a battalion main body or detachment is achieving. It is easily determined from the Situation Report (SITREP). The overall battalion goal is 30 percent while main body averages are 20 percent. The formula is the fraction (written as percent) of actual direct labor divided by the total strength of the battalion. It is used where actual direct labor is the total labor charged to the project tasking, and is accounted for by the timekeepers at each job site. The total strength includes every enlisted person in the battalion, both Occupational Field 13 (OF-13) and non OF-13.

(2) Production Efficiency factor is used to estimate the amount of man-days necessary to complete a specific project. The average Seabee production is 67 percent *(table 4-1)*. The efficiency is impacted by eight production elements (workload, site area, labor, supervision, job conditions, weather, equipment, tactical and logistical) at each job site.

(3) Availability factor (percentage) determines how much of the planned direct labor is available. Each main body and detachment side has an historical availability factor that can be used to determine how much manpower is available during a deployment. Such items as leave and liberty, battalion inspections, collateral duties, all impact on how much time the direct labor planned becomes actual. The average availability factor ranges from 60 percent to 90 percent and depends on the deployment site. Thus, the formula is: *Direct Labor Planned x Availability Factor = Direct Labor Actual.* This factor is used in the Man-Day Capability equation shown below.

Man-Day Capability: **MC = DL x AF x WD x ME**

MC	=	Man-Day Capability, Man-Day Availability or Tasked Man-Days
DL	=	Planned Direct Labor
AF	=	Availability Factor
WD	=	Available Workdays, Total Deployment Days less Sundays, holidays, turnover, training and off Saturdays. (Obtained from the deployment calender.)
ME	=	Man-Day Equivalent, Planned work hours per day divided by 8 hours (one man-day). Example: a 9-hour workday can be shown 9/8 or 1.125

An example of the use of these factors to staff a detachment is shown below.

GIVEN:	Tasking (MC)	= 3,000 Man-Days
	Work Days (WD)	= 120 days
	Man-Day Equivalent (ME)	= 1.125 or 9/8
	Availability Factor (AF)	= .80 or 80 percent

FIND: Size of Detachment necessary to achieve tasking.

SOLUTION:

$$MC = DL \times AF \times WD \times ME$$
$$3000 = DL \times .80 \times 120 \times 1.125$$
$$3000 = DL \times 108$$
$$\frac{3000}{108} = \frac{DL \times 108}{108}$$
$$DL = 28 \text{ Seabees}$$

Note: The planned direct labor is 28 Seabees. Actual direct labor equals 28 x .8 or 22.4 Seabees. This means that 22.4 Saebees will be on the job at any given time.

If the Detachment received 10 Seabees for overhead or indirect labor, such as Admin Personnel, Central Tool Room (CTR), Material Liaison Office (MLO), Construction Mechanics (CM), etc., the total strength becomes 28 + 10 = 38 Seabees. The percent of actual direct labor for the Detachment would be 22.4/38 = 58.9 or 59 percent.

This same formula can be used by the crewleader (estimator) to determine duration or crew size for a given activity by making the following substitution in the basic equation:

MC	=	MD (Man-Day Estimates)
DL	=	CS (Crew Size)
WD	=	DUR (Duration)

$$MD = CS \times AF \times DUR \times ME$$

Solving for Duration the equation becomes:

$$DUR = MD / (CS \times AF \times ME)$$

Solving for Crew Size the equation becomes:

$$CS = MD / (DUR \times AF \times ME)$$

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DIVISION 1. GENERAL

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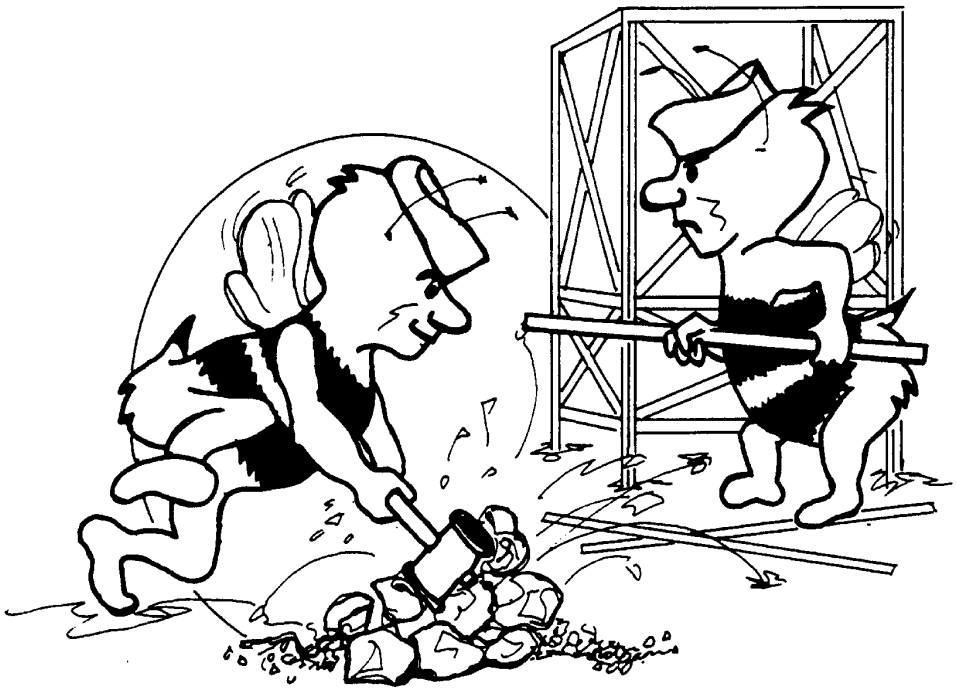

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TABLE 4-2. Asphalt Plant Operation

Work Element Description	Unit	Man-Hours Per Unit
Setup and Dismantle Plant	Each	120 (**1155**)
Operation of Asphalt Plant	TN	0.08 (**1156**)
Haul Asphalt to Job	TN / MI	0.048 (**1157**)

SUGGESTED CREW SIZE:
Setup and Dismantle Plant: five EOs, one CE, one SW, one CM
Asphalt Plant Operation: five EOs
Hauling Asphalt to Job Site: EOs required depend on scop of job
Maintenance (support): one CE, one CM, two EOs
(one plant operator, one ground man, one loader operator)

NOTES:
1. Figures are based on drum mix plant, 70 ton per hour.
2. Site preparation and concrete curing time not included in table.

TABLE 4-3. Rock Crushing Plant Operation

Work Element Description	Unit	Man-Hours Per Unit
Setup and Dismantle	Each	320 (**1158**)
Operate Crushing Plant	CD	0.16 (**1159**)
Stockpile Crushed Material	CD	0.0 24 (**1160**)
Haul Crushed Material to Job	CD	0.048 (**1161**)

SUGGESTED CREW SIZE:
Setup and Dismantle Plant: seven EOs, one SW, one CE, one CM
Operate Crushing Plant: two EOs
Stockpile Crushed Material: four EOs
Maintenance (support): one SW, one CE, one CM

NOTE:
1. The production figure is based upon 75 TPH plant operating at 50 percent of rated capacity crushing granite at 3,000 LB per cubic yard. For plants of other sizes use 50 percent of rated capacity and the size of your crew for calculations.

2. Production figures may have to be adjusted in accordance with the type of material being processed, and with other varying circumstances. For example: Coral weights (approximately 2,000 LB per loose cubic yard.

TABLE 4-4. Scaffolding, Runways, and Ramps

Work Element Description	Unit	Man-Hours Per Unit
Erect and Dismantle Tubular Scaffold (including Planks and Leveling)	SF of Wall Surface	0.04 (**1164**)
Construct Runways and Ramps	SF	0.064 (**1162**)
Place and Remove (runways and ramps)	FT	0.16 (**1163**)

SUGGESTED CREW SIZE:
Scaffolding Erection: three to four BUs, increase crew size for multiple tiers.

NOTE: 1. The first tier requires more time due to leveling and alignment procedures.

TABLE 4-5. Temporary Construction

Work Element Description	Unit	Man-Hours Per Unit
Barricades (Wood Frame and Plywood) Fabricate and Erect 4' High, 8' High	FT (4' High) FT (8' High)	0.64 (**1165**) 0.75 (**1166**)
Rubbish chute Prefabricated 36 Inches Diameter	FT	0.5 (**1167**)

SUGGESTED CREW SIZE:
Two to four non-skilled

NOTE: 1. For temporary roads and fencing refer to Division 2; for temporary water service refer to Division 15; for temporary lighting and electrical service refer to Division 16.

DIVISION 2. SITE WORK

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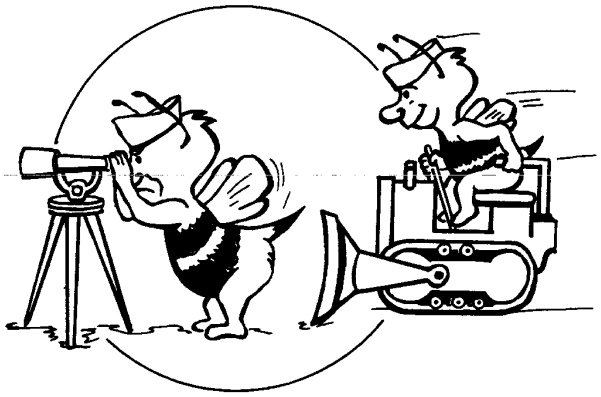

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TABLE 4-6. Acreage and Areas

	Square Tracts of Land	
Acres	**Length of One Side of Square Track, FT.**	**Area SF**
1/10	66.0	4,356
1/8	73.8	5,445
1/6	85.2	7,260
1/4	104.4	10,890
1/3	120.5	14,520
½	147.6	21,780
3/4	180.8	32,670
1	208.7	43,560
1-1/2	255.6	63,340
2	295.2	87,120
2-1/2	330.0	108,900
3	361.5	130,680
5	466.7	217,800

TABLE 4-7. Clearing Striping and Grubbing

Work Element Description	Unit Per Hour	Bulldozer Size Medium	Bulldozer Size Large
Light Clearing: Vegetation, Brush, Saplings	SY	0.0012 (**1201**)	0.0006 (**1202**)
Moderate Clearing: Vegetation, Thick Brush, Saplings	SY	0.0024 (**1203**)	0.0021 (**1204**)
Stripping Top Soil: Pile on Site	CD	0.0526 (**1205**)	0.027 (**1206**)

Work Element Description	Unit	Man-Hours Per Unit
Trees w/stumps 6 - 12" dia. Fell and Cut for Loading	EA	4.00 (**1207**)
Trees w/stumps 13-18" dia. Fell and Cut for Loading	EA	12.00 (**1208**)
Trees w/stumps 19-24" dia. Fell and Cut for Loading	EA	18.00 (**1209**)
Stump Removal w/Bulldozer	EA	1.6 (**1210**)

Work Element Description	Unit	Man-Hours Per Unit
Survey, Topographical (level area) (hilly area)	SY SY	0.003 (**1211**) 0.012 (**1212**)
Stake Out Clearing Limits (Roads/Runways)	FT	0.005 (**1213**)
Layout Baseline with Offset Hubs at 100-Foot Intervals (level area) (hilly area)	FT FT	0.0051 (**1214**) 0.0078 (**1215**)
Set Blue Top at 25-FT Interval	FT	0.0091 (**1216**)
Layout Bounds (Building)	EA	4.5 (**1217**)
Layout and Grade Pipe/Culvert	EA	4.5 (**1218**)

SUGGESTED CREW SIZE:
Two to three EOs
Two to four non-skilled

TABLE 4-8. Demolition and Removal

Work Element Description	Unit	Man-Hours Per Unit
Concrete Foundations	CD	5.0 (**1068**)
Concrete Walls	CD	6.0 (**1069**)
Concrete Slabs on Grade. No Reinforcing	CD	4.0 (**1070**)
Concrete Slabs on Grade w/Wire Mesh Reinforcing	CD	4.0 (**1071**)
Concrete Slabs on Grade w/Rebar and Mesh Reinforcing	CD	6.0 (**1072**)
Ceilings, Sheetrock	SF	0.024 (**1073**)
Ceilings, Suspended Acoustic	SF	0.024 (**1074**)
Doors and Frames, 3' x 7' Wood	Each	2.0 (**1075**)
Doors and Frames, 3' x 7' Steel	Each	2.0 (**1076**)
Flooring, Ceramic or Quarry Tile	SF	0.05 (**1077**)
Flooring, Resilient Tile	SF	0.03 (**1078**)
Flooring, Wood Floor Finish	SF	0.06 (**1079**)
Flooring, Wood Subfloor	SF	0.03 (**1080**)
Framing, Steel	Ton	6.8 (**1081**)
Framing, Wood	BF	0.016 (**1082**)
Wallboard, Gypsum	SF	0.03 (**1083**)
Wallboard, Plywood	SF	0.03 (**1084**)
Roofing, Corrugated	SF	0.03 (**1085**)
Roofing, Buildup 5 Ply	SF	0.03 (**1086**)
Windows, Metal	SF	0.096 (**1087**)
Windows, Wood	SF	0.1 (**1088**)
Asphaltic Concrete	SY	0.053 (**1089**)
Rubbish disposal up to 5 miles	CD	1.5 (**1090**)

SUGGESTED CREW SIZE: Minimum crew sizes for various operations will be dictated by safety and weight, or bulk of materials handled.

NOTE:

1. Work includes removal of item and stacking or piling on site for removal at ground level.

2. Second floor or upper story work includes dumping into rubbish chutes.

3. Concrete demolition is figured on using pneumatic tools with average crew of two tool operators and three to five laborers.

4. No allowance for salvage of materials (cleaning, pulling nails) is included in this table.

TABLE 4-9. General Excavation Factors

Depth in Inches or Feet	CD to be Removed per SF of Area	Depth in Feet	CD to be Removed per SF of Area
2.0 IN	0.006	4.5	0.167
4.0 IN	0.012	5.0	0.185
6.0 IN.	0.018	5.5	0.204
8.0 IN	0.025	6.0	0.222
10.0 IN	0.031	6.5	0.241
1.0 FT	0.037	7.0	0.259
1.5 FT	0.056	7.5	0.278
2.0 FT	0.074	8.0	0.296
2.5 FT	0.093	8.5	0.314
3.0 FT	0.111	9.0	0.332
3.5 FT	0.130	9.5	0.350
4.0 FT	0.148	10.0	0.369

NOTES: 1. Example: Assume that excavation is 24' x 30' and 6' deep (24 x 30 = 720). In the table, the 6 FT depth has a factor of 0.222 (the number of CD in an excavation 1SF and 6 FT deep). Therefore: 720 x 0.222 = 159.84 CD.

TABLE 4-10. Front End Loaders Production

Excavation From Pit to Truck/Pile, Hours per Lose Cubic Yard				
Bucket Size	**Haul Distance (Feet)**			
CD	50'	100'	150'	200'
1.25	0.0256 (**1221**)	0.0357 (**1222**)	0.0476 (**1223**)	0.0588 (**1224**)
2.5	0.0081 (**1225**)	0.0109 (**1226**)	0.0133 (**1227**)	0.0161 (**1228**)
4.0	0.0047 (**1229**)	0.0062 (**1230**)	0.0075 (**1231**)	0.0091 (**1232**)

NOTES: 1. Figures are in loose CD. Use table 4-18 to find the amount of bank CD (in place) removed. Example: 2-1/2 CD loader at 50' haul = 1/0.0081=124 loose CD in one hour. 124 CD x swell factor for earth, loam, dry = 124 x .81 = 100 bank CD in one hour.

TABLE 4-11. Bulldozer Production

Loose Cubic Yardage Production Hours Per Loose Cubic Yard Based on 50-Minute Hour						
	Haul Distance					
Dozer Size	**50 FT**	**100 FT**	**150 FT**	**200 FT**	**300 FT**	**400 FT**
Large (D-8)	0.0023 (**1252**)	0.0035 (**1253**)	0.0048 (**1254**)	0.0059 (**1255**)	0.008 (**1256**)	0.0105 (**1257**)
Medium (D-7/FD20)	0.0027 (**1258**)	0.0049 (**1259**)	0.0065 (**1260**)	0.01 (**1261**)	0.0135 (**1262**)	0.0182 (**1263**)
Small (D-5/150)	0.0095 (**1264**)	0.0154 (**1265**)	0.0217 (**1266**)	0.0294 (**1267**)	0.0455 (**1268**)	----

NOTES:
1. Figures are in loose CD. Use table 4-18 to find the amount of bank CD (in place).
2. Production is based on "slot dozing." If work is done without slots, use .75 multiplier

TABLE 4-12. Clamshell Production

Clamshell Production - 90 Degree Swing Hour Per Loose Cubic Yard (50-Minute Hour)			
Type of Work	**0.75 CD**	**1.50 CD**	**2.50 CD**
Loose Sand/Gravel	0.025 (**1272**)	0.0143 (**1273**)	0.0095 (**1274**)
Pit Excavation	0.0294 (**1275**)	0.0167 (**1276**)	0.0111 (**1277**)

SUGGESTED CREW SIZE: Two EOs minimum

NOTE:
1. Figures are based on loose CD. Use table 4-18 to find the amount of bank CD (in-place).
2. Boom swing is for 90 degrees.

TABLE 4-13. Draglines Production

Dragline Production - 90 Degree Swing Hour per Bank Cubic Yard (50-Minute Hour)				
Bucket Size	Optimum Digging Depths	Class of material		
		Sand/Gravel	Common Earth	Dense Clay
0.75 CD	6 . 00 FT	0.0143 (**1282**)	0.0147 (**1285**)	0.02 (**1288**)
1.50 CD	7 . 33 FT	0.0086 (**1283**)	0.0095 (**1286**)	0.0112 (**1289**)
2.50 CD	8 . 50 FT	0.0061 (**1284**)	0.00687 (**1287**)	0.0079 (**1290**)

SUGGESTED CREW SIZE: Two EOs minimum.

NOTE: 1. Figures are in bank CD. Use table 4-18 to find loose CD.

TABLE 4-14. Trench Excavation Factors

Trench Depth (Inches)	Trench Width (inches)						
	12	18	24	30	36	42	48
	Content of Trench, CD, per foot of length						
6	0.019	0.028	0.037	0.046	0.056	0.066	0.074
12	0.037	0.560	0.074	0.093	0.111	0.130	0.148
18	0.056	0.083	0.111	0.139	0.167	0.194	0.223
24	0.074	0.111	0.148	0.185	0.222	0.260	0.296
30	0.093	0.138	0.185	0.232	0.278	0.324	0.370
36	0.111	0.166	0.222	0.278	0.333	0.389	0.445
42	0.130	0.194	0.259	0.324	0.389	0.454	0.520
48	0.148	0.222	0.296	0.370	0.445	0.520	0.592
54	0.167	0.250	0.333	0.416	0.500	0.584	0.667
60	0.186	0.278	0.370	0.463	0.555	0.649	0.741

TABLE 4-15. Power Excavators Production

Power Excavators Production Hour per Bank Cubic Yard (50-Minute Hour)		
Equipment Type	**Bucket Size**	**Hour/Bank CD**
Tractor Mtd. Backhoes	3/8 CD ½ CD	0.1 (**1302**) 0.0769 (**1303**)
Gradalls	30" w/ ½ CD 48" w/ 1 CD	0.0588 (**1304**) 0.0294 (**1305**)
Excavator Hyd. Hoes	3/4 CD 1 CD 1-1/2 CD	0.025 (**1306**) 0.0182 (**1307**) 0.0139 (**1308**)

SUGGESTED CREW SIZE: Two EOs

NOTE: 1. Figures are in bank CD. Use table 4-18 for loose CD.

TABLE 4-16. Trencher/Ditchers Production

Trencher Production Hour per Bank Cubic Yard		
Equipment Type and Size	**Width (Inches)**	**Hour/Bank Cubic Yard**
Ladder Type Ladder Type	6 24	0.0833 (**1322**) 0.01 (**1323**)
Wheel Type Wheel Type	12 24	0.0125 (**1324**) 0.0047 (**1325**)

NOTE: 1. Use table 4-18 to figure loose CD.

TABLE 4-17. Sheeting and Shoring Excavations

Work Element Description	Unit	Man-Hours per Unit
Installation and Removal of Solid 2-inch Sheeting for Trenches 5 FT to 10 FT Deep and 42 IN to 12 FT Wide.	SF of Bank Surface	0.16 (**1332**)

SUGGESTED CREW SIZE: Four EOs. Two cribbing and two helpers.

NOTES:

1. Work for typical unstable soil includes: Solid sheeting. 4" x 6" stringers. 4' C to C hangers. Cleats and 4" x 6" cross bracing spaced 7' C to C.

2. Design of shoring and sheeting will vary with soil conditions, width and depth of trench, etc.

3. Installation should be in accordance with the National Safety Council Industrial Data Sheets No. 254 (Trench Excavation) and No. 482 (General Excavation), or designed by a competent engineer.

TABLE 4-18. Material Weights and Swell Factors

Material	# per CD (Loose)	# per CD (In Place)	% of Swell	Swell Factor
Cement, Portland	2450	2950	20	.83
Clay, Natural Red	2700	3500	30	.77
Clay and Gravel, Dry	2300	3100	34	.74
Clay and Gravel, Wet	2600	3500	34	.72
Concrete	2650	3700	40	.72
Concrete, Wet Mix	3600	3600	40	.72
Earth, Loam, Dry	2300	2850	25	.81
Earth, Loam, Wet	2750	3400	24	.81
Granite	2800	4560	65	.60
Gravel, 1/4 to 2 IN, Dry	2850	3200	12	.89
Gravel, 1/4 to 2 IN, Wet	3200	3600	13	.89
Laterite	3900	5200	33	.75
Limestone, Blasted	2500	4250	69	.59
Limestone, Crushed	2700	4500	67	.60
Limestone, Marble	2700	4500	69	.59
Mud, Dry	2100	2550	21	.82
Mud, Wet	2650	3200	21	.83
Sand, Dry	2750	3100	13	.89
Sand, Wet	3150	3600	14	.88
Sandstone, Shot	2700	4250	58	.64
Shale, Riprap	2100	2800	33	.75
Slate	3600	4700	30	.77
Coral, Class #2, Soft	2030	2900	67	.60
Coral, Class #1, Hard	2440	4075		

NOTES:

1. Percent of Swell times the bank (in place) CD equals the loose cubic yards to be moved.

2. Swell Factor times the loose cubic yards equals bank cubic yards being moved.

3. Compaction Factor times the volume of the fill equals the loose material required for compacted fill.

TABLE 4-19. Dump Trucks Production

Dump Truck Production Hourper Loose Cubic Yards					
Average Speed	Average Haul Distance One Way				
	1 MI	2 MI	3 MI	4 MI	5 MI
10 MPH	0.0877 (**1342**)	0.1429 (**1346**)	0.2 (**1350**)	0.25 (**1354**)	0.303 (**1358**)
15 MPH	0.068 (**1343**)	0.1064 (**1347**)	0.1429 (**1351**)	0.1786 (**1355**)	0.2174 (**1359**)
20 MPH	0.0595 (**1344**)	0.087 (**1348**)	0.1149 (**1352**)	0.1429 (**1356**)	0.1695 (**1360**)
30 MPH	0.0505 (**1345**)	0.069 (**1349**)	0.087 (**1353**)	0.1053 (**1357**)	0.125 (**1361**)

NOTES:
1. All figures are in loose CD for 5-ton military dump trucks.
2. For 15-ton civilian trucks use 2 multiplier.
3. 2.5 CD F.E.L. required to load 5-ton trucks. 4 CD F.E.L. for 15-ton trucks.
4. Table based on loading time of 4 min. and a dumping time of 3 min.

TABLE 4-20. Wheel Tractor Scrapers Production

Wheel Tractor Scraper Production Hourper Loose Cubic Yard					
Scraper Size	One Way Haul Distance (FT)				
	1000	2000	3000	4000	5000
14-18 LCD	0.0082 (**1372**)	0.0116 (**1373**)	0.0159 (**1374**)	0.02 (**1375**)	0.0233 (**1376**)
21-31 LCD	0.0038 (**1377**)	0.0061 (**1378**)	0.0083 (**1379**)	0.0105 (**1380**)	0.0123 (**1381**)

NOTES:
1. All figures in loose CD.
2. Estimates figures on required size crawler tractor push loading.

TABLE 4-21. Motor Grader Production

Motor Grader Production,Hour per Bank Cubic Yard (BCD)	
Type of Operation	**Hour per Bank Cubic Yard**
Cut "V" Ditch, Easy Soil	0.006 (**1392**)
Cut "V" Ditch, Medium Soil	0.01 (**1393**)
Cut "V" Ditch, Hard Soil	0.0175 (**1394**)
Trim and Spread Material	0.0133 (**1395**)
Motor Grader Grading Production,Hour per Square Foot	
Type of Operation	**Hour per Square Foot**
Shape Banks and Slopes	0.0013 (**1396**)
Rough Grade	0.0004 (**1397**)
Fine Grade (Blue Top)	0.0017 (**1398**)

SUGGESTED CREW SIZE: For fine grading, one EO, one grade checker.

NOTES:
1. All figures are in bank CD.
2. For small areas that require directional changes and maneuvering, use 2.0 multiplier.

TABLE 4-22. Compaction Factors

Material (Compacted)	Multiplier
Sand	1.17
Loam	1.39
Clay	1.59
Rock (blasted)	1.15
Coral	1.15

NOTE:
1. Cubic volume in place times the multiplier equals the cubic yards of loose material to be moved.

TABLE 4-23. Rollers (Hourly Production)

Roller Production: Hourper Compacted Cubic Yard (CCD/HR)						
Type of Roller	**Speed in MPH**	**Lift in Inches**	**Number of Passes**			
			3	**4**	**5**	**6**
Towed Grid	5	6	0.0018 (**1402**)	0.0025 (**1403**)	0.0031 (**1404**)	0.0037 (**1405**)
Vibratory	2	6	0.0034 (**1406**)	0.0046 (**1407**)	0.0057 (**1408**)	0.0069 (**1409**)
Smooth Steel Drums	1.5	3	0.0093 (**1410**)	0.0122 (**1411**)	0.0154 (**1412**)	0.0185 (**1413**)
Multi-Tired Pneumatic	2	3	0.0079 (**1414**)	0.0105 (**1415**)	0.0132 (**1416**)	0.0156 (**1417**)
High Speed Tamping Foot	6	6	0.0011 (**1418**)	0.0015 (**1419**)	0.0019 (**1420**)	0.0023 (**1421**)

NOTES:
1. All figures are in HR /compacted CD
2. Use table 4-18 to estimate loose CD of fill requirements.
3. For small areas that require more directional changes and maneuvering, use .5 multiplier
4. The number of machine passes required is dependent on soil type, moisture content, desired density, and machine compactive effort.
5. The number of passes can only be determined by testing the density of the compacted material on site.

TABLE 4-24. Seal Coats

Work Element Description	Unit	Man-Hours Per Unit
Load Distributor Trk. from Drums	GL	0.009 (**1123**)
Load Distributor Trk. from Tank	GL	0.003 (**1124**)
Heat	GL	0.004 (**1125**)
Hand Spray from Distributor Trk.	GL	0.003 (**1126**)
Apply Print, Tack, Seal Coat 12 FT Bar	GL	0.001 (**1127**)
Sweep Base with Tractor Mtd.	SY	0.001 (**1128**)
Spread Aggregate with 8-FT wide Spreader Box	SY	0.001 (**1129**)

SUGGESTED CREW SIZE: Loading distributor, three EOs for drums, two EOs for tank
Heating asphalt, two EOs
Hand spraying asphalt, three EOs
12-FT spray bar, two EOs
Spread aggregate, two EOs

NOTES:
1. Drum loading is figured on top loading using a crane or forklift to raise drums.
2. Dump truck and man-hours are not included in estimate for spreading aggregate, see table 4-19.

TABLE 4-25. Bituminous Paving

Work Element Description	Unit	Man-Hours Per Unit
Asphalt Walks/Hand Spread:		
Form Work	FT	0.04 (**1130**)
Spread Asphalt	SF	0.025 (**1131**)
Hand Compact/Roll	SF	0.008 (**1132**)
Asphalt Paver:		
Paving with Asphalt Finisher	TN	0.09 (**1133**)
Mix in place 2-inch thick with grader	SY	0.002 (**1134**)
Intermediate Roll	SY	0.002 (**1135**)
Finish Roll	SY	0.003 (**1136**)

SUGGESTED CREW SIZE: Asphalt paver. One operator, one screed man, and four laborers with hand tools
Hand spread, 4-12 men. Spreading, leveling, forming, 2-3 men.

NOTE: 1. Asphalt paving figures based on actual laydown time on straight course. When parking lots or short courses are to be laid, double the estimate.

TABLE 4-26. Rock Drilling and Blasting

Work Element Description	Unit	Man-Hours Per Unit
Drill Holes:		
Sinker Drill 2.5" dia. med.	FT	0.2 (**1137**)
Sinker Drill 2.5" dia. hard	FT	0.3 (**1138**)
Air Trac 2.5" dia. med.	FT	0.09 (**1139**)
Air Trac 2.5" dia. hard	FT	0.14 (**1140**)
Load and Shoot Holes	EA	0.5 (**1141**)

SUGGESTED CREW SIZE: Sinker Drill (Jack Hammer) one man per drill.
Air Trac Driffer Drill two EOs per drill.
Load/Shoot 4-20 men.

NOTES: 1. Times may vary depending on type of rock, equipment and/or explosives.
2. Figures for blasting are for stick dynamite.

TABLE 4-27. Hand Excavation

Work Element Description	Unit	Man-Hours Per Unit
General Excavation of Earth	CD	2.7 (**1142**)
Trenches to 5' in Earth	CD	2.2 (**1143**)
Post Holes. Small 3' deep	FT	0.5 (**1144**)
Fill Wheelbarrel, Georgia Buggys, and Haul	CD	1.9 (**1145**)
Spread Excess Earth	CD	0.9 (**1146**)
Trim and Fine Grade	SF	0.019 (**1147**)
Hand Compact w/Pneumatic	CD	0.8 (**1148**)
Hand Compact w/Vibratory	CD	0.2 (**1149**)

NOTE: 1. When wheeling over 100 FT, use 1.25 multiplier for each additional 40 FT

TABLE 4-28. Erosion Control

Work Element Description	Unit	Man-Hours Per Unit
Place Jute Mesh, Plastic Netting, or Polyropylene Membrane	SY	0.0143 (**1150**)
Machine Place RIPRAP Class "C" Material	CD	0.012 (**1151**)
Hand Fill Voids in RIPRAP	SY	1.6 (**1152**)

SUGGESTED CREW SIZE: Place membrane/mesh 4-80 men.
Place RIPRAP: two EOs for crane, using tongs/clamshell, with two men on tag lines placing rock.

NOTE: 1. Placing RIPRAP should entail 120 man-hours if interlocked.

TABLE 4-29. Landscape

Work Element Description	Unit	Man-Hours Per Unit
Spread Topsoil with Machine	CD	0.22 (**1000**)
Top Dress by Hand (Rake and Clean)	SY	0.079 (**1001**)
Seed and Fertilize by Hand	SY	0.105 (**1002**)
Hydro-Mulch	SY	0.013 (**1003**)
Plant Shrubs, 1 Gallon Size	EA	0.5 (**1004**)

SUGGESTED CREW SIZE:
Spreading topsoil with equipment, one to two EOs.
Top dress by hand, 1-20 men with hand tools.
Seed and fertilize by hand, two to six men with hand tools.
Hydro-Mulch, three EOs.
Plant shrubs, one to six men with hand tools.

NOTE:
1. Hydro-Mulch figure based on 1,000-gallon capacity machine and includes charging time.

TABLE 4-30. Fencing

Work Element Description	Unit	Man-Hours Per Unit
Install Wood Fence 4' High	SF	0.054 (**1005**)
Install Metal Fence 5' High Chainlink	FT	0.219 (**1006**)
Install Metal Fence 8' High Chanlink	FT	0.244 (**1007**)
Hang Gates	Leaf	8.0 (**1008**)

SUGGESTED CREW SIZE:
Digging Operations, one EO, auger truck
Fencing Operations, four to six laborers

NOTES:
1. Fence installation includes: Digging Holes; Unloading and distributing materials; Setting, plumbing, aligning, and concreting posts; Installing braces: Stretching and fastening fence fabric; Installing caps or brackets on posts; and Stringing lone and barbed wire.

2. Hanging gates includes installation of hardware.

TABLE 4-31. Concrete Culvert Pipe Installation

Work Element Description		Unit	Man-Hours Per Unit
Install Concrete Pipe Laying Lengths			
15"' to 18 " I.D.	3 FT	FT	0.48 (**1009**)
18 " to 24" I.D.	4 FT	FT	0.64 (**1010**)
30 " to 48 " I.D.	5 FT	FT	0.88 (**1011**)
48 " to 72 " I.D.	5 FT	FT	1.12 (**1012**)

SUGGESTED CREW SIZE: Crane Operations: one EO. Cherry Picker; one EO signalman. Installing Operations: three to seven laborers, depending on pipe size.

NOTES:
1. Work includes handling, placing, caulking, grouting and bedding pipe.
2. Adjust man-hour figures for laying lengths, other than indicated in table.
3. If gasket of spediseal-type joints are used, use 0.8 multiplier
4. For headways, drop inlets, catch basins, and other drainage structures. Refer to Division 3.
5. For excavation and backfill, refer to tables 4-11 and 4-16.
6. For sheeting and shoring of banks of excavations, refer to table 4-18.

TABLE 4-32. Galvanized Culvert Installation

Work Element Description	Unit	Man-Hours Per Unit
Install Galvanized Pipe Culverts		
12 " to 24 "	FT	0.32 (**1013**)
26 " to 45 "	FT	0.5 (**1014**)
48 " to 72 "	FT	0.72 (**1015**)
Install Galvanized Culvert (Bolted)		
12 " to 24 "	FT	0.48 (**1016**)
26 " to 45 "	FT	0.65 (**1017**)
48 " to 72"	FT	0.88 (**1018**)

SUGGESTED CREW SIZE: Three to seven laborers, depending on size of culvert to be installed.

NOTES:
1. Installation of galvanized culvert includes unloading, fine grading, placing, caulking, and installing joint clamps.
2. Installation of galvanized culvert (bolted) includes bolting together of sections, unloading, fine grading, and placement.
3. Man-Hour estimates for galvanized culvert (bolted) are based on sections being bolted into desired lengths in a prefabrication yard.
4. When installing culverts over 48 " in diameter, it is recommended that cross bridging be used to prevent culverts from being bent or twisted during hauling or installation. Cross bridging can easily be removed upon completion of backfilling and compaction.

TABLE 4-33. Piledriving

Work Element Description	Unit	Man-Hours Per Unit
25 FT Wood Piling	Each	3.0 (**1019**)
50 FT Wood Piling	Each	6.5 (**1020**)
75 FT Wood Piling	Each	9.6 (**1021**)
25 FT Steel Piling	Each	4.0 (**1022**)
50 FT Steel Piling	Each	7.2 (**1023**)
75 FT Steel Piling	Each	12.0 (**1024**)
40 FT Precast Concrete Piling	Each	13.2 (**1025**)
60 FT Precast Concrete Piling	Each	18.0 (**1026**)
80 FT Precast Concrete Piling	Each	24.0 (**1027**)
Steel Sheet Piling	SF	0.102 (**1028**)
Assemble and Rig Leads and Hammer	Each	48.0 (**1029**)
Dismantle Leads and Hammer	Each	32.0 (**1030**)

SUGGESTED CREW SIZE: Two EOs, two EAs, six to ten BUs.

NOTES:
1. Man-Hour figures are preliminary estimate only. The many variables of this work require on-site determinations for accurate estimates.
2. Factors of importance are: Design, soil, equipment and method used, tides, access to site, currents, materials storage, etc.
3. Work included is preparation of pile, placing in leads, driving and cut off.
4. For concrete filled, fluted hollow steel piling and pipe piling for spudding pontoon small craft finger piers, use the steel bearing pile figures.

TABLE 4-34. Miscellaneous Pier Hardware

Work Element Description	Unit	Man-Hours Per Unit
Bits	Each	13.0 (**1031**)
Bollards	Each	16.0 (**1032**)
Chocks	Each	13.0 (**1033**)
Cleats	Each	11.0 (**1034**)
Padeyes	Each	2.5 (**1035**)

SUGGESTED CREW SIZE: Two EOs, two Bus

TABLE 4-35. Wood Pile Dolphins

Work Element Description	Unit	Man-Hours Per Unit
Place in Leads and Drive	Each	0.80 (**1036**)
Lash with Wire Rope	Each	0.75 (**1037**)
Install Fenders	Each	0.60 (**1038**)
Fender Pile	Each	0.75 (**1039**)

SUGGESTED CREW SIZE: Two EOs, two EAs, Six to eight BUs.

NOTE: 1. Based on 50 FT piles.

TABLE 4-36. Pier Framing

Work Element Description	Unit	Man-Hours Per Unit
Stringers	BF	0.024 (**1040**)
Bridging	FT	0.144 (**1041**)
Decking (4" thick)	FT	0.056 (**1042**)
Wearing Surface (2" thick)	FT	0.032 (**1043**)
Bull Rail	FT	0.32 (**1044**)
Bumpers	FT	0.288 (**1045**)
For Quick Estimates:		
Pier Framing Complete (less Piles, Capping, Bracing)	SF	0.176 (**1046**)

SUGGESTED CREW SIZE: Two EOs, six to ten BUs.

NOTE: 1. Estimates include precutting, bolting, or drifting members in place.

TABLE 4-37. Pile Bracing and Capping

Work Element Description	Unit	Man-Hours Per Unit
Diagonal Bracing	EA	6.5 (**1047**)
Horizontal Bracing	EA	4.0 (**1048**)
Wood Caps	FT	0.48 (**1049**)
Concrete Caps	FT	3.2 (**1050**)
Steel Caps	FT	0.48 (**1051**)

SUGGEST CREW SIZE: Four to eight Bus.

NOTE: 1. Based on bolting or drifting members in place.

TABLE 4-38. Pile Extraction

Work Element Description	Unit	Man-Hours Per Unit
Wood Bearing Piles	EA	2.0 (**1052**)
Wood Sheet Piling	SF	0.024 (**1053**)
Steel Sheet Piling	SF	0.028 (**1054**)
Piles Cut Off Below Water Line	EA	2.5 (**1055**)

SUGGESTED CREW SIZE: Two EOs, two to four BUs.

NOTE: 1. Based on using pile extractor.

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DIVISION 3. CONCRETE CONSTRUCTION

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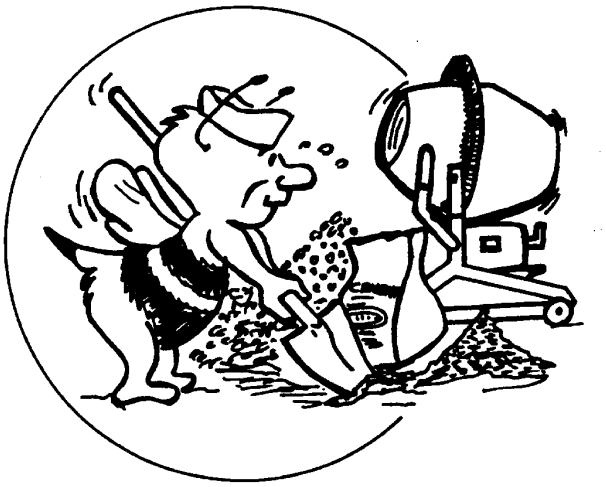

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TABLE 4-39. Form Work

Work Element Description	Unit	Man-Hours Per Unit			
		Fabricate	Erect	Strip	Repair
Footing, Foundation Walls, and Grade Beams	SFCS	0.09 (**2001**)	0.07 (**2002**)	0.04 (**2003**)	0.04 (**2004**)
Slabs on Grade and Screed (up to 8" thick including edge form)	SFCS	----------0.13 Complete---------- (**2005**)			
Thicken Edge and Slabs Greater Than 8" Thick. Use Grade Beam Estimate.					
Walls to 10FT High	SFCS	0.08 (**2007**)	0.07 (**2008**)	0.05 (**2009**)	0.05 (**2010**)
Columns and Piers	SFCS	0.09 (**2011**)	0.1(**2012**)	0.05 (**2013**)	0.05 (**2014**)
Suspended Slabs	SFCS	0.08 (**2015**)	0.12 (**2016**)	0.04 (**2017**)	0.05 (**2018**)
Beams and Girders	SFCS	0.11 (**2019**)	0.1 (**2020**)	0.05 (**2021**)	0.05 (**2022**)
Stairs	SFCS	---------- 0.55 (**2023**) Complete----------			

SUGGESTED CREW SIZE: Forming/Stripping, five BUs
Forming/Stripping (Gang forms), five BUS, two EOs

NOTES:

1. Concrete forming estimates are based on using form accessories, form ties, and steel column clamps.

2. Suspended slabs, beam, and girders are figures using 4" x 4" shores and wooden wedges. For adjustable shores, use .**9** multiplier

3. When forming and stripping are combined, stripping and cleaning forms will be approximately 17 percent of total labor.

4. On multiple use jobs allow three man-hours for form repair per 100 SF of contact surface after four uses.

5. Gang forming usually requires a crane, an operator, and a signalman.

6. Forming walls over 10 FT high, and other high work will increase erection time, to compensate use **1.1** - **1**.5 multiplier depending on job complexity.

TABLE 4-40. Reinforcing Steel Fabrication

Man-Hours Required for Making 1 Bend or Hook				
Size of Bar (inches)	By Hand		By Machine	
	Hours/ Bend	Hours/ Hook	Hours/ Bend	Hours/ Hook
½ or less	0.04 (**2024**)	0.06 (**2025**)	0.015 (**2026**)	0.025 (**2027**)
5/8, 3/4, 7/8	0.05 (**2028**)	0.02 (**2030**)	0.02 (**2029**)	0.03 (**2031**)
1 and 1-1/8	0.06 (**2032**)	0.1 (**2033**)	0.025 (**2034**)	0.04 (**2035**)
1-1/4 and 1-1/2	0.07 (**2036**)	0.12 (**2037**)	0.03 (**2038**)	0.05 (**2039**)

SUGGESTED CREW SIZE: Two to eight SWs, depending on amount of reinforcing steel to be cut and/or bent.

NOTE: 1. Reinforcing steel fabrication includes cutting, banding, tagging. Assembly and tying into mats and beams in the shop are also included.

TABLE 4-41. Numbers, Sizes, Areas, and Weights of Bars

Bar Number	Size (Dia. IN)	Area (Sq. IN)	Weight (LB Per FT)	Waste (Percent)
2*	1/4	0.049	0.167	10
3	3/8	0.110	0.376	10
4	½	0.196	0.668	10
5	5/8	0.307	1.043	10
6	3/4	0.442	1.502	10
7	7/8	0.601	2.044	10
8	1	0.785	2.670	10
9+	1-1/8	1.000	3.4	10
10+	1-1/4	1.2656	4.30	10
11+	1-3/8	2.405	5.31	10
14	1-3/4	3.976	8.18	10
18	2-1/4		13.52	10

LEGEND: * = No. 2 bar is a plain round bar
+ = Nos. 9, 10, 11 correspond to the old 1-, 1-1/8, and 1-1/4 inch. square bars, and are equivalent to those three square bars in weights and nominal cross-sectional areas.

Splicing is equal to 30 times diameter, or a minimum of 12 inches per splice, or whichever is greater.

TABLE 4-42. Placing Reinforcing Steel

Labor Hours for Placing 1 Bar			
Bar size in Inches	**Length of Bar in Feet**		
	Under 10	**10 - 20**	**20 - 30**
½ or less	0.06 (**2068**)	0.07 (**2069**)	0.08 (**2070**)
5/8, 3/4, and 7/8	0.07 (**2071**)	0.08 (**2072**)	0.095 (**2073**)
1 and 1-1/8	0.08 (**2074**)	0.1 (**2075**)	0.115 (**2076**)
1-1/4 and 1-1/2	0.09 (**2077**)	0.12 (**2078**)	0.14 (**2079**)

Welded Wire Fabric	Unit	Man-Hours
Slabs on Grade, Concrete Paving, Precast Roof Panels	SF	0.08 (**2080**)
Gunite and Head Walls	SF	0.01 (**2081**)

SUGGESTED CREW SIZE: Two to six SWs

NOTES:

1. Placement of reinforcing steel includes handling into place, tying, supporting, and any cutting which becomes necessary at the site, such as cutting around imbedded items or cutting stock lengths of straight bars to fit slab dimensions.

2. Man-Hour estimates are based on all reinforcing steel being shop fabricated (cut to length and bent ready to place in the structure).

3. If reinforcing steel is to be welded in place,use 1.5 multiplier.

4. Order three 4-LB rolls of the wire for each ton of rebar (16 GA black annealed wire).

TABLE 4-43. Mixing Concrete

Work Element Description	Unit	Man-Hours Per Unit
Hand Mixing on Site:		
2 Boards or Boats	CD	3.2 (**2040**)
Machine Mixing on Site:		
(16 S Mixer)	CD	1.6 (**2041**)
(11 S Mixer)	CD	2.7 (**2042**)
Transit Mix Truck	CD	0.56 (**2043**)

SUGGESTED CREW SIZE: Refer to Notes.

NOTES:

1. Hand mixing tables are based on enough men to keep a smooth constant flow of materials, approximately eight men. Man-hour figure (hand) does not include placing. Maximum output about 20 CD per day.

2. Hand mixing using two boards eliminates waiting for a batch to be mixed before dry charging the mixing board, as the mixer alternate boards. With twelve men the maximum output is about 28 CD per day.

3. Warm weather (90 to 100 degrees) will slow mixing time and add 0.5 man-hours per CD.

4. Labor to charge a 16 S Mixer can be reduced by the use of a small front end loader, but at least one man must remain on each aggregate stock pile to monitor bucket loading.

5. Transit mix man-hours are based on using four trucks, average haul of five miles, and four men operating a dry cement batching plant (Ross or equal).

6. Large paving job man-day estimates are dependent on equipment used, manufacturers ratings and recommendations.

7. 11 S Mixer replaces 16 S Mixer in the NCF.

TABLE 4-44. Placing Concrete

Man-Hours Per Unit					
Work Element Description	**Unit**	**Direct From Chute**	**Wheeled**	**Pumped**	**Crane and Bucket**
Place Footings, Foundations:					
Grade Beams	CD	1.0 (**2044**)	2.0 (**2045**)	1.50 (**2046**)	1.50 (**2047**)
Slabs on Grade	CD	1.5 (**2048**)	3.0 (**2049**)	2.00 (**2050**)	2.50 (**2051**)
Walls to 10' High	CD	--	--	1.68 (**2052**)	2.24 (**2053**)
Columns	CD	--	--	1.68 (**2054**)	2.24 (**2055**)
Suspended Slabs	CD	--	--	1.68 (**2056**)	2.24 (**2057**)
Beams and Girders	CD	--	--	1.68 (**2058**)	2.24 (**2059**)
Stairs	CD	2.4 (**2060**)	4.8 (**2061**)	1.68 (**2062**)	2.88 (**2063**)

NOTES:
1. For each 40 feet wheeled add 25 percent.
2. For upper stories, add per story: Placed by pump, use **1.07** multiplier; placed by bucket or crane, use **1.05** multiplier.
3. Construction that moves in and out of ramps, runways, or staging is not included. For moving and in and out use 0.22 man-hours per linear foot.
4. Major items of consideration in planning concrete placement are: Method of placement, accessability, the rate of placement in regard to form design, the amount and frequency of delivery is governed by the ability to screed, tamp, and finish.

TABLE 4-45. Finishing and Curing Concrete

Work Element Description	**Unit**	**Man-Hours Per Unit**
Finishing		
Steel Trowel: Machine	SF	0.015 (**2106**)
Hand	SF	0.03 (**2064**)
Float Only	SF	0.025 (**2065**)
Curing		
Liquid Spray, Membrane, Burlap, Water Spray	SF	0.005 (**2066**)
Cold Weather Protection	CD	0.5 (**2067**)

SUGGESTED CREW SIZE: Four to eight BUS, depending on size of pour and type of finish.

NOTE:
1. Cold weather protection figure is average. Variations depend on method, additives, straw and tarps, heated aggregate, salamanders, etc.

TABLE 4-46. Miscellaneous and Imbedded Items

Work Element Description	Unit	Man-Hours Per Unit
Anchor Bolts	EA	0.08 (**2082**)
Pickup and Brace Inserts	EA	0.064 (**2083**)
Curb Angles	FT	0.16 (**2084**)
Ceiling Inserts	EA	0.06 (**2085**)
Dovetail Anchor Slots	FT	0.0023 (**2086**)
Steel Base Plates 12" X 14" X ½"	EA	1.0 (**2087**)
Reglets (metal or PVD)	FT	0.1 (**2088**)
Waterstops (PVC dumbells or copper)	FT	0.04 (**2089**)
Premolded Expansion Joint	FT	0.04 (**2090**)
Poured Expansion Joint ½" X ½"	FT	0.04 (**2091**)
Vapor Barriers	SF	0.02 (**2092**)
Floor Hardeners (Magnesium Fluosilicate) 1 coat	SF	0.01 (**2093**)
Silicon Waterproofing	SF	0.01 (**2094**)
Acid Wash (walls)	SF	0.02 (**2095**)
Patch Tie Holes (walls)	EA	0.05 (**2096**)
Nonshrink Grout under Steel Plate, 1"	SF	1.0 (**2097**)
Carborundum Rub	SF	0.04 (**2098**)
Concrete Cutting --OLD 2" deep cut	FT	0.08 (**2099**)
4" deep cut	FT	0.12 (**2100**)
--Green 2" deep cut	FT	0.05 (**2101**)
4" deep cut	FT	0.08 (**2102**)
Concrete Core Drilling		
Slab Vertical 3" dia. X 6" thick	EA	2.0 (**2103**)
Wall Horiz. 4" dia. X 8" thick	EA	2.5 (**2104**)
Architectural concrete: patched, honed, sack rubbed	SF	0.08 (**2105**)

NOTES:

1. Tables are for installation only, and do not include fabrication time.
2. Premolded expansion joint figures is based on material ½-inch thick, and of sufficient width to extend the required depth. Use **1.15** multiplier for 1-inch material.
3. Concrete sawing is based on 4,000 FT per inch blade life, which reduces in proportion to depth.
4. Core drilling labor varies if slabs or walls are heavily reinforced with 3/4 inch to 1-1/2 inch rebar, or holes are widely spaced.

TABLE 4-47. Concrete Requirements for Footings

Amount of Concrete Required			
Footing Size (Inches)	**CF per FT**	**CF per 100 FT**	**CD per 100 FT**
6 x 12	0.50	50.00	1.9
8 x 12	0.67	66.67	2.5
8 x 16	0.89	88.89	3.3
8 x 18	1.00	100.00	3.7
10 x 12	0.83	83.33	3.1
10 x 16	1.11	111.11	4.1
12 x 12	1.00	100.00	3.7
12 x 16	1.33	133.33	4.9
12 x 20	1.67	166.67	6.1
12 x 24	2.00	200.00	7.4

TABLE 4-48. Volume Factors of Various Mixes

Mix by Volume Job Damp Materials					
Kind of Concrete Work	**Cement Bags**	**Sand (CF)**	**Stone, Gravel (CF)**	**Workability, Consistency**	**One Bag Batch = CF**
Footings, Heavy Foundations	1	3.75	5.0	stiff	6.2
Watertight Concrete for Cellar Walls and Walls Above Ground	1	2.5	3.5	medium	4.5
Driveways, Floors, Walks --One Course	1	2.5	3.0	stiff	4.1
Driveways, Floors, Walks --Two Course	1	Top 2.0 Base 2.5	0.0 4.0	stiff stiff	2.14 4.8
Pavements	1	2.2	3.5	stiff	4.2
Watertight Concrete for Tanks, Cisterns, Precast Units (Piles, Posts, Thin Reinforced Slabs, etc.)	1	2.0	3.0	medium wet	3.8 3.9
Heavy Duty Floors	1	1.25	2.0	stiff	2.8

Table continued next page.....

TABLE 4-48. Volume Factors of Various Mixes (Continued)

Materials for One CD of Concrete				
Kind of Concrete Work	**Total Water per Bag (GL)**	**Cement Bags**	**Sand (CF)**	**Stone, Gravel (CF)**
Footings, Heavy Foundations	8.0	4.3	16.3	21.7
Watertight Concrete for Cellar Walls and Walls Above Ground	6.0	6.0	15.0	21.0
Driveways, Floors, Walks --One Course	5.5	6.5	16.3	19.5
Driveways, Floors, Walks --Two Course	Top ---- Base 6.0	12.6 5.7	25.2 14.2	---- 22.8
Pavements	5.25	6.4	14.1	22.4
Watertight Concrete for Tanks, Cisterns and Precast Units (Piles, Posts, Thin Reinforced Slabs, etc.	medium 5.0 wet 5.75	7.1 6.9	14.2 13.8	21.3 20.7
Heavy Duty Floors	--	9.8	12.3	19.6

TABLE 4-49. Materials for 100 Square Feet of Concrete

Concrete Base						
	1 : 1-3/4 : 2-3/4			1 : 2 : 3		
Slab Thickness (Inches)	Cement Bags	Sand (CD)	Stone (CD)	Cement Bags	Sand (CD)	Stone (CD)
2.5	5.7	0.36	0.62	5.2	0.40	0.59
3.0	6.8	0.43	0.74	6.3	0.48	0.71
3.5	8.0	0.51	0.86	7.3	0.56	0.83
4.0	9.1	0.58	0.99	8.4	0.64	0.95
4.5	10.3	0.65	1.11	9.4	0.72	1.06
5.0	11.4	0.73	1.23	10.5	0.80	1.19
5.5	12.6	0.80	1.36	11.6	0.88	1.31
6.0	13.7	0.87	1.48	12.6	0.96	1.42
Concrete Base						
	1 : 2-1/2 : 4			1 : 3 : 5		
Slab Thickness (Inches)	Cement Bags	Sand (CD)	Stone (CD)	Cement Bags	Sand (CD)	Stone (CD)
2.5	4.2	0.40	0.63	3.4	0.39	0.65
3.0	5.0	0.48	0.75	4.1	0.47	0.78
3.5	5.8	0.56	0.88	4.8	0.55	0.92
4.0	6.6	0.64	1.01	5.5	0.63	1.05
4.5	7.5	0.72	1.13	6.1	0.70	1.17
5.0	8.3	0.80	1.26	6.8	0.79	1.31
5.5	9.2	0.88	1.39	7.5	0.87	1.45
6.0	10.0	0.96	1.52	8.2	0.94	1.57

TABLE 4-50. Concrete Requirements for Slabs

Slab Thickness (Inches)	CF of Concrete Required per SF of Slab	Slab Area Coverage SF per CD
2	0.167	162
3	0.250	108
4	0.333	81
5	0.417	65
6	0.500	54

TABLE 4-51. Concrete Requirements for Walls

Concrete Required per 100 SF of Wall		
Wall Thickness (Inches)	**CF**	**CD**
4	33.3	1.24
6	50.0	1.85
8	66.7	2.47
10	83.3	3.90
12	100.0	3.70

TABLE 4-52. How to Change Cubic Feet to Cubic Yard

CF	CD	CF	CD	CF	CD
1	0.37	10	.370	19	.703
2	0.74	11	.407	20	.740
3	.111	12	.444	21	.777
4	.148	13	.481	22	.814
5	.185	14	.518	23	.851
6	.222	15	.555	24	.888
7	.259	16	.592	25	.925
8	.296	17	.629	26	.962
9	.333	18	.666	27	1 or .999

While the table may be useful for reference, the figure .037 is the only one that you must remember, because of the fact that there are .037 cubic yards to 1 cubic foot.

1. The usual procedure is to divide the amount of cubic feet by 27 to find the number of cubic yards. The .037 rule is faster and more accurate than the division method.

2. The 037 rule is a decimal equivalent. If you divide one number by a larger one, you get a decimal equivalent. Therefore, if you divide the number "1" by "27" you will find that you will get a decimal .0370370. For estimating purposes, it is not necessary to extend decimals beyond three spaces.Thus:

1/27 of 1 = 0.037	1 CF = 0.037 CD
1/27 of 10 = 0.370	10 CF = 0.370 CD
1/27 of 100 = 3.700	100 CF = 3.700 CD

3. Estimators work from "squares" or 100 square feet (SF). Hence, an excavation of 20 FT x 20 FT covers 400 SF., or 4 squares. If there are 3.7 cubic yards (CD) for each 100 SF for each foot of depth, then excavation amounts to 4 X 3.7 = 14.8 CD per foot; and if at a 4 FT depth, there would be 14.8 X 4 = 59.2 CD total.

4. Extending the .037 method is far more useful in figuring trenches and other tricky problems.

EXAMPLE (1): Assume you have a trench 65-FT long X 2-FT wide X 2-FT deep. The cross-sectional area is 4 SF, therefore, it actually contains 4/27 of a CD per foot in length. From the table you will find the decimal equivalent of 4 is .148. Thus, .148 X 65 = 9.6 CD in this trench.

EXAMPLE (2): A basement is 24-FT long X 30-FT wide X 6-FT deep. 24 X 30 = 720: 720 X 6 = 4,320 CF in excavation. Convert this into CD by two methods:

(1) 4,320 X .037 = 159.84 or 160 CD

(2) From the table use 4 and move decimal 3 places . . . . . = 48.000
From the table use 3 and move decimal 2 places . . . . . = 11.100
From table use 20 . . . . . = .740
159.840

TABLE 4-53. Concrete Compressive Strength
Plain Concrete (Proper Curing Conditions)

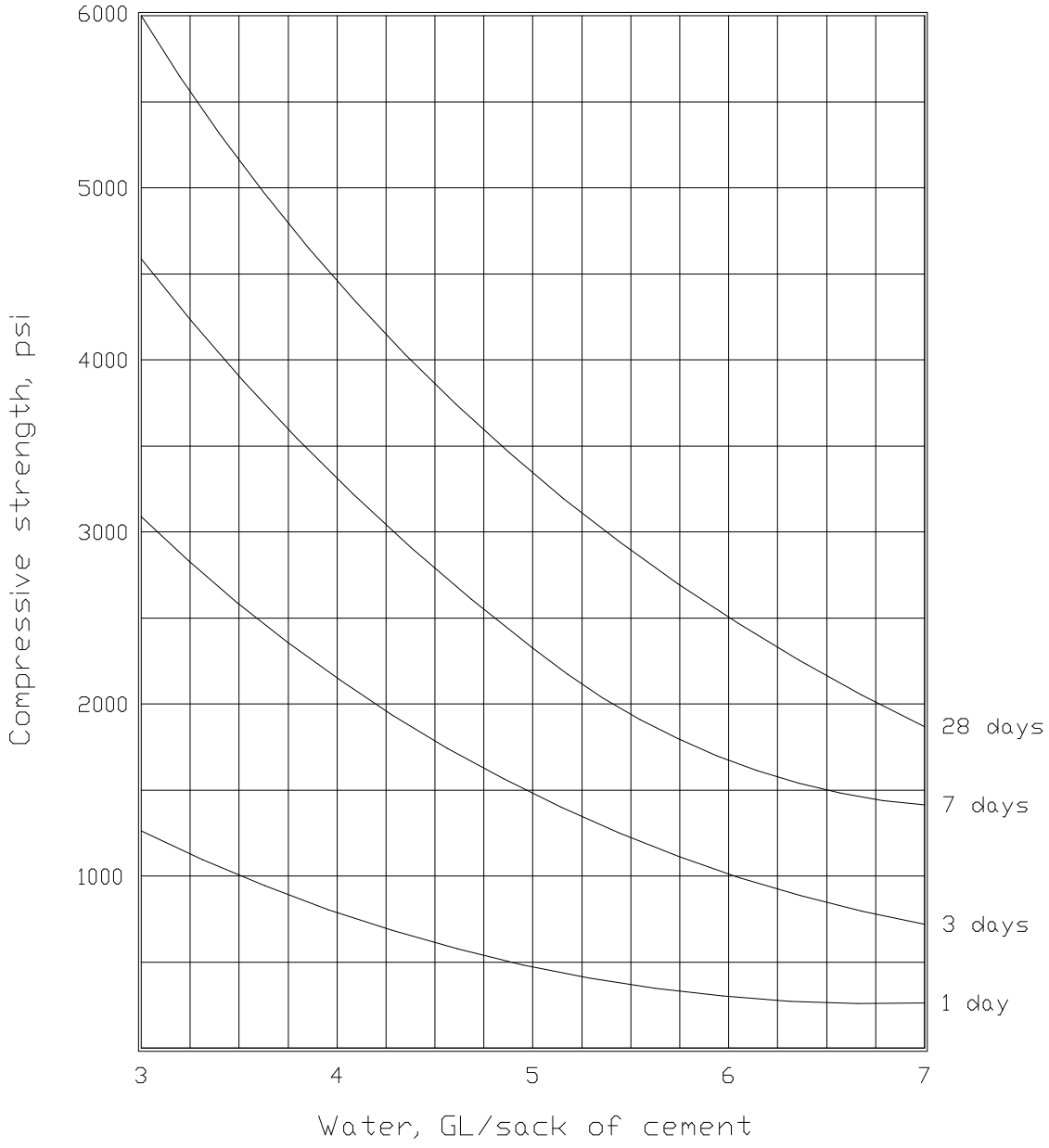

TABLE 4-54. Conversion and Waste Factors: Concrete Construction

Material	Conversion	Percent Waste
Concrete (1:2:4)		
Cement	6.0 SK/ CD	10
Fine aggregate	0.5 CD/ CD	10
Coarse aggregate	0.9 CD/ CD	10
Curing Compound	0.5 GAL/ 100 SF	10
Forms		
Footings and piers		
2 X 4	1.5 FT / SFCS	20
2 X 8	0.2 FT / SFCS	10
2 X 12	0.7 FT / SFCS	5
Walls and columns		
2 X 4	1.3 FT / SFCS	20
Plywood (50% reuse)	0.5 SF / SFCS	5
Beams and susp. slabs		
1 X 6	0.3 FT / SFCS	5
2 X 4	0.5 FT / SFCS	20
2 X 10	0.1 FT / SFCS	10
4 X 4	0.4 FT / SFCS	5
4 X 6	0.1 FT / SFCS	5
Plywood	0.5 SF / SFCS	5
Form oil	0.5 GL / 100 SF	10
Tie wire	12.0 LB / TON	5
Snap tie wedges	0.1 EA / SFCS	5
Snap ties	0.1 EA / SFCS	5
She bolts	0.1 SE / SFCS	
Nails (BF lumber + SF)		
Plywood, ordered as MFBM		
6d box	6 LB / MFBM	10
8d common	4 LB / MFBM	10
16d common	6 LB / MFBM	10
20d common	2 LB / MFBM	10
6d duplex	4 LB / MFBM	10
8d duplex	9 LB / MFBM	10
16d duplex	9 LB / MFBM	10

TABLE 4-55. Material Weights and Measures

Material	Weight LB / CF	Weight LB / CD
Concrete		
Cinder	112	
Gravel/ Limestone	150	
Reinforced	150	
Crushed Stone	100	2,700
Gravel	95	2,565
Hydrated Lime	40	
Mortar	103	
Sand		
Dry	97 to 117	2,619 to 3,159
Wet	120 to 140	3,240 to 3,780
Slag	70	1,755 to 1,890
Stone Riprap	65	1,775
Wood		
Douglas Fir	34	
Oak	46	
Western Hemlock	29	

DIVISION 4. MASONRY

Page

A. CONCRETE BLOCK, COMMON BLOCK, AND RUBBLE MASONRY

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TABLE 4-56. Length of Concrete Masonry Walls by Stretchers

*Based on units 15-3/8 inches long and half units 7-5/8 inches long, with 3/8-inch thick head joints.

Number of Stretchers	Wall Length*
1.0	1 FT 4 IN
1.5	2 FT 0 IN
2.0	2 FT 8 IN
2.5	3 FT 4 IN
3.0	4 FT 0 IN
3.5	4 FT 8 IN
4.0	5 FT 4 IN
4.5	6 FT 0 IN
5.0	6 FT 8 IN
5.5	7 FT 4 IN
6.0	8 FT 0 IN
6.5	8 FT 8 IN
7.0	9 FT 4 IN
7.5	10 FT 0 IN
8.0	10 FT 8 IN
8.5	11 FT 4 IN
9.0	12 FT 0 IN
9.5	12 FT 8 IN
10.0	13 FT 4 IN
10.5	14 FT 0 IN
11.0	14 FT 8 IN
11.5	15 FT 4 IN
12.0	16 FT 0 IN
12.5	16 FT 8 IN
13.0	17 FT 4 IN
13.5	18 FT 0 IN
14.0	18 FT 8 IN
14.5	19 FT 4 IN
15.0	20 FT 0 IN
20.0	26 FT 8 IN

TABLE 4-57. Height of Concrete Masonry Walls by Courses

Wall Height						
	3/8-IN Bed Joint		7/16-IN Bed Joint		½-IN Bed Joint	
No. of Courses	8-IN Block	4-IN Block	8-IN Block	4-IN Block	8-IN Block	4-IN Block
1	8"	4"	8-1/16"	4-1/16"	8-1/8"	4-1/8"
2	1'4"	8"	1'4-1/8"	8-1/8"	1'4-1/4"	8-1/4"
3	2'0"	1'0"	2'0-3/16"	1'0-3/16"	2'0-3/8"	1'0-3/8"
4	2'8"	1'4"	2'8-1/4"	1'4-1/4"	2'8-1/2"	1'4-1/2"
5	3'4"	1'8"	3'4-5/16"	1'8-5/16"	3'4-5/8"	1'8-5/8"
6	4'0"	2'0"	4'0-3/8"	2'0-3/8"	4'0-3/4"	2'0-3/4"
7	4'8"	2'4"	4'8-7/16"	2'4-7/16"	4'8-7/8"	2'4-7/8"
8	5'4"	2'8"	5'4-1/2"	2'8-1/2"	5'5"	2'9"
9	6'0"	3'0"	6'0-9/16"	3'0-9/16"	6'1-1/8"	3'1-1/8"
10	6'8"	3'4"	6'8-5/8"	3'4-5/8"	6'9-1/4"	3'5-1/4"
15	10'0"	5'0"	10'0-15/16"	5'0-15/16"	10'1-7/8"	5'1-7/8"
20	13'4"	6'8"	13'5-1/4"	6'9-1/4"	13'6-1/2"	6'10-1/2"
25	16'8"	8'4"	16'9-9/16"	8'5-9/16"	16'11-1/8"	8'7-1/8"
30	20'0"	10'0"	20'1-7/8"	10'1-7/8"	20'3-3/4"	10'3-3/4"
35	23'4"	11'8"	23'6-3/16"	11'10-3/16"	23'8-3/8"	12'0-3/8"
40	26'8"	13'4"	26'10-1/2"	13'6-1/2"	27'1"	13'9"
45	30'0"	15'0"	30'2-13/16"	15'2-13/16"	30'5-5/8"	15'5-5/8"
50	33'4"	16'8"	33'7-1/8"	16'11-1/8"	33'10-1/4"	17'2-1/4"

TABLE 4-58. Block, Brick, and Rubble Masonry

Work Element Description	Unit	Man-Hours Per Unit
Concrete Block.		
12" X 8" X 16"	SF	0.167 (**3000**)
8" X 8" X 16"	SF	0.16 (**3001**)
6" X 8" X 16"	SF	0.145 (**3002**)
4" X 8" X 16"	SF	0.118 (**3003**)
Common Brick. 2-1/4" X 3-3/4" X 8"		
8" Thick Wall	SF	0.5 (**3004**)
12" Thick Wall	SF	0.7 (**3005**)
4" Thick Brick Veneer on Frame Walls	SF	0.28 (**3006**)
Mortar Bound Rubble Masonry.		
18" to 24" Thick	CD	45.0 (**3007**)
Grouting - Corefill. (High lift or conventional method). Reinforced Grouting Brick Work	CD	16.0 (**3008**)

SUGGESTED CREW SIZE: Eight to ten BUs, depending on size of work area.

NOTES:

1. The masonry estimates are based on the following conditions:
   (a) All joints are 3/8 inches.
   (b) Units layed up in running or bond.
   (c) All mortar mixed by machine.
   (d) A ratio of three tenders to four masons.

2. For 12" X 12" terra cotta use concrete block table and use **0.9** multiplier
3. For glazed concrete block (SPECTOR-GLAZE) or similar) use **1**.25 multiplier.
4. A ration of 3 tenders for 2 masons.

TABLE 4-59. Tile Masonry

Work Element Description	Unit	Man-Hours Per Unit
Ceramic and Quarry Tile.		
Floors:		
1" X 1" Ceramic (paper mounted)	SF	0.24 (**3009**)
3" X 3" Ceramic	SF	0.24 (**3010**)
4" X 4" Quarry	SF	0.33 (**3011**)
6" X 6" Quarry	SF	0.265 (**3012**)
9" X 9" Quarry	SF	0.28 (**3013**)
Base:	SF	0.336 (**3014**)
Cap:	SF	0.29 (**3015**)
Walls: Ceramic Tile	SF	0.44 (**3016**)

SUGGESTED CREW SIZE: Two to four BUs

NOTES:

1. Tables are based on half of the crew experienced in the work.
2. All setting beds being machine made.
3. A ration of one helper to one tile setter.
4. Cutting tile masonry or tile saw.
5. If thin set, using organic adhesive, use 0.75 multiplier.
6. Production will be affected by type and scope of work. Large open areas will go faster than small rooms with many corners. If a crew arrives at a natural stopping point late in the day, hours are lost as the next phase will not be started until the following day.

TABLE 4-60. Volume of Grout in Grouted Concrete Block Walls*

Wall Thickness (Inches)	Spacing of Grouted Cores (Inches)	Grout, CD, for 100 SF Wall Area**	Wall Area, SF, for 1 CD of Grout**
6	All cores grouted	0.79	126
	16	0.40	250
	24	0.28	357
	32	0.22	450
	40	0.19	526
	48	0.17	588
8	All cores grouted	1.26	79
	16	0.74	135
	24	0.58	173
	32	0.49	204
	40	0.44	228
	48	0.39	257
12	All cores grouted	1.99	50
	16	1.18	85
	24	0.91	110
	32	0.76	132
	40	0.70	143
	48	0.64	156

* Adapted from *Volume of Grout Required in Masonry Walls*, Design Aid 15, Masonry Institute of America, Los Angeles, Calif., 1971. **A 3-percent allowance has been included for waste and job conditions. All quantities include grout for intermediate and top bond beams in addition to grout for cores.

TABLE 4-61. Maximum Unsupported Heights of CMU Wall During Construction

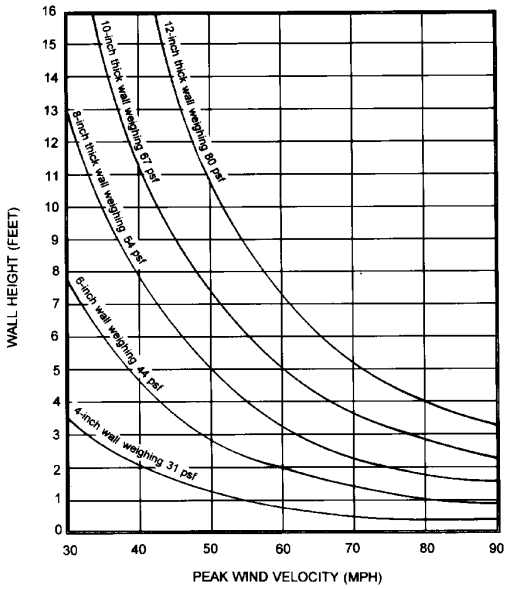

TABLE 4-62. Masonry Conversion Units

Material Description	Conversion Unit	Waste Percentage	Unit
Masonry Units.			
A. 8-inch Blocks:	.89 SF per block		
Full Stretcher	8" X 8" X 16"	10	EA
Half Stretcher	8" X 8" X 8"	10	EA
Corner Block	8" X 8" X 16"	10	EA
Full Jamb	8" X 8" X 16"	10	EA
Half Jamp	8' X 8" X 8"	10	EA
B. 6-inch Blocks:	.89 SF per block		
Full Stretcher	6" X 8" X 16"	10	EA
Half Stretcher	6" X 8" X 8"	10	EA
Corner Block	6" X 8" X 16"	10	EA
Full Jamb	6" X 8" X 16"	10	EA
Half Jamb	6" X 8" X 8"	10	EA
Mortar Materials. (Includes 20 percent waste)			
A. Cement, Portland Type I:			
1/4-inch Joint	.80 CF/100 SF Wall	--	BG
3/8-inch Joint	1.10 CF/100 SF Wall	--	BG
½2-inch Joint	1.40 CF/100 SF Wall	--	BG
B. Lime, Hydrated, Dry Type M:			
1/4-inch Joint	.60 CF/100 SF Wall	--	BG
3/8-inch Joint	.81 CF/100 SF Wall	--	BG
1/2-inch Joint	1.05 CF/100 SF Wall	--	BG
Masonry Wash Materials. (For 1 to 3 Mix and *' X 16" blocks)			
A. Muriatic Acid	10 LBS/100 SF Surface	10	LB
B. Soap, Powdered, Navy Type	2 LBS/100 SF Surface	10	LB
Core Fill Materials. (Conversion units for RST spaced at 24" OC)			
A. Cement,Portlandt Type I:			
8- and 6-inch Walls	3 BG/100 SF Wall	10 BG	BG
4-inch Walls	2 BG/100 SF Wall	10 BG	BG

NOTES:

1. All specials that require field cutting shall be ordered as full size blocks.
2. One (1) bag (BG) of lime equals one (1) cubic foot (CF).
3. Volume of one cell in an 8" X 8" block is equal to 1/8 CF.
4. Seven (7) bags (BG) ofPortlandt Type I cement equals one (1) CD.

TABLE 4-63. Material Weights and Measures: Masonry

Material	Length IN	Width IN	Thickness IN	Weight LBS/ EA	Weight LBS/ CF	Weight LBS/ CD	Weight TONS/ 1000
Asbestos					110 to 120		
Brick:							
Common	8-1/4	4	2-1/2	5.4			2.7
Fire, Std.	9	4-1/2	2-1/2	7.0			3.5
Hard	8-1/2	4-1/4	2-1/4	6.48			3.24
Soft	8-1/4	4	2-1/4	4.32			2.6
Cement:							
Bag				94.0			
Clay:							
Dry					63-95	1,700 to 2,295	
						3,500	
Fire					130		
						2,970	
Wet					120 to 140	to 3,200	

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DIVISION 5. METALS

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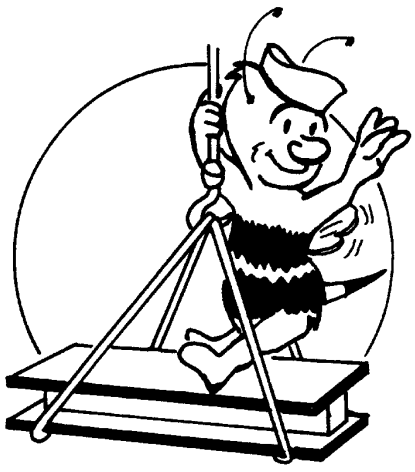

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TABLE 4-64. Structural Steel Fabrication

Work Element Description	Unit	Man-Hours Per Unit
FABRICATE:		
Structural Frames	Ton	16.0 (**4001**)
Columns	Ton	16.0 (**4002**)
Girders	Ton	16.0 (**4003**)
Beams	Ton	10.4 (**4004**)
Trusses	Ton	8.0 (**4005**)
Purlins: Girts and Struts	Ton	12.8 (**4006**)
Frames for Openings	Ton	2.8 (**4007**)
Stairs	Ton	28.0 (**4008**)
Platforms	Ton	36.0 (**4009**)
Railings (simple tube pipe)	FT	1.6 (**4010**)

SUGGESTED CREW SIZE: Two to six SWs, depending on weight and length of materials

NOTES:
1. Fabrication of structural steel includes cutting, riveting, burning, drilling, milling, fitting, assembling, welding, bolting, storing loading, and hauling to the job site.
2. Man-hour units are based on bolted connection. If sections are to be welded use 1.25 multiplier for welded joint preparation.

TABLE 4-65. Structural Steel Erection

Work Element Description	Unit	Man-Hours Per Unit
UNLOAD, ERECT, PLUMB		
Columns	Ton	13.6 (**4011**)
Beams	Ton	13.6 (**4012**)
Girders	Ton	9.0 (**4013**)
Trusses	Ton	17.0 (**4014**)
Girts and Purlins	Ton	11.9 (**4015**)
Bracing and Tiers	Ton	17.9 (**4016**)
Light Framing	Ton	23.8 (**4017**)
High strength bolting	Bolt	.075 (**4018**)
Grating	SF	0.192 (**4019**)

SUGGESTED CREW SIZE: Six SWs (erecting, connecting, plumbing)

NOTES:
1. Erection of structural steel includes handling, erecting, temporary bolting, plumbing, leveling, high strength bolting, and/or welding.
2. Man-hour figures are based on using new construction materials.
3. For shop and field painting, see Division 9, table 4-112.

TABLE 4-66. Flame Cutting Structural Steel

Work Element Description	Man-Hours per 1 Foot
1/8 inch	0.19 (**4020**)
3/16 inch	0.2 (**4021**)
1/4 inch	0.23 (**4022**)
5/16 inch	0.23 (**4023**)
3/8 inch	0.24 (**4024**)
7/16 inch	0.27 (**4025**)
½ inch	0.27 (**4026**)
9/16 inch	0.28 (**4027**)
5/8 inch	0.3 (**4028**)
3/4 inch	0.3 (**4029**)
7/8 inch	0.4 (**4030**)
1 inch	0.42 (**4031**)
1-1/8 inch	0.44 (**4032**)
1-1/4 inch	0.49 (**4033**)
1-1/2 inch	0.57 (**4034**)

TABLE 4-67. Welding Structural Steel

(per foot material thickness in man hours)

	Horizontal	Vertical	Overhead
FILET ARC WELDING			
1/8 inch	0.15 (**4035**)	0.27 (**4036**)	0.36 (**4037**)
3/16 inch	0.37 (**4038**)	0.36 (**4039**)	0.42 (**4040**)
1/4 inch	0.45 (**4041**)	0.49 (**4042**)	0.53 (**4043**)
5/16 inch	0.49 (**4044**)	0.69 (**4045**)	0.93 (**4046**)
3/8 inch	0.76 (**4047**)	0.93 (**4048**)	1.10 (**4049**)
½ inch	1.05 (**4050**)	1.10 (**4051**)	1.40 (**4052**)
3/4 inch	2.06 (**4053**)	1.90 (**4054**)	2.30 (**4055**)
1 inch	2.40 (**4056**)	2.30 (**4057**)	2.60 (**4058**)
BUTT WELDING			
1/8 inch	0.53 (**4059**)	0.55 (**4060**)	0.61 (**4061**)
3/16 inch	0.76 (**4062**)	0.63 (**4063**)	0.79 (**4064**)
1/4 inch	0.87 (**4065**)	0.73 (**4066**)	0.93 (**4067**)
5/16 inch	1.05 (**4068**)	0.93 (**4069**)	1.10 (**4070**)
3/8 inch	1.90 (**4071**)	1.50 (**4072**)	2.30 (**4073**)
½ inch	2.06 (**4074**)	1.70 (**4075**)	2.50 (**4076**)
3/4 inch	3.40 (**4077**)	2.80 (**4078**)	3.70 (**4079**)
1 inch	3.70 (**4080**)	3.40 (**4081**)	4.30 (**4082**)

TABLE 4-68. Install Steel Welded Pipe Lines

Work Element Description	Unit	Man-Hours Per Unit
SCHEDULE 40. PIPE AND FITTINGS		
1 inch	per joint	1.00 (**4083**)
2 inch	per joint	1.48 (**4084**)
4 inch	per joint	2.90 (**4085**)
6 inch	per joint	4.22 (**4086**)
8 inch	per joint	5.67 (**4087**)
10 inch	per joint	7.32 (**4088**)
12 inch	per joint	8.76 (**4089**)
14 inch	per joint	10.91 (**4090**)
16 inch	per joint	12.69 (**4091**)
18 inch	per joint	14.85 (**4092**)
20 inch	per joint	17.08 (**4093**)
24 inch	per joint	18.98 (**4094**)

SUGGESTED CREW SIZE: Two to four SWs

NOTE:
1. Butt weld to include cut, fit, and install.
2. For Schedule 80, use **1.6** multiplier.

TABLE 4-69. Gage, Thickness, and Weight of Black and Galvanized Flat and Corrugated Sheets

Black					Galvanized			
		Weight LB per SF				Weight LB per SF		
U.S. Gage	Thickness	Flat	Corrugated		Thickness	Flat	Corrugated	
12	0.1046	4.3	4.7	5.0	0.1084	4.5	4.9	5.2
14	0.0747	3.1	3.4	3.6	0.0785	3.2	3.5	3.7
16	0.0598	2.5	2.7	2.8	0.0635	2.6	2.9	3.0
18	0.0478	2.0	2.1	2.3	0.0516	2.1	2.3	2.4
20	0.0359	1.5	1.6	1.7	0.0396	1.6	1.8	1.9
22	0.0299	1.2	1.3	1.4	0.0336	1.4	1.5	1.6
24	0.0239	1.0	1.0	1.1	0.0276	1.1	1.2	1.3
26	0.0179	0.75	0.8	0.8	0.0217	0.91	0.9	1.0
28	0.0149	0.6	0.6	0.7	0.0187	0.7	0.8	0.8
29	0.0135	0.5	0.6	0.6	0.0172	0.7	0.7	0.8
	Corrugations, IN		2-2/3 X ½	3 X 3//4	Corrugations, IN		2-2/3 X ½	3 X 1/4

TABLE 4-70. Weights of Steel Plates in Pounds Per Square Foot

Thickness	Steel - Estimating	Thickness	Steel - Estimating
3/16	7.6	3/4	30.6
1/4	10.2	7/8	35.7
5/16	12.7	1	40.8
3/8	15.3	1-1/4	51.0
7/16	17.8	1-1/2	61.2
½	20.4	1-3/4	71.4
5/8	25.5	2	81.6

TABLE 4-71. Weights of Standard Diamond Steel Floor Plates

Thickness Inches	Weight per SF Pounds	Thickness Inches	Weight per SF Pounds
1/8	8.0	5/16	13.7
3/16	8.7	3/8	16.2
1/4	11.2	½	21.5

TABLE 4-72. Electrode/Wire Requirements for Horizontal Fillet Weld

Size of Fillet (in inches)	LBS of Stick Electrode Required per FT of Weld (approx.)	LBS of Wire Electrode Required per FT of Weld (approx.)
1/8	0.04	0.02
3/16	0.11	0.06
1/4	0.18	0.10
5/16	0.29	0.16
3/8	0.42	0.23
½	0.76	0.42
5/8	1.18	0.66
3/4	1.70	0.95
1	3.03	1.69

TABLE 4-73. Electrode/Wire Requirements for "V" Groove Butt Joint

Joint Dimensions (In inches)			LBS of Stick Electrode Required per FT of Weld (Approx.)		LBS of Wire Electrode Required per FT of Weld (Approx.)	
T	B	G	Without Reinforcement	With Reinforcement	Without Reinforcement	With Reinforcement
1/4	.207	1/16	0.1	0.2	0.80	0.14
5/16	.311	3/32	0.3	0.4	0.17	0.25
3/8	.414	1/8	0.5	0.7	0.28	0.39
½	.558	1/8	0.8	1.1	0.48	0.64
5/8	.702	1/8	1.3	1.6	0.75	0.94
3/4	.847	1/8	1.9	2.3	1.08	1.32
1	1138	1/8	3.4	4.0	1.93	2.24

TABLE 4-74. Electrode/Wire Requirements for Square Groove Butt Joints

Joint Dimensions (In inches)			LBS of Stick Electrode Required per FT of Weld (Approx.)		LBS of Wire Electrode Required per FT of Weld (Approx.)	
T	B	G	Without Reinforcement	With Reinforcement	Without Reinforcement	With Reinforcement
3/16	3/8	0	____	.16	____	.08
		1/16	.04	.20	.02	.10
1/4	7/16	1/16	.05	.23	.02	.12
		3/32	.07	.26	.03	.14
5/16	½	1/16	.06	.27	.03	.15
		3/32	.09	.30	.05	.17

TABLE. 4-75. Weights of Flat Steel Bars 1-Foot Long in LBS

Thickness in inches	Width of Bars					
	1 inches	2 inches	3 inches	4 inches	5 inches	6 inches
3/16	.638	1.28	1.91	2.55	3.19	3.83
1/4	.850	1.70	2.55	3.40	4.25	5.10
5/16	1.06	2.12	3.19	4.25	5.31	6.38
3/8	1.28	2.55	3.83	5.10	6.38	7.65
7/16	1.49	2.98	4.46	5.95	7.44	8.95
½	1.70	3.40	5.10	6.80	8.50	10.20
9/16	1.92	3.83	5.74	7.65	9.57	11.48
5/8	2.12	4.25	6.38	8.50	10.63	12.75
11/16	2.34	4.67	7.02	9.35	11.69	14.03
3/4	2.55	5.10	7.65	10.20	12.75	15.30
13/16	2.76	5.53	8.29	11.05	13.81	16.58
7/8	2.98	5.95	8.93	11.90	14.87	17.85
15/16	3.19	6.38	9.57	12.75	15.94	19.13
1	3.40	6.80	10.20	13.60	17.00	20.40
1-1/16	3.61	7.22	10.84	14.45	18.06	21.68
1-1/8	3.83	7.65	11.48	15.30	19.13	22.95
1-3/16	4.04	8.08	12.12	16.15	20.19	24.23
1-1/4	4.25	8.50	12.75	17.00	21.25	25.50
1-5/16	4.46	8.93	13.39	17.85	22.32	26.78
1-3/8	4.67	9.35	14.03	18.70	23.38	28.05
1-7/16	4.89	9.78	14.66	19.55	24.44	29.33
1-1/2	5.10	10.20	15.30	20.40	25.50	30.60
1-9/16	5.32	10.63	15.94	21.25	26.57	31.88
1-5/8	5.52	11.05	16.58	22.10	27.63	33.15
1-11/16	5.74	11.47	17.22	22.95	28.69	34.43
1-3/4	5.95	11.90	17.85	23.80	29.75	35.70
1-13/16	6.16	12.33	18.49	24.65	30.81	36.98
1-7/8	6.38	12.75	19.13	25.50	31.87	38.25
1-15/16	6.59	13.18	19.77	26.35	32.94	38.53
2	6.80	13.60	20.40	27.20	34.00	40.80

TABLE 4-76. Weights of Square and Round Bars 1-Foot Long in LBS

Thickness or Diameter in Inches	Weight of Square Bar	Weight of Round Bar	Thickness or Diameter in Inches	Weight of Square Bar	Weight of Round Bar
1/4	.21	.16	1-11/16	----	7.60
5/16	.33	.26	1-3/4	10.41	8.18
3/8	.47	.37	1-13/16	----	8.77
7/16	.65	.51	1-7/8	11.95	9.39
½	.85	.66	2	13.60	10.68
9/16	1.07	.84	2-1/8	15.35	12.06
5/8	1.38	1.04	2-1/4	17.21	13.52
11/16	1.60	1.26	2-3/8	----	15.06
3/4	1.91	1.50	2-1/2	21.25	16.69
13/16	2.24	1.76	2-5/8	23.43	18.40
7/8	2.60	2.04	2-3/4	25.71	20.20
15/16	----	2.35	2-7/8	----	22.07
1	3.40	2.67	3	30.60	24.03
1-1/16	----	3.01	3-1/8	----	26.08
1-1/8	4.30	3.38	3-1/4	35.91	28.21
1-1/4	5.31	4.17	3-3/8	----	30.42
1-5/16	----	4.60	3-1/2	41.65	32.71
1-3/8	6.42	5.05	3-5/8	----	35.09
1-7/16	----	5.52	3-3/4	47.81	37.55
1-1/2	7.65	6.01	4	54.40	42.73
1-5/8	8.92	7.05			

TABLE 4-77. Weights of Standard Channels

Depth of Channels (inches)	Weight Per Foot (pounds)	Thick-ness of Web (inches)	Width of Flange (inches)	Depth of Channels (inches)	Weight Per Foot (pounds)	Thick-ness of Web (inches)	Width of Flange (inches)
3	6.00	0.362	1.602	9	20.00	0.452	2.652
	5.00	0.264	1.504		15.00	0.288	2.488
	4.10	0.170	1.410		13.40	0.230	2.430
4	7.25	0.325	1.725	10	30.00	0.676	3.036
	5.40	0.180	1.580		25.00	0.529	2.889
5	9.00	0.330	1.890		20.00	0.382	2.742
	6.70	0.190	1.750		15.30	0.240	2.600
6	13.00	0440	2.160	12	30.00	0.513	3.173
	10.50	0.318	2.038		25.00	0.390	3.050
	8.20	0.200	1.920		20.70	0.280	2.940
7	14.75	0.423	2.303	15	50.00	0.720	3.720
	12.25	0.318	2.198		40.00	0.524	3.524
	9.80	0.210	2.090		33.90	0.400	3.400
8	18.75	0.490	2.530				
	13.75	0.307	2.347				
	11.50	0.220	2.260				

TABLE 4-78. Weights of Steel Angles

Size in Inches	Weight per FT LB	Size in Inches	Weight per FT LB	Size in Inches	Weight per FT LB
3 x 2 x 1/4	4.1	4 x 3 x 5/8	13.6	6 x 3-1/2 x 5/16	9.8
3 x 2 x 5/16	5.0	4 x 3 x 3/4	16.0	6 x 3-1/2 x 3/8	11.7
3 x 2 x 3/8	5.9			6 x 3-1/2 x 7/16	13.5
		4 x 3-1/2 x 1/4	6.2	6 x 3-1/2 x ½	15.3
3 x 2-1/2 x 1/4	4.5	4 x 3-1/2 x 5/16	7.7	6 x 3-1/2 x 5/8	18.9
3 x 2-1/2 x 5/16	5.6	4 x 3-1/2 x 3/8	9.1		
3 x 2-1/2 x 3/8	6.6	4 x 3-1/2 x 7/16	10.6	6 x 4 x 5/16	10.3
3 x 2-1/2 x ½	8.5	4 x 3-1/2 x ½	11.9	6 x 4 x 3/8	12.3
				6 x 4 x 7/16	14.3
3 x 3 x 1/4	4.9	4 x 4 x 1/4	6.6	6 x 4 x ½	16.2
3 x 3 x 5/16	6.1	4 x 4 x 5/16	8.2	6 x 4 x 9/16	18.1
3 x 3 x 3/8	7.2	4 x 4 x 3/8	9.8	6 x 4 x 5/8	20.0
3 x 3 x 7/16	8.3	4 x 4 x 7/16	11.3	6 x 4 x 3/4	23.6
3 x 3 x ½	9.4	4 x 4 x ½	12.8	6 x 4 x 7/8	27.2
3 x 3 x 5/8	11.5	4 x 4 x 5/8	15.7		
		4 x 4 x 3/4	18.5	6 x 6 x 3/8	14.9
3-1/2 x 2-1/2 x 1/4	4.9			6 x 6 x 7/16	17.2
3-1/2 x 2-1/2 x 5/16	6.1	4-1/2 x 3 x 3/8	9.1	6 x 6 x ½	19.6
3-1/2 x 2-1/2 x 3/8	7.2			6 x 6 x 9/16	21.9
3-1/2 x 2-1/2 x ½	9.4	5 x 3 x 5/16	8.2	6 x 6 x 5/8	24.2
3-1/2 x 2-1/2 x 5/8	11.5	5 x 3 x 3/8	9.8	6 x 6 x 3/4	28.7
		5 x 3 x 7/16	11.3	6 x 6 x 7/8	33.1
3-1/2 x 3 x 1/4	5.4	5 x 3 x ½	12.8	6 x 6 x 1	37.4
3-1/2 x 3 x 5/16	6.6	5 x 3 x 3/4	18.5		
3-1/2 x 3 x 3/8	7.9			7 x 3-1/2 x 3/8	13.0
3-1/2 x 3 x ½	10.2	5 x 3-1/2 x 5/16	8.7	7 x 3-1/2 x 7/16	15.0
		5 x 3-1/2 x 3/8	10.4	7 x 3-1/2 x ½	17.0
3-1/2 x 3-1/2 x 1/4	5.8	5 x 3-1/2 x 7/16	12.0	7 x 3-1/2 x 5/8	21.0
3-1/2 x 3-1/2 x 5/16	7.2	5 x 3-1/2 x ½	13.6		
3-1/2 x 3-1/2 x 3/8	8.5	5 x 3-1/2 x 5/8	16.8	8 x 3-1/2 x ½	18.7
3-1/2 x 3-1/2 x 7/16	9.8				
3-1/2 x 3-1/2 x ½	11.1	5 x 4 x 3/8	11.0	8 x 6 x ½	23.0
3-1/2 x 3-1/2 x 5/8	13.6	5 x 4 x ½	14.5	8 x 6 x 3/4	33.8
4 x 3 x 1/4	5.8	5 x 5 x 3/8	12.3	8 x 3 x ½	26.4
4 x 3 x 5/16	7.2	5 x 5 x 7/16	14.3	8 x 3 x 5/8	32.7
4 x 3 x 3/8	8.5	5 x 5 x ½	16.2	8 x 3 x 3/4	38.9
4 x 3 x 7/16	9.8	5 x 5 x 5/8	20.0	8 x 3 x 7/8	45.0
4 x 3 x ½	11.1	5 x 5 x 3/4	23.6	8 x 3 x 1	51.0
				8 x 3 x 11/8	56.9

TABLE 4-79. Bolted Steel Tanks

Estimated Time for Tank Erection		
Work Element Description	**Unit**	**Man-Hours Per Unit**
100 BBL tank	EA	55 (**4101**)
250 BBL tank	EA	130 (**4102**)
500 BBL tank	EA	220 (**4103**)
1,000 BBL tank	EA	440 (**4104**)
3,000 BBL tank	EA	750 (**4105**)
10,000 BBL tank	EA	1,600 (**4106**)
50,000 BBL tank	EA	6,660 (**4107**)

SUGGESTED CREW SIZE: 6 to 16 SWs

NOTE: 1. Basis: Tank erection only. Does not include site preparation or uncrating.

DIVISION 6. CARPENTRY

Page

A. ROUGH CARPENTRY

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TABLE 4-80. Rough Carpentry

Work Element Description	Unit	Man-Hours Per Unit
Floor Joists; Sills; Girders and Blocking	BF	0.04 (**5001**)
Wall Framing-Studs; Plates and Bracing	BF	0.04 (**5002**)
Ceiling Joists	BF	0.05 (**5003**)
Roof Framing (pitch type); Eave Blocking Roof Framing (flat type)	BF BF	0.06 (**5004**) 0.04 (**5005**)
Beams (shaped and dapped) Beams (exposed framing)	BF BF	0.13 (**5006**) 0.10 (**5007**)
Trusses, Light (nailed) Trusses, Heavy (bolted)	BF BF	0.07 (**5008**) 0.10 (**5009**)
Cross Bridging, 2" X 3 "	SET	0.16 (**5010**)
Metal Studs	SF of Wall Surface	0.01 (**5011**)
Fabricate and Install Rough Door Bucks (masonry walls)	Each Opening	3.0 (**5012**)
Ceiling Stripping	FT	0.03 (**5013**)
Furring on Concrete and Masonry Walls	FT	0.035 (**4014**)
Wood Plaster Grounds on Masonry Walls	FT	0.06 (**5015**)
Wood Fences	SF	0.08 (**5016**)

SUGGESTED CREW SIZE: Framing: Four BUs working in pairs; Two BUs cutting materials.
Miscellaneous: Two BUs performing various jobs.

NOTES:

1. Rough carpentry includes measuring, cutting, and installing wood framing, floor joists, sills, cross bridging, wall framing, plates, door bucks, roof framing, and rafters, install wall and roof sheathing, and siding.

2. Wall framing studs, plates and bracing, window and door headers.

3. Metal studs more than 18 GS use 1.2 multiplier.

TABLE 4-81. Sheathing and Siding

Work Element Description	Unit	Man-Hour Per Unit
Roof Sheathing: 1" X 6" and 1" X 8" Boards 2" T&G Laid Straight (Add 20 percent for diagonal)	BF	0.04 (**5017**)
Plywood	SF	0.025 (**5018**)
Wall Sheathing: 1" X 6" and 1" X 8" Boards 2" T&G Laid Straight (Use **1.2** multiplier for diagonal)	SF	0.03 (**5019**)
Plywood	SF	0.025 (**5020**)
Siding:		
Wood Shingles	SF	0.07 (**5021**)
Board and Batten	SF	0.05 (**5022**)
Shiplap, Drop Siding	SF	0.05 (**5023**)
Plywood	SF	0.04 (**5024**)

SUGGESTED CREW SIZE: Sheathing: Four BUS working in pairs placing materials; Two BUS cutting; Two BUS handling materials.

NOTE: 1. Siding includes building paper.

TABLE 4-82. Number of Wood Joists Required for Any Floor and Spacing

Spacing of Joists (Inches)			
Length of Span (Feet)	**12 Inches**	**16 Inches**	**24 Inches**
6	7	6	4
7	8	6	5
8	9	7	5
9	10	8	6
10	11	9	6
11	12	9	7
12	13	10	7
13	14	11	8
14	15	12	8
15	16	12	9
16	17	13	9
17	18	14	10
18	19	15	10
19	20	15	11
20	21	16	11
21	22	17	12
22	23	18	12
23	24	18	13
24	25	19	13
25	26	20	14
26	27	21	14
27	28	21	15
28	29	22	15
29	30	23	16
30	31	24	16
31	32	24	17
32	33	25	17
33	34	26	18
34	36	27	18
35	36	27	19
40	41	31	21

TABLE 4-83. Board Feet of Lumber Required Per 100 Square Feet of Surface

When used for Studs, joists, rafters, wall and floor furring strips, etc.			
Board Feet Required Per 100 SF of Surface			
Lumber Size (Inches)	**On 12-Inch Centers**	**On 16-Inch Centers**	**On 24-Inch Centers**
1 X 2	16-2/3	12-1/2	8-1/3
2 X 2	33-1/3	25	16-2/3
2 X 4	66-2/3	50	33-1/3
2 X 6	100	75	50
2 X 8	133-1/3	100	66-2/3
2 X 10	166-2/3	125	83-1/3
2 X 12	200	150	100
3 X 6	150	112-1/2	75
3 X 8	200	133-1/3	100
3 X 10	250	187-1/2	125
3 X 12	300	225	150

NOTE: 1. Data in this table does not include any allowance for waste in cutting, extra joists at the end of each span, doubling joists under or around stiarwells, top or bottom plates, etc. These items vary with each job and must be added as required.

TABLE 4-84. Material Required for Built-Up Girders

Size of Girder (Inches)	Board FT Required	Nails Required per 1,000 BF
4 X 6	2.15	53
4 X 8	2.85	40
4 X 10	3.58	32
4 X 12	4.28	26
6 X 6	3.21	43
6 X 8	4.28	32
6 X 10	5.35	26
6 X 12	6.42	22
8 X 8	5.71	30
8 X 10	7.13	24
8 X 12	8.56	20

TABLE 4-85. Board Feet Content

Size in Inches	Length in Feet								
	8	10	12	14	16	18	20	22	24
1 X 2	1-1/3	1-2/3	2	2-1/3	2-2/3	3	3-1/3	3-2/3	4
1 X 4	2-2/3	3-1/3	4	4-2/3	5-1/3	6	6-2/3	7-1/3	8
1 X 6	4	5	6	7	8	9	10	11	12
1 X 8	5-1/3	6-2/3	8	9-1/3	10-2/3	12	13-1/3	14-2/3	16
1 X 10	6-2/3	8-1/3	10	11-2/3	13-1/3	15	16-2/3	18-1/3	20
1 X 12	8	10	12	4	16	18	20	22	24
5/4 X 4	3-1/3	4-1/6	5	5-5/6	6-2/3	7-1/2	8-1/3	9-1/6	10
5/4 X 6	5	6-1/4	7-1/2	8-3/4	10	11-1/4	12-1/2	13-3/4	15
2 X 4	5-1/3	6-2/3	8	9-1/3	10-2/3	12	13-1/3	14-2/3	16
2 X 6	8	10	12	14	16	18	20	22	24
2 X 8	10-2/3	13-1/3	16	18-2/3	21-1/3	24	26-2/3	29-1/3	32
2 X 10	13-1/3	16-2/3	20	23-1/3	26-2/3	30	33-1/3	36-2/3	40
2 X 12	16	20	24	28	32	36	40	44	48
3 X 4	8	10	12	14	16	18	20	22	24
3 X 6	12	15	18	21	24	27	30	33	36
3 X 8	16	20	24	28	32	36	40	44	48
3 X 10	20	25	30	35	40	45	50	55	60
3 X 12	24	30	36	42	48	54	60	66	72
3 X 14	28	35	42	49	56	63	70	77	84
3 X 16	32	40	48	56	64	72	80	88	96
4 X 4	10-2/3	13-1/3	16	18-2/3	21-1/3	24	26-2/3	29-1/3	32
4 X 6	16	20	24	28	32	36	40	44	48
4 X 8	21-1/3	26-2/3	32	37-1/3	42-2/3	48	53-1/3	58-2/3	64
4 X 10	26-2/3	33-1/3	40	46-2/3	53-1/3	60	66-2/3	73-1/3	80
4 X 12	32	40	48	56	64	72	80	88	96
4 X 14	37-1/3	46-2/3	56	65-1/3	74-2/3	84	93-1/3	102-2/3	112
4 X 16	42-2/3	53-1/3	64	74-2/3	85-1/3	96	106-2/3	117-1/3	128
6 X 6	24	30	36	42	48	54	60	66	72
6 X 8	32	40	48	56	64	72	80	88	96
6 X 10	40	50	60	70	80	90	100	110	120
6 X 12	48	60	72	84	96	108	120	132	144
6 X 14	56	70	84	98	112	126	140	154	168
6 X 16	64	80	96	112	128	144	160	176	192
8 X 8	42-2/3	53-1/3	64	74-2/3	85-1/3	96	106-2/3	117-1/3	128
8 X 10	53-1/3	66-2/3	80	93-1/3	106-2/3	120	133-1/3	146-2/3	160
8 X 12	64	80	96	112	128	144	160	176	192

TABLE 4-86. Board Feet Required for Wood Partitions

2-inch by 4-inch Studs 16 inches on Centers
with Single Top and Bottom Plates

		Height of Partition		
Length of Partition	**No. Studs Required**	**8 FT 0 IN**	**10 FT 0 IN**	**12 FT 0 IN**
3'0"	3	20	24	28
4'0"	4	27	32	37
5'0"	5	33	40	47
6'0"	6	40	48	56
7'0"	6	41	49	57
8'0"	7	48	57	67
9'0"	8	55	65	76
10'0"	9	61	73	85
11'0"	9	63	75	87
12'0"	10	69	83	96
13'0"	11	76	91	105
14'0"	12	83	99	115
15'0"	12	84	100	116
16'0"	13	91	108	125
17'0"	14	97	116	135
18'0"	15	104	124	144
19'0"	15	105	125	145
20'0"	16	112	133	155

NOTES:
1. Includes top and bottom plates.
2. Add 2/3 foot of lumber BM for each foot of double top or bottom plate.

TABLE 4-87. Number of Studs for Required for Variable Spacing

(Partition, Floor Joist, and Ceiling Joist)

Distance on Center (Inches)	**Multiply Length of Partition BY**	**Add**
12	1.0	1
16	0.75	1
24	0.50	1

NOTE:
1. Add for top and bottom plates on stud walls.

TABLE 4-88. Material Required for Rafters

Center-To-Center Spacing of Rafters				
Board Feet Required per 100 SF of Area				
Rafter Size (Inches)	**12 Inches**	**16 Inches**	**24 Inches**	**LBS of Nails Required per 1000 BF**
2 X 4	89	71	53	17
2 X 6	129	102	75	12
2 X 8	171	134	112	9
2 X 10	212	167	121	7
2 X 12	252	197	143	6

Lengths of Common, Hip, and Valley Rafters per 12 Inches of Run			
1 Rise and Run or Cut	**2 Length in Inches Common Rafter per 12" of Run**	**3 Length in Inches Hip or Valley Rafters**	**4 Conversion Factor**
2 and 12	12.165	17.088	1.014
3 and 12	12.369	17.233	1.031
4 and 12	12.649	17.433	1.054
5 and 12	13.000	17.692	1.083
6 and 12	13.417	18.000	1.118
7 and 12	13.892	18.358	1.158
8 and 12	14.422	18.762	1.202
9 and 12	15.000	19.209	1.250
10 and 12	15.620	19.698	1.302
11 and 12	16.279	20.224	1.357
12 and 12	16.971	20.785	1.413
13 and 12	17.692	21.378	1.474
14 and 12	18.439	22.000	1.537
15 and 12	19.210	22.649	1.601
16 and 12	20.000	23.324	1.667
17 and 12	20.809	24.021	1.734
18 and 12	21.633	24.739	1.803
19 and 12	22.500	25.475	1.875
20 and 12	23.375	26.230	1.948
21 and 12	24.125	27.000	2.010
22 and 12	25.000	27.785	2.083
23 and 12	26.000	28.583	2.167
24 and 12	26.875	29.394	2.240

NOTES:

1. Includes common rafters, hip and valley rafters, ridge boards and collar beams.
2. To obtain the SF of roof area for a given pitch, use the building SF of floor area and multiply it by the appropriate conversion factor in column 4 (include the overhang).
Example: Bld 10' X 10' with 2' overhang on all sides, using 6" and 12" out. 14' X 14' = 196 SF X 1.118 = 219.12 SF of roof area.

TABLE 4-89. Roof Areas of Pitched Roofs

Pitch	Increase of Area Over Flat Root (Percent)	Multiplication Factor
1/4	12	1.12
1/3	20	1.20
3/8	25	1.25
½	42	1.42
5/8	60	1.60
3/4	80	1.80
7/8	101	2.01

TABLE 4-90. Criteria for Plywood Roof Sheathing

Design Load Factor in LBS PSF*				Nail Spacing		
Plywood Thickness (Inches)	20 PSF	30 PSF	40 PSF	Nail Size and Type	Panel Edge (Inches)	Interme-diate (Inches)
½	32	32	30	6d Common	6	12
5/8	42	42	39	8d Common	6	12
3/4	48	47	42	8d Common	6	12

*per square foot

NOTES:
1. Plywood continuous over two or more spans with grain of face ply across supports.
2. Provide blocking or other means of suitable edge support when span exceeds 28 inches for ½-inch, 32 inches for 5/8-inch, or 36 inches for 3/4-inch plywood.

TABLE 4-91. Criteria for Plywood Flooring

Nail Spacing					
Application	**Thickness of Plywood (Inches)**	**Max Spacing of Supports CTR to CTR**	**Nail Size and Type**	**Panel Edge**	**Inter-mediate**
Subflooring	½ 5/8 3/4	16d 20b 24b	6d Common 8d Common 8d Common	6 6 6	10 10 10
Underlayment	3/8 5/8		6d Ring-Shank or Cement Coated 8d Flathead	6	8 Each Way

NOTES:
1. Provide blocking at panel edge for other than 25 32-inch thick strip flooring.
2. If strip flooring is perpendicular to supports, ½-inch thick strip flooring can be used on a 24-inch span.
3. If resilient flooring is to be applied without underlaying, set nails 1/16-inch below surface.
4. If supports are not well seasoned, use ring-shank nails.

TABLE 4-92. Finish Carpentry

Work Element Description	Unit	Man-Hours Per Unit
Baseboard (two member)	FT	0.08 (**5026**)
Mouldings		
Chair Rails	FT	0.06 (**5027**)
Ceiling	FT	0.0 6 (**5028**)
Finish Facias	FT	0.06 (**5029**)
Chalk and Tackboard Trim	FT	0.08 (**5030**)
Stairs		
Cellar Complete 10 FT Rise	Complete	10.0 (**5031**)
Back or Enclosed 12 FT Rise	Complete	24.0 (**5032**)
Front, Open 12 FT Rise	Complete	54.0 (**5033**)
Front, Open Ornate	Complete	102.0 (**5034**)
Shelving, Plywood , or 1" X 12" (Metal Brackets)	FT	0.01 (**5035**)
Closet Unit, Shelf, and Pole Only	EA	2.0 (**5036**)
Soffits, Plywood	FT	0.12 (**5037**)
False Beams (Built-Up)	FT	0.18 (**5038**)

SUGGESTED CREW SIZE: Trim work: two BUS; Cabinets: two BUS; Miscellaneous: two BUS

NOTES:
1. Finish carpentry includes the work of installing baseboard, molding, wooden stairs, closet units, wooden shelving, soffits, and false beams.
2. For cornice estimates, use soffit figures.

TABLE 4-93. Wire Nails: Length and Approximate Number Per Pound

Size	Length (Inches)	Common	Finish
2d	1.00	874	
3d	1.25	574	
4d	1.50	320	574
5d	1.75	254	
6d	2.00	200	300
7d	2.25	154	
8d	2.50	110	190
9d	2.75	90	
10d	3.00	72	135
12d	3.25	60	
16d	3.50	48	
20d	4.00	30	

DIVISION 7. MOISTURE PROTECTION

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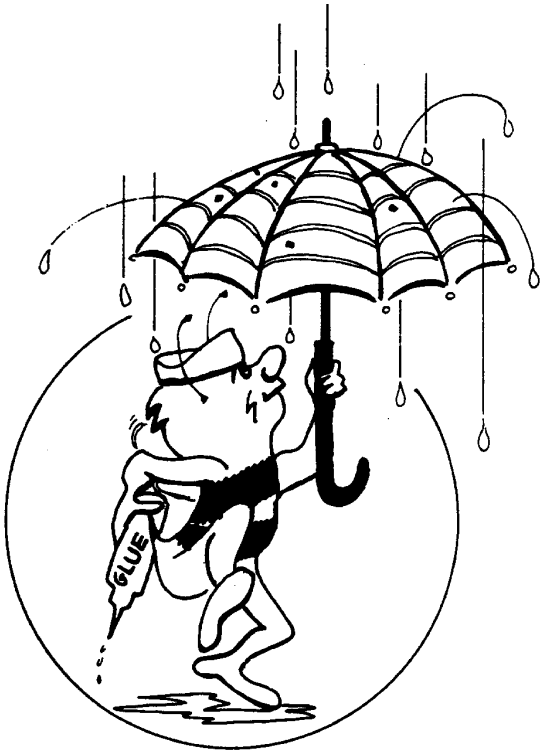

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TABLE 4-94. Waterproofing

Work Element Description	Unit	Man-Hours Per Unit
Built-Up Roofing		
3 Ply	SF	0.04 (**3017**)
4 Ply	SF	0.05 (**3018**)
5 Ply	SF	0.06 (**3019**)
Roof Insulation	SF	0.06 (**3020**)
Asphaltic Aluminum Roofing		
Asphaltic Primer	SF	0.015 (**3021**)
Asphaltic Aluminum	SF	0.015 (**3022**)
Shingle Roofing (includes felt paper)		
Asphalt Shingles	SF	0.05 (**3023**)
Wood Shingles	SF	0.07 (**3024**)
Asbestos Shingles	SF	0.09 (**3025**)
Corrugated Roofing		
Corrugated or V-Crimp Metal		
on Wood Purlins	SF	0.035 (**3026**)
on Metal Framing	SF	0.07 (**3027**)
Corrugated Asbestos, Cement		
on Wood Purlins	SF	0.06 (**3028**)
on Metal Framing	SF	0.08 (**3029**)

SUGGESTED CREW SIZE: 4 to 12 BUs

NOTE:
1. All estimates are based on 50 percent experienced crews with good supervision.
2. Insulation installation should not exceed that which can be covered with roofing the same day.
3. For below grade waterproofing use 0.75 multiplier for figures listed.
4. Crew size will be dictated by safety, equipment used, scope of work, and the number of operations involved.

TABLE 4-95. Sheet Metal Work

Work Element Description	Unit	Man-Hours Per Unit
Fabrication		
Roof Gutters	FT	0.05 (**3030**)
Down Spouts	FT	0.05 (**3031**)
Roof Ridges	FT	0.04 (**3032**)
Roof Valleys	FT	0.04 (**3033**)
Flashing	FT	0.06 (**3034**)
Installation		
Roof Gutters	FT	0.08 (**3035**)
Down Spouts	FT	0.08 (**3036**)
Roof Ridges	FT	0.05 (**3037**)
Roof Valleys	FT	0.05 (**3038**)
Flashing	FT	0.07 (**3039**)

SUGGESTED CREW SIZE: Three to five SWs

NOTES:
1. Fabrication is usually performed in the sheet metal shop and includes making patterns, cutting, forming, seaming, soldering, attaching stiffeners, and loading for delivery.
2. Installation includes unloading, storing on site, handling into place, hanging, fastening, and soldering.

TABLE 4-96. Insulation

Work Element Description	Unit	Man-Hours Per Unit
Ceilings and Walls Aluminum Foil; 1- and 2-sided Foil; Mineral Wool 2" to 6" Batts; Pouring wool over ceiling at 3-1/2" depth; Fiberglass insulation; Kraft paper faced, and Masonry Fill.	SF	0.015 (**3040**)
Rigid Insulation Board Walls, Ceilings, and Roofs Perimeter Foundation Walls	SF	0.02 (**3041**)

SUGGESTED CREW SIZE: Two to six BUs

NOTE:
1. The installation of insulation includes scaffolding when required, fastening insulation into place, and cutouts in insulation, as required.

TABLE 4-97. Fastener Requirements for Batts of Insulation

Size of Batt (Inches)	Area of Batt (SF)	Number of Batts Required per 100 SF	Number of Staples Required per 100 SF
15 X 24	2.50	40	160
15 X 48	5.00	20	160
19 X 24	3.70	32	160
19 X 48	6.33	16	160
23 X 24	3.84	26	160
23 X 48	7.67	13	160

TABLE 4-98. Loose Fill Insulation Requirements

Density of Fill, LB Per CF					
	6 LB	7 LB	8 LB	9 LB	10 LB
Area in SF Covered per CF of Fill					
Thickness of Fill (Inches)					
1	21.2	18.0	15.9	14.1	13.0
2	10.6	9.1	8.0	7.1	6.4
3	7.1	6.1	5.3	4.7	4.2
4	5.3	4.6	4.0	3.5	3.2

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DIVISION 8. DOORS, WINDOWS, AND GLASS

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TABLE 4-99. Door Installation

Work Element Description	Unit	Man-Hours Per Unit
Wood Doors and Frames		
Door Frames and Trim		
Single Exterior	EA	3 (**6001**)
Double Exterior	EA	3 (**6002**)
Single Interior	EA	3 (**6003**)
Double Interior	EA	4 (**6004**)
Sliding Door Frame	EA	4 (**6005**)
Doors, Fit, Hand, and Lock		
Single Exterior	EA	5 (**6006**)
Double Exterior	EA	8 (**6007**)
Single Interior	EA	5 (**6008**)
Double Interior	EA	7 (**6009**)
Screen Doors	EA	2 (**6010**)
Metal Doors		
Single	EA	6 (**6011**)
Double	EA	9 (**6012**)
Miscellaneous Doors Complete with Trim and Hardware		
Rolling, Manual Operated	EA	29 (**6013**)
Rolling, Motor Operated	EA	36 (**6014**)
Sliding, Manual Operated	EA	20 (**6015**)
Sliding, Motor Operated	EA	26 (**6016**)
Sliding, Fire	EA	19 (**6017**)
Garage Doors		
Wood 16' X 7'	EA	8 (**6018**)
Aluminum 16' X 7'	EA	10 (**6019**)
Scuttles	EA	10 (**6020**)
Caulking	FT	0.005 (**6021**)

NOTES:
1. Includes jambs, stops, casings, and weather stripping.
2. Does not include sills or thresholds.
3. On wood doors, if power planes, hinge butt routers, and lock mortisers are used, use 0.75 multiplier on installation time.

TABLE 4-100. Window Installation

Work Element Description	Unit	Man-Hours Per Unit
Wood Windows		
Double Hung	EA	4.0 (**6022**)
Casement, Single	EA	4.0 (**6023**)
Fixed, Wood Sash	EA	3.0 (**6024**)
Jalouse	EA	2.0 (**6025**)
Skylights	EA	8.0 (**6026**)
Metal Windows		
Casement	EA	2.0 (**6027**)
Commercial Projected	EA	2.0 (**6028**)
Skylights	EA	2.0 (**6029**)
Double Hung	EA	9.0 (**6030**)
Louvers	EA	5.0 (**6031**)
Screens	EA	2.0 (**6032**)
Venetian Blinds	EA	2.0 (**6033**)
Weatherstripping	EA	3.0 (**6034**)
Caulking	FT	0.003 (**6035**)

SUGGESTED CREW SIZE: Two to six BUs

NOTES:
1. Installation includes drilling for fasteners, expansion shields, installing plugs, toggle bolts, blocking, hinges, locks, and other hardware.
2. For special panic device for doors add three hours for single, four hours for double doors.

TABLE 4-101. Glass and Glazing

Work Element Description	Unit	Man-Hours Per Unit
Small Panes 2-FT. Square or Less	SF	0.16 (**6036**)
Medium Panes 2- to 6-FT Square	SF	0.17 (**6037**)
Large Panes 6- to 10-FT Square	SF	0.21 (**6038**)
Plate Glass Store Fronts 200- to 400- FT Square	SF	21.0 (**6039**)

NOTES:
1. Estimates are based on putty set installation: if installed with metal stops and rubber, double the man-hour figures; if vinyl set, snap-on triple man-hour figures; for insulated glass use **0.67** multiplier
2. When glazing from outside using scaffolding or swinging staging, one man is required on the ground to support two glaziers; use **1.5** multiplier
3. For winter work add use **1.25** multiplier.
4. Do not air ship insulated glass units such as Thermopane, Twindow, etc., due to unequal pressurization.

DIVISION 9. FINISHES

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TABLE 4-102. Portland Cement, Stucco, and Plaster

Work Element Description	Unit	Man-Hours Per Unit
Three Coats on Interior Masonry Units	SY	0.42 (**7001**)
Three Coats on Exterior Masonry Units	SY	0.28 (**7002**)
Three Coats on Metal Lath	SY	0.62 (**7003**)
Install Metal Lath	SY	0.1 (**7004**)

SUGGESTED CREW SIZE: Four to eight BUs

NOTES: 1. Lathing and plastering includes handing material into place; installing furring strips, metal lath, and mixing plaster; installing and finishing plaster.

TABLE 4-103. Material Requirements for Cement, Stucco, and Plaster

Materials Required per 100 SF of Wall					
		Mortar: Mixture Ratio 1:2-1/2		Mortar: Mixture Ratio 1:3	
Thickness (Inches)	Mortar CF	Cement Bags	Sand CF	Cement Bags	Sand CF
1/4	2.08	0.84	2.08	0.73	2.20
3/8	3.13	1.26	3.14	1.10	3.30
½	4.17	1.68	4.19	1.47	4.40
5/8	5.21	2.09	5.23	1.83	5.50
3/4	6.25	2.51	6.28	2.20	6.60
1	8.33	3.35	8.37	2.93	8.80

TABLE 4-104. Acoustical Treatment

Work Element Description	Unit	Man-Hours Per Unit
Acoustical Tile Ceiling		
Cemented in Place	SF	0.028 (**7005**)
Nailed to Furring Strips	SF	0.039 (**7006**)
Suspension System for Ceiling: Includes Ceiling Panels	SF	0.042 (**7007**)
Drilling holes in concrete to ecure hangers	SF	0.008 (**7101**)

SUGGESTED CREW SIZE: Two to four BUs working in pairs.

NOTES: 1. Acoustical treatment includes layout, fitting and placing ceiling tile, installing suspended ceiling framework; setting up and moving platform or scaffold along with work.

TABLE 4-105. Flooring and Tiling Soft

Work Element Description	Unit	Man-Hours Per Unit
Subflooring: Plywood	BF	0.019 (**7008**)
1" X 6" and 1" X 8" Laid Straight	BF	0.025 (**7009**)
1" X 6" and 1" X 8" Diagonal	BF	0.031 (**7010**)
2" T&G Laid Straight	BF	0.025 (**7011**)
2" T&G Diagonal	BF	0.030 (**7012**)
Blocking at Plywood Edges	BF	0.028 (**7013**)
Finish Flooring		
Hardwood Flooring, End Matched, Laid Straight	BF	0.063 (**7014**)
Softwood Flooring, Laid Straight	BF	0.042 (**7015**)
Tiling, Soft		
Tile cemented directly to Floor: Asphalt, Rubber, Vinyl, Cork	SF	0.033 (**7016**)
Tile with Felt Lining	SF	0.047 (**7017**)
Linoleum with Felt Lining	SF	0.047 (**7018**)
Carpet		
Roll, Nail Strip and Padding	SF	0.050 (**7079**)
Tile, 12"	SF	0.035 (**7080**)
Tile, 24"	SF	0.012 (**7081**)

SUGGESTED CREW SIZE: Flooring Operations: Two BUs laying Flooring; two BUs sawing and handling. Tiling Operations: Two to four BUs, as required.

NOTES:
1. Flooring includes measuring, cutting, and installing Subflooring, finish flooring, and soft tile (asphalt, rubber, vinyl, cork, linoleum); installing building paper under finish floors; adhesive under tile floors; building paper under soft tile when laid over wooden floors.
2. Hardwood flooring is estimated on 25/32" x 2-1/4"; Softwood flooring is estimated on 25/32" x 3-1/4".

TABLE 4-106. Estimating Floor Tile Requirements

Tile Size (Inches)			
	6 X 6	9 X 9	12 X 12
Number of Tiles Required			
Area SF	INCLUDES WASTE ALLOWANCE		
1	4	2	1
2	8	4	2
3	12	6	3
4	16	8	4
5	20	9	5
6	24	11	6
7	28	13	7
8	32	15	8
9	36	16	9
10	40	18	10
20	80	36	20
30	120	54	30
40	160	72	40
50	200	89	50
60	240	107	60
70	280	125	70
80	320	143	80
90	360	160	90
100	400	178	100
200	800	356	200
300	1200	534	300
400	1600	712	400
500	2000	890	500

NOTE: 1. To find the number of the required for an area not shown in this table, such as 9" X 9" tile for 550 SF, add the number of tile needed for 50 SF to the number needed for 500 SF. The result is 1,028 tile.

TABLE 4-107. Floor Tile Waste Allowances

Area to be Tiled (SF)	**Waste Allowance (Percent)**
1 to 50	14
51 to 100	10
101 to 200	8
201 to 500	7
501 to 1000	5
Over 1000	3

TABLE 4-108. Mastic Requirements for Resilient Floor

Type of Resilient Flooring	Mastic Required GL per 100 SF
Asphalt Tile	0.33
Rubber Tile	0.33
Plastic Tile	0.76
Cork Tile	0.91
Linotile	0.91

NOTE: 1. On gallon covers 300 to 400 square feet. Current coverage for today's products.

TABLE 4-109. Wall Covering

Work Element Description	Unit	Man-Hours Per Unit
Finish Walls		
Plywood	SF	0.041 (**7019**)
Insulated Plank	SF	0.036 (**7020**)
Paneling	SF	0.061 (**7021**)
Gypsum Wallboard		
½-Inch Thick (includes Perf Tape System)		
Applied on Wall Studs (Wood)	SF	0.033 (**7022**)
Applied on Ceiling Joists (Wood)	SF	0.039 (**7023**)

SUGGESTED CREW SIZE: Four to six BUs working in pairs

NOTES:
1. Wall covering includes measuring, cutting, and installing plywood, insulated plank, paneling, and gypsum wallboard.
2. Estimate is based on installing wall covering only with nails or an adhesive, if any furring nailing strips, special joining, or fasteners are included, allow extra time.
3. Thin-type paneling should have substantial backing of gypsum board, plaster, or plywood. Inside corners and ceilings can be scribed to fit.
4. Gypsum wallboard perforated joint system man-hour estimate is based on two applications.

TABLE 4-110. Estimating Ready Mix Joint Compound and Tape

Gypsum Wallboard (SF)	Estimated Amount of Ready Mix Joint Compound	Estimated Amount of Wallboard Tape
100-200	1 GL	Two 60 FT Rolls
300-400	2 GL	Three 60 FT Rolls
500-600	3 GL	One 250 FT Roll
700-800	4 GL	One 60 FT. Roll
900-1000	1-5 GL Pail	One 250 FT Roll Two 60 FT Rolls One 500 FT Roll

NOTES:

1. In the adhesive and nail-on method, gypsum board adhesive is applied to the joists and studs before each piece of wallboard is positioned and mailed. The adhesive is applied to the framing member from a caulking gum in about 3/8-inch diameter bead. For each 1000 SF of wallboard use eight quart size tubes of adhesive.
2. Using your sketch, determine the lengths and number of boards required. Nails can be estimated from table 4-95.

TABLE 4-111. Estimating Fastener Requirements for Wallboard

Type of Wall Board	Size of Panels (Inches)	Fastening Method	Amount of Adhesive (in GL) or Nails (in LB) required per 100 SF
Gypsum	48 X 96	Nailed to Studs	1.00 LB
Perforated Hardboard	48 X 96	Nailed to Studs	4.00 LB
Plant T&G Board	8 X 96	Nailed to Studs	2.00 LB
Plant T&G Board	12 X 96	Nailed to Studs	2.00 LB
Plywood Panels	48 X 96	Nailed to Studs or Wall	1.25 LB
Rock Lath	16 X 96	Nailed to Studs	5.00 LB
Tempered Tileboard	48 X 48	Nailed to Studs	1.00 LB
Tempered Tileboard	48 X 48	Adhesive Applied to Wall	1.50 GL

TABLE 4-112. Painting Structural and Miscellaneous Steel

Work Element Description	Unit	Man-Hours Per Unit
Structural Steel, per coat		
Brush	TN	3.0 (**7024**)
Spray	TN	2.0 (**7025**)
Wire Brush Clean	TN	4.0 (**7026**)
Sandblasting	TN	6.0 (**7027**)
Miscellaneous Iron and Steel, per coat		
Brush	TN	5.0 (**7028**)
Wire Brush Clean	TN	5.0 (**7029**)

SUGGESTED CREW SIZE: Brush Painting: four to eight men. Spray Painting: One to two men spraying, one or two tending

NOTE:
1. Structural steel painting includes removing rust, scale, oil, grease, and dirt; mixing and applying paint; sanding between coats when required.
2. For wire brush cleaning and sandblasting see table 101.

TABLE 4-113. Fence Metal Painting

Work Element Description	Unit	Man-Hours Per Unit
Fence Posts		
2.5 inches to 3.5 inches diameter	FT	0.021 (**7030**)
4.0 inches to 5.0 inches diameter	FT	0.03 (**7031**)
6.0 inches diameter	FT	0.033 (**7032**)
Paint Fence Fabric with Roller and Brush	SF	0.015 (**7033**)

NOTE:
1. Fence metal painting includes removing rust, scale, oil, grease, and dirt; mixing, and applying paint.

TABLE 4-114. Interior Painting

Work Element Description	Unit	Man-Hours Per Unit
Brush Painting, per coat		
Wood Flat Work	SF	0.011 (**7034**)
Doors and Windows Area	SF	0.012 (**7035**)
Trim	SF	0.009 (**7036**)
Plaster, Sand Finish	SF	0.01 (**7037**)
Plaster, Smooth Finish	SF	0.01 (**7038**)
Plasterboard	SF	0.008 (**7039**)
Masonry	SF	0.012 (**7040**)
Metal	SF	0.012 (**7041**)
Varnish Flat Work	SF	0.009 (**7042**)
Enamel Flat Work	SF	0.007 (**7043**)
Enamel Trim	SF	0.013 (**7044**)
Roller Painting, per coat		
Wood Flat Work	SF	0.007 (**7045**)
Doors	SF	0.009 (**7046**)
Plaster, Sand Finish	SF	0.004 (**7047**)
Plaster, Smooth Finish	SF	0.005 **(7048**)
Plasterboard	SF	0.005 (**7049)**
Masonry	SF	0.005 (**7050**)
Metal	SF	0.007 (**7051**)
Spray Painting, per coat		
Wood Flat Work	SF	0.004 (**7052**)
Plaster, Plasterboard	SF	0.004 (**7053**)
Masonry	SF	0.004 (**7054**)
Metal	SF	0.005 (**7055**)
Taping, Flushing Joints, Sanding Plasterboard	FT of Joint	0.054 (**7056**)
Sanding Wood Floors	SF	0.012 (**7057**)
Finish Wood Floors		
Sealer and One Finish Coat	SF	0.021 (**7058**)

NOTE: 1. The painting of interior surfaces includes surface preparation, mixing paint materials, and application of paint to surface.

TABLE 4-115. Drying Times For Finishes

Material	Tough	Recoat	Rub
Lacquer	1 to 10 min.	1.5 to 3 hours	16-24 hours
Lacquer Sealer	1 to 10 min.	30-45 min.	1 hour (sand)
Paste Wood Filler	----	24-48 hours	----
Paste Wood Filler (Quick Dry)	----	3-4 hours	----
Water Stain	1 hour	12 hours	----
Oil Stain	1 hour	24 hours	----
Spirit Stain	zero	10 min.	----
Shading Stain	zero	zero	----
Non-Grain Raising Stain	15 min.	3 hours	----
NGR Stain (Quick Dry)	2 min.	15 min.	----
Pigment Oil Stain	1 hour	12 hours	----
Pigment Oil Stain (Quick Dry)	1 hour	3 hours	----
Shellac	15 min.	2 hours	12-18 hours
Shellac (Wash Coat)	2 min.	30 min.	----
Varnish	1 hour 30 min.	18-24 hours	24-48 hours
Varnish (Quick Dry, Synthetic)	30 min.	4 hours	12-24 hours

Average Drying Time: Different products will vary.

TABLE 4-116. Coverage for Paints

Square Feet to Gallon			
Material	**1 Coat**	**2 Coats**	**3 Coats**
Enamels	500	250	195
Flat Wall Paint: White/light colors on smooth finish	575	290	215
Flat Wall Paint: Dark colors on rough sand finish	725	365	240
Inside Floor Paint	500	275	----
Outside House Paint: White/light tints, porous woods	475	255	190
Outside House Paint; White/light tints, close grained woods	525	275	190
Outside House Paint: Dark colors, grey, tan, porous grained woods	525	280	215
Outside House Paint: Dark colors, grey, ten, close grained woods	575	300	215
Stain: Wood tints	500	----	----

Refer to manufacturers' specifications and coverage figure.

TABLE 4-117. Exterior Painting

Work Element Description	Unit	Man-Hours Per Unit
Brush Painting, per coat		
Masonry	SF	0.012 (**7059**)
Metal, Flat	SF	0.012 (**7060**)
Metal Roofing and Siding	FT	0.01 (**7061**)
Steel Sash, area of opening	SF	0.009 (**7062**)
Trim	SF	0.011 (**7063**)
Wood Siding	SF	0.012 (**7064**)
Wood Doors and Windows, area of opening	SF	0.012 (**7065**)
Roller Painting, per coat		
Doors	SF	0.009 (**7066**)
Masonry	SF	0.01 (**7067**)
Metal, Flat	SF	0.009 (**7068**)
Spray Painting, per coat		
Airfield Lines and Numbers, including Glass Beads	SF	0.014 (**7069**)
Doors	SF	0.009 (**7070**)
Masonry	SF	0.008 (**7071**)
Metal, Flat	SF	0.007 (**7072**)
Metal Roofing and Siding	SF	0.008 (**7073**)
Wood Siding	SF	0.005 (**7074**)
Cementitious Paint, including curing	SF	0.016 (**7075**)
Sandblasting Steel	SF	0.066 (**7076**)
Wirebrush Cleaning of Steel	SF	0.038 (**7077**)
Waterproofing on Masonry: clean and spray	SF	0.014 (**7078**)

SUGGESTED CREW SIZE: One to five men spraying; one to five men tending (one man is used to mix and prepare paint for larger crews). Sandblasting crew a minimum of four.

NOTES:
1. Surface preparation for exterior painting includes removing mill scale from metal surfaces with wire brushes or by sandblasting, removing dust with brush or cloth, removing oil and grease, masking and taping adjacent surfaces, removing masking and taping. Sometimes it is necessary to lightly sand between coats, or size and fill porous materials before painting, all of which is surface preparation.
2. Labor for erecting scaffolding not included.

DIVISION 10. SPECIALTIES

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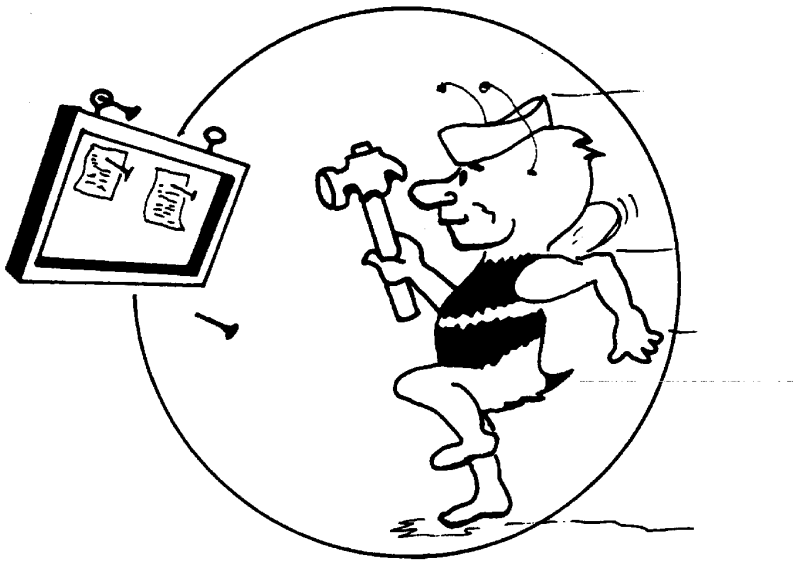

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TABLE 4-118. Install Partitions and Miscellaneous Metal Products

Work Element Description	Unit	Man-Hours Per Unit
Partitions		
Panel	SF	0.104 (**5039**)
Single Panel Doors	EA	6.5 (**5040**)
Swing Door, mesh	EA	4.0 (**5041**)
Toilet Stalls, complete with doors	Stall	10.0 (**5042**)
Wire Mesh	SF	0.048 (**5043**)
Lockers	EA	2.0 (**5044**)
Shelf and Bin Units	SF of back area	0.16 (**5046**)
Security Grills, including track and hardware	SF	0.22 (**5047**)

SUGGESTED CREW SIZE: Two to four men

NOTE: 1. Installation of miscellaneous metal products includes unloading, handing into place, installing fastening devices including drilling, fastening metal products in place, and installing hardware and trim.

TABLE 4-119. Bulletin Boards, Chalkboards, Directory Boards, and Bathroom Accessories

Work Element Description	Unit	Man-Hours Per Unit
Bulletin Boards, Chalkboards, Directory Boards	SF	0.05 (**5048**)
Bathroom Accessories One Set: Mirror and Shelf; Towel Rack; Soap Holder; Soap Dispenser; Paper Holder; Paper Towel Dispenser	Each Set	5.0 (**5049**)

SUGGESTED CREW SIZE: Two men or more depending on scope of job

NOTE: 1. Installation of specialties include unloading, storing at site, handling into place, installing fastening devices including drilling, plugging, anchoring, leveling, and plumbing as needed for bulletin boards, chalkboards, directory boards, and bathroom accessories.

TABLE 4-120. Manufacture Wood Cabinets

Work Element Description	Unit	Man-Hours Per Unit
Manufacture Kitchen Cabinets: Based on 8' Lengths		
Base Unit, no drawers	EA	20.0 (**5050**)
Base Unit, with drawers	EA	32.0 (**5051**)
Sink Unit	EA	24.0 (**5052**)
Wall Unit	EA	20.0 (**5053**)
Work Top, including laminated plastic covering	FT	0.375 (**5054**)
Manufacture Book Shelves (cases)	FT of Shelf	0.5 (**5055**)
Install Pre-Manufactured Cabinets		
2' to 4' (small)	EA	1.5 (**5056**)
4' to 6' (medium)	EA	2.0 (**5057**)
6' to 10' (large)	EA	3.0 (**5058**)

SUGGESTED CREW SIZE: Two to six BUs

NOTES:
1. The operation of the wood fabrication shop (carpentry shop) includes handling and storing materials, cutting, fitting, planning, mortising, fastening together.
2. The laminated plastic covering should not be attached to the work top until the base unit is set and work top fitted securely in place. A water base contact adhesive (waterproof type) is ideal for bonding laminate because it can be smoothly applied with paint brush or roller and easily cleaned with water.

DIVISION 11. ARCHITECTURAL EQUIPMENT

A. LIMITED APPLICATION TO NORMAL SEABEE CONSTRUCTION

B. CONSULT OTHER APPROPRIATE TABLES AS INDICATED BY DESIGN, MATERIALS, SPECIFICATIONS, AND MANUFACTURERS DATA

DIVISION 12. FURNISHINGS

A. CONSULT OTHER APPROPRIATE TABLES AS INDICATED BY DESIGN, MATERIALS, SPECIFICATIONS AND MANUFACTURERS DATA

DIVISION 13. SPECIAL CONSTRUCTION

Tables formerly contained in this division were based on Naval Facilities Engineering Command (NAVFACENGCOM) drawings in the NAVFAC P-437,*Facilities Planning Guide*.

Volume 1 of the NAVFAC P-437, now on CD ROM, contains preengineered facility designs and corresponding material lists. These designs relate primarily to expected needs at advanced bases and to the Advanced Base Functional Component (ABFC) System. Use of these designs to satisfy peacetime requirements is appropriate. Facilities, logistic, and construction planners will find the information required to select and document the material necessary to construct facilities. All drawings contained in Volume 1 are reproducible on a CD ROM printer.

Volume 2 of the NAVFAC P-437, now on diskette or on CD ROM, contains the data display for Volume 1. Components are divided into facilities, facilities are divided into assemblies, and assemblies are divided into individual material lists, complete with National Stock Numbers (NSN) and costs. Each division level reflects manpower requirements by Occupational Field Thirteen (OF-13) Seabee rates. These requirements are by total Man-days, with partial man-days have been rounded to the next full day, and are based on information derived from this handbook.

DIVISION 14. CONVEYING SYSTEMS

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B. CONSULT OTHER APPROPRIATE TABLES AS INDICATED BY DESIGN MATERIALS, SPECIFICATIONS, AND MANUFACTURERS DATA

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DIVISION 15. MECHANICAL CONSTRUCTION

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TABLE 4-121. Install Cast Iron No Hub Pipe and Fittings
(in Man-Hours)

	UNIT	2IN	3IN	4IN	6IN	8IN	12IN
Pipe	FT	**0.09** (**8001**)	**0.14** (**8002**)	**0.18** (**8003**)	**0.26** (**8004**)	**0.37** (**8005**)	**0.52** (**8006**)
Bends	EA	0.42 (**8013**)	0.49 (**8014**)	0.63 (**8015**)	0.95 (**8016**)	1.19 (**8017**)	1.75 (**8018**)
Combination Wyes, Tees	EA	0.84 (**8019**)	0.95 (**8020**)	1.26 (**8021**)	1.89 (**8022**)	2.38 (**8023**)	2.42 (**8024**)
Reducing Wyes, Tees/Combination	EA	0.77 (**8025**)	0.84 (**8026**)	1.16 (**8027**)	1.75 (**8028**)	2.31 (**8029**)	2.73 (**8030**)
1-1/4 to 1-1/2 to 2 Tees, Tapped	EA	0.42 (**8031**)	0.49 (**8032**)	0.63 (**8033**)	0.95 (**8034**)	1.00 (**8035**)	1.75 (**8036**)
Crosses, Tapped	EA	0.84 (**8037**)	0.95 (**8038**)	1.26 (**8039**)	1.89 (**8040**)	2.42 (**8041**)	4.69 (**8042**)
Reducers	EA	0.77 (**8043**)	0.84 (**8044**)	1.16 (**8045**)	1.68 (**8046**)	2.17 (**8047**)	4.59 (**8048**)
Plugs, Clean-out Traps, Closet Bends	EA	0.42 (**8049**)	0.49 (**8050**)	0.63 (**8051**)	0.95 (**5052**)	1.19 (**8053**)	1.75 (**8054**)

SUGGESTED CREW SIZE: Three to six UTs

NOTES:
1. Lifting equipment will be required on larger sizes.
2. Straping and securing included in Man-Hour estimate.

TABLE 4-122. Install Types K, L, and M Copper Pipe with Cast or Wrought Fittings
(In Man-Hours)

ITEM	Unit	1/8 - 1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	2-1/2"	3"	3-1/2"	4"
Adapters, Caps	EA	.25 (**8055**)	.28 (**8056**)	.41 (**8057**)	.64 (**8058**)	.74 (**8059**)	.98 (**8060**)	1.31 (**8061**)	1.74 (**8062**)	1.90 (**8063**)	2.40 (**8064**)
Couplings Elbows	EA	.41 (**8065**)	.47 (**8066**)	.65 (**8067**)	1.00 (**8068**)	1.25 (**8069**)	1.67 (**8070**)	2.23 (**8071**)	2.98 (**8072**)	3.20 (**8073**)	3.28 (**8074**)
Tees	EA	.62 (**8075**)	.71 (**8076**)	.98 (**8077**)	1.61 (**8078**)	1.88 (**8079**)	2.50 (**8080**)	3.35 (**8081**)	4.47 (**8082**)	4.92 (**8083**)	5.14 (**8084**)
Unions	EA	.46 (**8085**)	.53 (**8086**)	.74 (**8087**)	1.17 (**8088**)	1.37 (**8089**)	1.82 (**8090**)	2.43 (**8091**)	3.23 (**8092**)	3.55 (**8093**)	3.73 (**8094**)
Valves, Solder	EA	.56 (**8095**)	.62 (**8096**)	.88 (**8097**)	1.29 (**8098**)	1.55 (**8099**)	2.26 (**8100**)	2.98 (**8101**)	3.88 (**8102**)	4.62 (**8103**)	4.92 (**8104**)
Pipe and Tubin	FT	.022 (**8105**)	.025 (**8106**)	0.28 (**8107**)	.040 (**8108**)	.043 (**8109**)	.043 (**8110**)	.047 (**8111**)	.065 (**8112**)	.074 (**8113**)	0.149 (**8114**)

SUGGESTED CREW SIZE: Two to eight UTs

NOTES:
1. Use **1.15** multiplier for silver solder joints.
2. Use **1.1** multiplier for overall tasking for straping and securing.

TABLE 4-123. Install Threaded or Flanged Steel Pipe

(In Man-Hours)

Item	Unit	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	3"	4"	6"
Pipe	FT	0.07 (**8119**)	0.07 (**8120**)	0.09 (**8121**)	0.10 (**8122**)	0.10 (**8123**)	0.12 (**8124**)	0.16 (**8125**)	0.19 (**8126**)	0.28 (**8127**)
Elbows, Couplings, Reducers	EA	0.45 (**8128**)	0.57 (**8129**)	0.69 (**8130**)	0.81 (**8131**)	0.90 (**8132**)	1.01 (**8133**)	1.55 (**8134**)	2.18 (**8135**)	3.31 (**8136**)
Tees	EA	0.67 (**8137**)	0.85 (**8138**)	1.03 (**8139**)	1.21 (**8140**)	1.34 (**8141**)	1.52 (**8142**)	2.33 (**8143**)	3.27 (**8144**)	4.97 (**8145**)
Caps, Plugs, Bushings	EA	0.25 (**8146**)	0.33 (**8147**)	0.37 (**8148**)	0.43 (**8149**)	0.48 (**8150**)	0.54 (**8151**)	0.82 (**8152**)	1.12 (**8153**)	1.72 (**8154**)
Crosses	EA	0.90 (**8155**)	1.13 (**8156**)	1.37 (**8157**)	1.61 (**8158**)	1.79 (**8159**)	2.03 (**8160**)	3.10 (**8161**)	4.36 (**8162**)	6.63 (**8163**)
Nipples	EA	0.09 (**8164**)	0.12 (**8165**)	0.15 (**8166**)	0.18 (**8167**)	0.18 (**8168**)	0.22 (**8169**)	0.34 (**8170**)	0.59 (**8171**)	0.60 (**8172**)
Valves (Screw Type)	EA	0.54 (**8173**)	0.67 (**8174**)	0.82 (**8175**)	0.99 (**8176**)	1.07 (**8177**)	1.19 (**8178**)	1.82 (**8179**)	2.63 (**8180**)	3.99 (**8181**)
Flanges	EA	0.45 (**8182**)	0.45 (**8183**)	0.45 (**8184**)	0.49 (**8185**)	0.49 (**8186**)	0.49 (**8187**)	0.55 (**8188**)	0.90 (**8189**)	0.98 (**8190**)
Unions	EA	0.48 (**8191**)	0.60 (**8192**)	0.72 (**8193**)	0.83 (**8194**)	0.93 (**8195**)	1.04 (**8196**)	1.58 (**8197**)	2.21 (**8198**)	3.34 (**8199**)

SUGGESTED CREW SIZE: Two to six UTs

NOTE: 1. Includes cutting, fitting, installation.

TABLE 4-124. Install Steel Grooved Pipe (Single or Double Groove)

(In Man-Hours)

Pipe Size (Inches)	UNIT	1"	2"	4"	5"	6"	8"	10"	12"	14"	16"	18"
Elbows, Reducers	EA	.16 (**8501**)	.21 (**8502**)	.42 (**8503**)	.60 (**8504**)	.62 (**8505**)	.83 (**8506**)	.96 (**8507**)	1.08 (**8508**)	1.37 (**8509**)	1.58 (**8510**)	1.79 (**8511**)
Tees	EA	.23 (**8512**)	.31 (**8513**)	.62 (**8514**)	.90 (**8515**)	.94 (**8516**)	1.25 (**8517**)	1.44 (**8518**)	1.62 (**8519**)	2.03 (**8520**)	2.37 (**8521**)	2.68 (**8522**)
Adapters	EA	.13 (**8523**)	.16 (**8524**)	.40 (**8525**)	.59 (**8526**)	.61 (**8527**)	.66 (**8528**)	.77 (**8529**)	.98 (**8530**)	1.16 (**8531**)	1.34 (**8532**)	1.48 (**8533**)
Crosses	EA	.29 (**8534**)	.39 (**8535**)	.80 (**8536**)	1.10 (**8537**)	1.19 (**8538**)	1.59 (**8539**)	1.84 (**8540**)	2.06 (**8541**)	2.59 (**8542**)	3.01 (**8543**)	3.39 (**8544**)
Valves	EA	.16 (**8545**)	.21 (**8546**)	.42 (**8547**)	.60 (**8548**)	.63 (**8549**)	.83 (**8550**)	.96 (**8551**)	1.08 (**8552**)	1.29 (**8553**)	1.58 (**8554**)	1.79 (**8555**)
Couplings (77)	EA	.08 (**8556**)	.10 (**8557**)	.21 (**8558**)	.30 (**8559**)	.31 (**8560**)	.42 (**8561**)	.48 (**8562**)	.54 (**8563**)	.68 (**8564**)	.79 (**8565**)	.89 (**8566**)
Couplings (780/81)	EA	.06 (**8567**)	.07 (**8568**)	.16 (**8569**)	.23 (**8570**)	.24 (**8571**)	.31 (**8572**)	.36 (**8573**)	.40 (**8574**)	.51 (**8575**)	.59 (**8576**)	.66 (**8577**)
Wyes	EA	.24 (**8578**)	.35 (**8579**)	.60 (**8580**)	.88 (**8581**)	.90 (**8582**)	1.19 (**8583**)	1.38 (**8584**)	1.51 (**8585**)	1.91 (**8586**)	2.21 (**8587**)	2.52 (**8588**)

SUGGESTED CREW SIZE: Two to four UTs

NOTES:
1. Lifting equipment will be required on larger sized (12 inches and above.)
2. Time includes placing and leveling.

TABLE 4-125. Install CPVC/PVC Solvent Welded Pipe and Fittings (Schedule 40)

(In Man-Hours)

Pipe Size (Inches)	Unit	1/2-3/4"	1"	1-1/2"	2"	2-1/2"	3"	4"	6"	8"	10-12"
45-90^0 Els and Couplings	EA	.20 (**8201**)	.20 (**8202**)	.20 (**8203**)	.20 (**8204**)	.30 (**8205**)	0.35 (**8206**)	.40 (**8207**)	.45 (**8208**)	.45 (**8209**)	.50 (**8210**)
Tees	EA	.30 (**8211**)	.30 (**8212**)	.30 (**8213**)	.30 (**8214**)	.35 (**8215**)	.40 (**8216**)	.55 (**8217**)	.60 (**8218**)	.60 (**8219**)	.65 (**8220**)
Adapters	EA	.22 (**8221**)	.22 (**8222**)	.22 (**8223**)	.22 (**8224**)	.43 (**8225**)	.53 (**8226**)	.65 (**8227**)	.65 (**8228**)	.70 (**8229**)	.75 (**8230**)
Unions	EA	.28 (**8231**)	.28 (**8232**)	.28 (**8233**)	.28 (**8234**)	.33 (**8235**)	.40 (**8236**)	.40 (**8237**)	.45 (**8238**)	.45 (**8239**)	.50 (**8240**)
Flanges	EA	.15 (**8241**)	.15 (**8242**)	.15 (**8243**)	.15 (**8244**)	.20 (**8245**)	.20 (**8246**)	.25 (**8247**)	.30 (**8248**)	.30 (**8249**)	.35 (**8250**)
Bolt-Up	EA	.30 (**8251**)	.30 (**8252**)	.30 (**8253**)	.33 (**8254**)	.37 (**8255**)	.37 (**8256**)	.60 (**8257**)	.60 (**8258**)	.65 (**8259**)	.70 (**8260**)
Valves	EA	.40 (**8261**)	.40 (**8262**)	.45 (**8263**)	.45 (**8264**)	.45 (**8265**)	.55 (**8266**)	.60 (**8267**)	.65 (**8268**)	.65 (**8269**)	.70 (**8270**)
Pipe	FT	.02 (**8271**)	.03 (**8272**)	.05 (**8273**)	.06 (**8274**)	.07 (**8275**)	.10 (**8276**)	.10 (**8277**)	.13 (**8278**)	.13 (**8279**)	.19 (**8280**)

SUGGESTED CREW SIZE: Two to four UTs

NOTES:
1. Figures include cleaning, applying solvent and drying time, installation of hangers and supports.
2. PVC Solvent will not work with CPVC. Each must have their own solvent cement.
3. For Schedule 80 pipe use **1**.5 multiplier.

TABLE 4-126. Install Concrete Pipe

Work Element Description	Unit	Man-Hours Per Unit
12-Inch Diameter	FT	.2 (**8291**)
18-Inch Diameter	FT	.34 (**8292**)
24-Inch Diameter	FT	.46 (**8293**)
30-Inch Diameter	FT	.80 (**8294**)
36-Inch Diameter	FT	1.0 (**8295**)
48-Inch Diameter	FT	1.17 (**8296**)

SUGGESTED CREW SIZE: Four to eight UTs

NOTES:
1. Lifting equipment required for all sizes of concrete pipe.
2. Man-hours estimates for manholes or catch basins based on making tie into existing manholes or catch basins.
3. Types of cement pipe joins: concrete, oakum, mortar, and speed seal.

TABLE 4-127. Install Pipe Insulation and Lagging

Work Element Description	Unit	Man-Hours Per Unit
Install Magnesia Covering:		
1-1/2 inch and smaller	FT	0.30 (**8297**)
2 inch to 3 inch	FT	0.35 (**8298**)
3-1/2 inch to 4 inch	FT	0.40 (**8299**)
5 inch to 6 inch	FT	0.45 (**8300**)
Install Fiberglass Covering with Metal:		
1-1/2 inch and smaller	FT	0.30 (**8301**)
2 inch to 3 inch	FT	0.35 (**8302**)
3-1/2 inch to 4 inch	FT	0.40 (**8203**)
4 inch to 6 inch	FT	0.45 (**8304**
6 inch to 8 inch	FT	0.50 (**8305**)
8 inch to 10 inch	FT	0.70 (**8306**)
Install Molded Cork Covering:		
1-1/2 inch and smaller	FT	0.30 (**8307**)
2 inch to 3 inch	FT	0.35 (**8308**)
3-1/2 inch to 4 inch	FT	0.50 (**8309**)

SUGGESTED CREW SIZE: Two to six UTs, depending on pipe size and job scope

NOTE: 1. Work includes the following items: mudding fittings and valves; installing metal lagging; and water proofing valves and fittings.

TABLE 4-128. Finished Plumbing

Work Element Description	Unit	Man-Hours Per Unit
Bathtub	EA	9.0 (**8310**)
Bathtub and Shower	EA	9.0 (**8311**)
Floor Drain (to 4-inch diameter)	EA	2.0 (**8312**)
Grease Trap, Single Cast Iron	EA	6.0 (**8313**)
Kitchen Sink, Single	EA	3.0 (**8314**)
Kitchen Sink, Double	EA	4.0 (**8315**)
Laundry Tubs	EA	5.0 (**8316**)
Lavatory, Wall Hung	EA	3.0 (**8317**)
Lavatory, Pedestal	EA	5.0 (**8318**)
Shower and Stall	EA	5.0 (**8319**)
Service Sink, Slop Sink	EA	6.0 (**8320**)
Urinal, Wall Hung	EA	2.5 (**8321**)
Urinal, Pedestal or Floor	EA	3.0 (**8322**)
Water Closet and Tank	EA	3.0 (**8323**)
Water Closet and Tank, Wall Hung	EA	5.0 (**8324**)
Water Heater, Electric:		
Plumbing only 40-60 gals., and Vent	EA	3.0 (**8325**)
Drinking Fountains, Wall Hung or Floor Mounted	EA	3.0 (**8326**)
Test (per fixture)	EA	0.75 (**8327**)

SUGGESTED CREW SIZE: One to two UTs

NOTE: 1. Work includes setting and connecting all supply piping, plumbing fixtures and trim.

TABLE 4-129. Install Compressed Air System

Work Element Description	Unit	Man-Hours Per Unit
Supply Piping		
1/2 inch	FT	0.07 (**8328**)
1/4 inch	FT	0.07 (**8329**)
1 inch	FT	0.09 (**8330**)
1-1/2 inch	FT	0.09 (**8331**)
2 inch	FT	0.12 (**8332**)
Valves		
1/2 inch	EA	0.53 (**8333**)
3/4 inch	EA	0.67 (**8334**)
1 inch	EA	0.82 (**8335**)
1-1/2 inch	EA	1.00 (**8336**)
2 inch	EA	1.00 (**8337**)
Hangers, Overhead Wood Joists or Concrete Insert		
1/2 inch	EA	0.50 (**8338**)
3/4 inch	EA	0.50 (**8339**)
1 inch	EA	0.50 (**8340**)
1-1/2 inch	EA	0.60 (**8341**)
2 inch	EA	0.60 (**8342**)
Install Hose Reels	EA	4.00 (**8343**)
Install Electric Driven Compressor Tank		
5 CFM to 20 CFM	EA	11.00 (**8344**)
25 CFM to 50 CFM	EA	14.00 (**8345**)
Install Electric Motor and Compressor on Anchor Bolts		
100 CFM to 250 CFM	EA	24.00 (**8346**)
275 CFM to 500 CFM	EA	47.00 (**8347**)
550 CFM to 750 CFM	EA	60.00 (**8348**)

SUGGESTED CREW SIZE: Two to four UTs, depending on job scope

NOTES:
1. Use **1**.2 multiplier if gas or diesel engines are used.
2. Use **1.1** multiplier for scaffold or ladder work.

TABLE 4-130. Install Fire Protection Systems

Work Element Description	Unit	Man-Hours Per Unit
Riser and Supply Piping, including Valves. (See tables 4-105 or 4-107)		
Sprinkler Heads, including Laterals and Hangers		
Pendant	EA	2.0 (**8349**)
Upright	EA	1.5 (**8350**)
Hose Cabinets, complete with Glass Door, Hose and Nozzle	EA	15.0 (**8351**)
Hose Racks, complete with Nozzle	EA	9.0 (**8352**)
Does not include Electrical Alarm System		

SUGGESTED CREW SIZE: Two to four UTs, depending on scope of job

TABLE 4-131. Install Galley Equipment

Work Element Description	Man-Hours Per Unit
Deep Fat Fryer (Electric0	6.0 (**8353**)
Dishwasher (3HP, 208 Volts, 3PH)	16.0 (**8354**)
Grill (208 Volts)	6.0 (**8355**)
Kittle, 20-60 gals.	12.0 (**8356**)
Oven Bake (Oil Fired)	10.0 (**8357**)
Range (Oil Fired)	10.0 (**8358**)
Refrigerator, 15 CF, and smaller	4.0 (**8359**)
Refrigerator, 20 to 60 CF	8.0 (**8360**)
Steam Talbe	16.0 (**8361**)
Urn (Steam)	8.0 (**8362**)
Work Tables	1.0 (**8363**)
Cooker	8.0 (**8364**)

SUGGESTED CREW SIZE: Two to four UTs, depending on size of equipment and job scope

NOTES:
1. Man-hour estimates include assembly and placing equipment. Figures include traps and strainer, vals and drip legs, relief val, reducing vals.
2. Does not include hard wiring to panel.

TABLE 4-132. Install Warm Air Furnaces

Work Element Description	Unit	Man-Hours Per Unit
Set and Connect Warm Air Furnaces Complete (less Duct, Diffusers, and Hard Wiring)		
100,000 BTU and smaller	EA	17.0 (**8365**)
105,000 BTU to 145,000 BTU	EA	36.0 (**8366**)
145,000 BTU to 280,000 BTU	EA	56.0 (**8367**)
450,000 BTU to 750,000 BTU	EA	109.0 (**8368**)
1,000,000 BTU to 2,000,000 BTU	EA	159.0 (**8369**)
Fuel Oil Storage Tanks Set on Floor		
275 to 500 GL	EA	15.0 (**8370**)
1,000 to 2,000 GL	EA	28.0 (**8371**)
5,000 GL	EA	55.0 (**8372**)

SUGGESTED CREW SIZE: Two to four UTs, depending on size of equipment and job scope

NOTES:
1. Man-hour figures include the positioning and connecting of units complete with fans, filters, safety controls, and light oil burners.
2. Man-hour figures for installation of fuel storage tanks set on floors includes supports, saddles, coatings, and fittings.

TABLE 4-133. Install Heating Boilers, Expansion Tanks, and Hot Water Storage Heaters (Heat Exchangers)

Work Element Description	Unit	Man-Hours Per Unit
Set and connect Iron Sectional Boilers with Insulating Jacket and Safety Devices		
95,000 BTU/Hr. and smaller	EA	21.0 (**8373**)
100,000 to 250,000 BTU/Hr.	EA	29.0 (**8374**)
260,000 to 450,000 BTU/Hr.	EA	43.0 (**8375**)
500,000 to 750,000 BTU/Hr.	EA	60.0 (**8376**)
800,000 to 1,000,000 BTU/Hr.	EA	90.0 (**8377**)
1,050,000 to 1,500,000 BTU/Hr.	EA	127.0 (**8378**)
Set and connect Expansion Tanks		
50 GL and smaller	EA	8.0 (**8379**)
55 to 100 GL	EA	13.0 (**8380**)
Set and connect Hot Water Storage Heaters		
80 GL and smaller	EA	12.0 (**8381**)
81 to 150 GL	EA	17.0 (**8382**)
151 to 300 GL	EA	33.0 (**8383**)

SUGGESTED CREW SIZE: Two to four UTs, depending on equipment size and job scope. Two EOs required for larger equipment item placement

NOTES:
1. Mechanical or powered lifting equipment required for larger items.
2. Piping and electrical systems not included in man-hour figures.
3. For steel packed boilers use 0.8 multiplier.

TABLE 4-134. Duct Sheet Metal and Fiberglass

Work Element Description	Unit	Man-Hours Per Unit
Fabricate Sheet Metal Duct		
20-inch to 94-inch perimeter	FT	0.340 (**8384**)
96-inch to 126-inch perimeter	FT	0.650 (**8385**)
128-inch to 190-inch perimeter	FT	0.980 (**8386**)
192-inch to 240-inch perimeter	FT	1.220 (**8387**)
242-inch to 360-inch perimeter	FT	1.490 (**8388**)
Install Sheet Metal Duct (rectangular)		
20-inch to 94-inch perimeter	FT	0.420 (**8389**)
96-inch to 126-inch perimeter	FT	0.700 (**8390**)
128-inch to 190-inch perimeter	FT	1.440 (**8391**)
192-inch to 240-inch perimeter	FT	2.000 (**8392**)
242-inch to 360-inch perimeter	FT	2.640 (**8393**)
Install Sheet Metal Duct (round)		
20-inch to 94-inch perimiter	FT	0.525 (**8407**)
94-inch to 126-inch perimiter	FT	0.875 (**8408**)
127-inch to 190-inch perimiter	FT	1.8 (**8409**)
191-inch to 240-inch perimiter	FT	2.5 (**8410**)
241-inch to 360-inch perimiter	FT	3.3 (**8411**)
Insulate Sheet Metal Duct	FT	0.060 (**8394**)
Install Fibre Duct for Slab Heating or Cooling System		
6-inch inside diameter	FT	0.020 (**8395**)
8-inch inside diameter	FT	0.022 (**8396**)
10-inch inside diameter	FT	0.022 (**8397**)
12-inch inside diameter	FT	0.025 (**8398**)
16-inch inside diameter	FT	0.032 (**8399**)
20-inch inside diameter	FT	0.042 (**8400**)
24-inch inside diameter	FT	0.060 (**8401**)
Fabrication	FT	0.280 (**8402**)
Installation includes Hangers, does not include Grills and Registers		
Grills and Registers (Plaster Ground)		
4 inch X 8 inch	EA	0.030 (**8403**)
6 inch X 12 inch	EA	0.090 (**8404**)
16 inch X 16 inch	EA	0.100 (**8405**)
20 inch X 36 inch	EA	0.130 (**8406**)

SUGGESTED CREW SIZE: Two to six SWs, depending on job scope

NOTES:
1. Fabrication is to be performed in the sheet metal shop.
2. Time for grills and registers will vary according to type of materials used in ceilings and walls.
3. Installation of fiberglass duct will vary with manufacturer.

TABLE 4-135. Install Air Conditioners, Dehumidifiers, and Refrigerators

Work Element Description	Unit	Man-Hours Per Unit
Install Window Type Air Conditioners		
1/2 to 3/4 ton	EA	3.0 (**8413**)
1 to 1-1/2 ton	EA	5.0 (**8414**)
2 ton	EA	7.0 (**8415**)
Install Self-Contained Air Conditioning Units		
3 to 5 ton	EA	24.0 (**8416**)
5 to 8 ton	EA	32.0 (**8417**)
10 to 15 ton	EA	48.0 (**8418**)
Install Air Conditioning Equipment		
25 ton system	EA	240.0 (**8419**)
26 to 50 ton system	EA	384.0 (**8420**)
51 to 785 ton system	EA	560.0 (**8421**)
76 to 100 ton system	EA	840.0 (**8422**)
Set and Connect Dehumidifiers (per CUBIC FOOT of space)	CF	0.002 (**8423**)
Heat Pumps, Air-to-Air Split Systems		
2 ton cooling - 8.5 MBH heating	EA	20.0 (**8424**)
5 ton cooling - 27 MBH heating	EA	47.0 (**8425**)
7 ton cooling - 33 MBH heating	EA	79.0 (**8426**)
10 ton cooling - 50 MBH heating	EA	94.0 (**8427**)
15 ton cooling - 64 MBH heating	EA	137.0 (**8428**)
40 ton cooling - 193 MBH heating	EA	397.0 (**8429**)
Heat Pumps, Air-to-Air Single Package		
2 ton cooling - 6.5 MBH heating	EA	20.0 (**8430**)
4 ton cooling - 13 MBH heating	EA	23.0 (**8431**)
7 ton cooling - 35 MBH heating	EA	59.0 (**8432**)
15 ton cooling - 56 MBH heating	EA	117.0 (**8433**)
Water Chillers, Reciprocating Air Cooled		
20 ton	EA	143.0 (**8434**)
40 ton	EA	191.0 (**8435**)
65 ton	EA	340.0 (**8436**)
100 ton	EA	477.0 (**8437**)
Water Chillers, Water Cooled		
20 ton	EA	131.0 (**8438**)
50 ton	EA	226.0 (**8439**)
100 ton	EA	397.0 (**8440**)
140 ton	EA	529.0 (**8441**)
Erect and Connect Walk-In Refrigerators		
150 CF	EA	6.0 (**8442**)
600 CF	EA	42.0 (**8443**)
1800 CF	EA	50.0 (**8444**)
4000 CF	EA	92.0 (**8445**)
Testing		
Self contain unit (A/c, Heat Pump, Refrigirator up to 200 CF)	EA	2.0 (**8446**)
Unit 1/2-15 ton	EA	8.0 (**8447**)
Unit 15-25 ton	EA	12.0 (**8448**)
Unit 26-50 ton	EA	16..0 (**8449**)
Unit 51-75 ton	EA	24.0 (**8450**)
Unit 76-100 ton	EA	32.0 (**8451**)

SUGGESTED CREW SIZE: Two to six UTs

NOTES:
1. Man-hour figures setting and connecting all equipment except remote coils or units
2. Man-hour figures do not include the installation of piping or electrical between various pieces of equipment, installation of ductwork or diffusers, curbs, or slabs.

TABLE 4-136. Refrigerant Recovery

Work Element Description	Unit	Man-Hours Per Unit
Recover Refrigerant		
1/2 to 3/4 ton	TN	1.00 (**8461**)
1 to 1-1/2 ton	TN	1.50 (**8462**)
2 ton	TN	2.25 (**8463**)
Retrofit to Non-CFC Refrigerant		
1/2 to 3/4 ton unit	EA	4.00 (**8471**)
1 to 1-1/2 ton unit	EA	7.00 (**8472**)
2 to 3 ton unit	EA	12.00 (**8473**)
3-1/2 to 5 ton unit	EA	16.00 (**8474**)
5-1/2 to 8 ton unit	EA	22.00 (**8475**)
8-1/2 to 12 ton unit	EA	30.00 (**8476**)

NOTES:
1. Man-hour figures may vary by ambient temperature and capacity of recovery unit.
2. Retrofit figures include four-step process: (a) Recover refrigerant; (b) Empty oil; (c) Change filter/drier to XH7/9; (d) Fill new oil; (e) Evacuate system; (f) Recharge non-CFC refrigerant.
3. Repeat steps four times.

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DIVISION 16. ELECTRICAL CONSTRUCTION

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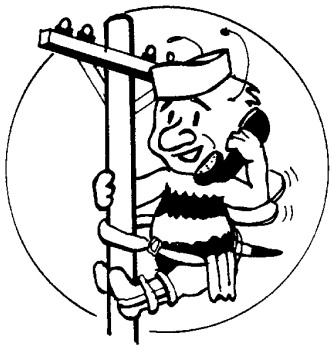

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TABLE 4-137. Electrical Line Work: General Information on Setting Poles

Pole Length in Feet	Unit	Line Truck Man-Hours	Crane Man-Hours	Pike-Method Man-Hours
20 to 35	EA	3.2 (**9001**)	3.2 (**9002**)	6.4 (**9003**)
40 to 50	EA	4.0 (**9004**)	4.0 (**9005**)	
55 to 60	EA	4.0 (**9006**)	4.0 (**9007**)	
65 to 80	EA	6.3 (**9008**)	4.8 (**9009**)	

SUGGESTED CREW SIZE: Line Truck Method: Four CEs
Crane Method: Four CEs
Pike Pole Method: Eight CEs

NOTES:
1. Time for setting poles includes backfilling and tamping.
2. Man-hours based on normal working conditions and average terrain.
3. Use **1.1** multiplier for framing.

TABLE 4-138. Digging Pole and Anchor Holes: General Information

Pole Holes Depth in Feet	Hand Digging Man-Hours per Hole	Hand Digging Man-Hours per Hole	Machine Digging Man-Hours per Hole	Machine Digging Man-Hours per Hole
	In Soil	In Rock	In Soil	In Rock
4	0.8 (**9010**)	4.0 (**9011**)	0.5 (**9012**)	1.0 (**9013**)
5	0.8 (**9014**)	4.8 (**9015**)	0.5 (**9016**)	1.0 (**9017**)
6	1.6 (**9018**)	5.6 (**9019**)	0.5 (**9020**)	1.2 (**9021**)
7	1.6 (**9022**)	6.4 (**9023**)	0.6 (**9024**)	1.2 (**9025**)
8	1.6 (**9026**)	7.2 (**9027**)	0.6 (**9028**)	1.6 (**9029**)

Anchor Holes Depth in Feet	In Soil	In Rock	In Soil	In Rock
4	0.8 (**9030**)	4.0 (**9031**)	0.5 (**9032**)	1.0 (**9033**)
6	1.6 (**9034**)	5.6 (**9035**)	0.5 (**9036**)	1.2 (**9037**)
8	1.6 (**9038**)	7.2 (**9039**)	0.5 (**9040**)	1.6 (**9041**)

SUGGESTED CREW SIZE: Hand Digging Operations: Two CEs
Power Digging Operations: One EO; Auger truck: Two CEs

NOTES:
1. Times for anchor holes includes backfill, tamping, and securing tail of guy.
2. Times for machine digging include setting up machine.
3. When using power installed screw anchor machines, Use **0.5** multiplier.
4. Pole hole depth is determined by:
Length of pole, in feet, divided by 10; plus 1 foot for rock or 2 feet for dirt; equals Depth of Hole.

TABLE 4-139. Overhead Primary and Secondary Conductors and Devices

Work Element Description	Unit	Man-Hours Per Unit
Cross Assembly (standard 8 FT arm)		
Single Arm	EA	4.0 (**9042**)
Double Arm	EA	5.6 (**9043**)
Install Guys (common grade seven strand)		
Down Guys	EA	4.0 (**9044**)
Head Guys	EA	6.4 (**9045**)
Construct H-Frame and Install Three Phase Transformer Bank	EA	132.0 (**4046**)
String Primary Conductors		
AWG #6 to AWG #1 Bare Copper	FT	0.016 (**9047**)
AWG #0 to AWG #0000 Bare Copper	FT	0.0232 (**9048**)
Larger than AWG #0000 Bare Copper	FT	0.0328 (**9049**)
Install Transformer on Poles		
Single Transformer 10 to 75 kVA	EA	12.0 (**9050**)
Three Single-Phase Transformer 10 to 75 kVA	Bank	16.0 (**9051**)
Install Secondary Racks	EA	2.4 (**9052**)
Install Secondary Conductors and Service Drops		
AWG #4 and Smaller: Four wire, weatherproof	FT	0.053 (**9053**)
AWG #2 to AWG #0: Four wire, weatherproof	FT	0.069 (**9054**)
Install Voltage Regulators		
25 kVA, Single Phase, Pole Mounted	EA	17.6 (**9055**)
75 to 125 kVA, Three Phase, Slab Mounted	EA	81.6 (**9056**)
Capacitor Units, Pole Mounted, Factory Preassembled, All kVA ratings	EA	16.8 (**9057**)
Install Primary Protective Devices		
Pole Top Air Break Switches, Three Pole	EA	43.2 (**9058**)
Enclosed-Fused Disconnect Switch	EA	8.0 (**9059**)
Open-Fused Disconnect Switch	EA	8.0 (**9060**)

SUGGESTED CREW SIZE:
Single Cross Assembly Installation: Two CEs (one lineman, one groundman)
Install Wire Guys: Three CEs (two linemen, one groundman)
H-Frame: Six CEs (four linemen, two groundmen)
String Primary Conductors: Ten CEs (four linemen, six groundmen)
Install Transformers on Poles: Four CEs (two linemen, two groundmen)
Install Secondary Conductors and Service: Two CEs (one linemen, one groundman)
Double Arm Installation: Three CEs (two linemen, one groundman)
Install Primary Protective Devices: Four CEs (two linemen, two groundmen
Capacitor Units: Three CEs (two linemen, one groundman)
Install Voltage Regulators: Three CEs (two linemen, one groundman)
Install Secondary Racks: Two CEs (one lineman, one groundman)

NOTE: 1. Crossarm Assembly figures are based on work being done before pole is set. If work must be done after pole is set, use 1.15 multiplier.
2. When using Bucket Truck use 0.85 multiplier.

TABLE 4-140. Street and Security Lighting

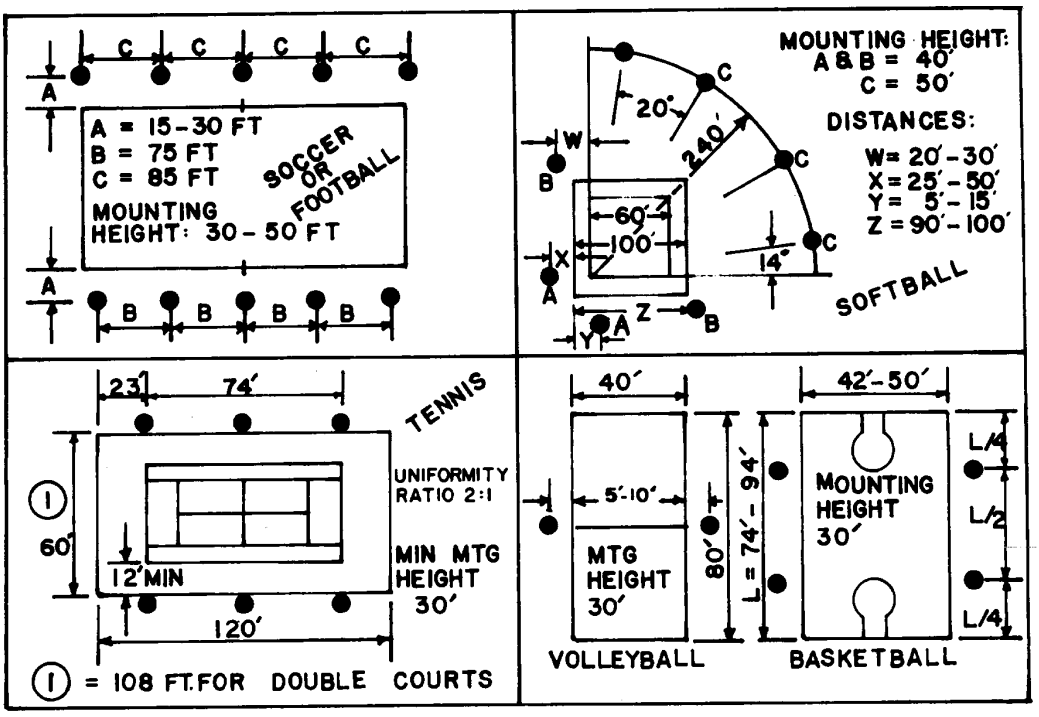
Work Element Description	Unit	Man-Hours Per Unit
Install Foundations for Metal Standards[1]	EA	12.0 (**9061**)
Install Metal Light Standards (30 FT)[2]		
Aluminum Standard	EA	11.2 (**9062**)
Steel Standard	EA	12.0 (**9063**)
Install Wooden Street Light Pole[3]	EA	11.2 (**9064**)
Install Wooden Floodlight Pole (Two Floods)	EA	9.6 (**9065**)
String One Conductor for Series Lighting[4]	FT	0.0208 (**9066**)
Connect Streetlight Floodlight to Power[5]	EA	4.8 (**9067**)
Install Lighting Transformer	EA	12.0 (**9068**)
Install Constant Current Regulator and Control Devices for Street Lighting		
Installed in Vault	EA	6.4 (**9069**)
Installed on Pole	EA	8.0 (**9070**)

SUGGESTED CREW SIZES:
Install Foundations for Metal Standards: One CE
Install Metal Light Standards: Two CEs, one EO with crane
Install Streetlight/Floodlight Pole: Two CEs
String One Conductor for Series Lighting: Two CEs
Connect Streetlight/Floodlight to Power: Two CEs

NOTES:

1. CE work includes approximately 10 feet of 2-inch rigid steel conduit and pull box.
2. Assembly and wiring performed on the ground.
3. Work is the same as Overhead Power Construction. If light is to be added to existing pole.
4. Work is approximately the same as Overhead Power Construction. Use 30 percent of primary conductors Man-hours for series circuits. Secondary installation of floodlights is the same as secondary conductors and service drops.
5. Work does not include installation of power source.
6. Refer to table 4-126 for man-hours figures for excavating and burial of power cables.
7. To install foundations for metal standards, increase crew size to include one BU.

TABLE 4-141. Athletic Facility Lighting



SUGGESTED CREW SIZE: Refer to the various tables listed below for specific construction tasks.

Dig Pole and Anchor Holes: . . . . . Table 4-122
Frame, Set, and Guy Poles: . . . . . Table 4-121
Install Transformers: . . . . . Table 4-123
Install Overhead Wiring: . . . . . Table 4-123
Install Underground Wiring: . . . . . Table 4-126
Install Disconnect Switches and Related Hardware: . . . . . Table 4-123
Install, Connect, and Aim Floodlights: . . . . . Table 4-124

NOTES:

1. Use IES Type 5 (70^0 to 100^0) or IES Type 6 (100^0 to 130^0) beam spread floodlights in all applications. High Pressure Sodium or Mercury Vapor floodlights with high power factor ballasts are preferred.
2. All calculations of man-hours are determined from other tables in this manual.
3. Lighting requirements for various athletic facilities are:

Football (Class IV or V) and Soccer		20 Footcandles
Softball, semi-pro:	Infield	30 Footcandles
	Outfield	20 Footcandles
Tennis (Club Play)		20 Footcandles
Volleyball and Basketball (Recreational)		10 Footcandles

TABLE 4-142. Underground Power System

Work Element Description	Unit	Man-Hours Per Unit
Excavate Trench for Duct or Direct Burial of Cable		
Hard Excavating	CD	13.6 (**9071**)
Machine Excavating	FT	0.011 (**9072**)
Install 4-Inch Transite Duct[2]		
Two Conduits without Concrete	FT	0.051 (**9073**)
Encasement		
Four Conduits without Concrete	FT	0.085 (**9074**)
Two Conduits Encased in 3-Inch Concrete	FT	0.08 (**9075**)
Four Conduits Encased in 3-Inch Concrete	FT	0.072 (**9076**)
Install Direct Burial Cable in Trench		
Up to AWG #0. Three Conductor	FT	0.086 (**9077**)
AWG #00 to 500 MCM. Three Conductor	FT	0.179 (**9078**)
Pull Cable into Duct		
AWG #6. Three Conductor	FT	0.058 (**9079**)
AWG #2. Three Conductor	FT	0.11 (**9080**)
AWG #0000. Three Conductor	FT	0.178 (**9081**)
Underground Service to Building [3]		
AWG #2. Four Conductor	FT	0.144 (**9082**)
AWG #0. Four Conductor	FT	0.224 (**9083**)

SUGGESTED CREW SIZE:
Trench Excavation: Two EOs with ditching machine; Two CEs
Installing Duct: Six CEs
Installing Underground Service: Three CEs

NOTES:
1. All excavating is figured on average soil conditions.
2. Duct man-hour figures allow for a normal number of bends, bells, fittings, and installing pull line.
3. Work includes setting up cable reel, measuring and cutting to length, pulling cable into building and identifying conductors.
4. Direct burial cable in trench requires sand bed.
5. Concrete encasement under roadway requires reinforcing steel (include one SW).
6. When using mechanical-cable puller use 0.85 multiplier.

TABLE 4-143. Electrical Rough-In (Housing and Barracks)

Work Element Description	Unit	Man-Hours Per Unit
Install Service Main, Four-Wire Conductor[1]		
60 Ampere	EA	11.2 (**9084**)
100 Ampere	EA	13.8 (**9085**)
200 Ampere	EA	15.2 (**9086**)
400 Ampere	EA	19.2 (**9087**)
Install Rigid Steel Conduit[2]		
½ inch to 3/4 inch	FT	0.16 (**9088**)
1 inch to 1-1/2 inch	FT	0.2 (**9089**)
2 inch to 3 inch	FT	0.304 (**9090**)
3-1/2 inch to 4 inch	FT	0.352 (**9091**)
Install Thinwall (EMT) and Flexible Conduit[3]		
½ inch to 3/4 inch	FT	0.072 (**9092**)
1 inch to 1-1/2 inch	FT	0.096 (**9093**)
2 inch to 2-1/2 inch	FT	0.136 (**9000**)
3 inch to 4 inch	FT	0.192 (**9094**)
Install 8 FT Ground Rod and Ground Wire	EA	2.4 (**9095**)
Install Type NM Cable[4]		
AWG #10/3 with Ground and Smaller	FT	0.026 (**9096**)
AWG #8/2 with Ground and Larger	FT	0.056 (**9097**)
Install Boxes for Type NM Cable[5]	EA	0.32 (**9098**)
Install Pull Boxes[6]		
12 X 12 X 6 Inches, NEMA Type 1	EA	2.4 (**9099**)
16 X 20 X 8 Inches, NEMA Type 1	EA	3.2 (**9100**)
24 X 36 X 8 Inches, NEMA Type 1	EA	4.8 (**9101**)
6 X 6 X 6 Inches, NEMA Type 3R and 4	EA	2.4 (**9102**)
10 X 6 X 6 Inches, NEMA Type 3R and 4	EA	4.8 (**9103**)
16 X 16 X 6 Inches, NEMA Type 3R and 4	EA	7.2 (**9104**)
24 X 18 X 8 Inches, NEMA Type 3R and 4	EA	12.0 (**9105**)
Pull Wire In Conduit, 3-600 V Conductors #7		
AWG #12	FT	0.009 (**9106**)
AWG #10	FT	0.01 (**9107**)
AWG #8	FT	0.12 (**9108**)
AWG #6	FT	0.16 (**9109**)
AWG #4	FT	0.21 (**9110**)
AWG #1	FT	0.33 (**9111**)
AWG #1/0	FT	0.39 (**9112**)
AWG #2/0	FT	0.43 (**9113**)
AWG #3/0	FT	0.49 (**9114**)
AWG #4/0	FT	0.58 (**9115**)
AWG #350 MCM	FT	0.78 (**9116**)
AWG #500 MCM	FT	0.96 (**9117**)

SUGGESTED CREW SIZE: Three CEs

NOTES:
1. Use 1.25 multiplier for underground service.
2. For installation in concrete slabs increase use 0.5 multiplier. For intermediate Metal Conduit (MC) use 0.75 multiplier.
3. For installation on concrete increase use 0.9 multiplier.
4. Surface Mounted on wood or behind wall or ceiling.
5. Plastic or metal boxes on wood surface or behind wall or in ceiling.
6. Includes attaching conduit to pull box.
7. Time includes reel set-up and removal.

TABLE 4-144. Electrical Finish and Trim (Housing and Barracks)

Work Element Description	Unit	Man-Hours Per Unit
Install Receptacles and Plates		
Duplex Convenience Outlets	EA	0.4 (**9118**)
Range and Dryer Receptacles	EA	1.6 (**9119**)
Install Standard Grade Toggle Switches and Plates		
Single Pole	EA	0.32 (**9120**)
Three or Four Way	EA	0.4 (**9121**)
Install Incandescent Lighting Fixtures up to 150 Watt. Medium Base		
Surface Mounted	EA	1.6 (**9122**)
Flush Mounted	EA	1.6 (**9123**)
Porcelain Lampholder	EA	0.32 (**9124**)
Install Fluorescent Lighting Fixtures[1]	EA	2.4 (**9125**)
Install Fluorescent Tubes and Diffusers	EA	1.6 (**9126**)
Connect Small Appliances:		
Water Heater (80 gal. capacity)	EA	3.2 (**9127**)
Space Heater (2000 watts)	EA	1.6 (**9128**)
Air Conditioning Units (up to 18000 BTU)	EA	4.0 (**9129**)
Exhaust Fans	EA	4.8 (**9130**)
Testing:		
Receptacles, Switches, Lighting Fixtures	EA	0.08 (**9260**)
Small Appliances	EA	0.4 (**9261**)

SUGGESTED CREW SIZE: Two CEs

NOTE: 1. Two or four tube, surface, stem, or chain mounted on wood or masonry. Commercial industrial, residential: normal high output or power groove type.

TABLE 4-145. Electrical Rough-In (Industrial)

Work Element Description	Unit	Man-Hours Per Unit
Install Safety Switch, Three Pole, General or Heavy Duty[3]		
30 Ampere	EA	2.4 (**9131**)
60 Ampere	EA	3.2 (**9132**)
100 Ampere	EA	4.0 (**9133**)
225 Ampere	EA	7.2 (**9134**)
400 Ampere	EA	11.2 (**9135**)
600 Ampere	EA	17.6 (**9136**)
Install Circuit Breakers, Enclosed, NEMA Type 1, 600 Volt, Three Pole		
30 Ampere	EA	2.4 (**9137**)
60 Ampere	EA	3.2 (**9138**)
100 Ampere	EA	4.8 (**9139**)
225 Ampere	EA	6.4 (**9140**)
400 Ampere	EA	11.2 (**9141**)
600 Ampere	EA	17.6 (**9142**)
Install Panel Boards, Lighting, and Power Four-Wire, Three-Phase, 100 to 225 Ampere Main Lugs		
12 Circuits or less	EA	9.6 (**9143**)
13 to 20 Circuits	EA	16.0 (**9144**)
21 to 24 Circuits	EA	17.6 (**9145**)
25 to 30 Circuits	EA	20.0 (**9146**)
31 to 36 Circuits	EA	23.2 (**9147**)
37 to 42 Circuits	EA	26.4 (**9148**)
Install Wireway, 5-Ft. Length, Screw Cover with Fittings and Supports		
4 Inches X 4 Inches	FT	0.32 (**9149**)
6 Inches X 6 Inches	FT	0.32 (**9150**)
8 Inches X 8 Inches	FT	0.48 (**9151**)
Install Cable Trays, Ladder Type, Galvanized Steel with Fittings and Supports		
12-Inches Wide	FT	0.248 (**9152**)
18-Inches Wide	FT	0.28 (**9153**)
24-Inches Wide	FT	0.32 (**9154**)

SUGGESTED CREW SIZE: Two CEs

NOTES:
1. For explosion-proof work use **3.0** multiplier.
2. All work estimates based on surface mounting.
3. For aluminum cable trays use **1.05** multiplier.

TABLE 4-146. Conduit Spacings

Spacing in inches between centers of conduits for under slab stub-ups

Conduit Size	½	3/4	1	1-1/4	1-1/2	2	2-1/2	3	3-1/2	4	4-1/2	5	6
½	1-3/8	___	___	___	___	___	___	___	___	___	___	___	___
3/4	1-1/2	1-5/8	---	___	___	___	___	___	___	___	___	___	___
1	1-3/4	1-7/8	2	___	___	___	___	___	___	___	___	___	___
1-1/4	2	2-1/8	2-1/4	2-1/2	___	___	___	___	___	___	___	___	___
1-1/2	2-1/8	2-1/4	2-3/8	2-5/8	2-3/4	___	___	___	___	___	___	___	___
2	2-3/8	2-1/2	2-3/4	3	3-1/8	3	___	___	___	___	___	___	___
2-1/2	2-5/8	2-3/4	3	3-1/4	3-3/8	3-5/8	4	___	___	___	___	___	___
3	3	3-1/8	3-3/8	3-5/8	3-3/4	4	4-3/8	4-3/4	___	___	___	___	___
3-1/2	3-3/8	3-1/2	3-5/8	3-7/8	4	4-3/8	4-5/8	5	5-3/8	___	___	___	___
4	3-3/4	3-7/8	4	4-1/4	4-3/8	4-3/4	5	5-3/8	5-5/8	6	___	___	___
4-1/2	4	4-1/8	4-1/4	4-1/2	4-3/4	5	5-1/4	5-5/8	6	6-1/4	6-1/2	___	___
5	4-3/8	4-1/2	4-5/8	4-7/8	5	5-3/8	5-5/8	6	6-1/4	6-5/8	7	7-1/4	___
6	5	5-1/8	5-1/4	5-1/2	5-5/8	6	6-1/4	6-5/8	7	7-1/4	7-5/8	8	8-5/8

TABLE 4-147. Electrical Finish and Trim (Industrial)

Work Element Description	Unit	Man-Hours Per Unit
Connect Light Equipment (Bench Tools, Table Mounted Galley Equipment)	EA	2.2 (**9155**)
Connect Heavy Equipment (Large Floor Mounted Machines and Galley Equipment)	EA	4.0 (**9156**)
Motor Starters and Controls, Magnetic FVNR with Heaters and Enclosures		
5 HHorsepower Size 0	EA	3.2 (**9157**)
10 Horse power, Size 1	EA	5.6 (**9158**)
25 Horsepower, Size 2	EA	10.4 (**9159**)
50 Horsepower, Size 3	EA	12.8 (**9160**)
100 Horsepower, Size 4	EA	21.6 (9161)
Combination Starters, Magnetic FVNR with Circuit Breaker or Fused Switch and		
Heater	EA	5.6 (**9162**)
5 Horsepower, Size 0	EA	8.0 (**9163**)
10 Horsepower, Size 1	EA	12.0 (**9164**)
25 Horsepower, Size 2	EA	15.2 (**9165**)
50 Horsepower, Size 3	EA	23.2 (**9166**)
100 Horsepower, Size 4		
Control Stations, Heavy Duty		
Start and Stop	EA	0.8 (**9167**)
Start, Stop, and Pilot Light	EA	1.6 (**9168**)
Hand, Off, Automatic	EA	1.6 (**9169**)
Stop, Start, and Reverse	EA	1.6 (**9170**)
Circuit Testing and Balance Three Phase Circuit	EA	1.6 (**9171**)

SUGGESTED CREW SIZE: Two CEs

NOTE: 1. For combination reversing type controls use 1.2 multiplier.

TABLE 4-148. Substation Installation

Work Element Description	Unit	Man-Hours Per Unit
Install and Wire Complete Oil Filled Transformer		
300 kVA and smaller	EA	36.0 (**9172**)
500 kVA	EA	60.0 (**9173**)
750 kVA	EA	63.2 (**9174**)
1000 kVA	EA	95.2 (**9175**)
Install and Wire Complete Three-Phase Dry-Type Air Cooled Transformer in Vault or Building		
Up to 150 kVA	EA	24.8 (**9176**)
151 kVA and larger	EA	45.6 (**9177**)
Install Three-Phase Metal Clad Switch Gear Unit	EA	16.0 (**9178**)
Install Oil Circuit Breakers (OCB)		
100 to 600 Ampere, Single Circuit	EA	8.4 (**9179**)
601 to 1200 Ampere, Single Circuit	EA	24.0 (**9180**)
Install Open or Enclosed Disconnect Switches		
100 Ampere and smaller. Single Circuit	EA	8.8 (**9181**)
150 Ampere and larger. Single Circuit	EA	12.8 (**9182**)
Install Air-Break Switches and Components		
100 to 600 Ampere, Single Pole, Single Throw	EA	8.8 (**9183**)
601 to 1200 Ampere, Single Pole, Single Throw	EA	12.8 (**9184**)
Install Capacitor Bank with Associated Equipment		
3 to 9 Capacitor Bank	EA	27.2 (**9185**)
12 to 24 Capacitor Bank	EA	42.4 (**9186**)

SUGGESTED CREW SIZE: Four CEs (two linemen and two groundmen)

TABLE 4-149. Fire Alarm and Signal Systems

Work Element Description	Unit	Man-Hours Per Unit
Burglar Alarm, Mechanical or Electrical	EA	3.2 (**9187**)
Card Reader, Flush, Standard or Multi-Channel	EA	4.0 (**9188**)
Door Switch, Hinged or Magnetic	EA	2.4 (**9189**)
Exit Control Lock, Horn or Flashing Light	EA	3.2 (**9190**)
Indication Panels		
1 Channel	EA	4.0 (**9191**)
10 Channel	EA	6.4 (**9192**)
70 Channel	EA	14.4 (**9193**)
Ultrasonic Unit with Horn: 12, 24, or 120V	EA	4.8 (**9194**)
Control Panel, Fire, Sprinkler and Stand Pipe		
4 Zone	EA	4.8 (**9195**)
8 Zone	EA	10.4 (**9196**)
12 Zone	EA	15.2 (**9197**)
Battery Rack	EA	3.2 (**9198**)
Automatic Charger	EA	2.4 (**9199**)
Signal Bell, Trouble Buzzer or Manual Station	EA	1.6 (**9200**)
Detector, Rate of Rise or Fixed Temperature	EA	1.6 (**9201**)
Smoke Detector		
Ceiling Type	EA	1.6 (**9202**)
Duct Type	EA	3.2 (**9203**)
Light and Horn	EA	2.4 (**9204**)
Fire Alarm Horn	EA	1.6 (**9205**)
Master Box	EA	4.0 (**9206**)
Break Glass Station	EA	1.6 (**9207**)
Remote Annunciator		
8 Zone Drop	EA	5.6 (**9208**)
12 Zone Drop	EA	7.2 (**9209**)
16 Zone Drop	EA	8.8 (**9210**)
Standpipe or Sprinkler Alarm, Alarm Device	EA	1.6 (**9211**)
Actuation Device	EA	1.6 (**9212**)
Annunciator, Control and Indicator Panel	EA	1.0 (**9213**)
Testing all other devices	5 EA	0.16 (**9214**)

SUGGESTED CREW SIZE: Two CEs

TABLE 4-150. Overhead Telephone Line Construction

Work Element Description	Unit	Man-Hours Per Unit
Install Messenger Suspension Clamps	EA	0.16 (**9252**)
Attach Messenger to Suspension Clamps	FT	0.032 (**9253**)
Splicing Overhead Cable (Straight Splice) Polyethylene Sheath and Insulation. 100 Pair	Splice	5.6 (**9254**)
Terminating Cable at Terminal Box or Main Distribution Frame (Tag Splice) Polyethylene Sheath and Insulation. 100 Pair	Splice	8.0 (**9255**)

SUGGESTED CREW SIZE: Two CEs (one lineman and one groundman)

TABLE 4-151. Interior Telephone Service

Work Element Description	Unit	Man-Hours Per Unit
Pull Cable in Conduit Polyethylene Sheath, 100 Pair	FT	0.4 (**9217**)
Install Exposed Interior Cable, 26 Pair	FT	0.32 (**9218**)
Install Telephone Terminal Box	EA	2.4 (**9219**)
Install Polyethylene Cable Terminal, 26 Pair	EA	1.6 (**9220**)
Connect Terminal Stub to Cable Polyethylene Sheath, 26 Pair	EA	2.4 (**9221**)
Install Telephone, Complete, Any Style, 1 Line	EA	3.2 (**9222**)
Splice Telephone Cable in Building, Vault, or Manhole Polyethylene Sheath	Splice	5.6 (**9223**)
Testing	EA	0.4 (**9224**)

SUGGESTED CREW SIZE: Two CEs

TABLE 4-152. Underground Telephone Line Construction

Work Element Description	Unit	Man-Hours Per Unit
Pull Cable in Duct or Conduit Polyethylene Sheath, 100 Pair	FT	0.032 (**9261**)
Attach Lead of Polyethylene Cable Riser Direct to Concrete Wall	FT	8.0 (**9262**)
Install 1 Inch to 6 Inch Conduit for Riser	FT	8.0 (**9263**)
Pull Riser Cable into Installed Conduit	FT	8.0 (**9264**)

SUGGESTED CREW SIZE: Three CEs

NOTE: 1. Refer to Table 4-17, Division 2, for estimating figures on Trench Excavation.

TABLE 4-153. Installing Intercommunication System

Work Element Description	Unit	Man-Hours Per Unit
Public Address System Conventional		
Office	EA	2.4 (**9228**)
Industrial	EA	4.0 (**9229**)
Sound System		
Speakers, Ceiling or Wall Mounted	EA	1.6 (**9230**)
Speakers, Trumpt	EA	3.2 (**9231**)
Volume Control	EA	1.6 (**9232**)
Amplifier, 250 Watt	EA	9.6 (**9233**)
Cabinets	EA	9.6 (**9234**)
Intercom, Master		
Up to 25 Station Capacity	EA	9.6 (**9235**)
Remote Station	EA	1.6 (**9236**)
Emergency Call System		
12 Zones, Annunciator	EA	11.2 (**9237**)
Bell	EA	1.6 (**9238**)
Light or Relay	EA	1.6 (**9239**)
Transformer	EA	4.0 (**9240**)
House Telephone		
Talking Station	EA	5.6 (**9241**)
Press to Talk, Release to Listen	EA	1.6 (**9242**)
Combination Speaker and Microphone	EA	1.6 (**9243**)
Terminal Box	EA	3.2 (**9244**)
Amplifier or Power Supply	EA	4.8 (**9245**)
Annunciator, Master Intercom, and Amplifier	EA	1.0 (**9246**)
Testing all other devices	EA	0.16 (**9247**)

SUGGESTED CREW SIZE: Three CEs

DIVISION 17. EXPEDITIONARY STRUCTURES

Page

A. TENSION FABRIC STRUCTURES
Table 4-154 Tension Fabric Structures 4-147

B. K - SPAN BUILDINGS
Table 4-155 K - Span Buildings 4-147

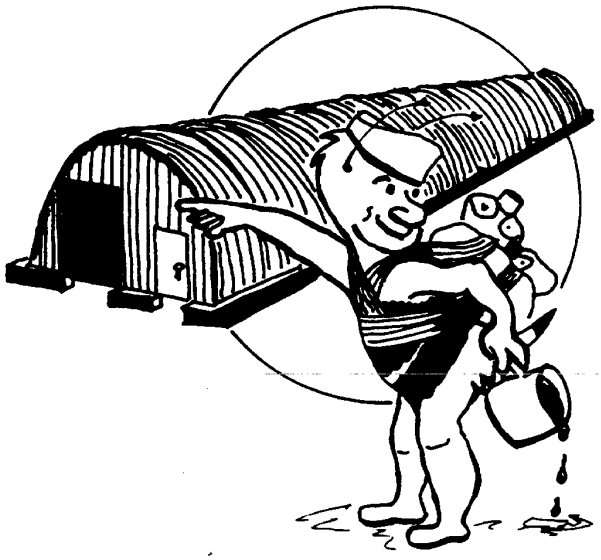


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Table 4-154. Tension Fabric Structures

Frame and Shell Only

Structure		Unit	Manhours
Length (FT)	Width (FT)		
10 - 30	20 - 40	SF	0.42 (**1701**)
31 - 50	41 - 60	SF	0.32 (**1702**)
51 - 100	61 - 120	SF	0.4 (**1703**)
101 - 300+	121 - 200+	SF	0.48 (**1704**)

Suggested Crew Size: One BU1, two SW, Six NS

NOTE: (1) These estimates are for frame and shell only.
(2) Duckbill anchors furnished with basic TFS are for unpaved surface only.
(3) For asphalt and concrete surfaces use expansion type anchors.
(4) Refer to other sections of this P-405 for other estimates.

Table 4-155. K - Span Buildings

MIC-120 MIC-240
Shell and End-Walls Only

Bldg. Width	Unit *Building* Length	Manhours
10 - 50	FT	0.6 (**1705**)
51 - 100+	FT	1.0 (**1706**)

Bldg. Width	Unit *End-Wall* Length	Manhours
10 - 50	FT	1.2 (**1707**)
51 - 100+	FT	2.0 (**1708**)

Suggested Crew Size: One SW MIC-120 MIC-240 certified,
One EO crane certified, Eight NS.

NOTE: (1) This estimate is for shell and end-walls only.
(2) For footings, utilities, and other components refer to other sections of this P-405.

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CHAPTER 5. NETWORK ANALYSIS TECHNIQUES

1. **HISTORY.** Beginning in the post-World War II period, the construction industry found itself under the same critical examination the manufacturing industry had experienced 50 years previously. Large construction projects were coming under the same pressures of time, resources, and cost that had prompted studies in scientific management in factories at the turn of the century.

The emphasis, however, was not on actual building methods, but upon the management techniques of programming and scheduling. The only planning methods were those which had been developed for use in factories, and management attempted to use these for the control of large construction projects. These techniques suffered from serious limitations as far as project work was concerned, and it was the need to overcome these limitations that led to the development of network analysis techniques.

In the late 1950's this new system of project planning, scheduling, and control came into widespread use in the construction industry. Critical Path Analysis (CPA), Critical Path Method (CPM), and Project Evaluation and Review Techniques (PERT) are representative of about 50 titles. The basis of any of these approaches is the Analysis of a Network of Events and Activities. For this reason, the generic title covering the various systems is "**Network Analysis.**"

2. **NETWORK ANALYSIS ADVANTAGES.** The main advantages are listed below.

a. **Separation of Sequence and Time.** Network analysis separates the planning of the sequence of jobs from the scheduling of times for the jobs, thus overcoming simultaneous, and less effective, planning and scheduling.

b. **Job Interdependency.** The interdependencies between jobs are shown and thus it enables people to see not only the overall plan, but the ways in which their own activities depend upon, or influence, those of others.

c. **View Complete Plan.** Network analysis sets out the complete plan for examination by everyone involved in the project, simplifies the task of assessing its soundness, and prevents unrealistic or superficial planning.

d. **Resource and Time Restraints.** Resource and time restraints are shown in the plan before its evaluation. For example, a resource restraint is where several operations use a crane, but only one is available. A minimum delivery period for materials is a time restraint.

e. **Divides Projects into Activities.** The analysis splits up the project into activities, assists in estimating their durations, and leads to a more accurate target date.

f. **Project Duration.** The shortest length of time (duration) in which a project can be completed is determined, based upon the order and relationship of all activities.

g. **Critical Activities Identified**. Critical activities that must start on time to avoid extending the project duration are identified.

h. **Deviation Controls**. Stricter controls are permitted because any deviation from the schedule is quickly noticed.

I. **Requirement Calculations**. The total requirements of men, materials, and equipment resources are allowed to be readily calculated. The delaying or slowing down of noncritical jobs (those not immediately affecting the duration of the project) are indicated and may be used to make the best allowance for any limitations in available resources.

j. **Constant Logic Statement**. The network is a statement of logic and policy and remains constant whether the activities take a longer or shorter time than estimated.

k. **Modification Impact Assessment**. Modifications of policy are allowed to be built in, and the impact of these modifications can be assessed quickly.

l. **Critical Path Identification**. Identification of the critical path is advantageous if the completion date has to be advanced and attention can then be concentrated on speeding up the relatively few "critical" jobs.

m. **Bar Chart Basis**. A more accurate and effective basis for the preparation of bar charts is provided, which results in better control of projects.

3. **NETWORK ANALYSIS DISADVANTAGES**. The only real disadvantage of network analysis as a planning tools is that it is a tedious and exacting task if attempted manually. Depending upon just what the project manager wants as "output," the number of activities that can be handled without a computer varies, but it is never very high.

a. **Manual Calculations**. Calculations are done in terms of the sequence of activities, and if this is all that is required, a project that involves several hundred activities may be attempted manually. However, the possibility of error is high, and if the results are to be "sorted," for instance, by rate (so that all jobs to be undertaken by the builders are together, as those for equipment operators, or electricians), the time of manual operation rapidly becomes costly. The consideration of various alternative plans also becomes impossible, because of the large volumes of calculations involved.

b. **Computer Calculations**. On the other hand, standard computer programs for network analysis can handle project plans of 5,000 activities and more, and produce "output" in various forms. It must be emphasized, however, that a computer only assists with the calculations and prints plans of operations sorted into various orders. The project manager, not the computer, is still responsible for the planning and must still make the necessary decisions based on information supplied by the computer. Equally important is the fact that the computer output is only as accurate as its input, which is supplied in the first instance by human beings.

4. **PROJECT PLANNING.** The basic rules in analyzing a project are that planning and scheduling are considered to be two distinctly separate operations, and that planning must always precede scheduling. When these two are done simultaneously they generally introduce elements of scheduling prematurely, thus clouding the picture of the plan and severely limiting its flexibility. The planning steps most commonly followed in the NCF are listed in *appendix G.*

a. **Project Analysis.** Everyone concerned should know precisely what the project is, its start and end points, external factors such as schedule dates and requirements of others, and availability of resources such as men and equipment.

b. **Activity List Development.** All projects consist of separate but interrelated operations. In network analysis these are called "activities." The first stage in applying this technique is to obtain a list of all activities which constitute the project to be scheduled. This list is obtained in various ways: study of manufacturers' specifications; bills of materials and technical drawings; modification of a previous application; worksheets for a previous project; and a joint discussion by those persons who sufficiently understand the project. The last method should be employed even if a tentative list has been obtained by other means. These are no specific definitions as to what constitutes an "activity," and it is largely a matter for individual interpretation according to the requirement of a particular project. A useful guideline is to ask three questions about any particular activity in the network. (These are simply useful pointers, not infallible rules).

(1) *Would the activity normally be regarded as continuous from start to finish?* This does not mean that it may not prove expedient to split the activity later to facilitate scheduling. The key here is the word "normally."

(2) *Will the required resources remain constant throughout the duration of the activity?* In certain circumstances this may not be achievable but facilitates control if it can be done.

(3) *Is the amount of work involved small enough to allow a reliable duration estimate to be assigned to the activity?*

No attempt should be made to minimize the number of activities in a network by leaving out those considered to be unimportant and to have considerable float. They can easily be forgotten and their omission could lead to an entirely false analysis. A good rule is, don't plan a project in any more detail than is necessary to properly manage the scheduling of the work during the construction phase. The reason for this is to avoid being overwhelmed by a lot of detailed items of work that will change faster then the planner has time to adjust or plan for. For most NCF projects, detailed activities should not be less than one day in duration (preferably not less than three days). One further point to remember; there may be space limitations in the computer for activity descriptions. Each activity should be given a fairly concise title which will identify it in the computer printout.

c. **Network Construction.** A "network" is used to represent any sequencing of priorities among the activities that constitute a project. This sequencing is determined by two types of dependency.

(1) "**Hard**" dependencies are those which are based upon the physical characteristics of the job such as the necessity to place a foundation before building walls. A hard dependency is normally inflexible.

(2) "**Soft**" dependencies are those which are based upon practical considerations of policy and may be changed if circumstances demand. For example, the decision to start at the north end of a building rather than the south.

5. **PRECEDENCE DIAGRAMING.** In constructing networks the NCF uses Precedence Diagraming. A Precedence Network derives its name from the fact that each activity is identified in a computer program in terms of its immediately preceding and succeeding activities. Precedence Diagraming does not require the use of dummy activities, is easier to draw, and has greater applications and advantages when Networks are put into the computer.

a. **Activities and Events Representation.** An activity in a Precedence Diagram is represented by a rectangular box and is identified by an activity number. A typical activity block is shown in *figure 5-1*. The left side of the activity box represents the start of the activity and the right side represents the completion. Lines linking the boxes are called "logic connectors" and the general direction of flow is indicated by arrowheads.

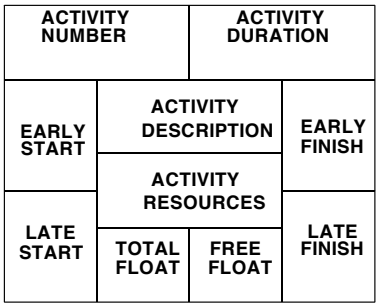


FIGURE 5-1. Typical Activity Block

The rule that governs the drawing of a network is that the start of an activity must be linked to the ends of all completed activities before that start may take place. Activities that take place at the same time are not linked in any way. In *figure 5-2* both activity 2 and activity 3 start as soon as activity 1 is completed. Activity 4 requires the completion of both activities 2 and 3 before it may start. *Figure 5-2* shows a finish to start Logic Relationship. This is the most common relationship used in the NCF.

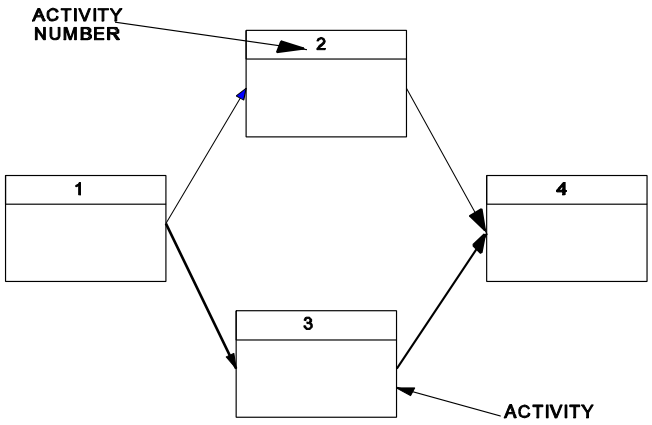


FIGURE 5-2. Precedence Diagram

b. Delay Representation. In certain cases there may be a delay or lag between the finish of one activity and the start of another. In this case the lag may be indicated on the connector itself incased in parenthesis as has been done in *figure 5-3*. Here, activity 3 may start as soon as activity 1 is completed, but activity 2 must wait two days. The "lag" is stated in the basic time units of the project, in which case the word "days" can be omitted.

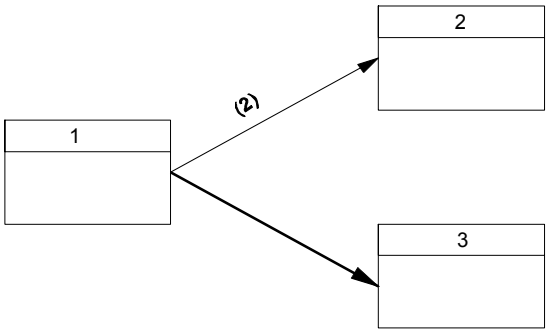


FIGURE 5-3. Representation of Lag

c. **Parallel Activities Representation.** Some activities may parallel other which can be achieved in precedence diagrams without increasing the number of activities. For instance, it is possible to start laying a long pipeline before excavations are complete. This is known as a start-to-start Logic connection, as shown in *figure 5-4*. Activity 3 cannot start until one day after activity 1 has started.

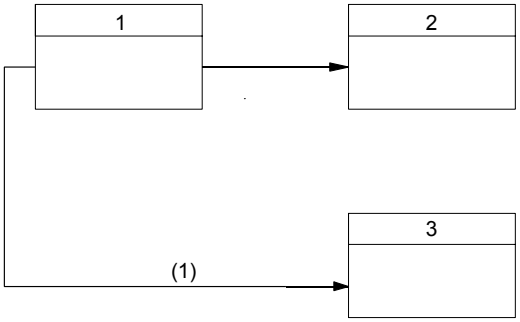


FIGURE 5-4. Start-to-Start Logic Connection

It is also possible to start an activity independently, but not to complete it before another activity is completed. This is known as a finish-to-finish logic connection, as shown in *figure 5-5*. Activity 3 cannot be completed until one day after activity 1 is completed.

Care should be taken in using either of these logic connections. If possible, the Finish-to-Start Connection should be used for all NCF planning.

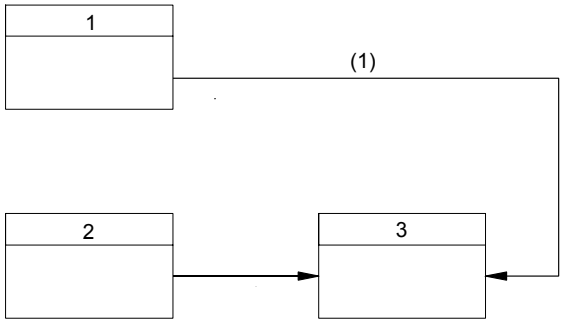


FIGURE 5-5. Finish-to-Finish Logic Connection

6. **PRECEDENCE NETWORK CALCULATIONS.** Precedence networks are the primary project scheduling tools used in the NCF. The scheduling of any construction activity is dependent on the duration of the construction activities that precede it. The forward pass, the backward pass, and float calculations are the basis to form the construction schedule.

a. **Definitions**

(1) **The Forward Pass** determines the Early Start and Early Finish of an activity. The earliest date that an activity can be started and finished based on the durations of activities that precede it. It determines the total project duration based on the sum of the activity durations along the longest path through the project.

Calculations:

Early Start	+	Duration	=	Early Finish
Early Finish	+	Lag (if any)	=	Early Start (of next activity)

NOTE: *With two or more predecessors, use the LARGER of the two Early Finish + Lag dates.*

(2) **The Backward Pass** determines Late Start and Late Finish of an activity. The latest that each activity can start and finish without delaying the total project duration calculated on the Forward Pass.

Calculations:

Late Finish	-	Duration	=	Late Start
Late Start	-	Lag (if any)	=	Late Finish (preceding activity)

NOTE: *With two or more follow-on activities, use the SMALLER of the Late Start - Lag dates.*

(3) **The Critical Path** is those activities whose early start/early finish and late start/late finish dates match. The critical activities form a critical path from the first activity to the last.

(4) **Total Float** is the total number of days an activity can be delayed without delaying the completion date of the project, and allows a crew leader or project supervisor the discretion to start an activity anywhere between the early and late start dates without delaying the completion date of the project.

Calculations:

Total Float = Late Start - Early Start or Late Finish- Early Finish

NOTE: *The total float for critical activities is always zero since the Early and Late Start and Finish dates are the same. Therefore, Total Float is calculated for non-critical activities only.*

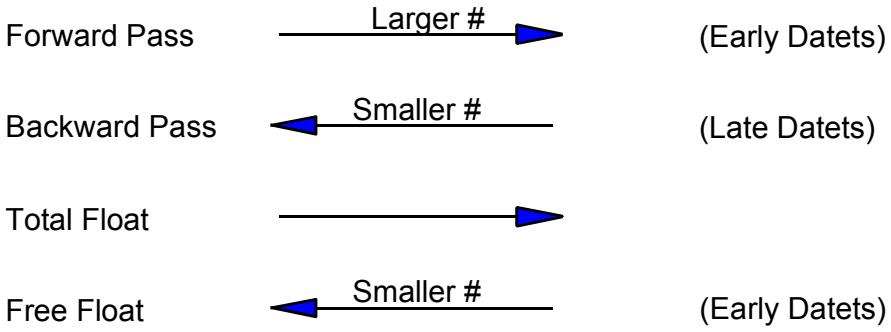
(5) **Free Float** is the number of days an activity can be delayed without delaying the next activity from its Early Start or the number of days of Float that can be used without taking Float from another activity.

All or a portion of the Total Float may be shared with follow-on activities. If Float is not shared with a follow-on activity, it is free. Using Free Float does not take Float away from follow-on activities nor does it delay the next activity from its Early Start date.

Calculations:

Free Float = Early Start (next activity) - Lag (if any) - Early Finish

NOTE: *With two or more follow-on activities use the smaller of the early start - lag.*



b. Calculation Sequence

NOTE: *All the calculations in a. and b. above are based on finish to start logic connectors.*

c. Sample Calculations. *Figures 5-6 through 5-10* show sample calculations. Equations marked with an asterisk (*) change with different types of logic. General Rule: **always follow the logic connector!**

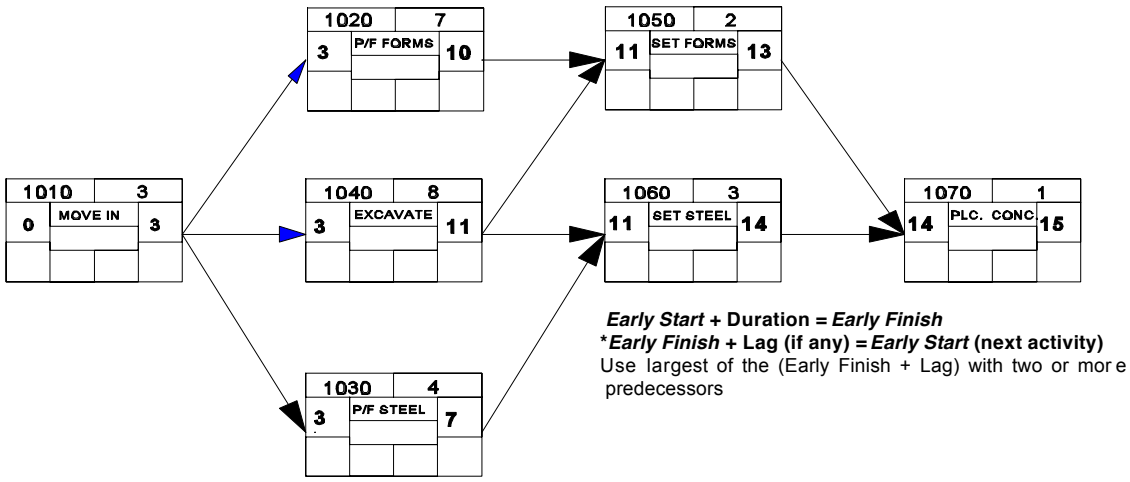


FIGURE 5-6. The Forward Pass

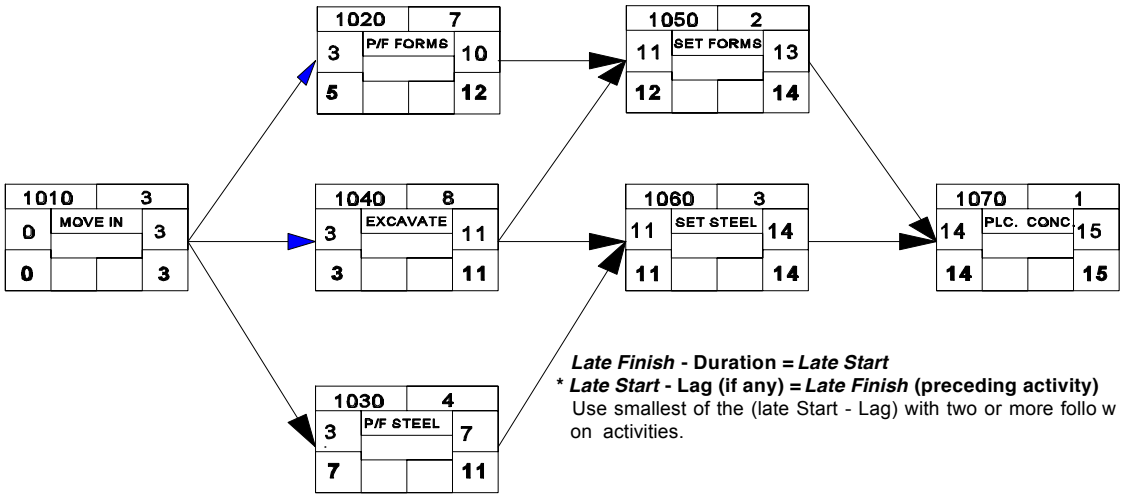


FIGURE 5-7. The Backward Pass

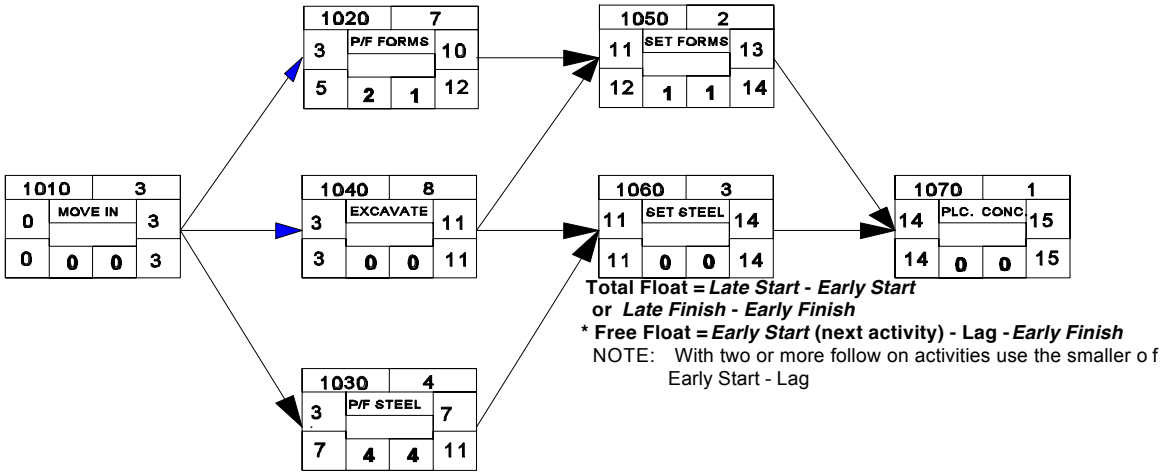


FIGURE 5-8. **Floats**

Equations shown for the following Logic Connections are the ones that change from Finish-to-Start Logic Connection. All other equations remain the same.

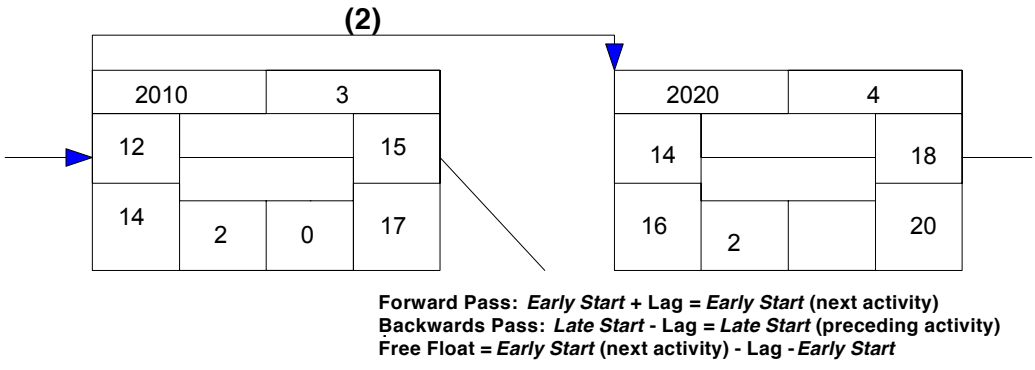


FIGURE 5-9. **Start-to-Start**

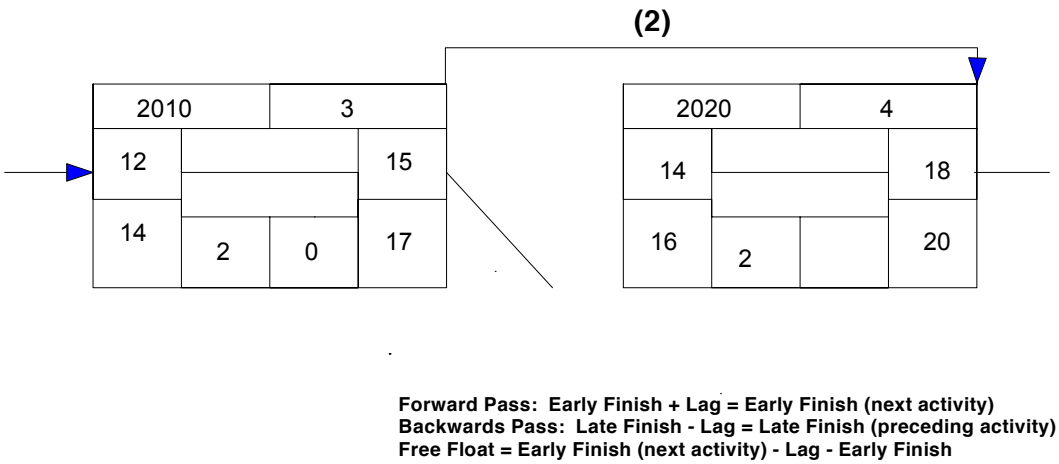


FIGURE 5-10. Finish-to-Finish

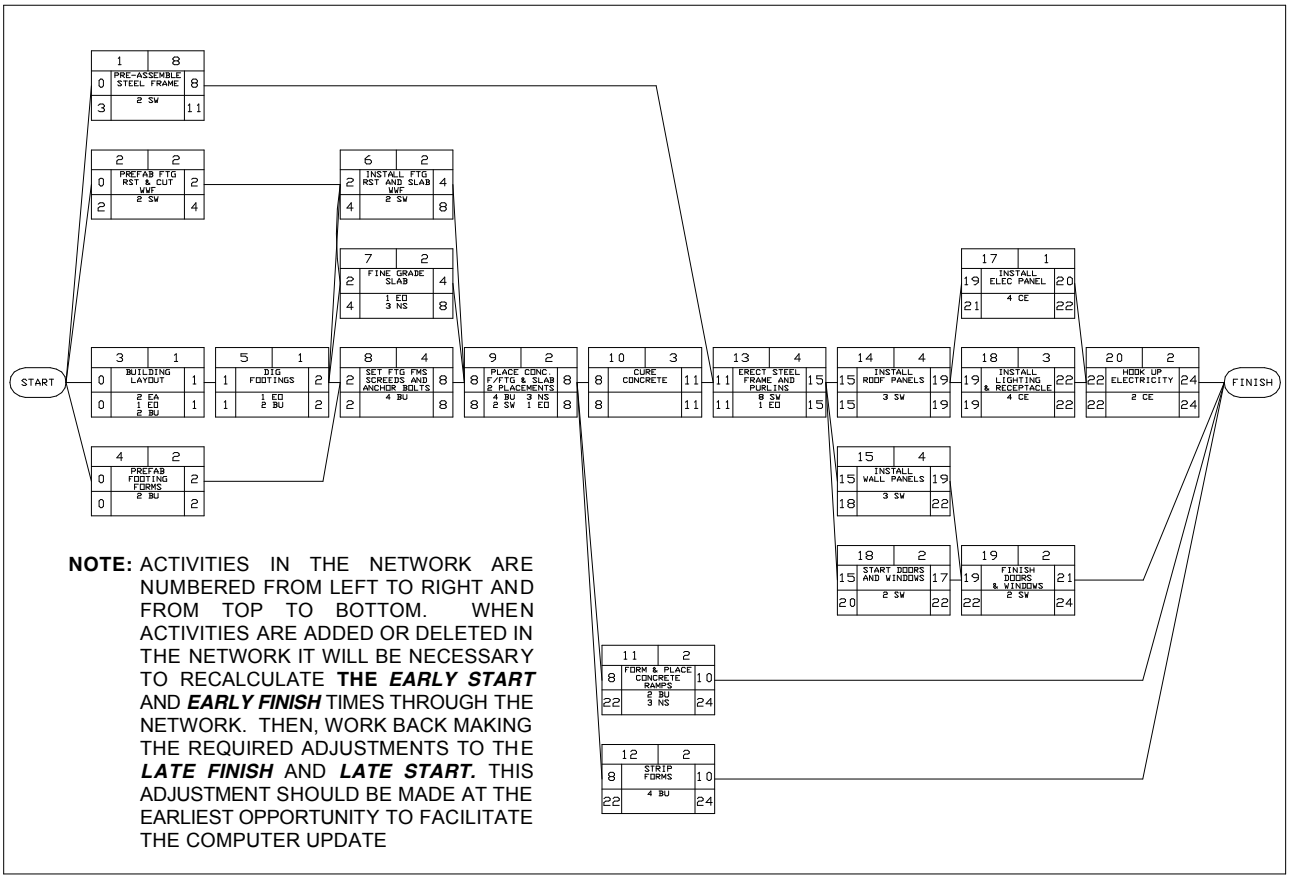


FIGURE 5-11.Typical Precedence Diagram for 40- by 100-foot rigid frame building

7. **COMPUTER USE IN THE NCF.** The usefulness of the computer as a construction management tool for the Naval Construction Force was first tested in September 1976 during the deployment of NMCB-3 to Diego Garcia. The results were encouraging and the decision was made to install a minicomputer system at each of the permanent deployment sites, each homeport regiment, CBLANT, and the Civil Engineer Support Office (CESO). In 1982 the Navy purchased an improved version of the original software package for construction management, CM-5. In 1983 the Seabee Automated Mobile Management (SAMM) system was approved by the Chief of Naval Operations (CNO). CESO procured and distributed over 1,000 microcomputers (also referred to as personal computers or PC) to NCF units. Microtrak replaced CM-5 in 1986. Microtrak is a commercial software package for use with the microcomputer. In 1996 CBCM2 software replaced Microtrack.

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CHAPTER 6. CBCM2 USER MANUAL

THE MANUAL WILL BE INSERTED AT LATER DATE

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GLOSSARY

ABFC	Advanced Base Functional Component
ABS	Acrylonitrile-Butadiene-Styrene (plastic pipe)
ASSY	Assembly
AVG	Average
AWD	Available Work Day
AWG	American Wire Gage
BBL	Barrel
BLDG	Building
BM	Bill of Material
BTU	British Thermal Unit
BU	Builder
CAS	Construction Activity Summary
CE	Construction Electrician
CFM	Cubic Feet per Minute
CM	Construction Mechanic
CMU	Concrete Masonry Unit
CN	Constructionman
CONST	Construction
CPVC	Chlorinated Polyvinyl Chloride (plastic pipe)
C to C	Center to Center
CTR	Central Tool Room
d	Penny (British pence). Size for a nail
DIA	Diameter
DWG	Drawing
EA	Engineering Aid
ELEC	Electric
EMT	Electrical Metal Tubing
EO	Equipment Operator
FEDSTRIP	Federal Standard Requisitioning and Issue Procedures
FY	Fiscal Year
GED	Gasoline-engine Drived
GMA	Gas Metal Arc
GPM	Gallons per Minute
GTA	Gas Tungsten Arc
Horiz	Horizontal
HP	Horsepower
ID	Inside Diameter
Imc	Intermediate Metal Conduit
IN	Inch or N

GLOSSARY

kV	Kilovolt
kVA	Kilovolt-Ampere
LTG	Lighting
LCD	Loose Cubic Yard
MATL	Material
M/D	Man-Days (8 hours)
MILSTRIP	Military Standard Requisitioning and Issue Procedures
MLO	Material Liaison Office
MPH	Miles per Hour
MTO	Material Take Off
NCFSU	Naval Construction Force Support Unit
NS	Non-Skilled
OF-13	Occupational Field 13 (Seabee rates)
PERF	Perforate
PVC	Polyvinyl Chloride (plastic pipe)
PH	Phase
QC	Quality Control
RCPT	Receptical
REBAR	Reinforcing Bar
REINF	Reinforce
RST	Reinforcing Steel
SFCS	Square Feet Contact Surface
SITREPS	Situation Reports
SQ	Square (100 square feet)
SQ IN	Square Inch
SW	Steel Worker
TA	Table of Allowance (same as TOA)
T&G	Tongue and Groove
THKNS	Thickness
TM	Technical Manual
TOA	Table of Allowance
TON MI	Tons per Mile
TPH	Tons per Hour
U/I	Units of Issue
UT	Utilitiesman
W/O	Without
YD MI	Yards per Mile

UNITS OF ISSUE. The designations shown are used to denote the units of issue and should be used on all FEDSTRIP/MILSTRIP requisitions.

AM	Ampoule	LB	Pound
AT	Assortment	LG	Length
AY	Assembly	LI	Liter
BA	Ball	MFBM	1000 Board feet measure
BD	Bundle	MC	Thousand cubic feet
BE	Bale	ME	Meal
BF	Board foot	MR	Mete r
BG	Bag	MX	Thousand
BK	Book	OT	Outfit
BL	Barrel	OZ	Ounce
BO	Bolt	PD	Pad
BR	Bar	PG	Package
BT	Bottle	PM	Plate
BX	Box	PR	Pair
CA	Cartridge	PT	Pint
CB	Carboy	PZ	Packet
CD	Cubic yard	QT	Quart
CE	Cone	RA	Ration
CF	Cubic foot	RL	Reel
CK	Cake	RM	Ream
CL	Coil	RO	Roll
CN	Can	SD	Skid
CO	Container	SE	Set
CT	Carton	SF	Square foot
CY	Cylinder	SH	Sheet
CZ	Cubic meter	SK	Skein
DR	Drum	SL	Spool
DZ	Dozen	SO	Shot
EA	Each	SP	Strip
FT	Foot (feet)	SX	Stick
GL	Gallon	SY	Square yard
GP	Group	TN	Ton
GR	Gross	TO	Troy ounce
HD	Hundred	TU	Tube
HK	Hank	VI	Vial
IN	Inch	YD	Yard
JR	Jar		
KT	Kit		

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APPENDIX A

Work Element Checklist

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WORK ELEMENT CHECKLIST
Arranged in Work Sequence

A. STRUCTURES

Remove existing structures
Clearing and grubbing
Blasting
Grading
Fill, place, and compact
Landscape, seed, sod
Excavation and backfill
Concrete foundations and footings
Pipe sleeves
Under-floor conduit and plumbing
Transformer vault
Grade beams
Ground floor slab
Concrete columns, beams, girders
Concrete floor and roof slabs
Precast wall and roof panels
Precast structural members
Precast sills and lintels
Concrete canopy and entrances
Treads and nosings
Pipe sleeves and openings
Alarm system: burglar, fire
Electric service

Structural steel
Masonry: concrete glock, brick, structural tile
Flashing
Framing floors, walls, roofs, stairs
Sheathing walls and roof
Subflooring
Door bucks and frames: wood
Door bucks and frames: metal
Window frames
Conduit in slabs and walls
Piping in walls
Electrical rough-in
Plumbing rough-in

A. **STRUCTURES** (Continued)

Siding: wood
Siding and roofing: metal
Hoods and ventilators
Insulation, roof

Roofing
Asphalt or wood shingles
Ductwork
Intercom system
Telephone switchboard equipment
Tile flooring: asphalt, rubber, vinyl, cork
Acoustical tile
Interior trim

Handrails
Caulking
Telephone service
wallboard
Lathing
Stairways
Studs and partitions: metal
Insulation, walls, and ceilings
Down spouts and gutters
Fire escape
Ladders
Platforms and catwalks
Roof scuttles
Doors: exterior
Doors: screen
Windows
Window screens
Jalousies
Exterior trim
Glazing
Louvers
Cabinets
Closet units
Lockers
Bulletin boards

A. **STRUCTURES** (Continued)

Mirrors and medicine cabinets
Paneling
Door: interior
Doors: metal
Toilet partitions: metal

Security grills
Plastering
Ceramic tile

Painting
Curbs and walks
Parking areas
Fencing
Cleanup
Air conditioning
Compressed air systems
Dehumidifiers
Dry cleaning equipment
Exhaust fans
Fire protection systems
Generators
Heating system
Laundry equipment
Pumps
Refrigerators
Shop equipment
Ventilation equipment
Galley equipment
Water coolers
Hospital equipment
Electric fixtures
Plumbing fixtures
Finish flooring

B. **OUTSIDE UTILITIES**

Clearing and grubbing
Blasting
Trenching and ditching

B. OUTSIDE UTILITIES (Continued)

Backfill and compact
Erosion control
Water mains
Water service lines
Sanitary sewer mains
Sanitary sewer service lines
Valves
Valve boxes
Manholes
Water storage tanks
Water pumps
Sewage pumps
Storm sewers and manholes
Catch basins
Culverts

Culvert head and wing walls
Sewage treatment plants
Poles
Cable
Transformers
Telephone cable
Underground duct
Conduit risers
Manholes and handholes
Street Lights
Security lights
Control devices
Capacitors and voltage regulators

C. PLANT OPERATIONS

Stripping quarry
Drilling and blasting
Handling and loading quarried material
Hauling to crusher or job
Setting up crusher plant
Operating crusher
Stockpiling crushed material
Hauling crushed material to plants or job

C. PLANT OPERATIONS (continued)

Setting up asphalt plant
Operating asphalt plant
Hauling asphalt to job
Setting up concrete batch plant
Hauling concrete to job
Manufacturing concrete block: all sizes
Manufacturing precast concrete units: all types
Hauling precast units to job
Reinforcing steel fabrication
Manufacturing doors, windows, jalousies, louvers
Manufacturing stairs, cabinets, closet units
Manufacturing concrete pipe

D. ROADS, PAVING, AND WALKS

Clearing and grubbing
Blasting
Cut and fill
Grading
Trenching and ditching
Move and change interfering utilities
Culverts
Head and wing walls
Catch basins
Storm drainage
Prepare base
Fine grading
Erosion control
Asphalt tack coat
Spread and roll asphaltic concrete
Spread and roll chip and gravel coats
Concrete paving forms
Reinforcing steel and dowels
Expansion and contraction joints
Finishing and curing
Concrete curbs complete
Concrete walks complete
Asphalt curbs complete
Asphalt erosion protection
Asphalt walks complete
Precast curbs installed

E. WATERFRONT CONSTRUCTION

Sheet piling
Pile dolphins
Pier piling
Pile capping
Pier capping
Pier framing
Pier decking
Pier deck hardware
Pile extraction
Tiebacks and deadman
Seawalls
Dredging

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APPENDIX B

Equipment and Tool Kit Description

(NMCB TOA-01, TOA-02
Power Tools and Naval Construction Force Support Unit Kits)

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EQUIPMENT AND TOOL KIT DESCRIPTIONS

This appendix contains equipment and tool kit descriptions for those kits found in the Naval Construction Battalion Table of Allowance (NMCB TOA-01). These descriptions are briefs of the kit capabilities and the number of personnel it has been designed to support. Due to frequent updates of kit items, a list of contents is not practical. Kit descriptions are presented by their section and numerical sequence as listed in the NMCB TOA-01 followed by assembly numbers which support the basic capabilities.

A complete list of content, stock numbers, and costs are found in the NMCB TOA-01, or are available from:

Commanding Officer
Code 1571
Naval Construction Battalion Center
1000 23rd Avenue
Port Hueneme, CA 93043-4301

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TABLE OF ALLOWANCE (TA01)

Assembly	Kit Name
80001	Plumbers (for four men)
80002	Plumbers Shop
80003	Tank Erection (for four men)
80004	Gas Cutting and Welding Rig
80005	Service Refrigeration
80006	Electricians Tools (for two men)
80007	Linemans Tools (for two men)
80010	Surveyors Equipment
80011	Draftsman (for three men)
80019	Carpenters Tools (for four men)
80024	Electric Arc Welding Accessories, 300 AMP
80026	Soils
80029	20 X 48 and 40 X 100 Rigid Frame Erection Tools
80042	No-Skive Hose and Crimp Fitting
80078	Hot Line Tools Electrical
80087	Electronic Distance Measuring System
80096	Welding Gas Tungsten Arc
80119	Installation for Concertina Fencing
80125	Saw Filing and Blade Sharpening
80514	Alfa Co. Shops Support Operating Space Items
82001	Saw Chain GED 18N
82002	Set Paving Breaker Tamler Driver/Drill
82011	Wrench Set IMP Pneumatic 1DR SCKTS 3/4 to 3-1/8
82012	Hammer, Scaling, Pneumatic
82015	Drill, Electric Portable, 3/4
82016	Saw, Circular, Portable 7-1/4 Electric
82019	Grinder/Sander, Electric Portable 7N
82020	Wrench Set, IMP, Pneumatic, 1/2 DR. SCKTS with Accessories
82021	Borer, Wood, Pneumatic Port 1-1/4
82023	Saw, Reciprocating, Horizontal, Portable
82025	Hammer, Pneumatic Portable, Nail DR. DD-160 CAxxxxxxxxxx
82026	Hammer, Nail, Pneumatic, 20-60D
82031	Drill, Electric, Portable, 1/2
82033	Hammer, Pneumatic, Portable, Riveting with Chisels
82036	Paving Breaker Set, Portable, Pneumatic, 80 lb.
82038	Saw, Circular, Steel, Concrete, 12N GED
82039	Tamper, Pneumatic, 6N Butt, 48 lb.
82050	Tamper, Vibrating, Portable, Hammer Set, 4.2 HP
83001	Miscellaneous Construction Tools
83002	Miscellaneous "B" Company Equipment
83069	Security Fence Installation (Tool Suplement)
83070	Linemans Supplemental Tools
84000	Miscellaneous Rigging Gear
84007	Well Completion Kit (Water) 1500 Ft.
85100	Portable Scales for Load Planning/Mountout

TABLE OF ALLOWANCE (TA02)

Assembly	Augment Kit Name
80009	Welding GMA
80020	Mason Tools (for four men)
80021	Sheet Metal Tools
80022	Wire Rope Splicing Tools
80028	Quarrying and Demolition Equipment
80032	Drywall Installation Tools
80037	Overhead Power Line Conductor Installation
80038	Plastering Tools (for four men)
80039	Ceramic Tile Tools
80047	Laserplane Surveying System
80051	Pioneer and Rigging Tools
80055	Cast Iron Pipe Installation (for four men)
80056	Concrete Placement
80065	Power Installed Screen Anchor and Accessories
80066	Built-Up Roofing
80088	Power Threading
80097	Arcair Cutting and XXXXXXXXX, Electric
80110	Planning and Estimating (P&E)
80121	Asbestos Removal Protective Clothing Material
80127	Concrete Testing (Supplement Kit 80026)
80128	Asphalt Testing (Supplement Kit 80026)
80140	Conduit Installation, 0.5 to 2N, EMT,IMC Rigid
80141	Conduit Bending, 0.5 to 2N, EMT, 0.5 to 1.5 IMC
80142	Conduit Cutting and Threading, 2.5 to 6N
80143	Conduit Bending, 1.25 to 4N, EMT, IMC, Rigid
80144	Conduit Bending, 1.25 to 4N, One Shot, 2.5
80145	PVC Conduit Installation, 0.5 thru 6N
80146	Knockout for Conduits, 0.5 thru 5n
80147	Vacuum Fishtape System, 0.5 to 6N Conduits
80148	Wire Installation, Light Duty
80149	Wire/Cable Puller, Heavy Duty EMD
82003	Auger Earth GED, Portable
82004	Drill, Pneumatic, Sinker, 55 Lb.
82005	Screed, Vibratory, Concrete, GED, 3 HP
82007	Vibrator, Concrete, Electric Motor Drive, 1 HP, 1N
82008	Finishing Machine, Concrete, Rotary, GED
82009	Spray Paint Outfit with Compressor, 1 Qt.
82013	Saw, Circular, Pneumatic, 12
82017	Saw, Circular, Portable 8-1/4N, Double Insulated
82022	Drivers, Powder Actuated, Low Velocity
82024	Drill, Hand, Portable, 1/2 GED
82032	Wrench Set, IMP, Electrical, 1/2 DR with Accessories
82034	Plane, Electrical, Portable, 2-1/2N
82035	Sander, OSCIL, Electrical, Portable, High Speed

TABLE OF ALLOWANCE (TA02) (Continued)

Assembly	Augment Kit
82037	Sander, Belt, Electrical, Portable, 3N
82040	Door Hanging, with Electric Plane and Router
82041	Mixer, Dual Purpose, Concrete and Mortar, 6CF
82042	Cutter, Rebar, Hydraulic-Electric, 3/4 CAP
82047	Drill, Electric, Portable, 3/8 Heavy Duty, Variable Speed
82051	Rotary Hammer, Electric, for Concrete
82058	Saw, Abrasive, Disc, Masonry, Block/Brick, 20N
82059	Vibrator, Concrete, Electric Motor Driven, 3 HP
82060	Vibrator, Concrete, Pneumatic, 1-3/8N, Round Head
82064	Drill, 3/4N, H/D, REV, with magnetic Base Press
82066	Compressor, 15 CFM, with Hose Kit
82067	Welder, Arc, 300 AMP, Electric Rectifier
82068	Welder Kit, Plastic, Portable, for PVC and ABS
82072	Saw, Radial Arm, Portable, EMD, 15 and 18N
82500	Miscellaneous Electrical Test Equipment
83037	Supplemental Tools, Material, for Peacetime

TABLE OF ALLOWANCE OTHER ASSEMBLIES

Assembly	TA	Miscellaneous Kit Name
80018	TA10	Kit, Plumbers Shop, CBU
80027	TA13/19	Kit, Railroad Tools
80035	TA13/16	Support materials for Line construction
80036	TA13	Kit, Tool, Lead Cable, Splicing F/2 Men
80041	TA13/19	Kit, Heavy Timber Constr. Tools F/4 Men
80046	ABFC	Kit, Snow Removal Tools
80054	TA10	Kit, Materials Testing (Smoke)
80063	TA04	Kit, Construction Tools, Mini
80064	TA04	Kit, Engineering Aid, Mini
80152	TA55/56	Safety Support Equip/Mat'l Stored
81007	TA70	Kit, Misc. Tools, Wrenches, Shovels, Hand
82006	TA10/13/19/29/44	Tamper, Vibrating, Port, 4HP, GED
82010	TA10	Saw, Circular Table and Accessories
82014	TA13	Drill, Pneu, Port 7/8
82018	TA13	Hammer, Mail, Pneu 60D 3/8
82043	TA13/56	Wrench, Elec, Impact 1/2 DR ADJ Torque
82045	TA03/6/9	Driver, Powder Actuated Micro Kit
82049	TA13	Screed Vibratory. Twin Beam, GED 21FT
82073	TA70	Gen. Set,GED,Port.5kW,120V,60HZ,42AMPS
82501	TA29	Misc. Electronics Test Equipment, F/RSA
82502	TA10	Misc. Electronic Test Equipment
82504	TA45/50	100-Man Det Misc. Elec. Test Equip.
83006	TA03	Electricians Equipment and Supplies
83007	TA03	Builders Equipment and Supplies
83008	TA03	Utilitiesman Equipment and Supplied
83009	TA03	Steelworkers Equipment and Supplied
83010	TA03	Surveyors Equipment and Supplies
83014	TA13	Misc. "B" Company Equipment
83023	TA65/66	Carpenter Shop Equipment
83024	TA45/50	100-Man Det Misc. Construction Tools
83035	TA10	Misc. Tools/Equipment
83039	TA65/66	Steel Shop Equipment
83041	TA09	Misc. "B" Company Material for RSA
83043	TA09/13/29	Misc. Construction Tools and Equipment
83044	TA09/13	Misc "A" Company Equipment for RSA
83059	TA19/42	Misc. "B" Company Material
83077	TA10	Misc. Shop Equipment, Bravo Company
83079	TA13	NMCB-Load Bank Gen. Test 5/250 kW
85002	ABFC	Kit, Camp Maint. Tools and Consumables
85003	TA13/63/64	Kit, Valve Reconditioning Tools
85014	TA10/13	Scaffold, Port. 2 inch Aluminum with 8 inch

85017	ABFC	Slings/Rope/Blocks
85018	ABFC	Saw, Woodworking, Circular
85019	ABFC	Saw, Woodworking, Circular and Radial
85025	TA13	Saw, Chain, 36N, GED, 2 Man
85036	ABFC	Rapid Runway Repair Tools F/AM2 Matting
85037	ABFC	Rapid Runway Repair Tools F/Fiber Glass, Reinf.
90006	TA13	Clothing, Desert Support for 100-Men Det.

Assembly	Kit Name
82001	Saw, Chain, GED, 18n
82002	Set Paving Breaker, Tamper DR
82011	Wrench Set, IMP, Pneumatic, 1 DR SCKTS
82012	Hammer, Scaling, Pneumatic
82015	Drill, Electric, Portable, 3/4
82016	Saw, Circular, Portable, 7-1/4N
82019	Grinder/Sander, Electric, Portable, 7
82020	Wrench Set, IMP, Pneumatic, 1/2 DR, SCKT
82021	Borer, Wood, Pneumatic, Portable, 1-1/4
82023	Saw, Reciprocating, Horizontal, P
82025	Hammer, Pneumatic, Portable, Nail DR, 6D-16
82026	Hammer, Pneumatic, Nail 20-60D
82031	Drill, Electrical, Portable, 1/2
82033	Hammer, Pneumatic, Portable Drive
82036	Paving Breaker Set, Portable, Pneumatic, 80 Lb.
82038	Saw, Circular, Steel-Concrete, 12N, GED
82039	Tamper, Pneumatic, 6N Butt, 48 Lb.
82050	Tamper, Vibraaating, Portable, Rammer

NAVAL CONSTRUCTION FORCE SUPPORT UNIT KITS

Assembly	Kit Name
80027	Railroad Tools
80035	Support Materials for Line Construction/Maintenance Vehicle
80036	Tool, Lead Cable Splicing (for two men)
80041	Heavy Timber Construction (for four men)
82006	Tamper, Vibrating, Portable, 4 HP, GED
82014	Drill, Pneumatic, Portable, 7/8
82018	Hammer, Nail, Pneumatic, 60D, 3/8
82043	Wrench, Electric, Impact, 1/2 Drive
82049	Screed, Vibratory, Twinbeam, GED, 21 Ft.
83014	Miscellaneous "B" Company Equipment
83079	NMCB Load Bank Gen. Test 5/250 kW
85003	Valve Reconditioning Tools
85014	Scaffold, Portable, 2-inch Aluminum
85025	Saw, Chain, 36N, GED, (for two men)

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APPENDIX C

Conversion and Waste Factors

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TABLE C-1. Conversion and Waste Factors

Material	Conversion	% Waste
CONCRETE CONSTRUCTION		
Concrete (1:2:4)		
Cement	6.0 SK/CD	10
Fine aggregate	0.6 CD/CD	10
Coarse aggregate	1.0 CD/CD	10
Curing Compound	0.5 GL/100 SF	10
Forms: Footings and Piers		
2 X 4	1.5 FT/SFCS	20
2 X 8	0.2 FT/SFCS	10
2 X 12	0.7 FT/SFCS	5
Forms: Ground Slabs		
1 X 4	0.1 FT/SF area	20
2 X 4	0.1 FT/SF area	5
Forms: Walls and Columns		
2 X 4	1.3 FT/SFCS	20
Plywood (50% reuse)	0.5 SF/SFCS	5
Forms: Beams and Suspension Slabs		
1 X 6	0.3 FT/SFCS	5
2 X 4	0.5 FT/SFCS	20
2 X 10	0.1 FT/SFCS	10
4 X 4	0.4 FT/SFCS	5
4 X 6	0.1 FT/SFCS	5
Plywood	0.5 SF/SFCS	5
Form oil	0.5 GL /100 SF	10
Tie wire	12.0 LB/TN	10
Snap tie wedges	0.1 EA/SFCS	5
Snap ties	0.1 EA/SFCS	5
She bolts	0.1 SE/SFCS	5
Nails (bf lumber + sf plywood, ordered as mfbm)		
6d box	6 LB/MFBM	10
8d common	4 LB/MFBM	10
16d common	6 LB/MFBM	10
20d common	2 LB/MFBM	10
6d duplex	4 LB/MFBM	10
8d duplex	9 LB/MFBM	10
16d duplex	9 LB/MFBM	10
Trim		
6d finish	7 LB/1000 FT	10
8d finish	14 LB/1000 FT	10

TABLE C-1. Conversion and Waste Factors (Continued)

Material	Conversion	% Waste
CONCRETE CONSTRUCTION(Continued)		
Reinforcing Steel		
#3	0.4 LB/FT	10
#4	0.7 LB/FT	10
#5	1.0 LB/FT	10
#6	1.5 LB/FT	10
#7	2.0 LB/FT	10
#8	2.7 LB/FT	10
Lumber		
Framing	____	15
Sheathing	____	25
Flooring	____	25
Roofing	____	25
Wallboard	____	15
Trim	____	10
STEEL ERECTION		
Rivets	25 EA/TN	10
Bolts (field)		
Temporary	5 EA/TN	5
Permanent	25 EA/TN	5
Sheet Metal	____	10
ROOFING		
Corrugated Steel (6-inch end lap)		
26-inch width	115 SF/SQ	10
27.5-inch width	122 SF/SQ	15
Wood Shingles		
16 inch (4-inch exposure)	900 EA/SQ	15
18 inch (6-inch exposure)	600 EA/SQ	15
24 inch (8-inch exposure)	450 EA/SQ	15
Nails (4d)	4 LB/1000 shingles	15
Built-Up Roofing (4 ply)		
Sheathing paper	1 SQ/SQ	20
Felt	4 SQ/SQ	20
Pitch	125 LB/SQ	10
Gavel	400 LB/SQ	10

TABLE C-1. Conversion and Waste Factors (Continued)

Material	Conversion	% Waste
TILING		
Floor Tile		
Asphalt, vinyl, asbestos	____	10
Primer	5 GL/1000 SF	20
Adhesive	10 GL/1000 SF	20
Cleaner	5 GL/1000 SF	20
Wax	5 GL/1000 SF	20
Acoustic Tile		
Tile	____	10
Cement	25 GL/1000 SF	20
GLASS AND GLAZING		
Glass		
8 X 12	75 panes/BX	10
10 X 16	45 panes/BX	10
12 X 20	30 panes/BX	10
14 X 24	22 panes/BX	10
16 X 28	16 panes/BX	10
Glazing Clips	____	10
Putty		
8 X 12	0.6 LB/pane	20
10 X 16	0.8 LB/pane	20
12 X 20	0.9 LB/pane	20
14 X 24	1.1 LB/pane	20
16 X 28	1.4 LB/pane	20
CAULKING		
Primer	2 GL/1000 FT	10
Compound (1/2 X 1/2)	13 GL/1000 FT	10
PAINTING		
Metal		
Enamel	0.2 GL/100 SF	10
Zinc white	0.2 GL/100 SF	10
White lead	0.2 GL/100 SF	10

TABLE C-1. Conversion and Waste Factors (Continued)

Material	Conversion	% Waste
PAINTING (Continued)		
Wood		
Enamel	0.2 GL/100 SF	10
Zinc white	0.2 GL/100 SF	10
White lead	0.3 GL/100 SF	10
Varnish	0.2 GL/100 SF	10
Flat	0.2 GL/100 SF	10
Gloss	0.3 GL/100 SF	10
Brick, Concrete, Plaster		
Enamel	0.2 GL/100 SF	10
Zinc white	0.3 GL/100 SF	10
White lead	0.4 GL/100 SF	10
Varnish	0.2 GL/100 SF	10
Flat	0.3 GL/100 SF	10
Gloss	0.4 GL/100 SF	10
Size	0.3 GL/100 SF	10
Primer	0.3 GL/100 SF	10
Calcimine	0.4 GL/100 SF	10
PLUMBING		
Pipe		
Cast iron	FT	10
Clay, vitrified	FT	10
Plastic	FT	10
Wrought iron, G.V., B.I.	FT	10
Copper	FT	10
Grooved steel (invasion)	FT	10
Fittings		
Cast iron		
2 inch and smaller	EA	10
6 inch and smaller	EA	10
8 inch and smaller	EA	5
Clay and Concrete		
4 inch to 10 inch	EA	10
12 inch to 24 inch	EA	5
Plastic	EA	10
Wrought iron	EA	10
Copper	EA	10
Grooved steel	EA	5

TABLE C-1. Conversion and Waste Factors (Continued)

Material	Conversion	% Waste
PLUMBING (Continued)		
Valves		
Globe and gate		
2 inch and smaller	EA	5
2-1/2 inch and larger	EA	3
Check		
2 inch and smaller	EA	3
2-1/2 inch and larger	EA	2
Special applications	EA	0
Solder, Soft	1 LB/100 joints	10
Copper fittings		
3/8 inch	0.5 LB	
1/2 inch	0.75 LB	
3/4 inch	1.0 LB	
1 inch	1.25 LB	
1-1/4 inch	1.7 LB	
1-1/2 inch	1.8 LB	
2 inch	2.4 LB	
2-1/2 inch	3.2 LB	
3 inch	3.9 LB	
3-1/2 inch	4.5 LB	
4 inch	5.5 LB	
Solder, Hard		
Hard solder requirements equal 75% of soft per individual size 100 joints.		
Flux		
Soft solder	10 LB/100 LB	10
Silver braze (hard)	7.5 LB/75 LB	2
Lead and Oakum		
Joint size	LB/joint	
2 inch	2 LB	
3 inch	3 LB	
4 inch	4 LB	
5 inch	5 LB	
6 inch	6 LB	
Oakum	1 LB per 5 LB lead	0

TABLE C-1. Conversion and Waste Factors (Continued)

Material	Conversion	% Waste
ELECTRICAL		
Conduit	FT	5
Wire	FT	10
Fittings	EA	5
STEEL		
Bolts (field)		
Temporary	5 EA/TN	5
Permanent	25 EA/TN	5
Rivets (field)	25 EA/TN	10
Sheet		
Galvanized sheet	____	10
Copper sheet	____	10
Aluminum	____	10
Black iron	____	10
Electrode, Mild Steel, Carbon, and Stainless	1 LB/FT	
1/8 inch thickness	0.064	
3/16 inch thickness	0.113	
1/4 inch thickness	0.158	
5/16 inch thickness	0.232	
3/8 inch thickness	0.345	
1/2 inch thickness	0.581	
5/8 inch thickness	0.874	
3/4 inch thickness	1.395	
1 inch thickness	2.148	
NOTE: Above figures are for fillets, butt, and groove welds with no backing strips.		

APPENDIX D

Conversion Factors for English to Metric System

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TABLE D-1. Conversion Factors for English to Metric System

Basic Metric Length Relationships

One Unit Equals	Millimeters	Centimeters	Meters	Kilometers
Millimeter (mm)	1.0	0.1	0.001	0.000,001
Centimeter (cm)	10.0	1.0	0.01	0.000,01
Meters (m)	1,000.0	100.0	1.0	0.001
Kilometer (km)	1,000,000.0	100,000.0	1,000.0	1.000

Length Conversion Tables for English to Metric System

inches	centimeters	feet	meters	yards	miles	kilometers
1	0.62	1.61	1.09	.091	3.28	0.30	0.39	2.54
2	1.24	3.22	2.19	1.83	6.56	0.61	0.79	5.08
3	1.86	4.83	3.28	2.74	9.84	0.91	1.18	7.62
4	2.49	6.44	4.37	3.66	13.12	1.22	1.57	10.16
5	3.11	8.05	5.47	4.57	16.40	1.52	1.97	12.79
6	3.73	9.66	6.56	5.49	19.68	1.83	2.36	15.24
7	4.35	11.27	7.66	6.40	22.97	2.13	2.76	17.73
8	4.97	12.87	8.75	7.32	26.25	2.44	3.15	20.32
9	5.59	14.48	9.84	8.23	29.53	2.74	3.54	22.86
10	6.21	16.09	10.94	9.14	32.81	3.05	3.93	25.40
20	12.43	32.19	21.87	18.29	65.62	6.10	7.87	50.80
30	18.64	48.28	32.31	27.43	98.42	9.14	11.81	76.20
40	24.85	64.37	43.74	36.58	131.23	12.19	15.75	101.60
50	31.07	80.47	54.68	45.72	164.04	16.24	19.68	127.00
60	37.28	96.56	65.62	54.86	196.85	18.29	23.62	152.40
70	43.50	112.65	76.55	64.00	229.66	21.34	27.56	177.80
80	49.71	128.75	87.49	73.15	262.47	24.38	31.50	203..20
90	55.92	144.34	98.42	82.80	295.28	27..43	35.43	228.60
100	62.14	160.94	109.36	91.44	328.08	30.48	39.37	254.00

*Example: 3 yards = 2.74 meters, 3 feet = 0.91 meeters, 3 meters = 3.28 yards

Fractions of an Inch

Inch	1/16	1/8	3/16	1/4	5/12	3/8	7/16	½
Centimeters	0.16	0.32	0.48	0.64	0.79	0.95	1.11	1.27

Inch	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1
Centimeters	1.43	1.59	1.75	1.91	2.06	2.22	2.36	2.54

Units of Centimeters

Centimeters	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Inches	0.04	0.08	0.12	0.16	0.20	0.24	0.28	0.31	0.35	0.39

TABLE D-1. Conversion Factors for English to Metric System (Continued)

Basic Metric Weight Relationships

One Unit Equals	Grams	Kilograms	Metric Ton
Gram (gm)	1.0	0.0001	0.000,001
Kilogram (kg)	1,000.0	1.000	0.001
Metric ton	1,000,000.0	1,000.000	1.000

Weight(1) Conversion Tables for English to Metric Systems

ounces----------grams
grams----------ounces
pounds----------
kilograms
kilograms----------pounds
short----------metric
ton(2)----------ton
metric----------short
ton(3)----------ton

1	1.10	.91	2.20	0.46	0.04	28.4
2	2.20	1.81	4.41	0.91	0.07	56.7
3	3.31	2.72	6.61	1.36	0.11	85.0
4	4.41	3.63	8.82	1.81	0.14	113.4
5	5.51	4.54	11.02	2.67	0.18	141.8
6	6.61	5.44	13.23	2.72	0.21	170.1
7	7.72	6.35	15.43	3.18	0.25	198.4
8	8.82	7.26	17.64	3.63	0.28	226.8
9	9.92	8.16	19.84	4.08	0.32	255.2
10	11.02	9.07	22.05	4.54	0.35	283.5
20	22.05	18.14	44.09	9.07	0.71	567.0
30	33.07	27.22	66.14	13.61	1.06	850.5
40	44.09	36.29	88.18	18.14	1.41	1134.0
50	55.12	45.36	110.23	22.68	1.76	1417.5
60	66.14	54.43	132.28	27.22	2.12	1701.0
70	77.16	63.50	154.32	31.75	2.47	1984.5
80	88.18	72.57	176.37	36.29	2.82	2268.0
90	99.21	81.65	188.42	40.82	3.17	2551.5
100	110.20	90.72	220.46	45.36	3.53	2835.0

*Example: Convert 28 pounds to kilograms
28 pounds = 20 pounds + 8 pounds
From the tables: 20 pounds = 9.07 kg, and 8 pounds = 3.63 kg
Therefore: 28 pounds = 9.07 kg + 3.63 kg = 12.70 kg

[1]The weights used for the English system are avoirdupois (common) weights.
[2]The short tone is 2,000 pounds
[3]The metric ton is 1,000 kg.

TABLE D-1. Conversion Factors for English to Metric System (Continued)

Volume Conversion Tables for English to Metric System

CU. FEET	CU. YARDS	CU. METERS	CU. YARDS	CU. FEET	CU. METERS
	CU. METERS		CU. FEET	CU. YARDS	
1	0.037	0.028	27.0	0.76	35.3	1.31
2	0.074	0.057	54.0	1.53	70.6	2.62
3	0.111	0.085	81.0	2.29	105.9	3.92
4	0.148	0.113	108.0	3.06	141.3	5.23
5	0.185	0.142	135.0	3.82	176.6	6.54
6	0.212	0.170	162.0	4.59	211.9	7.85
7	0.259	0.198	189.0	5.35	247.2	9.16
8	0.296	0.227	216.0	6.12	282.5	10.46
9	0.333	0.255	243.0	6.88	317.8	11.77
10	0.370	0.283	270.0	7.65	353.1	13.07
20	0.741	0.566	540.0	15.29	706.3	26.16
30	1.111	0.850	810.0	22.94	1059.4	39.24
40	1.481	1.133	1080.0	30.58	1412.6	52.82
50	1.852	1.416	1350.0	38.23	1765.7	65.40
60	2.222	1.700	1620.0	45.87	2118.9	78.48
70	2.592	1.982	1890.0	53.52	2472.0	91.56
80	2.962	2.265	2160.0	61.16	2825.2	104.63
90	3.333	2.548	2430.0	68.81	3178.3	117.71
100	3.703	2.832	2700.0	76.46	3531.4	130.79

*Example: 3 cubic yards = 81.0 cubic feet

Volume: The cubic meter is the only common dimension used for measuring the volume of solids in the metric system.

TABLE D-2. Conduit and Wire Conversion Factors

Wire Size		
Wire Ampacity	**AWG**	**Millimeters**
20	12	2.5
25	10	4
30	8	6
45	6	10
60	4	16
80	3	25
100	2	35
130	1/0	50
165	3/0	70
200	4/0	95
235	250 MCM	120
280	280	150
325	400	185
415	500	240
	600 MCM	300

Conduit Size	
Inches	**Millimeters**
3/4	20
1	25
1-1/4	30
1-1/2	40
2	50
2-1/2	60
3	75
3-1/2	90
4	100
4-1/2	125

TABLE D-3. Decimal Equivalent Chart

Inch	Decimal	Inch	Decimal	Inch	Decimal	Inch	Decimal
1/32	.03125	5/32	.15625	9/32	.28125	13/32	.40625
1/16	.0625	3/16	.1875	5/16	.3125	7/16	.4375
3/32	.09375	7/32	.21875	11/32	.34375	15/32	.46875
1/8	.125	1/4	.250	3/8	.375	1/2	.500
17/32	.53125	21/32	.65625	25/32	.78125	29/32	.90625
9/16	.56125	11/16	.6875	13/16	.8125	15/16	.9375
19/32	.59375	23/32	.71875	27/32	.84375	31/32	.96875
5/8	.625	3/4	.750	7/8	.875	1	1.0000

TABLE D-4. Time Conversion Factors

Man-Hours to Minutes

Fractional Man-Hours	Minutes Equivalent	Fractional Man-Hours	Minutes Equivalent
.017	1	0.517	31
.033	2	0.533	32
.050	3	0.550	33
.067	4	0.567	34
.083	5	0.583	35
.100	6	0.600	36
.117	7	0.617	37
.133	8	0.633	38
.150	9	0.650	39
.167	10	0.667	40
.183	11	0.683	41
.200	12	0.700	42
.217	13	0.717	43
.233	14	0.733	44
.250	15	0.750	45
.267	16	0.767	46
.283	17	0.783	47
.300	18	0.800	48
.317	19	0.817	49
.334	20	0.833	50
.350	21	0.850	51
.368	22	0.867	52
.383	23	0.883	53
.400	24	0.900	54
.417	25	0.917	55
.433	26	0.933	56
.450	27	0.950	57
.467	28	0.967	58
.483	29	0.983	59
.500	30	1.000	60

TABLE D-4. Time Conversion Factors

Man-Day to Hours	
Fractional Man-Day	**Man-Hour Equivalent**
.1	0 hr. 48 min.
.2	1 hr. 36 min.
.3	2 hr. 24 min.
.4	3 hr. 12 min.
.5	4 hr. 0 min.
.6	4 hr. 48 min.
.7	5 hr. 36 min.
.8	6 hr. 24 min.
.9	7 hr. 12 min.

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APPENDIX E

Average Temperature and Rainfall Chart

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TABLE E-1. Average Temperature and Rainfall Outside The United States

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jul
ANDROS IS. Bahamas	77 1.4 2	77 1.5 2	79 1.4 3	81 2.5 5	84 4.6 8	87 6.4 12	88 5.8 11	89 5.3 11	88 6.9 11	85 6.5 10	81 2.8 5	79 1.3 2
ARGENTIA Canada	34 4.8 19	33 3.8 9	35 3.1 8	41 2.9 8	47 2.5 6	55 2.4 6	62 3.2 6	65 3.2 7	59 3.1 6	52 3.6 8	46 4.9 9	38 4.5 10
BAHRAIN Saudi Arabia	70 0.8 2	72 0.4 1	79 0.4 1	90 0.1 1	99 0 0	106 0 0	108 0 0	108 0 0	103 0 0	95 0 0	84 0.1 1	73 0.8 2
BARBADOS IS. U.K.	83 0.8 3	84 1.0 4	84 0.6 3	85 2.1 5	86 5.1 10	86 2.7 5	86 6.5 12	87 6.9 15	86 4.3 10	86 7.7 10	85 7.4 10	84 3.4 11
BERMUDA	64 4.5 16	63 4.1 15	63 4.2 15	66 3.3 11	71 3.7 10	76 4.9 11	80 4.0 12	81 4.8 14	79 5.6 14	75 6.6 16	70 4.4 14	66 4.4 15
CRETE Khania	60 5.1 10.6	62 3.9 9.7	62 2.6 6.8	69 1.1 3.9	76 0.6 1.8	83 0.1 0.0	86 0 0	87 0.1 0.1	82 1.3 4.1	75 1.5 4.7	69 4.8 9.3	62 6.7 11.1
CUBA Guanto. Bay	76 1.1 3	76 0.9 3	78 1.1 3	79 1.0 3	81 3.0 6	83 2.4 6	84 1.0 3	84 1.9 6	83 3.5 8	82 6.1 11	80 1.6 6	78 1.0 4
DIEGO GARCIA	82 12.8 21	82 8.9 20	83 6.5 16	83 6.6 15	81 6.0 15	80 5.2 16	79 5.2 16	79 9.1 14	79 8.9 17	80 12.9 18	81 5.9 13	82 6.7 15
GREECE Nea Makri	56 2.5 6	59 1.0 3	59 1.5 5	68 1.2 3	78 1.0 2	86 0.4 1	91 0.2 1	92 0.2 1	84 0.8 1	73 2.5 4	65 2.3 6	59 1.9 4
GUAM Anderson AFB	81 4.2 9	81 4.6 8	81 2.4 6	83 4.9 8	83 5.7 9	84 4.6 11	84 8.0 14	84 11.7 16	83 13.5 19	83 15.4 18	83 6.8 13	82 6.7 12
GUAM Agana	80 4.6 19	80 3.0 15	80 2.4 17	81 3.6 17	82 5.0 19	82 4.9 21	82 9.5 24	81 12.2 24	81 13.8 25	81 12.4 24	81 8.4 23	81 4.9 22
HOLY LOCH Scotland	43 4.6 10	44 3.2 9	48 2.5 7	53 2.3 6	59 2.6 7	64 2.4 6	66 3.1 8	65 3.3 8	61 3.6 8	54 4.7 9	47 4.1 9	43 4.2 10

NOTE: 1st Number - Average Monthly Temperature
2nd Number - Average Monthly Precipitation
3rd Number - Average Monthly Days of Rain

TABLE E-1. Average Temperature and Rainfall Outside the United States (Continued)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
ITALY	47	48	52	59	65	72	77	77	72	63	56	51
Naples	3.7	2.8	2.9	2.9	2.0	1.5	0.7	0.9	2.9	5.3	4.5	4.7
	11	8	9	8	5	4	1	2	4	8	7	13
JAPAN	39	41	46	56	64	70	77	80	73	62	53	44
Atsugi	1.9	2.0	3.9	4.8	5.9	7.6	5.6	5.7	7.1	5.7	3.1	2.3
	6	8	11	13	13	14	13	12	13	13	10	5
JAPAN	41	42	47	57	65	71	80	81	75	64	55	46
Iwakuni	2.6	2.6	4.3	7.6	7.1	11.0	10.1	5.6	6.9	4.0	3.2	1.7
	9	8	11	12	13	12	13	9	11	8	8	7
JAPAN	35	37	43	56	65	68	76	80	74	64	51	40
Misawa AB	4.2	3.3	0.36	2.8	3.1	4.7	4.4	3.4	5.9	4.6	3.3	3.4
	10	8	6	6	6	8	8	6	9	7	7	8
MIDWAY IS.	66	66	67	68	71	76	78	79	79	76	72	68
	4.8	3.9	2.9	2.5	2.3	2.7	3.6	4.5	3.3	3.6	4.1	4.1
	16	13	12	10	8	10	14	14	14	14	14	16
OKINAWA	60	61	64	69	75	79	83	83	81	75	71	64
Futema	4.6	3.5	5.5	4.7	10.7	13.3	7.4	9.2	5.1	4.4	4.0	5.8
	16	13	15	11	15	14	12	16	14	11	11	14
OKINAWA	67	67	70	76	80	85	89	88	87	81	75	70
Makiminato	5.3	5.4	6.1	6.1	8.9	10.0	7.1	10.0	7.1	6.6	5.9	4.3
	10.1	10.2	8.7	8.7	10.4	11	9.1	11	9.6	9	8.2	8.5
OKINAWA	65	66	70	75	80	84	88	87	86	81	75	69
Shields	4.0	4.8	5.1	5.6	8.3	10.8	7.4	8.4	10.4	6.1	4.7	4.4
	7.4	7.9	8.1	7.7	10.9	10.4	6.8	8.5	7.5	6.2	6	6.1
PHILIPPINES	80	81	83	85	85	83	81	81	81	82	82	81
Cubi Point	0.1	0.1	0.2	0.6	8.6	23.2	31.8	33.5	25.7	7.2	3.0	0.7
	1	1	2	2	10	20	25	25	22	12	7	4
PUERTO	77	72	78	79	81	82	83	83	83	86	80	79
RICO	3.8	2.2	2.8	3.7	7.3	4.8	4.8	5.5	6.3	6.9	6.8	4.9
Roosevelt Rds	17	14	13	14	19	18	21	19	19	18	18	19
SICILY	40	40	42	45	51	59	64	66	62	56	48	43
Sigonella	2.8	1.8	1.7	1.9	1.1	0.5	0.2	0.6	1.0	5.8	1.3	3.0
	11	8	9	8	5	4	1	2	4	8	7	13
SPAIN	53	55	57	61	66	70	75	75	72	67	58	53
Rota	3.4	2.9	2.8	1.4	1.5	0.6	0.0	0.1	0.7	3.3	4.1	3.8
	12	10	10	7	6	3	0	0	4	7	10	10

NOTE: 1st Number - Average Monthly Temperature
2nd Number - Average Monthly Precipitation
3rd Number - Average Monthly Days of Rain

TABLE E-2. Average Temperature and Rainfall for the United States

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ALASKA Adak	34 6.4 24	33 5.1 22	35 6.2 25	38 4.7 22	41 4.4 22	45 3.4 22	49 3.1 16	52 3.8 18	48 5.7 22	43 7.0 26	37 8.2 26	34 7.7 25
CALIFORNIA Alameda	50 3.6 10	53 2.2 8	56 2.2 8	58 1.2 5	60 0.4 2	63 0.2 1	64 0.0 0	64 0.0 1	66 0.2 1	63 1.1 4	57 2.3 8	51 3.3 10
CALIFORNIA Lemoore	44 1.1 6	50 1.1 6	54 0.7 4	59 0.6 4	68 0.3 2	74 0.1 1	81 0.0 0	80 0.0 0	73 0.1 1	64 0.3 2	53 1.2 6	44 1.0 8
CALIFORNIA Point Mugu	54 2.2 5	55 2.4 5	54 1.1 3	56 0.9 3	59 0.1 1	61 0.0 1	64 0.0 0	66 0.1 0	66 0.1 1	63 0.2 1	58 2.6 5	54 1.7 6
CALIFORNIA San Diego	55 1.7 6	56 1.2 5	58 1.2 5	60 0.6 4	62 0.2 2	65 0.1 1	69 0.0 0	71 0.1 0	69 0.1 1	66 0.3 2	61 1.2 5	57 1.4 5
CONNECTICUT New London	37 3.7 7	39 3.2 7	45 4.3 7	57 4.1 7	66 4.0 7	75 2.6 6	81 3.3 6	80 4.1 7	74 3.4 6	64 3.5 6	52 4.4 7	40 4.1 8
FLORIDA Jacksonville	57 2.4 7	59 3.1 8	64 3.1 7	71 2.5 6	77 3.3 8	81 5.1 12	83 6.0 15	83 7.5 15	80 6.0 13	73 3.9 9	64 1.4 6	58 2.2 7
FLORIDA Pensacola	51 3.7 10	54 4.5 10	59 4.1 10	68 3.6 6	75 3.0 7	80 5.0 9	82 5.9 13	82 5.9 12	79 7.0 10	70 4.2 6	60 2.6 7	55 3.9 9
HAWAII Pearl Harbor	66 3.8 9	66 3.3 10	662. 9 9	68 1.3 8	70 1.0 6	72 0.3 6	73 0.4 6	74 0.9 7	73 1.0 6	72 1.8 9	70 2.2 8	68 3.0 9
ILLINOIS Great Lakes	23 2.0 9	26 1.5 8	36 2.7 11	48 3.5 12	58 3.4 11	69 4.2 10	73 3.8 9	72 2.7 8	65 3.3 9	54 2.4 8	39 2.3 9	28 2.3 10
MARYLAND Annapolis	42 2.7 6	46 3.2 7	51 4.1 8	66 3.6 8	74 3.4 7	83 3.8 6	87 4.4 6	85 4.9 7	79 3.1 5	68 3.1 5	55 3.2 6	44 3.0 6
MISSISSIPPI Gulfport	61 4.0 8	63 4.7 9	70 5.9 8	71 4.9 8	83 4.6 8	89 5.3 8	90 7.1 10	90 6.3 9	87 6.1 9	79 3.2 6	69 3.2 6	62 4.9 9
RHODE ISLAND Davisville	30 3.6 11	31 3.7 9	39 3.9 10	48 3.8 11	57 3.8 11	67 2.5 10	73 2.7 9	71 4.0 9	65 3.1 8	55 2.6 7	45 4.3 11	34 4.3 12
SOUTH CAROLINA Charleston	49 3.1 10	51 3.5 9	56 4.4 11	65 2.9 7	72 4.3 9	78 5.9 11	80 8.0 15	80 6.6 13	75 5.2 9	66 3.2 6	57 2.3 7	50 3.1 8
TENNESSEE Memphis	41 4.1 10	43 4.6 10	51 4.8 10	63 5.0 11	71 4.2 9	79 3.3 8	81 3.6 9	80 3.1 7	74 3.5 7	63 2.4 6	51 3.7 8	43 5.0 10

TABLE E-2. Average Temperature and Rainfall for the United States (Continued)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
VIRGINIA	41	42	48	58	66	74	78	77	72	62	53	44
Oceana	4.1	3.7	3.5	2.5	3.5	3.2	5.1	6.0	4.4	4.1	2.8	3.1
	10	10	11	10	10	8	11	10	8	7	8	8
WASHINGTON	40	42	44	48	53	57	59	59	56	51	45	41
Whidbey Is.	2.4	1.7	1.6	1.4	1.1	1.2	0.6	0.8	1.2	2.0	2.3	2.8
	18	13	14	12	8	8	5	6	8	13	16	18

NOTE: 1st Number - Average Monthly Temperature
2nd Number - Average Monthly Precipitation
3rd Number - Average Monthly Days of Rain

APPENDIX F

Standard Drawing Symbols
(Partial List)

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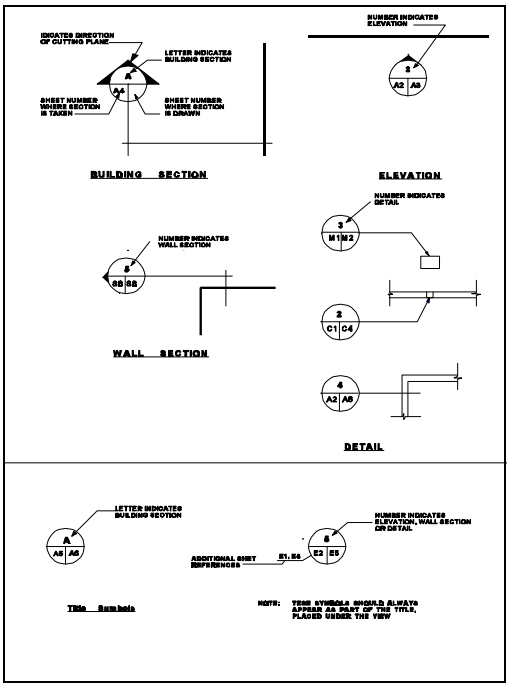


FIGURE F-1. Title Symbols

STANDARD SYMBOLS
(PARTIAL LISTING)

16	BILL OF MATERIAL ITEM		BREAK-PIPING, WIRING
A	EQIPMENT BY OTHERS		BREAKE LINE
A	REVISIONS		BREAKE LINE
	CENTER LINE	DIA	DIAMETER
N	INDICATES NORTH DIR.	C TO C	CENTER TO CENTER

UP TO 11 15/16" TO BE EXPRESSED AS INCHES, 12" AND ABOVE TO BE IN FEET AND INCHES.	PROVIDE ADDITIONAL GRAPHIC SUMBOL LEGEND ON PLANS AS REQUIRED.

FIGURE F-2 Standard Symbols

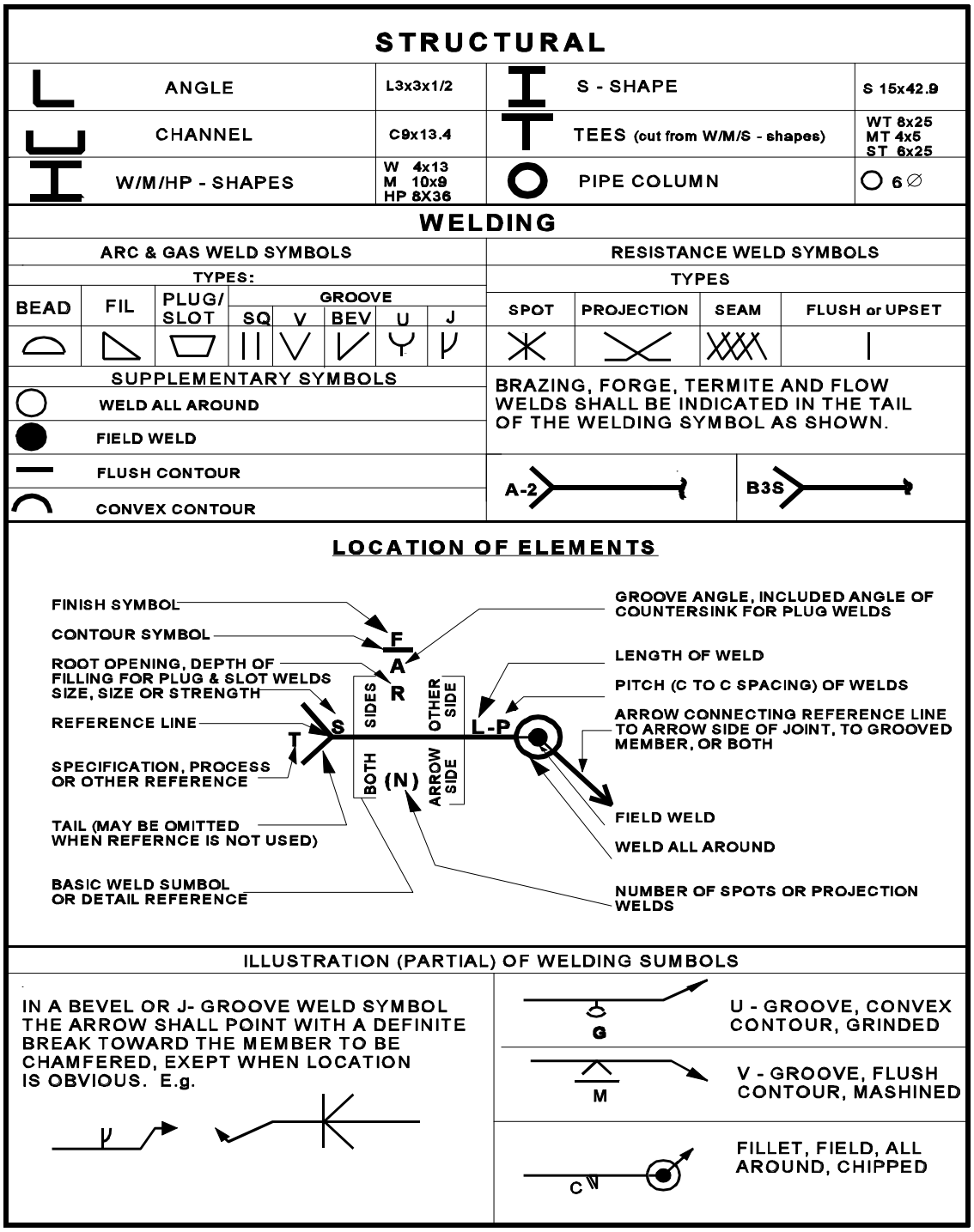


FIGURE F-3. Structural and Welding

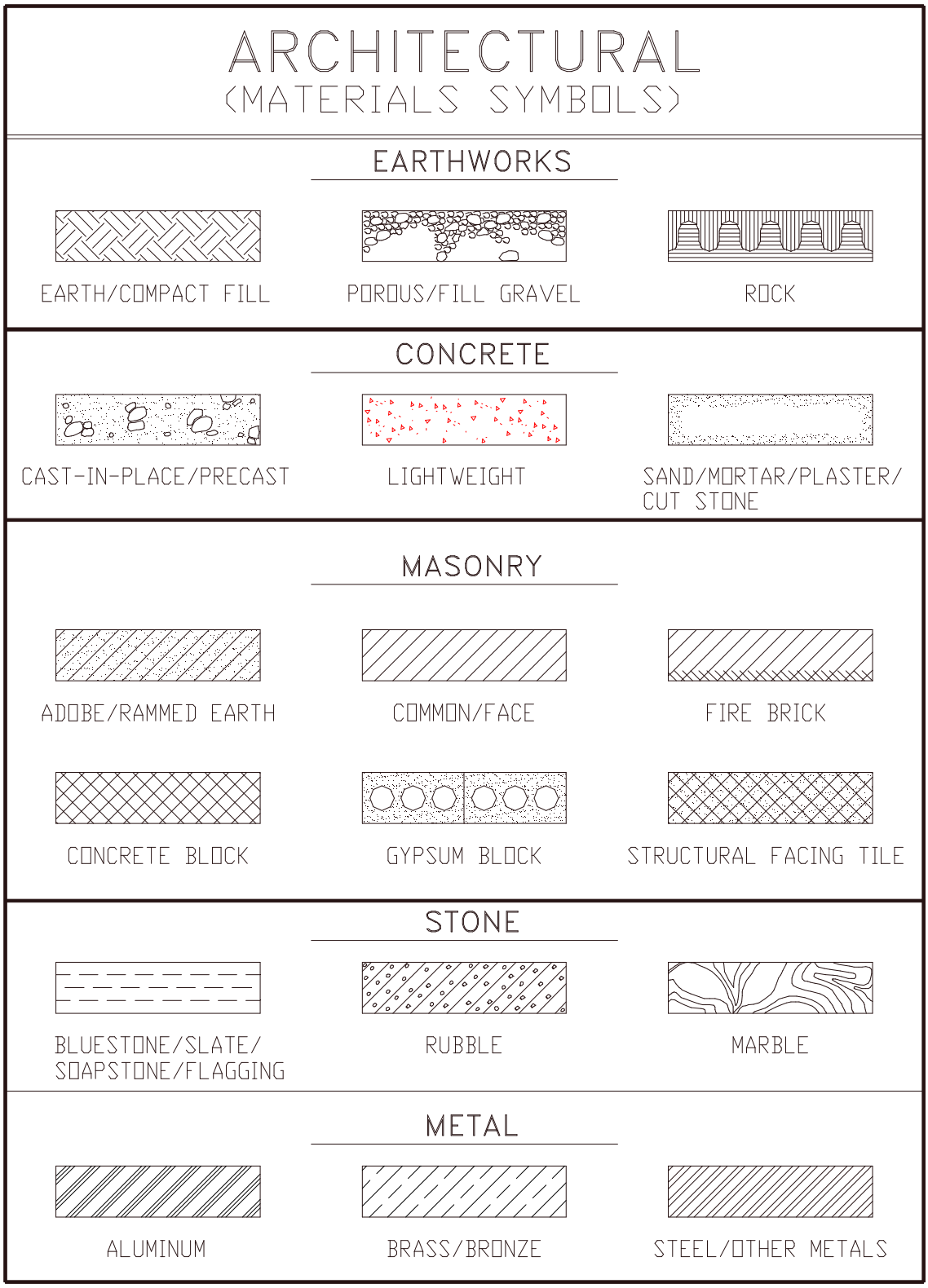


FIGURE F-4. Architectural (Materials) Symbols (Sheet1 of 3)

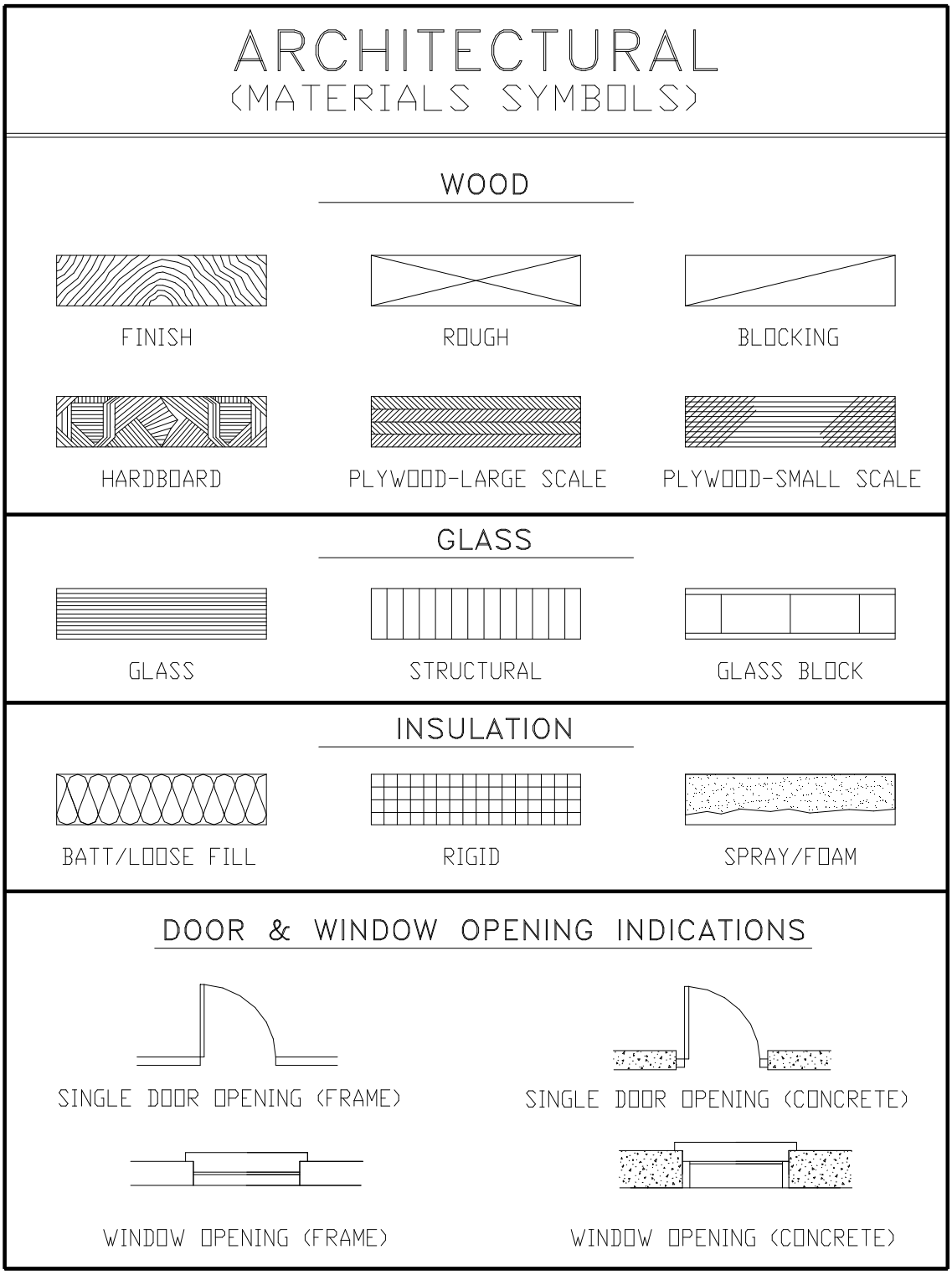


FIGURE F-4. Architectural (Materials) Symbols (Sheet 2 of 3)

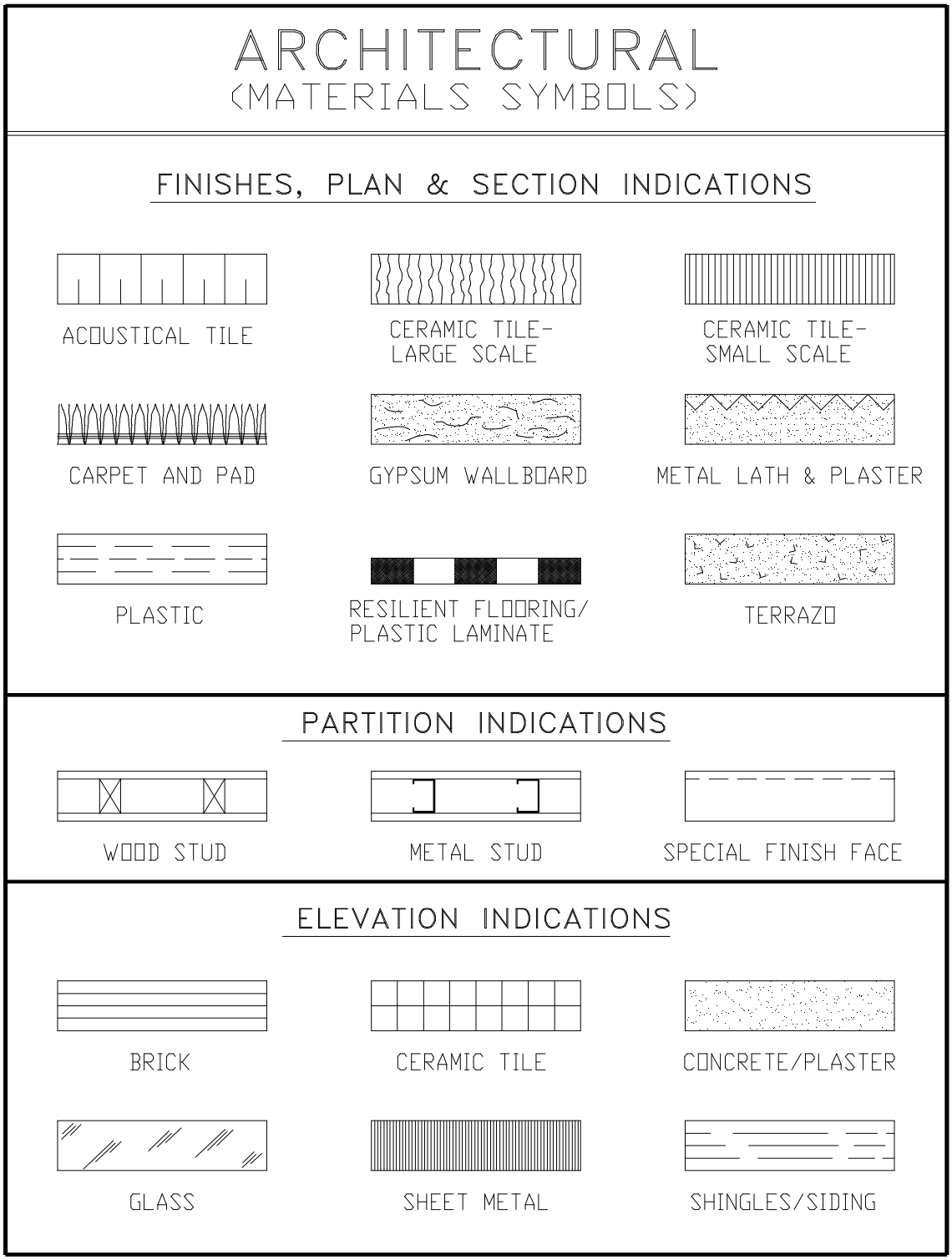


FIGURE F-4. Architectural (Materials) Symbols (Sheet 3 of 3)

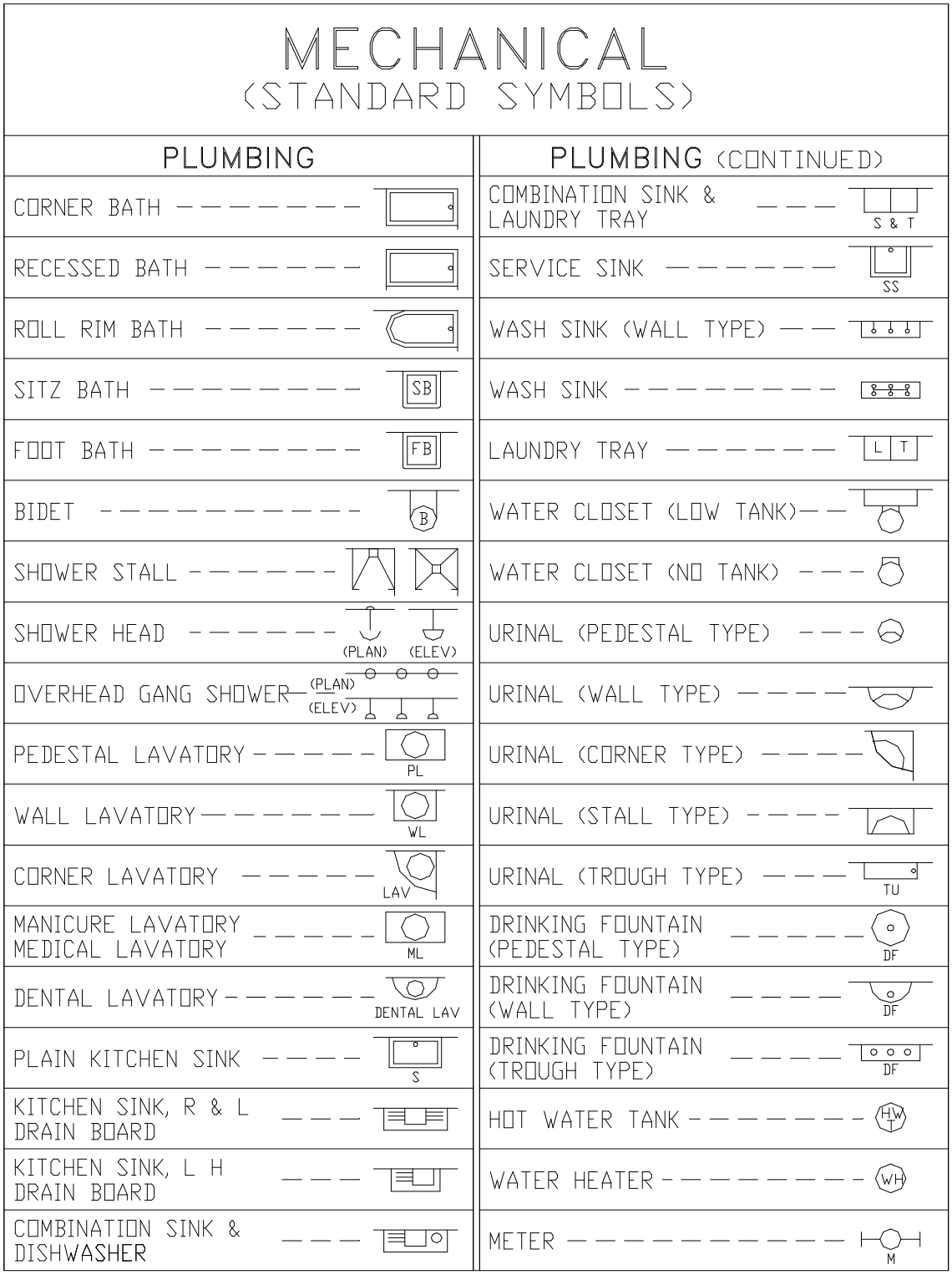


FIGURE F-5. Mechanical Symbols (Sheet 1 of 4)

MECHANICAL
(STANDARD SYMBOLS)

PLUMBING (CONTINUED)

HOSE RACK	HR
HOSE BIB	HB
GAS OUTLET	G
VACUUM OUTLET	
DRAIN	D
GREASE SEPARATOR	G
OIL SEPARATOR	O
CLEANOUT	C
GARAGE DRAIN	
FLOOR DRAIN WITH BACKWATER VALVE	
ROOF SUMP	

PIPING – GENERAL

SOIL AND WASTE	
SOIL & WASTE UNDERGROUND	
VENT	
COLD WATER	
HOT WATER	
HOT WATER RETURN	
FIRE LINE	F
GAS	G
ACID WASTE	AW
VACUUM CLEANING	V
COMPRESSED AIR	A
DRAIN	D
DIRECTION OF FLOW	

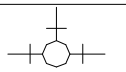
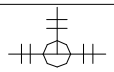
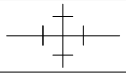
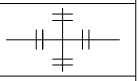
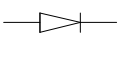
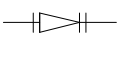
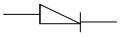
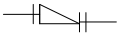
PIPE FITTINGS

TYPE	SCREW	FLANGE
JOINT		
ELBOW - 90°		
ELBOW - 45°		
ELBOW TURNED-UP		
ELBOW TURNED - DOWN		
ELBOW - LONG RADIUS	LR	LR
ELBOW - SIDE OUTLET DOWN		
ELBOW - SIDE OUTLET UP		
BASE ELBOW		
DOUBLE BRANCH ELBOW		
SINGLE SWEEP TEE		
DOUBLE SWEEP TEE		
REDUCING ELBOW		
TEE		
TEE OUTLET UP		
TEE OUTLET UP		
TEE - SIDE OUTLET UP		

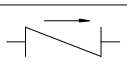
FIGURE F-5. Mechanical Symbols (Sheet 2 of 4)

MECHANICAL
(STANDARD SYMBOLS)

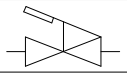
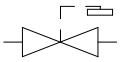
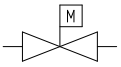
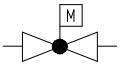
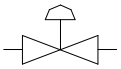
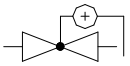
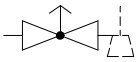
PIPE FITTINGS (CONTINUED)

TYPE	SCREW	FLANGE
TEE - SIDE OUTLET DOWN		
CROSS		
REDUCER		
ECCENTRIC REDUCER		
LATERAL		
EXPANSION JOINT FLANGED		

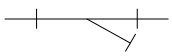
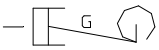
VALVES

GATE	
GLOBE	
HOSE GATE	
HOSE GLOBE	
ANGLE GATE - ELEV.	
ANGLE GATE - PLAN	
ANGLE GLOBE - ELEV.	
ANGLE GLOBE - PLAN	
CHECK	
ANGLE CHECK	

VALVES (CONTINUED)

SAFETY	
COCK	
QUICK OPEN	
FLOAT	
MOTOR OPERATED GATE	
MOTOR OPERATED GLOBE	
DIAPHRAGM	
AUTO BYPASS	
AUTO GOVERNOR OPERATION	

HEATING – GENERAL

STRAINER	
FILTER	
GAS OR DIESEL ENGINE (DESIGNATE)	

PIPING – HEATING

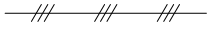
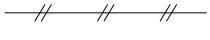
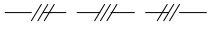
HIGH - PRESSURE STEAM	
MEDIUM - PRESSURE STEAM	
LOW - PRESSURE STEAM	
HIGH - PRESSURE RETURN	

FIGURE F-5. Mechanical Symbol (Sheet 3 of 4)

MECHANICAL
(STANDARD SYMBOLS)

PIPING—HEATING (CONTINUED)	MISCELLANEOUS (CONTINUED)
MEDIUM - PRESSURE RETURN	SOLDER BUSHING
LOW - PRESSURE RETURN	WELD BUSHING
BOILER BLOW - OFF	REDUCING FLANGE
MAKE - UP WATER (DESIGNATE)	PIPE PLUGS
FUEL OIL FLOW FOF	BULL PLUGS
FUEL OIL RETURN FOR	CAPS
FUEL OIL TANK VENT FOV	WELD BUSHING
MISCELLANEOUS	
FLANGED JOINT	
SCREWED JOINT	
BELL AND SPIGOT JOINT	
WELD JOINT	
SOLDER JOINT	
EXPANSION JOINT	
UNION	
SLEEVE	
SCREWED BUSHING	
BELL AND SPIGOT BUSHING 6 4	

FIGURE F-5. Mechanical Symbols (Sheet 4 of 4)

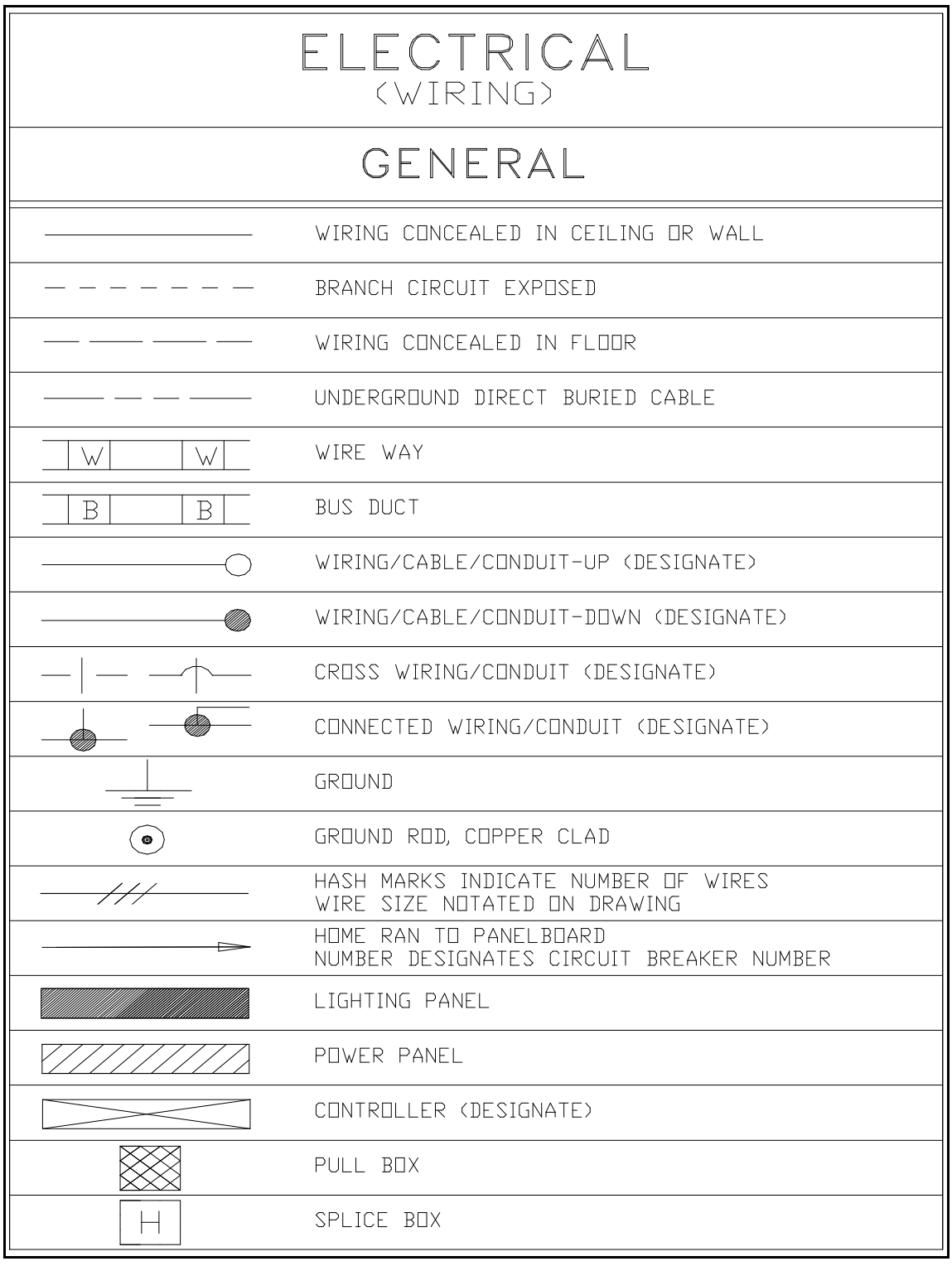


FIGURE F-6. Electrical Symbols (Sheet 1 of 3)

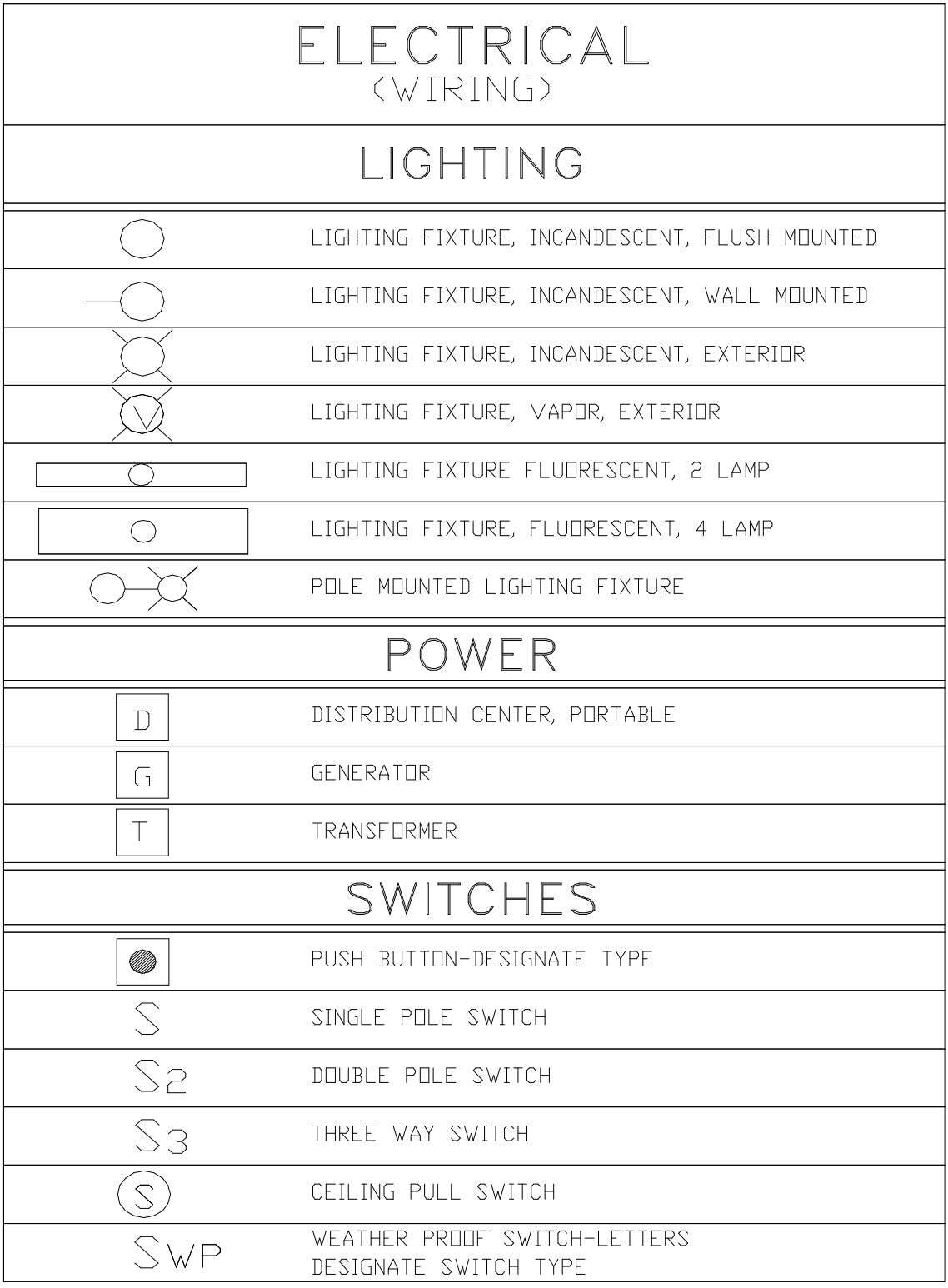


FIGURE F-6. Electrical Symbols (Sheet 2 of 3)

ELECTRICAL
(WIRING)

RECEPTACLES

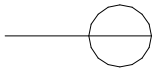
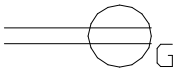
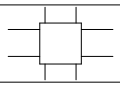
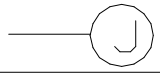
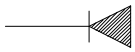
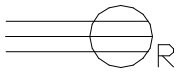
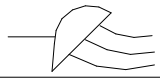
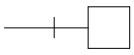
	SINGLE OUTLET, WALL MOUNTED
	DUPLEX OUTLET-GROUNDED, WALL MOUNTED
	DUPLEX OUTLET IN FLOOR
	SINGLE SPECIAL PURPOSE RECEPTACLE
	SPECIAL PURPOSE CONNECTION (DESIGNATE)
	FLOOR RECESSED JUNCTION BOX (NUMBER OF LINES INDICATE NUMBER OF DUCTS)
	JUNCTION BOX, FLUSH MOUNTED
	JUNCTION BOX, WALL MOUNTED
	PUBLIC TELEPHONE OUTLET
	220V OUTLET
	WEATHERHEAD
	THERMOSTAT
	FIRE ALARM SYSTEM DEVISES
	SAFETY SWITCH, FUSED
	MOTOR - (APPLICATION)

FIGURE F-6. Electrical Symbols (Sheet 3 of 3)

APPENDIX G

Project Planning Steps

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PROJECT PLANNING STEPS

A. PRELIMINARY

1. Obtain and review plans and specifications.
2. Write scope paragraph.
3. Develop master activities.

   NOTE: Between 10-15 activities keyed to major construction phases or like activities, these should be kept as rate specific as possible.

4. Place Master Activities into logical construction sequence (i.e., Logic Network)
5. Rough man-days per Master Activity (crew size X duration).
6. Select construction methods.
7. Identify lead time materials.
8. Visit site, if practical.

B. DETAILED

1. Break Master Activities into Level III (or construction) activities.
2. Develop construction activity subnets.

   NOTE: Construction activities should be between 3-15 days. There may be some exceptions, but much smaller and there are too many activities; much larger and there are too few.There should be no less than 15 and no more than 100 activities on any project.

3. Identify any training required and ensure it is provided.
4. Write quantity estimates for detailed activities:
   - permanent material
   - construction support
   - material (consumables
   - crew size and ratings
   - tools and equipment
   - durations
   - man-days

5. Complete Construction Activity Summary (CAS) sheet for each detailed activity.

B. DETAILED (continued)

6. Compare activity materials to the Naval Construction Regiment (NCR) Bill of Materials (BM).
7. Make or request shop drawings and notify S-3 of requirements.
8. Revise scope or methods, based on site visit.
9. Make up safety and Quality Control (QC) Plans and identify major items in each activity, using information contained on CAS sheets.
10. Monitor message traffic Situation Reports (SITREPS) and correspondence.
11. Calculate critical path and float using activity durations and logic diagram.
12. Use deployment calendar to relate project days to calendar dates.
13. Level resources and reschedule.
14. Identify other information as necessary, such as any constraints on start/finish. Examples: Utility tie-ins; outages; material delivery.
15. Supply Required Delivery Dates (RDD) for materials to Naval Construction Regiment.
16. Develop Level II Master Activity charts.
17. Develop milestones and, if minicomputer is to be used, enter the project into the computer.

APPENDIX H

FORMS

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_____ of _____

ESTIMATOR WORK SHEET

PROJECT LOCATION	PROJECT TITLE	PROJECT NUMBER	BM NUMBER	DATE PREPARED

PROJECT SECTION	ACTIVITY NUMBER	DRAWING NUMBER	PREPARED BY:	CHECKED BY:

DESCRIPTION							BM LINE ITEM	UNIT OF ISSUE	TOTAL QTY	REMARKS

BILL OF MATERIAL

PROJECT	PROJECT TITLE	AUTHORITY/ORIGINATOR	BM NO.	SECTION

M&S	SERV & REQNR	DEM	SERV & SUPP ADD	SIG	FUND	DIS	PRJ	PRI	JON	ROS	ACCOUNTING DATA
7	30-35	44	45-50	51	53-53	54	57-59	60-61	62-64	72-77	

COG	NSN	UNIT OF ISSUE	QTY	DOCUMENT NUMBER	ADV	LI	DESCRIPTION VENDOR/SOURCE INTENDED USE	UNIT PRICE	TOTAL COST
55-56	8-20	23-24	25-26	36-43	65-66				

BM SUBMITTED BY/DATE	BM APPROVED BY/DATE	TARGET APPROVED/DATE	PAGE TOTAL	BM TOTAL	PAGE OF

BM/MTO COMPARISON WORK SHEET

ACTIVITY NO.	MATERIAL DESCRIPTION	U/I	BM LI NO.	BM QTY	MTO QTY	DIFF	REMARKS

____ OF ____

ADD-ON BM

PROJECT NUMBER	PROJECT TITLE	DATE	MLO USE ONLY

BM NUMBER	MASTER ACTIVITY NUMBER	DRAWING NO.	PREPARED BY:	UNIT PRICE	TOTAL COST	REQUESITION NUMBER

BM ITEM NO.	UNIT OF ISSUE	QTY	DESCRIPTION	JUSTIFICATION			

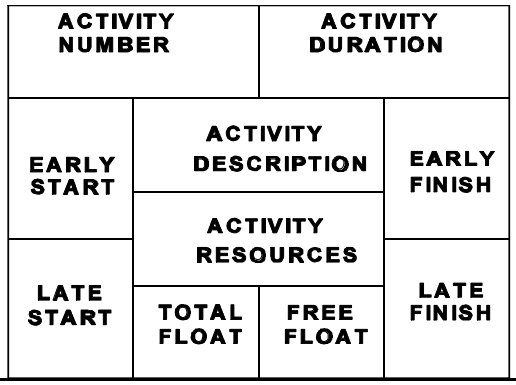
1. CREW LEADER	DATE	5. OPS	DATE	MLO NOTES & REMARKS
2. PROJECT SUP.		6. MLO CHIEF		
3. PROJECT MGR.		7. MLO SK		
4. QC REP.		8. PROCUREMENT APPROVAL		

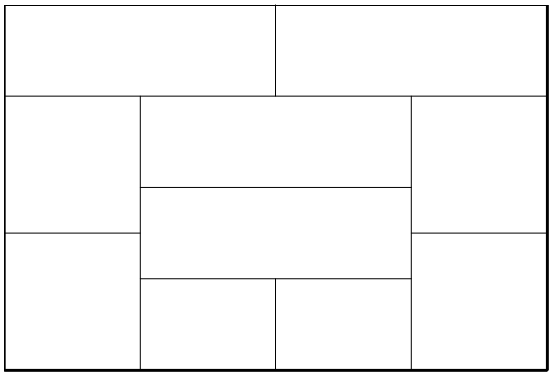
MASTER ACTIVITY LISTING

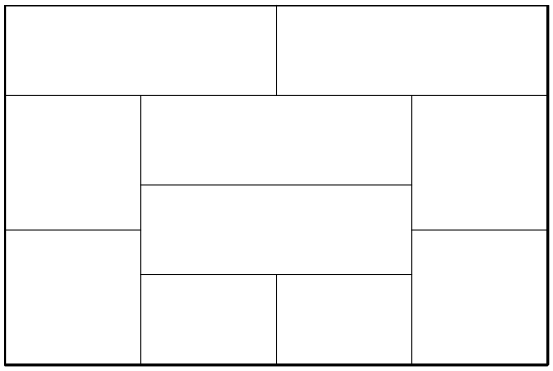
PROJECT #_____ PROJECT TITLE_____

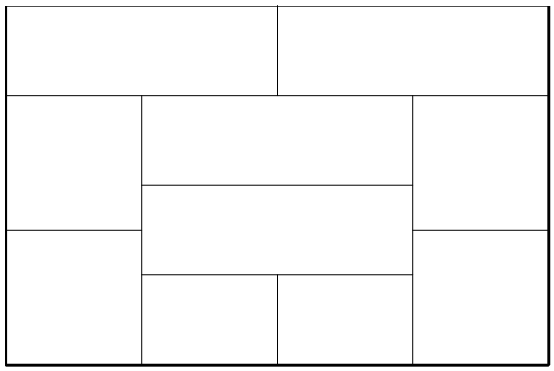
MASTER ACT. NUMBER/TITLE	MASTER ACTIVITY DESCRIPTION	MD's	DURATION

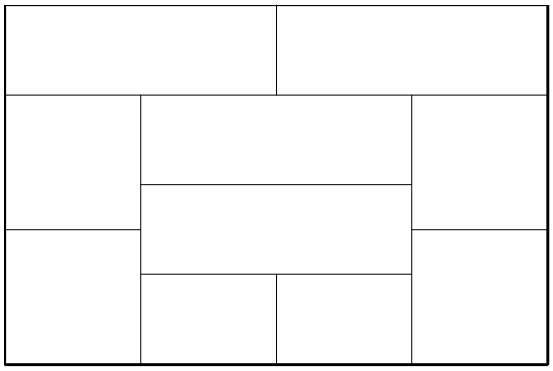
FORM CREATED BY EAC (SCW) R. KRUPA

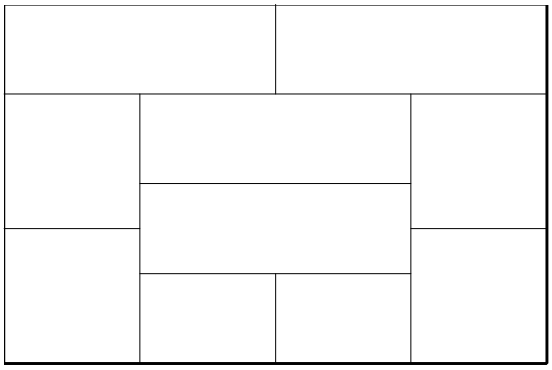


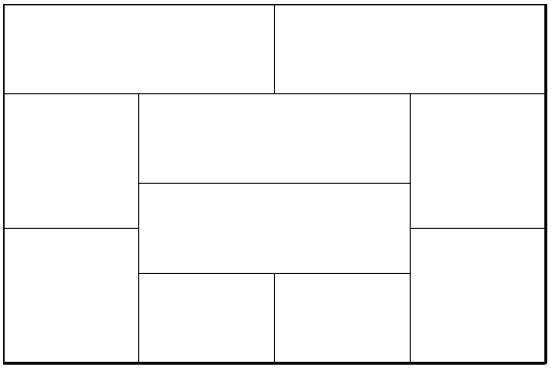


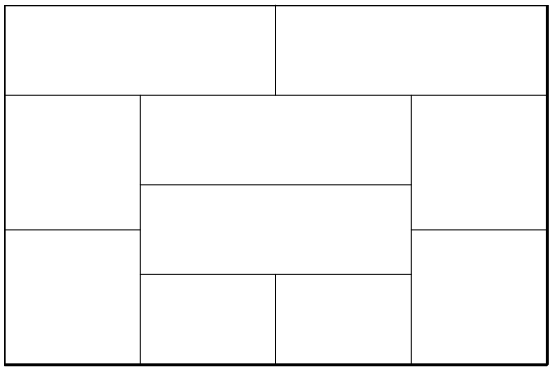












NCF LEVEL II

PROJECT #

TITLE:

TOTAL MANDAY ESTIMATE:

TASKED MANDAYS:

ACT #	MASTER ACTIVITY	MDS	WT %	JAN				FEB				MAR				APR				MAY				JUN				JUL				AUG				
10																																				100%
20																																				90%
30																																				80%
40																																				70%
50																																				60%
60																																				50%
70																																				40%
80																																				30%
90																																				20%
100																																				10%
TOTAL																																				0%

	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		
MD’s Scheduled This Period																	
Cummulative Mandays Scheduled																	
%Complete Scheduled (Plot)																	
MD’s Expended This Period																	
Cummulative mandays Expended																	
% Mandays Expended																	
% Work - In - Place (Plot)																	

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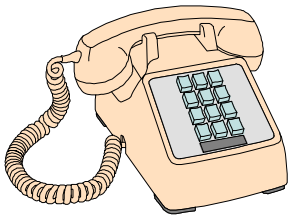

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