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ABSTRACT

This Rate Training Manual and Nonresident Career Course (RTM/NRCC) form a self-study package that will enable Steelworkers First and Chief to help themselves fulfill the requirements of their rating. (These positions direct and coordinate efforts of individuals and crews in cutting, welding, placing and erecting rigid frame and other pre-engineered buildings, structures, and tanks; lay out, cut, bend, and place reinforcing steel; maintain records and reports on job progress and material estimates; and supervise and coordinate all tasks assigned to a unit.) Designed for individual study and not formal classroom instruction, the RTM provides subject matter that relates directly to the occupational standards of the Steelworker rating. Topics covered in the eight chapters of the RTM include administration; supervision; shop and construction site organization; construction inspections and quality control; advanced base planning, embarkation, and project turnover; planning, estimating, and scheduling; metals identification and testing; and company chief. An appendix contains an illustrated list of hand signals used in this occupation. The NRCC provides a way of satisfying the requirements for completing the RTM. Assignments in the NRCC include learning objectives and supporting items designed to lead the student through the RTM. (KC)


# STEELWORKER 1 & C

CE

NAVAL EDUCATION AND TRAINING COMMAND

RATE TRAINING MANUAL AND NONRESIDENT CAREER COURSE

NAVEDTRA 10654-E

Although the words "he", "him", and "his", are used sparingly in this manual to enhance communication, they are not intended to be gender driven nor to affront or discriminate against anyone reading *Steelworker 1 & C*, NAVEDTRA 10654-F.

Naval Education And Training Program Development Center

# STEELWORKER 1 & C

## NAVEDTRA 10654-E

*1981 Edition Prepared by*
*SWC Patrick J. Essinger*

# PREFACE

The ultimate purpose of training Naval personnel is to produce a combatant Navy which can insure victory at sea. A consequence of the quality of training given them is their superior state of readiness. Its result is a victorious Navy.

This Rate Training Manual and Nonresident Career Course (RTM/NRCC) form a self-study package that will enable Steelworkers First and Chief help themselves fulfill the requirements of their rating. They direct and coordinate efforts of individuals and crews in cutting, welding, placing and erecting rigid frame and other pre-engineered buildings, structures, and tanks; lay out, cut, bend, and place reinforcing steel; maintain records and reports on job progress and material estimates; and supervise and coordinate all tasks assigned to a unit.

Designed for individual study and not formal classroom instruction, the RTM provides subject matter that relates directly to the occupational standards of the Steelworker rating. The NRCC provides a way of satisfying the requirements for completing the RTM. Assignments in the NRCC include learning objectives and supporting items designed to lead the student through the RTM.

This RTM/NRCC was prepared by the Naval Education and Training Program Development Center, Pensacola, Florida, for the Chief of Naval Education and Training. Technical assistance was provided by the Naval Facilities Engineering Command, Alexandria, Virginia; the Naval Construction Training Center, Port Hueneme, California; the Naval Construction Training Center, Gulfport, Mississippi; and the Civil Engineering Support Office, Port Hueneme, California.

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# THE UNITED STATES NAVY

## GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

## WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

## THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

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# CREDITS

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| United States Naval Institute | 7-5 |
| Wilson Mechanical Instrument Company | 7-1, 7-2 |

# CHAPTER 1

# ADMINISTRATION

As an SW1 or SWC, you will have many responsibilities added to those which you had as a second class petty officer. You have acquired a lot of valuable knowledge and now it is your turn to pass on the technical know-how of your job to others. In addition to supervising and training lower rated personnel, you must be able to perform various administrative duties, such as preparing official correspondence, maintaining company records and reports, and administering a company accident prevention program.

The type of activity to which you are assigned will determine just how you carry out your administrative responsibilities. But, the ability to plan and organize your work, to apply effective techniques of supervision, and get along with people will help you succeed in the Navy no matter to what activity you are assigned.

## RECORDS AND REPORTS

As you advance in rating, you can expect your job to require an increased amount of paperwork. If you have to spend a lot of time doing paperwork, you may want to assign an assistant to handle part of it; you will be responsible, however, for seeing that the work is done right. Keeping all your records and reports up to date will enable you to keep a close check on each job, each crewmember, and each piece of equipment under your supervision. Records and reports provide a means of checking the accomplished job progress against the planned-job progress. They summarize the experience gained on the present project, and are valuable in planning and scheduling future projects.

Your activity will have standard forms for keeping some of the required records and for making certain supply transactions; for example, job orders, work requests, and requisitions. In addition, forms used for records and reports often are designed locally and are likely to differ from one activity to another. At most activities, you will find it advantageous to maintain logs, notebooks, charts, and so on, of your own design to met specific needs. Some of the common types of records and reports with which you may be concerned, as a supervisor, will be discussed in this chapter.

### WORK PROGRESS LOG

A work progress log is a record of all current and completed work accomplished by your shop or crew and each person assigned to it. You can design your own work progress log or it can be supplied by your activity. In any event, it should contain the following information for each job:

1. The job order number.
2. The date the job order was received.
3. The name of the unit requesting the work.
4. A brief description of the job.
5. The names of the personnel assigned to work on the job.
6. The total number of man hours required to complete the job.

### JOB PROGRESS LOG

A job progress record sheet is used to present the status of all work being performed currently in the shop. At some activities, a progress record sheet like figure 1-1 is made up at the close of each working day and submitted to the division office; a similar record sheet may be submitted to show progress on projects in the field. On the

JOB ORDER PROGRESS RECORD SHEET -- Sheet Metal SHOP

22 June 19--

| JOB ORDER NUMBER | DESCRIPTION OF JOB | DATE REC'D | PERCENT COMPLETE 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 143 - 70 | Repair 1 locker | 6/18/- | | | | | | | | | | | Barracks #57 |
| 145 - 70 | Mfg. 4 buckets | 6/18/- | | | | | | | | | | | |
| 146 - 70 | Mfg. 1 sheet metal bulkhead | 6/18/- | | | | | | | | | | | fabricate in shop install in CPO club |
| 151 - 70 | Mfg. 3 strainers | 6/19/- | | | | | | | | | | | for Komp SW1 at master galley |
| 156 - 70 | Repair 2 ventilation ducts | 6/22/- | | | | | | | | | | | |
| 157 - 70 | Mfg. 1 stainless steel top for galley table | 6/22/- | | | | | | | | | | | for Chief McCra[illegible] |
| 159 - 70 | Mfg. 12 ash trays | 6/22/- | | | | | | | | | | | for Wardroom |
| | [illegible] SWC | | | | | | | | | | | | |

18.3

Figure 1-1.--Job order progress record sheet.

record sheet, all uncompleted job orders are listed by number. A brief description of each job also is given, together with the date the job order was received. A chart is provided to indicate the percentage of work completed on each job.

## MATERIAL EXPENDED RECORD

A material expended record is used to keep track of the status of materials. However, such a record is worthless unless faithfully maintained. This record can best be kept in a notebook having a separate section for each type of material your shop uses. The information on a material expended record should include the date material is received, the amount of material received, the date material is expended, the amount of material expended, the order number of the job on which the material is used, and the balance of the material remaining on hand. Figure 1-2 shows a suggested method of logging this information.

## EQUIPMENT LOG

As the shop supervisor, you should keep an equipment log listing all portable tools for which you are accountable and showing where they are located (shop, storeroom, or toolroom) or to whom assigned. An equipment log, kept up to date, with adequate tool descriptions (make, model, and serial number) will help you in making periodic inventories.

## DAILY MAN-HOUR REPORT

At some activities, you may have to submit a daily man-hour report. This report gives an

STEEL, SHEET, GALV.-20 GAGE (.0359) - 1.656 LB PER SQ. FT.

| RECEIVED | | EXPENDED | | | | BALANCE | |
|---|---|---|---|---|---|---|---|
| DATE | AMOUNT | DATE | AMOUNT | J.O# | | DATE | AMOUNT |
| 4-13— | 240 SQ. FT | | | | | 4-13— | 240 SQ. FT |
| | | 4-15— | 48 SQ. FT | 10-70 | | 4-15— | 192 SQ. FT (8 SHTS. 36 by 96) |
| | | 4-17— | 5 SQ. FT. | SHOP UPKEEP | | 4-17— | 187 SQ. FT. |
| (10 SHEETS 36 by 96 | ORDERED 4-21-70) | | | | | | |
| | | 4-24— | 120 SQ. FT | 17-70 | | 4-24— | 67 SQ. FT. |
| 5-5— | 240 SQ. FT. | | | | | 5-5— | 307 SQ. FT. |

135.47

Figure 1-2.—Page from a material expended record.

overall picture of the way in which the working day is spent. A sample of a daily man-hour report is shown in figure 1-3.

In fieldwork, you will probably have to submit project reports to show completion of construction projects. The report in figure 1-4 illustrates the type of information generally required in a project report.

## OFFICIAL CORRESPONDENCE

On occasion, you may be expected to compose official correspondence, perhaps only from brief notes or oral instructions. Official correspondence in its true sense encompasses all recorded communications, including messages.

In general, official outgoing correspondence is prepared only in the rough at the department level and is "chopped" to the executive officer or the administrative assistant for approval and preparation in the smooth for the commanding officer's signature.

DAILY MAN-HOUR REPORT

SHOP Rigging Loft DATE 9-3-

NUMBER OF MEN 11 TOTAL MAN-HOURS 88

MAN-HOURS EXPENDED:

| | |
|---|---|
| JOB ORDERS | 40 |
| TRAINING | 16 |
| SPECIAL DETAIL | 24 |
| SICK BAY | 0 |
| SPECIAL LIBERTY | 0 |
| SHOP UPKEEP | 8 |
| TOTAL MAN-HOURS EXPENDED | 88 |

SIGNED G.A. Besson SWC

18.4

Figure 1-3.—Daily man-hour report.

EXAMPLE OF PROJECT REPORT*

| WORK ITEM | SIZE OF CREW | DAYS TO COMPLETE | WORKING HOURS PER DAY | TOTAL MAN-DAYS | TOTAL MAN-HOURS | REMARKS |
|---|---|---|---|---|---|---|
| 1 PIPELINE | | | | | | |
| COUPLING 6-INCH PIPE | 4 | 1½ | 10 | 6 | 60 | PER 1-MILE PIPELINE |
| WELDING 6-INCH PIPE | 39 | 1 | 10 | 39 | 390 | PER 1-MILE PIPELINE |
| 2 PUMPING STATION 6-INCH PIPELINE | 8 | 11 | 7½ | 88 | 660 | COMPLETE WITH MANIFOLDS, PIPING AND FUEL TANK |
| 3 TANK ERECTION | | | | | | |
| 250-BARREL | 6 | 4 | 7 | 24 | 168 | |
| 1,000-BARREL | 6 | 11 | 9 | 66 | 544 | |
| 3,000-BARREL | 16 | 8 | 9 | 128 | 1,152 | |
| 10,000-BARREL | 16 | 18 | 9 | 288 | 2,542 | |
| 4 AIRFIELD DISTRIBUTION SYSTEM | 24 | 102 | 12 | 2,448 | 29,376 | 50 HARDSTAND OUTLETS |
| 5 AIRFIELD TRUCK FILL SYSTEM | 5 | 3 | 10 | 15 | 150 | 3 FILLING STATIONS |
| 6 WATER-TESTING LINE | 10 | 10 | 9 | 100 | 900 | PER 10 MILES |

* WORK SUPERVISORS ARE NOT INCLUDED IN CREW SIZE OR MAN-HOURS

145.3

Figure 1-4.—Example of a project report.

## STANDARD NAVAL LETTERS

Figures 1-5 and 1-6 illustrate the standard naval letter in finished form. When preparing correspondence in the rough, always double space the text to allow for corrections or insertions by reviewing officers. Before starting the letter, find out from the drafting officer (you may physically prepare the draft, but the officer is responsible for the finished product) whether it is to be classified. If so, the classification must appear near the top and bottom of each page. Note the identification and indentation of paragraphs and subparagraphs. The drafting officer will have to determine who the "via" and "copy to" addressees (if any) are to be. There are two important rules of thumb: (1) references shown in the heading of the letter should be mentioned (in chronological order) within the text at least once, and (2) unless they are very closely related, do not cover two subjects in one letter. The latter practice can result in administrative confusion when replies are required.

When preparing correspondence, bear in mind that the usual purpose of Navy mail is to provide the reader with concisely stated information. If you turn out a confused, rambling, repetitious, or needlessly lengthy masterpiece of semantic purity, you only create an editing chore for the drafting officer—and you may wind up doing the whole thing over.

Before starting the letter, be sure you understand exactly what the letter is to accomplish. Then, its organization becomes essentially simple. The first paragraph should state the purpose of the letter; the following paragraph(s) explain circumstances and state the action (gives orders, make requests, give consent, or refuse permission).

When the letter is in answer or closely related to another letter, the first sentence should refer to that letter. For example: "1. Reference (a) requested information about the allowance lists for the next 3 fiscal years. Reference (b) pointed out that such information is available for only 2 years in advance. . ."

The usual causes of confusion and rambling in a letter are—

1. Failure to follow the basic pattern (purpose, circumstances, action).
2. Inclusion of more than a single idea in a sentence, more than one central thought in a paragraph, or more than a single subject in a letter.
3. Failure to consider the readers (can the letter be misinterpreted?).

In letters of average length, each significant unit may be one paragraph, although there is no rule about this; explaining the reasons why something should be done may take more than one paragraph, while other letters are so simple

DEPARTMENT OF THE NAVY
HEADQUARTERS NAVAL MATERIAL COMMAND
WASHINGTON, D.C 20360

*IN REPLY REFER TO
PBX:ABC:PLM
*5216
5 Jan 19—

*AIRMAIL

*From: Chief of Naval Material
To: Commander, Portsmouth Naval Shipyard
*Via: Commander, Naval Ships System Command

Subj: Correspondence practices; recommendations of NAVMAT team concerning

*Ref: (a) NAVMAT ltr PBX:ABC:PLM of 1 Jan 19— to COMONE
(b) FONECON between Mr. Dial, NAVMAT, and Mr. Davis, Portsmouth, 3 Jan 19—

*Encl: (1) NAVMAT survey team report of Portsmouth Naval Shipyard
(2) (SC) Department of the Navy Correspondence Manual (2 copies)

1. In response to reference (a), the findings of the Headquarters, Naval Material Command survey team are provided in detail in enclosure (1). The information on correspondence practices in this letter and in the accompanying material are submitted at the request of the Administrative Officer of the Portsmouth Naval Shipyard.

2. The copies of the Department of the Navy Correspondence Manual (enclosure (2)), which are forwarded under separate cover, may be retained for your use.

3. This letter is specifically designed to be used as a guide to the procedures contained in the NAVMAT team report, and in accordance with reference (b). Few letters will contain as many parts as this one; however, the general arrangement is the same, regardless of the number of elements in a letter or its length.

a. The identification symbols, and, if any, the postal instructions, the classification, and the "from" line, are fixed in their relative positions.

b. The positions of the other headings depend on the number of lines required for each entry:

(1) Between the "from" line and the "to" line, and the "to" line and the "via" line, if any, there is no blank line.

*INDICATES ITEMS THAT MAY NOT BE REQUIRED

95.17

Figure 1-5.—Standard naval letter.

PBX:ABC:PLM
*5216
*5 Jan 19—

*Subj: Correspondence practices; recommendations of NAVMAT team
concerning

(2) Between all other heading entries, and between the last heading entry and the body of the letter, there is a blank line.

4. The month may be abbreviated or spelled in full. The date may be either typed or stamped.

PETER L. MURPHY
*By direction

*Copy to:
CNO
COMONE

*Blind copy to:
(List of information addressees not shown on the original)
(Appears on copies retained in department or headquarters only)

Prepared by:
(Drafter's name and organization, *room number, and telephone extension, and date of typing)
(Appears on file copies only)

2

*INDICATES ITEMS THAT MAY NOT BE REQUIRED

95.17

Figure 1-6.—Standard naval letter—Continued.

that a single paragraph makes up the entire body. The important thing for the writer is to (1) arrange the units in what seems the most satisfactory order, (2) complete each unit before moving on to the next, and (3) maintain continuity by providing transition from one unit to another.

When you prepare the first draft, do not worry too much about the finished product. Get something on paper. You can go over it later for errors, clarity, and good order. If possible, let the first draft cool for awhile and occupy your mind with other matters before going over it again. This practice tends to make you more objective—you will find flaws not apparent to you earlier. Delete unneeded words, cut down the big ones, take out the intensives (very much, extremely), eliminate unnecessary introductory phrases such as "it is to be noted" and "we call your attention to the fact that," and avoid repetition.

## MEMORANDUMS

Although there are variations of the form of naval correspondence called a memorandum, the one most frequently utilized is the simple "From-To" type between subordinates within the same activity.

A preprinted Department of the Navy Memorandum (short or long) form is available, or you may use a plain or letterhead (when the memorandum is addressed outside the organization) sheet of paper. When using other than the preprinted form, type "MEMORANDUM" in capital letters at the left margin. Two spaces below that type "From:" and proceed as you would for a naval letter. For very informal communications, memorandums may be handwritten.

Variations of the "From-To" style include the "Memorandum For" and "2-Way Letter-Memo" types. The former is used between high-level officials within the Department of Defense. The "2-Way" incorporates the efficiencies of a preprinted format and preinserted carbon, it is employed only for communications that require a reply.

## SPEEDLETTERS

A speedletter is used for an urgent communication that does not require electrical transmission. It is prepared on a standard, preprinted form prominently marked across the top with NAVAL SPEEDLETTER in large letters. Unlike other types of correspondence, an extra copy is provided the addressee so that they may reply on the speedletter (copy) itself.

The main purpose of the speedletter format is to call attention to the communication so that it will be given priority handling by the addressee. To this end, a special speedletter envelope is available to insure that mail handlers give the speedletter immediate attention. If a regular envelope must be used, it should be conspicuously marked with the word "SPEEDLETTER" in capital letters.

With some variations, a speedletter is prepared in much the same way as a naval letter (except that if time is critical, the speedletter may be handwritten). Identifying blocks take care of most of the information normally placed at the top of a standard letter down through the "To" line Therefore, unless "Subj" and "Ref" lines are used, the writer places nothing in the textual portion of the speedletter form except the text itself, the signature, a list of enclosures, if any, and, if needed, downgrading and classification data.

## MESSAGES

A message is a written thought or idea, expressed briefly and to the point, and prepared for transmission by the most suitable means of telecommunication.

The originator of a message is the command by whose authority the message is sent. The drafter—usually the communications officer or a department head—is the person who actually composes the message for release. The releasing officer authorizes transmission of the message for and in the name of the originator. Usually the commanding officer is releasing officer, but may delegate the releasing authority.

### Basic Message Format

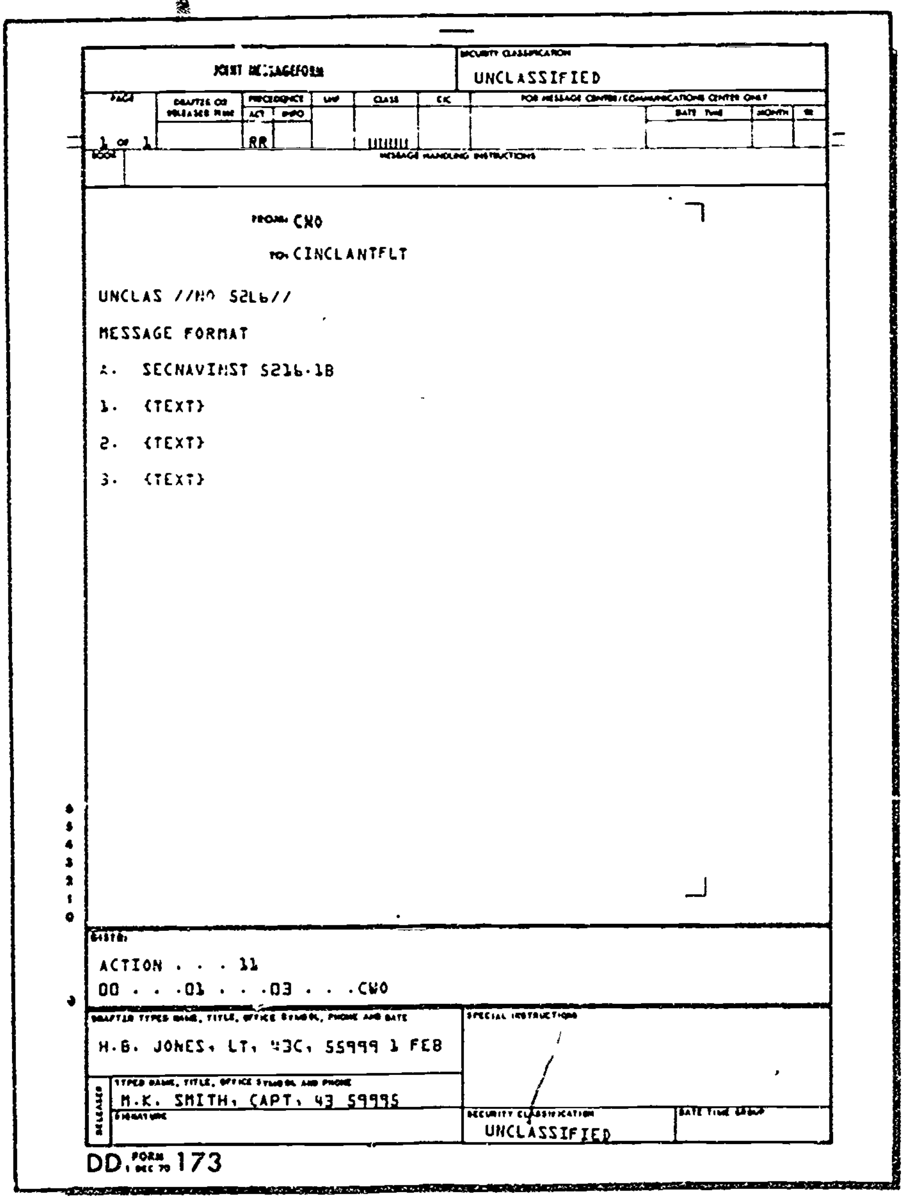
With few exceptions, military messages sent by electrical telecommunications are arranged in a basic naval message format. See figure 1-7.

Communications requiring expeditious delivery are prepared for transmission as brief, concise messages with a message heading and a message text.

### Heading

Figure 1-7 shows which parts of the heading must be completed. Although you do not fill in the date/time group block, you need to understand how to read this information.

The date/time group is expressed as six digits with a zone suffix, plus an abbreviated month and a two-digit year. The first pair of digits


JOINT MESSAGEFORM
SECURITY CLASSIFICATION
UNCLASSIFIED
1 OF 1
RR
FROM: CNO
TO: CINCLANTFLT
UNCLAS //N0 5216//
MESSAGE FORMAT
A. SECNAVINST 5216.1B
1. (TEXT)
2. (TEXT)
3. (TEXT)
DISTR:
ACTION . . . 11
00 . . . 01 . . . 03 . . . CNO
H.B. JONES, LT, 43C, 55999 1 FEB
M.K. SMITH, CAPT, 43 59995
UNCLASSIFIED
DD FORM 1 DEC 70 173

31.47

Figure 1-7.—Format for naval message.

(080005Z AUG 81) denotes the date of the month, the second pair (080005Z AUG 81) the hours, and the third pair (080005Z AUG 81) the minutes, followed by a capitalized letter which indicates the time zone. For standardization, all naval communications use Greenwich (Z) time. Duplicate date/time groups should not be used by the same originator during any one 24-hour period. Normally, the time included in the date/time group is the time at which the originator delivered the message to the communications center for transmission. All numerals in abbreviated titles used in naval messages are spelled out.

### Text

The text of a naval message is prepared as shown in figure 1-7. Notice that the message paragraphs are numbered, except for short, one-paragraph messages. Subparagraphs are indented and lettered or numbered as appropriate. If the message is classified, it is marked with the proper downgrading/declassification markings. The number of characters and spaces on a line is sixty-nine.

Short titles or abbreviations are not used in the text if the message is addressed to a Member of Congress, a commercial concern, or a nonmilitary address.

The following punctuation marks or symbols may be used to enhance clarity within the message text:

Hyphen (-)
Question mark (?)
Colon (:)
Dollar sign ($)
Apostrophe (')
Ampersand (&)
Parentheses (left and right) ( )
Period (.)
Comma (,)
Vergule (or slant) (/)
Quotation mark ('')
Number symbol (#)

Symbols that may NOT be used in a naval message are:

''At'' sign (@)
Percent (%)
Fractions (1/2, 1/4, et cetera)
Asterisk (*)
Underscore (_)
Cent sign (¢)

## ADMINISTERING A COMPANY ACCIDENT PREVENTION PROGRAM

Each command is required to establish a safety organization to develop, organize, and direct a comprehensive accident prevention program and to provide for the promulgation and enforcement of safety precautions and safe construction techniques. The safety program is usually under the direction of a SAFETY OFFICER, designated by the commanding officer. The safety officer has the authority to take immediate steps to stop any operation where there is impending danger of injury to personnel or damage to equipment or material.

The safety officer lays out the safety program after conducting job analyses and consultations with the supervisors in charge of the various phases of construction.

Under the direction of the safety officer, and with the assistance of the safety chief, each company is required to administer an accident prevention program. As an SW1 or SWC, you may be appointed to administer C or D Company's accident prevention program.

### SUPERVISION AND SAFETY

Safety and production go hand in hand. Supervisors should consider the safety, health, and physical welfare of their personnel as one of their chief responsibilities.

In teaching a new job or operation, always emphasize the safety measures that apply. In planning your jobs, make sure you keep safety in mind; do NOT wait until after an accident to teach safety. Remember that a lost-time injury means a nonproducer, and a high-accident rate certainly will NOT reflect favorably upon your ability to supervise. To show concern over the

health and physical welfare of your crewmembers not only will pay off in production, but also will enable you to earn their respect.

Some pointers that will be useful in preventing accidents are outlined below:

A. Size up the job.
   1. Analyze the job and spot the hazards.
   2. Review the previous accident experience on the job.
   3. Get help, if needed, from your project officer.

B. Plan to control the hazards.
   1. Weigh means for controlling the hazards.
   2. Select the right methods and the right personnel for the job.
   3. Decide on the proper tools and equipment.
   4. Check for protective equipment needs.

C. Work your plan.
   1. Make specific work assignments and give instructions.
   2. Check to see that everyone understands what is expected of them and that they do it.
   3. Remove hazards or protect the crew against them.
   4. Insist on safe practices.

D. Check results.
   1. Was the plan followed?
   2. How could the plan have been improved?
   3. What hazardous conditions or work practices, if any, need further attention?

## SAFEGUARDS AND SAFETY EDUCATION

Many supervisors feel that it is only necessary to provide safeguards, then safety will take care of itself. Provision of safeguards is a move in the right direction, but it alone will NOT get good results. To maintain a good safety record, you, as the supervisor, need to employ a combination of safety devices and safety training. If all your crewmembers have had sound safety training, they will be able to guard against even those hazards where safety devices are impracticable. You must, however, train them in the use of safeguards, explaining why, as well as how, they should be used. How many times have you seen a crewmember shut off the power on a machine and then walk away from it before it has stopped turning? Such a person uses a safeguard, but does not know why. By providing the necessary training, you, as an alert supervisor, must make sure that such careless uses of safeguards do NOT happen again.

Standup safety meetings should be held in the field once every week. The meeting should be held at or near the work area. Instead of a routine safety lecture, it is much better to hold a group discussion on specific accidents that are to be guarded against or that may have happened in the unit. Crewmembers should be encouraged to express their ideas. A group conclusion about how specific accidents can be prevented should be reached.

Another type of safety meeting is one in which you present a safety problem that has developed because of new work or new equipment. Again, crewmembers should be invited to express their ideas.

A third type of safety meeting is one in which actual demonstrations and practices by the group are carried out. You might demonstrate how to lift, and then have the crew practice lifting. Also, to make the reason for lifting in this manner more realistic, a little lesson on the classes of tools and a little problem in ratio and proportion should prove interesting.

If you are demonstrating how to use a forklift—bring in a forklift and use it—do NOT just talk about how to use it. Then, again, let the crew practice.

Making these meetings interesting is of the utmost importance. You should not complain or scold, and the meetings should be limited in time. The subject matter should be thought out carefully in advance, and it should be timely. Considerable ingenuity is required to keep these meetings from degenerating into dull routine affairs. Some supervisors have the crewmembers themselves rotate as leaders of the safety meetings—an excellent way to maintain interest. Hundreds of good motion pictures and other visual aids are available on safety subjects. Use them!

As company safety administrator, you are required to submit safety meeting reports periodically to the safety chief. You must keep a record of all meetings conducted within the company. Information required for this report will include the topics discussed, the number of personnel attending, and the length of the meeting.

## SAFETY INSPECTIONS

To do your part in the administration of the safety program, you must know the safety precautions which apply to the various types and phases of construction involving personnel and equipment. Furthermore, you must carry out the recommendations of the safety officer, which usually include the following:

1. Promulgate and enforce all safety regulations.
2. Instruct and drill your crewmembers in safe practices.
3. Caution your crew with regard to occupational hazards.
4. Inspect work areas regularly.
5. Assign crewmembers to jobs that are not beyond their technical and physical capabilities.
6. Report accidents, analyze them, and recommend appropriate action to prevent recurrence.

## ACCIDENT REPORTING

When an accident occurs in your shop, office, or within your crew, you must fill out an OPNAV Form 5102/1 Accidental Injury/Death Report (figures 1-8 through 1-11). This form provides a method of recording the essential facts concerning an accident, from which data for use in accident prevention can be compiled. Item 33—"Corrective action taken/recommended"—is the most important part of this report. Your response to this item provides a clue to your attitude toward safety. Too many supervisors respond with "The crewmember was warned to be more careful." Such a response is useless since it does not tie in with the rest of the report. If an unsafe working condition is the cause of the accident, you will NOT correct it by warning the crewmember to be more careful. Study the report; analyze it; then take corrective action. When properly used, this report is one of your best accident prevention tools. In many cases, the difference between a minor accident and a major one is a matter of luck. Do not ignore accidents that result in small cuts and bruises; investigate the reason for them and correct the causes. If you do this, you will have a safe and efficient shop or office.

## ACCIDENT INVESTIGATION

Before filling out OPNAV Form 5102/1, you must conduct an accident investigation to get an ers to questions, such as those in the six categories below.

1. Unsafe conditions. Was the equipment improperly guarded, unguarded, or inadequately guarded? Was the equipment or material rough, slippery, sharp-edged, decayed, worn, or cracked? Was there a hazardous arrangement, such as congested work space, lack of proper lifting equipment or unsafe planning? Was the proper safety apparel being worn? Were the proper respirator, goggle, gloves, etc., provided?
2. Type of accident. Did an object strike the person? Did the person fall at the same level or a different level or get caught between objects, or slip (not fall)?
3. Unsafe act. Was the crewmember operating a machine without proper authorization or working at an unsafe speed, that is, too fast or too slow? Was a safety device made inoperative, that is, blocked out or removed? Was the load made unsafe or were tools or equipment put in an unsafe place where they would fall? Did someone fail to wipe oil, water, grease, paint, etc., from working surfaces? Did the injured crewmember take an unsafe position of posture, or lift with a bent back or while in an awkward position, or lift jerkily, or ride in an unsafe position on a vehicle, or use improper means of ascending or descending? Was the injury caused by failure to wear the provided safe attire or personal protective devices, such as goggles, gloves, masks, aprons, or safety shoes?
4. Unsafe personal factor. Was the person absent-minded or inattentive, unaware of safe practices, unpracticed, of unskilled, unable to recognize or appreciate the hazards? Did the

**ACCIDENTAL INJURY/DEATH REPORT**
OPNAV 5102/1 (5-76)
S/N 0107-LF-051-0306

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REPORT SYMBOL OPNAV 5102–1
*Page 1 of 4 Pages*

TO: COMMANDER, NAVAL SAFETY CENTER, NAVAL AIR STATION, NORFOLK, VA 23511

A Complete instructions for filling out this form are contained in OPNAVINST 5102.1
B The entire form may be hand printed. Legibility is important.
C Where blocks are provided for the individual characters of the data follow these rules:
(1) If the entry is letters place the first letter in the left-hand block.
(2) If the entry is a number place it so that the last digit is in the right hand block.

CAUTION: Ensure compliance with the requirements of the Privacy Act of 1974 prior to recording personnel data. (See para 204b of this instruction.)

THIS SPACE FOR NAVSAFECEN USE ONLY

| | YR | MO | DAY | LOG | LINE | VEHICLE | PERSONNEL | FILE | |
|---|---|---|---|---|---|---|---|---|---|
| EVENT DATE | 01 02 | 03 04 | 05 06 | 07 | 08 09 | 10 11 | 12 13 14 | 15 16 17 | A 18 |

SECTION A – GENERAL

1 REPORTING ACTIVITY *(Incl. U.S. and UA)*
2 SHIP TYPE/HULL NO
3 UIC (23 24 25 26 27)
4 REPORT SERIAL
5 INJURY DATE
6 LIGHT CONDITION (28): A ADEQUATE; B INADEQUATE *(Explain in Item 10)*; Z UNKNOWN
7 PARENT TYCOM, SYSCOM or BUREAU OF PERSON'S PERMANENT DUTY STATION
8 LOCATION ABOARD ACTIVITY *where injury occurred (Mess, Engine Rm, Machine Shop, Warehouse, etc.) (If not aboard reporting activity give place name)*
9 SHIP STATUS (29): A UNDERWAY; B ANCHORED; C MOORED; D SUBMERGED; E DRY DOCK; Z OTHER *(Specify)*
10 EVOLUTION AT TIME OF INJURY *(UNREP, NGFS, ASW, etc.) (If aircraft is involved give model, BUNO, reporting custodian and mishap serial)*

SECTION B – INJURY/KILLED PERSON
*If multiple injuries are involved see OPNAVINST 5102.1*

11 NO. REPORTABLE INJURIES/DEATHS THIS ACCIDENT (30 31 32)
12 NAME *(Last, initials)* (33–47)
13 SOCIAL SECURITY NUMBER (48–56)
14 AGE (57 58)
15 SEX (59)
16 RANK/RATING OR GRADE AND JOB TITLE
17 YEARS EXPERIENCE: MIL in present regularly assigned duties; CIV in present occupation (60 61)
18 JOB OR ACTIVITY ACTUALLY ENGAGED IN AT TIME OF INJURY *(Driving forklift, loading aircraft, etc.)*
19 MONTHS EXPERIENCE IN JOB OR ACTIVITY SHOWN IN ITEM 18 (62 63 64)
20 EMPLOYMENT STATUS (65): A USN; B USMC; C FOREIGN NATIONAL; D NAVY FEDERAL CIVILIAN; E NAVY NON APPROPRIATED FUND CIVILIAN; Z OTHER *(Specify)*
21 DUTY STATUS (66): A ON DUTY; B OFF DUTY
22 MEDICAL STATUS (67): A DEAD; B MISSING; C HOSPITALIZED; D A AND C; Z NONE OF THESE
23 JOB DISPOSITION AFTER INJURY (68): A RETURN TO DUTY; B TEMPORARY TRANS TO NEW JOB; C PERMANENT TRANS TO NEW JOB; D EMPLOYMENT TERMINATED DUE TO INJURY; Z OTHER *(Specify)*
24 NO. OF LOST WORKDAYS: A AWAY FROM WORK (69 70 71); B RESTRICTED ACTIVITY (72 73 74)
25 SOURCE OF INJURY *(Cut by saw, overcome by fumes, etc.)*
26 PERMANENT DUTY STATION OF INJURED PERSON IF NOT REPORTING ACTIVITY
27A MEDICAL DIAGNOSIS FROM MEDICAL DEPARTMENT *(Include body part)*

Chemical/Toxic Exposure: Provide as much of the following information as is known: (1) Manufacturer name of product, manufacturer's stock number, manufacturer's part number, NSN, MILSPEC. (2) Type of exposure (inhaled, contact, etc.). (3) Length of exposure.
Electric Shock/Electrocution: If portable equipment is involved specify if grounded/ungrounded.

27B DISABILITY *(Check most probable)*
- [ ] PERMANENT TOTAL
- [ ] PERMANENT PARTIAL
- [ ] NONE

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29.52A

Figure 1-8.—Accident Injury/Death Report, OPNAV Form 5102/1 (page 1 of 4).

**ACCIDENTAL INJURY/DEATH REPORT** *(Continued)*

OPNAV 5102/1 (5-78)
S/N 0107-LF-051-0000

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REPORT SYMBOL OPNAV 5102–1
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SECTION C – PERSONAL PROTECTIVE EQUIPMENT — NOT APPLICABLE ☐

29. EQUIPMENT *(Name, MK/Mod, Model, etc.) (Include NSC if available)*

| 28. INVOLVED IN INJURY | 30. NEED AND AVAILABILITY | 31. EQUIPMENT ADEQUACY |
|---|---|---|
| 75 — A. NOT A FACTOR; B. REDUCED INJURY; C. INCREASED INJURY | 76 — A. NOT NEEDED; B. AVAILABLE USED; C. AVAILABLE NOT USED; D. NOT AVAILABLE, NEEDED | 77 — A. ADEQUATE; B. INADEQUATE; C. MISUSED; D. FAILED |

SECTION D – NARRATIVE

32. DESCRIBE THE CHAIN OF EVENTS LEADING UP TO AND THROUGH THE INJURY TO AID IN THE ANALYSIS OF WHAT HAPPENED, HOW IT HAPPENED AND WHY IT HAPPENED. DETAILED INFORMATION GIVEN ELSEWHERE IN THE REPORT NEED NOT BE REPEATED UNLESS IT IS REQUIRED FOR CLARITY.

33. COMMANDING OFFICER *(or Authorized Deputy)* REVIEW AND COMMENTS. INCLUDE CORRECTIVE ACTION TAKEN LOCALLY AND/OR CORRECTIVE ACTION RECOMMENDED TO HIGHER AUTHORITY.

| 34. NAME, TITLE, TELEPHONE NO. *(if applicable)* OF THE PERSON PREPARING THIS REPORT | DATE SIGNED | COMMANDING OFFICER *(or Authorized Deputy)* *(Printed name and rank)* *(Signature)* |
|---|---|---|

ENCLOSURES

☐ OPNAV 5102/2 ☐ PHOTOGRAPHS ☐ ____
☐ OPNAV 5102/2E ☐ ____ ☐ ____

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29.52B

Figure 1-9.—Accident Injury/Death Report, OPNAV Form 5102/1 (page 2 of 4).

**ACCIDENTAL INJURY/DEATH REPORT** *(Continued)*
OPNAV 5102/1 (5-76)
S/N 0107-LF-051-0206

REPORT SYMBOL OPNAV 5102-1
*Page 3 of 4 Pages*

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**SECTION E – CAUSE FACTORS**

In assigning cause factors the bare details of the injury and the determination of specific circumstances represent nothing more than a point of departure for further detailed analysis. It is not enough to conclude that an injury was caused by "poor judgment", "human error" or an "Act of God". The validity of conclusions about an investigation must be based upon the "why" of the injury, the reason for the sometimes obvious, sometimes obscure errors which may initiate or contribute to a mishap. Without this knowledge, projections from the immediate injury to other possibly similar situations cannot be made and injury prevention efforts will be degraded. Answers to the "why" of injuries only become available if the proper questions are asked. This section provides these questions.

36. PERSONNEL CAUSE FACTORS — NOT A CAUSE FACTOR ☐

**INSTRUCTIONS**

A WHO? Enter the number from LIST A which best describes WHO was a cause factor. Make your choice based on what the person was doing and not on his job title.
B WHAT? Enter the number from LIST B which best describes WHAT the person in Item A did not do which was a cause factor in this injury.
C WHY? Enter the number(s) (up to 4) from LIST C which best describe WHY the person in Item A did not do the action in Item B.

36-1 PERSON NUMBER 1 – THE INJURED PERSON HIMSELF IF HE WAS A CAUSE FACTOR

A WHO? 23 24 | B WHAT? 25 26 | C WHY? *(up to 4)* 27 28 29 30 31 32 33 34 | D *(Not applicable)* | E *(Not applicable)*
F *(Not applicable)* | G HOURS SINCE LAST SIGNIFICANT SLEEP 38 39 | H ADDITIONAL COMMENTS

36-2 PERSON NUMBER 2 – ANOTHER PERSON WHO WAS A CAUSE FACTOR

A WHO? 40 41 | B WHAT? 42 43 | C WHY? *(up to 4)* 44 45 46 47 48 49 50 51 | D JOB OR ACTIVITY ACTUALLY ENGAGED IN AT THE TIME OF THE INJURY | E MONTHS EXPERIENCE AT JOB or ACTIVITY SHOWN IN ITEM D 52 53 54
F RANK/RATING OR GRADE AND JOB TITLE | G HOURS SINCE LAST SIGNIFICANT SLEEP 56 55 | H ADDITIONAL COMMENTS

36-3 PERSON NUMBER 3 – ANOTHER PERSON WHO WAS A CAUSE FACTOR

A WHO? 57 58 | B WHAT? 59 60 | C WHY? *(Up to 4)* 61 62 63 64 65 66 67 68 | D JOB OR ACTIVITY ACTUALLY ENGAGED IN AT THE TIME OF THE INJURY | E MONTHS EXPERIENCE AT JOB or ACTIVITY SHOWN IN ITEM D 69 70 71
F RANK/RATING OR GRADE AND JOB TITLE | G HOURS SINCE LAST SIGNIFICANT SLEEP 72 73 | H ADDITIONAL COMMENTS

**LIST A – WHO WAS A CAUSE FACTOR?**

11 Supervisor/Foreman
12 Operator
13 Maintenance worker
14 Quality Assurance/Control Inspector
15. Watchstander
16 Off-duty military *(use for all off-duty injuries)*
99 Other *(specify)*

**LIST B – WHAT DID HE FAIL TO DO?**

21 Correctly operate controls/monitor displays
22 Perform PMS/maintenance properly/completely
23 Recognize hazardous situation
24 Use proper caution for known risk
25 Use protective equipment *(Complete Section C)*
26 Use proper tool/equipment for job *(specify in Item H)*
27 Take corrective action *(time was available)*
28 Plan adequately
29 Match task to man's ability
30 Coordinate tasks
31 Provide proper work/rest cycle
32 Supervise progress of work
33. Inspect completed work
99 Other *(specify in Item H)*

**LIST C – WHY DID HE FAIL TO DO IT?**

**Behavioral Factors**
41 Not conversant/comfortable
42 Lack of concern/interest
43 Distracted/inattentive
44 Haste
45 Habit
46 Overconfidence
47 Excessive Motivation
48. Emotionally aroused *(angry, worried, etc.)*

**Training/Experience Factors**
51 Inadequate knowledge of men/equipment
52 Insufficient experience/skill/training

**Medical Factors**
61 Fatigue
62 Alcohol/hangover
63. Drug use *(Note 1)*
64 Drug abuse *(Note 1)*
65 Illness *(Note 2)*
66. Physical Handicap/impairment

**Communication Factors**
71 Disrupted communications
72. Misunderstanding
73 Failure to detect warning signal/indicator

**Design Factors**
81 Restricted vision
82 Inadequate work space
83 Personal equipment interferences *(explain in Item H)*
84 Inadequate/unavailable tools/equipment *(specify in Item H)*
85 Poor design/location of controls/displays
79 Other *(explain in Item H)*

*NOTE 1* Drug use: (1) Prescribed drugs/medicine used as prescribed or (2) Non-prescription drugs/medicine used as directed. Any other use of drugs/medicine is drug abuse.
*NOTE 2* If the illness is a result of present or past employment give details in narrative.

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29.52C

Figure 1-10.—Accident Injury/Death Report, OPNAV Form 5102/1 (page 3 of 4).

**ACCIDENTAL INJURY/DEATH REPORT** *(Continued)*
OPNAV 5102/1 (5-76)
S/N 0107-LF-051-0305

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**36. MATERIAL CAUSE FACTORS** NOT A CAUSE FACTOR ☐

*NOTE. This item may not be applicable if OPNAV 5102/2E (Explosive Mishap Supplement) is submitted - see Chapter 7, OPNAVINST 5102.1. List all items of material/equipment, including components if applicable, which caused or contributed to the injury.*

| A. NAME, MK/MOD, MODEL, ETC. OF MATERIAL/EQUIPMENT AND/OR COMPONENTS | B. EIC (*if available*) TEC (*if available*) NATIONAL STOCK NO (*Indicate which is used*) | C. EXPLAIN HOW IT CONTRIBUTED TO THE INJURY AND, IF APPLICABLE, THE NATURE AND CAUSE OF THE FAILURE/MALFUNCTION. |
|---|---|---|
| | | |

**37. PROCEDURE/PRECAUTION CAUSE FACTORS** NOT A CAUSE FACTOR ☐

A. WHAT PROCEDURE/PRECAUTION CONTRIBUTED TO THE INJURY?

74
- A. OPERATING PROCEDURES
- B. SAFETY PRECAUTION
- C. TEST PROCEDURE
- D. MAINTENANCE PROCEDURE
- Z. OTHER (*Specify*)

B. WHAT IS WRONG WITH IT?

75
- A. INADEQUATE
- B. INCOMPLETE
- C. INCORRECT
- D. NON-EXISTENT
- E. NOT POSTED
- Z. OTHER (*Specify*)

C. SPECIFICALLY WHAT IS WRONG WITH IT? (*Give title and identification of source of procedure/precaution*)

**38. ENVIRONMENTAL CAUSE FACTORS** NOT A CAUSE FACTOR ☐

A. WHAT ENVIRONMENTAL CONDITIONS CONTRIBUTED TO THE INJURY? (*Enter up to 4*)

| | |
|---|---|
| A. WIND | H. TEMPERATURE |
| B. SEAS | J. VISIBILITY |
| C. SWELL | K. E M RADIATION |
| D. CURRENT | L. NOISE LEVEL |
| E. TIDES | M. VIBRATION |
| F. HUMIDITY | N. VENTILATION |
| G. LIGHTING | Z. OTHER (*Specify*) |

76 | 77 | 78 | 79

B. WHAT WERE THE SPECIFIC CONDITIONS AND THEIR EFFECT? (*Indicate if the conditions were normal/abnormal or expected/unexpected*)

**39. REMARKS** Use this space to expand or explain the cause factors as required.

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29.52D

Figure 1-11.—Accident Injury/Death Report, OPNAV Form 5102/1 (page 4 of 4).

person fail to understand instructions, regulations, or safety rules, willfully disregard instructions or safety rules, have a bodily defect, such as poor eyesight, defective hearing, or a hernia?

5. Type of injury. Was the injury sustained a cut, bruise, sprain, strain, hernia, or fracture?

6. Part of body affected. Did the injury involve an arm, leg, ribs, feet, fingers, head, etc.?

These categories suggest some of the things (not all) you must investigate and report when accidents occur. Remember there are some questions in these categories that request medical information which can only be obtained from a doctor. Each accident is different, and each should be investigated and judged on its own merits. Do not jump to conclusions. Start each investigation with an open mind. The most important reason for any accident investigation is prevention of a similar accident.

## THE PERSONNEL READINESS CAPABILITY PROGRAM (PRCP)

The Personnel Readiness Capability Program (PRCP) is a management tool now used throughout the active and reserve Naval Construction Force (NCF). Its purpose is to provide managers at all levels of the NCF with timely personnel information which will increase their capabilities in planni_, decision making, and control.

Before PRCP was developed, personnel information was kept on an "as required" basis by various members of the unit in personal notebooks, files, and records. This information was collected as management required it to determine military and construction capabilities, training requirements, logistics support, etc. The collecting of this information was usually a time-consuming, laborious task that required a piecemeal inventory of the command's capabilities or requirements. Another way of getting this information was through the use of rough estimates. Neither way, however, produced the accuracy or rapid response desired. PRCP has helped to do so by establishing standard procedures for identifying, collecting, processing, and utilizing this information.

The Personnel Readiness Capability Program requires each participating command to gather and continuously update information on each member of the unit. Most of this information concerns skills acquired through actual job experience or through some type of training program. Other information, such as expiration of enlistment or rotation date, is required for accurate planning. The gathering of this other information is called a SKILL INVENTORY.

## SKILL INVENTORY

An accurate and current skill inventory is the backbone of PRCP. Without it, the reliability of any planning based on information stored in the PRCP DATA BANK is questionable. Presently, all PRCP skills and other data are based on requirements established by COMCBPAC and COMCBLANT and promulgated in their joint instruction of the 1500.20 series. Additionally, these skills have been conveniently classified into five major categories:

(1) Individual General Skills. These are essentially nonmanipulative skills (knowledge) related to two or more ratings, such as construction inspection, planning and estimating, and safety inspection.

(2) Individual Rating Skills. These are primarily manipulative skills associated with one of the seven Occupational Field 13 (Construction) Ratings. Some examples are: light frame construction for Builder, cable splicing for Construction Electrician, and shore-based boiler operation for Utilitiesman.

(3) Individual Special Skills. These are technical skills performed by several ratings, including those other than Occupational Field 13's. For example: forklift operation, ham radio operation, or typing.

(4) Military Skills. These are further classified into two subcategories: General Military Requirements and SEABEE Combat Readiness. Examples are disaster recovery training and mines and booby traps, respectively.

(5) Crew Experience Skills. These are gained by working with others on specific projects. Most of these projects are related to advanced base construction, such as steel tank erection, pile driving, and SATS installation.

A skill inventory has three principal steps. First, each skill is closely defined so that each person will give it the same meaning. Second, a standard procedure for obtaining the information is developed. This procedure helps to insure that the information, regardless of where it is collected or by whom, will meet certain standards of acceptability. The third and last step is the actual collection of the skill data and includes the procedures for submitting the data to the data bank.

### Skill Definitions

A manual of standard SKILL DEFINITIONS, called Volume I PRCP Skill Definitions, contains a definition for every skill identified in the Personnel Readiness Capability Program. Each definition has been jointly approved by COMCBLANT, COMCBPAC, and CNRT (Chief of Naval Reserve Training) and is applicable to the entire Naval Construction Force.

### PRCP Standards and Guides

The skill definitions alone do not contain sufficiently detailed information to accurately classify people, nor do they provide any classification procedures. Recognizing this, the Civil Engineer Support Office (CESO) conducted special SEABEE workshops where Volume II PRCP Standards and Guides were developed under the guidance of CESO. This volume consists of seven separate manuals, one for each SEABEE rating. The PRCP Standards and Guides are the principal tools used in collecting and updating skill data. By following the interviewing procedures in the Standards and Guides, a trained interviewer is able to classify people to a predetermined skill level within an acceptable degree of uniformity. Also, by having a thorough knowledge of the tasks required of each skill, anyone so authorized can classify others to an appropriate skill level by actually observing them perform the tasks, either in training or on the job.

Skill information obtained from interviewing or observing is submitted to the Facilities Systems Office (FACSO), Port Hueneme, California on a special form known as a PRCP SKILL UPDATE RECORD (fig. 1-12). This form, which consists of multiple sheets of carbon sensitive paper, is preprinted with every skill identified in the PRCP. Normally, it is only necessary to mark the appropriate skill levels attained, then send a copy to FACSO—where the data bank is maintained—and retain a designated copy at the unit level. Complete instructions and information for using the transcript master, as well as other PRCP data processing information, can be obtained from the training officer of units participating in the program.

As a crew squad leader, you are directly responsible for using the PRCP Standards and Guides to interview your personnel (or others) and to provide the initial information for the PRCP data bank. Subsequent UPDATING of this initial information for each person is based on either performance on the job (which you observe) or performance at a school. New personnel, however, and others returning from long periods of certain types of shore duty, may require interviewing.

## PRCP INTERVIEWS

There are two types of PRCP interviews. The first and most important is the INDIVIDUAL RATING SKILL INTERVIEW. The second type is simply called OTHER INTERVIEWS. Both types require the use of the PRCP Standards and Guides.

### Rating Skill Interviews

In conducting an individual rating skill interview, the interviewer uses a discussion technique to classify other SEABEEs in the skill levels of the various individual rating skills. This technique requires a thorough understanding of the skills and tasks defined in the Standards and Guides. Since few individuals possess the talent required to interview in all the skills of a

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GEMS REPORT NO. 1200-0 80 JAN 15

NMCB 133 UIC 55451 DET COMPANY D
PROSPECTIVE ACTY EDATRAPRODECPNCL DATE OF LAST SKILL UPDATE 80-01

SWC PNFC 0000 SNEC 9502 TNEC 0000

GENERAL

| | 1 | 2 | 3 | SYR |
|---|---|---|---|---|
| 0000 | (X) | | | 8 |
| 0030 | (X) | ( )N | ( ) | 8 |
| 0040 | ( ) | ( ) | | |
| 0050 | ( )N | ( ) | | |
| 0080 | ( ) | ( ) | (X)N | 8 |
| 0090 | ( ) | ( ) | ( ) | |

CONST ELECTRICIAN

| | 1 | 2 | 3 | SYR |
|---|---|---|---|---|
| 0212 | ( ) | ( ) | ( ) | |
| 0216 | ( ) | ( ) | ( ) | |
| 0220 | ( ) | ( ) | ( ) | |
| 0231 | ( ) | ( ) | | |
| 0234 | ( ) | | | |
| 0237 | ( ) | ( )N | | |
| 0240 | ( ) | ( ) | | |
| 0250 | ( ) | | | |

ENGINEERING AID

| | 1 | 2 | SYR |
|---|---|---|---|
| 0400 | ( ) | ( ) | |
| 0403 | ( ) | ( ) | |
| 0410 | ( ) | ( ) | |
| 0420 | ( ) | ( ) | |
| 0440 | ( ) | ( ) | |

STEELWORKER

| | 1 | 2 | 3 | SYR |
|---|---|---|---|---|
| 0610 | ( ) | (X) | | 8 |
| 0612 | ( ) | | | |
| 0615 | ( ) | (X) | | 8 |
| 0618 | (X) | ( ) | | 8 |
| 0619 | ( ) | | | |
| 0620 | (X) | ( ) | | 8 |
| 0630 | ( ) | (X) | | 8 |
| 0634 | ( ) | (X) | | 8 |
| 0635 | (X) | | | 8 |
| 0640 | ( ) | | | |

MILITARY

| | 1 | 2 | 3 | SYR |
|---|---|---|---|---|
| 0901 | ( ) | ( ) | ( ) | |
| 0904 | (X) | ( ) | | 8 |
| 0907 | ( ) | (X) | | 0 |
| 0909 | (X) | | | 8 |
| 0940 | (X) | | | 0 |
| 0942 | (X) | | | 8 |
| 0944 | ( ) | | | |
| 0953 | ( ) | (X) | | 0 |
| 0954 | ( ) | (X) | | 0 |
| 0955 | ( ) | ( ) | | |
| 0958 | ( ) | (X) | | 8 |
| 0959 | ( ) | (X) | | 0 |
| 0960 | ( ) | (X) | | 8 |
| 0963 | (X) | ( ) | ( ) | 8 |
| 0964 | ( ) | (X) | | 8 |
| 0974 | (X) | | | 0 |
| 0978 | (X) | | | 8 |
| 0979 | ( ) | | | |
| 0980 | ( ) | | | |
| 0981 | ( ) | | | |

BUILDER

| | 1 | 2 | 3 | SYR |
|---|---|---|---|---|
| 0108 | ( ) | ( )N | | |
| 0110 | ( ) | ( ) | | |
| 0130 | ( ) | ( ) | | |
| 0132 | ( ) | ( ) | ( ) | |
| 0140 | ( ) | ( ) | ( ) | |
| 0150 | ( ) | ( ) | | |
| 0162 | ( ) | | | |
| 0164 | ( ) | ( ) | | |
| 0166 | ( ) | | | |
| 0167 | ( ) | | | |
| 0170 | ( ) | ( ) | ( ) | |
| 0190 | ( ) | ( ) | ( ) | |
| 0198 | ( ) | ( ) | | |

CONST MECHANIC

| | 1 | 2 | 3 | SYR |
|---|---|---|---|---|
| 0325 | ( ) | ( ) | | |
| 0332 | ( ) | ( ) | | |
| 0334 | ( ) | ( ) | ( ) | |
| 0345 | ( ) | ( ) | ( ) | |
| 0355 | ( ) | ( ) | ( ) | |
| 0365 | ( ) | ( ) | ( ) | |
| 0375 | ( ) | ( ) | ( ) | |
| 0385 | ( ) | ( ) | ( ) | |
| 0395 | ( )N | | | |
| 0398 | ( ) | | | |

EQUIPMENT OPERATOR

| | 1 | 2 | 3 | SYR |
|---|---|---|---|---|
| 0515 | ( ) | ( ) | | |
| 0517 | ( ) | | | |
| 0519 | ( ) | | | |
| 0521 | ( ) | ( ) | | |
| 0522 | ( ) | | | |
| 0523 | ( ) | | | |
| 0526 | ( ) | ( ) | | |
| 0530 | ( ) | ( )N | | |
| 0532 | ( ) | | | |
| 0536 | ( ) | | | |
| 0540 | ( ) | ( ) | ( ) | |
| 0542 | ( ) | ( ) | | |
| 0544 | ( ) | ( ) | | |
| 0546 | ( ) | ( ) | | |
| 0548 | ( ) | | | |
| 0549 | ( ) | ( ) | | |
| 0585 | ( )N | | | |
| 0590 | ( ) | | | |
| 0591 | ( ) | ( ) | | |

UTILITIESMAN

| | 1 | 2 | 3 | SYR |
|---|---|---|---|---|
| 0710 | ( ) | ( ) | | |
| 0720 | ( ) | ( ) | ( )N | |
| 0730 | ( ) | ( ) | | |
| 0740 | ( ) | ( ) | ( ) | |
| 0750 | ( ) | ( ) | | |
| 0760 | ( ) | ( )N | ( ) | |

SPECIAL

| | 1 | 2 | 3 | SYR |
|---|---|---|---|---|
| 0800 | ( ) | (X) | | 8 |
| 0801 | (X) | ( ) | ( ) | 8 |
| 0802 | ( ) | ( ) | | |
| 0803 | ( ) | ( ) | | |
| 0804 | ( ) | ( ) | ( ) | |
| 0805 | ( ) | ( ) | | |
| 0806 | ( ) | ( ) | | |
| 0807 | ( ) | ( ) | ( ) | |
| 0812 | ( ) | ( ) | | |
| 0813 | ( ) | ( ) | | |
| 0814 | ( ) | | | |

CREW SKILLS

| | 1 | 2 | SYR |
|---|---|---|---|
| 1000 | (X) | ( ) | 0 |
| 1001 | (X) | ( ) | 0 |
| 1002 | ( ) | ( ) | |
| 1003 | (X) | ( ) | 0 |
| 1004 | (X) | ( ) | 0 |
| 1005 | (X) | ( ) | 0 |
| 1006 | (X) | ( ) | 0 |
| 1007 | ( ) | ( ) | |
| 1008 | ( ) | ( ) | |
| 1009 | (X) | ( ) | 0 |

REFER TO NAVFAC P-458 (STANDARDS & GUIDES)
FOR SKILL TITLES.

SYR IS COMPUTER GENERATED AND IDENTIFIES YEAR SKILL LEVEL ASSIGNED.
SHELF LIFE WILL BE COMPUTED FROM 'SYR'.

1 CHANGES MUST BE MADE IN RED PENCIL.
2 TO ADD OR CHANGE SKILL LEVEL, INSERT 'X' IN APPROPRIATE BOX.
3 TO DELETE SKILL LEVEL DRAW LINE THROUGH APPROPRIATE 'X'.
4 SKILL LEVEL REQUIRING NEC IS INDICATED BY AN 'N' AND IS NOT UPDATABLE BY UNIT.
5 A CHANGE IN SKILL LEVEL OR RE-ENTRY OF EXISTING SKILL LEVEL WILL REVISE SKILL YEAR (SYR).
6 FORWARD CHANGES TO CBC PORHUE (CODF 18112).

PRIVACY ACT STATEMENT. AUTHORITY TO REQUEST SKILL INFORMATION IS DERIVED FROM 5 USC 301, DEPARTMENT REGULATIONS. PURPOSE IS TO OBTAIN INFORMATION CONCERNING YOUR SKILL DATA AND IS USED BY OFFICIALS OF THE DEPARTMENT OF THE NAVY IN THE MANAGEMENT AND TRAINING OF NAVY PERSONNEL. COMPLETION OF THIS UPDATE IS VOLUNTARY. FAILURE TO PROVIDE SKILL DATA MAY RESULT IN NONASSIGNMENT TO DUTY BENEFICIAL TO ADVANCEMENT OR MAY RESULT IN FAILURE TO BE CONSIDERED FOR CERTAIN TRAINING.

143.278A

Figure 1-12.—PRCP skill update record.

rating, the interviewers must be mature enough to recognize their own limitations and be willing to seek assistance from others in their rating.

**Other Interviews**

Other interviews are used to classify people into the individual general and special skills, military skills, and crew experience. With only a few exceptions, these skills do not require an experienced interviewer; and in many cases, skill levels can be assigned to individuals on the basis of their service or training record. This should be done whenever possible to cut down on interviewing time. Then, when the person is in for interviewing, it will be just a matter of verification or of updating.

## USING THE STANDARDS AND GUIDES FOR INDIVIDUAL RATING SKILLS

When assigned as an interviewer, you must obtain, read, understand, and use the PRCP Standards and Guides. The format is standard. After the SKILL TITLE, you will find the contents, SKILL DEFINITIONS and the TASKS which are broken down into TASK ELEMENTS. (See figures 1-13 through 1-15.)

610—Arc Welding (Structural)

CONTENTS

610 Arc Welding (Structural) Skill Definition

- .1 Skill Level 1
  - .01 Prepare arc welder for welding
  - .02 Arc weld mild steel plate up to and including 1/4″ thickness
- .2 Skill Level 2
  - .01 Read and interpret construction drawings
  - .02 Arc weld mild steel plate over 1/4″ thickness
  - .03 Hard-Face (Ware-Face)

**Figure 1-13.—Title and Contents of the PRCP Standards and Guides.**

SKILL DEFINITIONS

Skill Level 1: Individual must identify, set up, use, and care for items in the NMCB Electric Arc Welding Kit; clean, grind, or otherwise prepare mild steel for welding; select rod and weld mild steelplate up to and including 1/4-inch thickness in flat and vertical positions; chip, grind, dress, and prime (i.e., redlead, paint, etc.) welds; and perform operator's maintenance on welding machines.

Skill Level 2. Skill Level 1 plus read and interpret construction drawings, including structural and welding symbols; prescribe type and size of rod and specify welding procedures, including hard facing; and weld mild steelplate of any thickness in all positions.

Skill Level 3: Not applicable.

**Figure 1-14.—Individual Rating Skill Definition.**

**Skill Title and Contents**

The title identifies the skill. For example, figure 1-13 identifies the Individual Steelworker of 610, ARC WELDING (STRUCTURAL). The number 610 is a numerical code for this skill. The CONTENTS can be used to insure that there are no missing pages. The skill definition will always be listed first and directly under it will be .1 Skill Level 1. The tasks are listed under each skill level. You must interview each candidate to see if he or she is qualified for that level.

**Skill Definition**

Figure 1-14 illustrates an individual rating skill definition. This definition of Arc Welding (Structural) is a statement of tasks to be performed at each skill level.

610.2.03 TASK: Hard-face (Ware-face)

Apply these ACTION STATEMENTS to the TASK ELEMENTS listed below:

A. Describe the sequence of steps of this procedure and explain the reasons for each.
B. List significant tools/equipment used in this procedure.
C. Describe principal materials used in this procedure.
D. Describe indications that would be observed during this procedure.
E. Explain results if this procedure is not performed properly or if it is neglected.
F. Discuss safety precautions to be observed.
G. Perform the steps of this procedure when practical.

| TASK ELEMENTS: | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| .01 Prepare material for hard-face. | | | | | | X | X |
| a. Select electrodes. | X | X | X | X | X | | |
| b. Clean. | X | | X | | X | | |
| c. Position and secure. | X | X | X | | X | | |
| .02 Perform hard-face. | | | | | | X | X |
| a. Flat position. | X | | X | X | X | | |
| b. Horizontal position. | X | | X | X | X | | |
| .03 Clean and inspect. | X | X | | | X | X | X |
| .04 Perform final steps. | | | | | | X | X |
| a. Dress-up. | X | X | X | | X | | |

**Figure 1-15.—Typical Task with Related Action Statements and Task Elements.**

There are one, two, or three skill levels, depending upon the complexity and number of the tasks. Each level within a given skill is more difficult to attain than the previous one; however, it has no relationship to another skill. For example, a person having Skill Level 1 in Arc Welding (Structural) performs comparatively easy tasks; whereas, at Skill Level 1 in Arc Welding (Pipe) the person must perform everything required in that specific area.

The purpose of the skill definition in the Standards and Guides is to introduce the skill material to the interviewees. In fact, you begin your interview by reading the skill definition. If the interviewees say they can do the related work, you may continue with the interview for the skill level; however, if they say they can NOT do the work, it is obvious that you should go on to some other skill.

**Tasks and Task Elements**

A TASK is a specific portion of the overall skill level. Some tasks cover relatively broad areas; others are quite specific and brief. Each task is further broken down into several smaller jobs called task elements.

A task element is a basic part of each task. When interviewing, you will use the task elements and their related ACTION STATEMENTS to determine the interviewee's qualifications.

Action statements tell you the type of information you should get from the person being interviewed. Each action statement is identified in the Standards and Guides by a capital letter (A, B, C, etc.). The number of statements varies

from task to task. A matrix is used to show how the statements relate to the task elements.

To illustrate the matrix, refer to Task Element .01, "Prepare material for hard-face." Extend a line to the right and enter the matrix. You will find an X under columns F and G, indicating that action statements F and G are to be applied to this task element.

## STEPS FOR INTERVIEWING

When interviewing, you should first try to put the interviewees at ease. A good way of doing this is to explain the purpose of the interview. For example, the interview will:

a. Let the interviewees know what they are actually expected to know and to do.

b. Determine what the interviewees can actually do so they can be assigned to the right job.

c. Determine the interviewees' deficiencies so that they can be programmed to receive proper training.

Next, explain to the interviewees that they should discuss what they know of the skill honestly and that they should NOT be embarrassed if they do NOT know every item covered in the Guides.

Tell the interviewees what skill and skill level they are being interviewed for. Read the skill definition, as suggested previously, to see if the interviewees know the subject.

### Task Interviewing

Begin interviewing by reading the skill definition again. This helps interviewees to concentrate. The task should be rephrased: "The first thing we will discuss in arc welding is the setup, use, and care of items in the NMCB electric arc welding kit." Then read the first TASK ELEMENT, (.01 Prepare material for hard-face). When applied to action statement F (Discuss safety precautions to be observed), it goes something like this:

> "Describe the safety precautions you should follow when preparing material for hard-facing."

As you can see this is not a question. It is a statement directing interviewees to tell what they know about the safety precautions used in preparing material for hard-facing. There are no questions in the PRCP Standards and Guides; therefore, no answers are provided. The Standards and Guides point out the areas to be discussed (in terms of task elements and action statements), and the interviewees' replies are evaluated by the interviewer on the basis of personal experience, knowledge, and judgment.

It should be obvious now why all rating skill interviewers MUST be experienced in all skills for which they will interview. The only way you can determine whether or not an interviewee knows the task element is to thoroughly know it yourself. If you are unfamiliar with, or "rusty in," any tasks in the Standards and Guides, study them thoroughly before attempting to interview anyone. Also, if you do not understand how a particular action statement is used with a task element, find out before interviewing. Discuss the problem with others who are familiar with the skill.

Only discuss the task element with the action statements indicated in the columns of the matrix. For example, in figure 1-15 only action statements F and G are used with task element .01. And, in task element .03, only action statements A, B, E, F and G.

As an expert in the skill, you will probably have a desire to "ask questions" in tasks not covered by the Standards and Guides. This must be avoided as then there will be no standard. If you feel strongly that the Standards and Guides can be improved, discuss your recommendation with the PRCP coordinator.

### Scoring Interviews

If interviewees have an NEC in the skill for which they are being interviewed, they are automatically assigned to that skill level without being interviewed for any of the lower skill levels. When interviewing, use a positive approach. The interviewees either do or do NOT know the skill. The decision is left up to the interviewer. ALL TASKS must be accomplished for each skill level. The results of the interview are then introduced into the PRCP System.

## ON-THE-JOB-TRAINING

There are many forms of on-the-job training (OJT). It may be in the form of an especially tailored, well-organized program, such as one designed to help welders acquire advanced skills in welding. Then again, OJT may be in the form of simple instruction, like explaining and showing a person how to tie a certain kind of knot. In other words, when one person helps others learn to do a job and makes sure they learn the right way, it is a form of OJT.

You may not have realized it, but in the SEABEES, on-the-job training goes on about all the time. For instance, two SW strikers were assigned the job of fabricating a range hood of a certain design. Although they had performed many comparable jobs, they had not done that particular one. Their supervisor assigned an experienced crewmember to guide them. This person explained the exact procedure for laying out the component parts, how they were formed, how they were fastened, and why that particular design was necessary. The SW strikers understood and easily proceeded with the job.

There are as many examples of OJT as there are contacts between personnel in the SEABEES. Its importance becomes readily apparent in an organization, such as the SEABEES, where changes in equipment, personnel, and improvements call continuously for new and better methods of doing things.

In the SEABEES, as well as in private industry, the term on-the-job training has come to mean "helping an individual acquire the necessary knowledge, skill, and habits to perform a specific job." This definition implies that the job training applies not only to the Constructionman or new personnel in an organization, but also to any other person who is assigned a new job. It indicates that job training is a continuous function in the SEABEES. No person should be regarded as completely trained. One's performance can always be improved by keeping interest high and by passing on directions, suggestions, and information which will increase proficiency of the trainee.

Bear in mind, however, that OJT is an active process and requires active supervisors who are aware of the needs of the trainees and who can motivate them to learn. Use methods which will add meaningful experiences to the trainees' storehouse of knowledge.

A supervisor who does a good job of training personnel stands to benefit in many ways. For one thing, well-trained crewmembers brag about their supervisor, especially to their buddies in other crews. A remark they might make proudly is "I sure do enjoy working for Chief Murray because I learn so much." As you can see, this will multiply your effectiveness on the crew. If you have a skill, knowledge, or attitude of value to the Navy and can impart that skill, knowledge, or attitude to 10 others—you have multiplied your effectiveness 10 times.

## SETTING UP AN ON-THE-JOB TRAINING PROGRAM

In setting up an OJT program, one of the first things you will want to do is to make an administrative analysis to determine the type of training required.

One of the requirements may be for advancement in rate for your personnel. There is nothing that can make you feel any prouder than to see the SWCN's that you have helped make their first crow, with the beam and hook on it, that of a third class Steelworker. Do you know what their thoughts are? They are not, as commonly believed, "Oh boy, no more mess cooking." The real thought of that person is "I cannot wait until I can sew on the next one."

In preparing your program, keep in mind the broad knowledge you have about the objectives and how you can best utilize your experience. You will have to determine, of course, the subjects to be taught. It may be that you are going to teach SW strikers how to put a combination lock splice in a 1/2-inch wire rope. Or perhaps you are going to teach them how to solder a galley steamboat.

You will have to break your subjects down into lessons, taking into consideration the length of time to be devoted to each subject and whether you are going to teach your subjects in a classroom, field, or shop. You may have to establish lesson sequence, determine lesson objectives, analyze reference materials, prepare lesson plans, and so on. Remember that in any type of training program, an objective should be

to help the trainee learn the most and in the shortest time possible.

## IMPLEMENTING AN ON-THE-JOB TRAINING PROGRAM

You should consider various courses of action in implementing an OJT program. To the supervisor or trainer some of the most important are:

1. Survey unit assignments and insure that each assignment is in the best possible accord with the individual's classification and specific skills background.
2. Determine the exact need for training. To determine this need, establish two things: (A) the specific job requirements, and (B) the individual skills of the trainee. When A and B are known, the on-the-job training required can be stated in a simple formula:

   A − B = on-the-job training required.

3. Determine the method or methods of training which will be most effective. Number of people, time available, facilities required, nature of training, and individual capabilities are factors which will affect your decision.
4. Select the personnel who will actually conduct the training, remembering that the end product will be no better than those who conduct the training program.
5. Procure all available materials which may be helpful to supplement the program.
6. Follow-up. You should continuously monitor the program to see that it does not lag, that training records are kept current, and that newly developed skills are properly applied.

This is truly a large order. But now, more than ever, our Navy is dependent upon quality training. It is an important job, and it is one that never ends.

## METHODS OF ON-THE-JOB TRAINING

In OJT, you must be prepared to use a combination of training methods, depending upon the nature of the subject, time available, and the capabilities of the trainee. The following methods of training are basic to any well-planned unit training program.

No other method of training is as effective as intelligent, interested COACH-PUPIL INSTRUCTION. In addition to being a quick way of fitting a new worker into the operation of a unit, it serves as one of the best methods of training. Without specific directions and guidance in learning to perform the necessary duties, a worker is likely to waste time and material and form bad work habits.

It happens that many organizations in industry have apprenticeship courses which are designed to train workers in a trade or skill. Their training consists of coach-pupil supervision under skilled workers with periodic group instruction when it is advantageous.

SELF-STUDY should be encouraged. Skilled and semiskilled jobs require a considerable amount of job knowledge and judgment ability. Even in simple jobs there is much basic information that the worker must acquire. The more complicated technical jobs involve both basic and highly specialized technical knowledges and related skills, which must be taught.

GROUP INSTRUCTION is a practical adjunct to direct supervision and self-study. It is a timesaver when several workers are to be instructed in the same job knowledge or procedures. It affords an opportunity for the supervisor or trainer to check training progress and clarify matters which are difficult for the trainees to understand. Group instruction, if intelligently used, can expedite production. For example, suppose you have six trainees learning the same job. Four of the trainees are having trouble with a certain job element, while the other two have it "knocked." The four people having trouble can be brought over to the other two, and in a short time the difficulty will probably be solved. In OJT, this is called group instruction; and, as you can see, group instruction is not the same as classroom or so-called "academic-type" instruction.

Another type of OJT is PIECEMEAL INSTRUCTION. For instance, a crewmember asks you for information and you supply it. That is piecemeal instruction. A supervisor's orders are, in a sense, a piecemeal method of instruction because they let others know what, when, where, and, perhaps, how and why. Other examples of piecemeal instruction are: explaining regulations, procedures, and orders; holding special meetings; indoctrinating a new person; and conducting organized or unorganized meetings.

## DEVELOPMENTAL ON-THE-JOB TRAINING

In any type of effective training in which one individual is working directly under the supervision of another, it is important that the trainers and trainees understand the objectives at which the training is aimed. Factors deserving careful consideration include determining the training needs of the trainees, defining the purpose of training, and explaining or discussing different points concerning training with the trainees.

In determining training needs, it is often a good idea to interview the trainees. A summary of previously acquired skills and knowledges relative to the job they are to do can be learned by proper questioning. Compare the jobs the trainees know how to do with those they will be doing. Determine training needs (required knowledges and skills minus knowledges and skills already possessed). Training needs should be determined for each job pertaining to the trainee's position assignment. Analyze the job to be done and have all necessary equipment and materials available prior to each job training situation.

In defining the purpose of training, the trainers should clearly explain the purpose of the job, duty, or task to be performed by the trainees. Point out to the trainees their place on the team and explain to them how they assist in getting the unit mission accomplished. Emphasize the importance and advantages of doing the job well, and how the training benefits themselves, their organization, and the SEABEES.

The trainers should also explain facts about the job to be done, principles that are proved and workable, and directions on how to accomplish the job safely, easily, and economically. The trainers should explain, too, the techniques that will improve the skill of the trainees. The importance of each operation in a job should be stressed. The technical terms relating to the job should also be explained.

The trainers and trainees should discuss the problems that arise in doing a job, and endeavor to clear up any questions of the trainees concerning the job. Point out to the trainees any similarity of different operations of the job wherein transfer of knowledge or training may be utilized. The relationship of procedures in a particular job to things with which the trainees are acquainted, should also be discussed. This allows the trainees to learn through association with past experiences. It also is important to discuss the progress of the trainees.

Developmental training in any situation is a process which aids an individual in progressing from what one KNOWS to what one NEEDS TO KNOW--from the KNOWN to the UNKNOWN.

The end product of peacetime military operations is TRAINED PERSONNEL. Regardless of your unit mission, you must have trained personnel to carry it out. It is the responsibility of every petty officer in the Navy to train the personnel under their immediate supervision.

## SYSTEMATIC TRAINING

Effective training requires a great deal of planning and directed effort, organization of materials into a logical sequence to prevent a haphazard approach to the job of training, and accurate measuring methods for evaluation results. There must be some results if any learning takes place. If you push as hard as you can on an object and there is no result—if you fail to move it—no work has been done regardless of the energy expended. If no learning takes place, you have NOT trained. Three steps that may

help you in planning and carrying out your training programs are:

1. Insure learning by use of correct training methods;
2. Measure achievement at regular intervals to assure that learning is taking place; and,
3. Record results where interested parties can check progress; records in the open can create competition which often is a great motivating factor.

### Evaluation

It is nice to know that you are doing something worthwhile and that your efforts are appreciated. You and the trainees will want an evaluation of the work each does. Generally, the most valid trainer evaluation can be obtained by testing the trainees to see how much they have achieved under your guidance. If they have learned to perform in a highly satisfactorily manner, there is an indication that you are doing a good job of training. The effectiveness of the training is determined by how much training has taken place and the value of that training. The personnel must be trained correctly. Improper training, in many cases, is worse than no training at all.

### Performance Testing

Performance testing helps you do a better job of conducting an on-the-job program. You can use performance tests to find how well your trainees are performing their jobs. However, it is difficult to find a test that does its job well.

Performance tests should enable you to evaluate the work of subordinates accurately enough to accomp h the following objectives:

1. To help determine when trainees can actually perform the tasks that they are being trained to do;
2. To aid you in evaluating the improvement of persons in on-the-job training;
3. To help locate strengths and weaknesses in OJT programs;
4. To determine the qualifications of personnel entering OJT programs; and
5. To help assign new people to particular jobs.

Since it is a practical check on a work project, the performance test must be a sample work situation in which the trainee performs some active piece of work that can be examined. The test is not designed to measure what a person knows about the job (a written or oral test may fill that need for you). Instead, it is intended to help you evaluate that person's ability to actually do the job. Do the best you can in organizing and administering the performance test. There will always be room for improvement in most of the testing that you do.

## WORK REQUESTS AND JOB ORDERS

As a shop supervisor, your work will involve work requests and job orders. A work request, as the name implies, asks that work be done. A job order is issued primarily for the purpose of specifying what work is to be done and when it is to be accomplished. The job order also provides for the accumulation of cost data. Since the job order procedure will not be the same at all activities, learn the procedure for your activity and follow it carefully; this will help insure that jobs are accomplished without undue delay.

Wherever work requests and job orders are concerned, it is important that a work control system be established to designate who may request work, what they may request, and who will approve the request authorizing the job order. In the Public Works Department, the control and responsibility is usually designated within the framework of the work classification system. Public works uses eight classifications of work:

1. Emergency Work
2. Service Work
3. Minor Work
4. Specific Jobs
5. Standing Jobs
6. Supplements to Existing Work
7. Amendments to Existing Work
8. Rework

EMERGENCY WORK requires immediate action to accomplish any or all of the following purposes involving public works and/or public utilities:

1. Prevent loss or damage of Government property.
2. Restore essential services that have been disrupted by a breakdown of utilities.
3. Eliminate hazards to personnel or equipment.

Emergency or service work authorizations are limited to 2 man-days. When the work requires more than 2 man-days, emergency work initiated by an emergency work authorization must be superseded by a minor work authorization or by a specific job order, whichever is appropriate.

SERVICE WORK is relatively minor in scope, can be accomplished within 2 man-days, is not emergency work by nature, and does not exceed the dollar limitation which the Work Reception and Control Branch is authorized to approve ($75 to $150, depending upon the size of the activity).

MINOR WORK is work that is in excess of that authorized by an emergency or service work authorization and less than that authorized by a specific job order.

SPECIFIC JOB ORDERS authorize the accomplishment of a specific amount of work for which individual job costs are desired for financial and performance evaluation.

STANDING JOB ORDERS include all work that is highly repetitive on which accumulated costs are desired for a specified period, usually a fiscal year. Some examples where standing job orders are used are: trash and garbage disposal, powerplant watch standing, public works engineering, leave cost, and shop overhead.

SUPPLEMENTS TO AUTHORIZED WORK are issued for any portion of the work under a basic job order that is to be initially charged to an accounting classification other than that shown on the basic job order. A supplementary job order may be issued under a specific or standing job order.

A specific, standing or supplementary job order may use an AMENDMENT TO AUTHORIZED WORK for various reasons including:

1. To reopen a closed job order.
2. To modify the technical provisions.
3. To increase or decrease the scope.
4. To increase or decrease the dollar estimate.
5. To change the accounting classification.

REWORK is work that, in the judgment of the Public Works Officer, is necessary to correct faulty work of Public Works Department personnel.

Certain types of work require prior approval of authorization of the commanding officer, management bureau, or higher authority, but the issue of the job authorization to the public works shop is the responsibility of the Public Works Officer or a delegated representative. Although job authorization is, in effect, the actual signing of the authorizing document, the act presupposes knowledge and approval of every item contained in the work authorization document. Job authorization, therefore, presumes an understanding of the principles and workings of controlled maintenance, as well as familiarity with the action to be approved.

The PUBLIC WORKS OFFICER may approve and sign any or all work authorizations within the limitations established by the cognizant management bureau or the commanding officer. In actual practice, the Public Works Officer usually approves and signs only those documents authorizing work that exceeds the limitations for authorization established by him for the director of the Maintenance Control Divison. The ASSISTANT PUBLIC WORKS OFFICER may approve and sign any or all work authorization documents when such authority has been specifically delegated by the Public Works Officer.

The DIRECTOR, MAINTENANCE CONTROL DIVISION may approve and sign any or all work authorization documents not exceeding the monetary limitations for authorization

imposed by the Public Works Officer. The SHOPS ENGINEER may approve minor work, service work, and emergency work authorizations. The DIRECTOR OF THE MAINTENANCE OR UTILITIES DIVISION may approve minor work, service work, and emergency work authorizations. The WORK RECEPTION AND CONTROL BRANCH (MAINTENANCE CONTROL DIVISION) may approve and sign emergency work and service work authorizations within the limits established by the Public Works Officer.

At times, it may be necessary for you to make up work requests or job orders. Requests for all work, except service or emergency are made on a work request, NAVFAC 9-11014/20. (See fig. 1-16.) Job orders are prepared from these requests on a job order, NAVDOCKS 2356 and a continuation sheet, NAVDOCKS 2357. (See fig. 1-17.) For emergency or service work, an emergency or service work authorization, NAVFAC 9-11014/21, is used; this form is illustrated in figure 1-18. The work request becomes the job order when it is authorized.

In making up a work request or a job order, be sure that a clear description of the work is given and all necessary drawings and details are included. An accurate description of the work required is necessary to insure that the proper number and type of skilled personnel are assigned to the job.

You may be with a NMCB working with job orders dealing with Military Construction (MILCON). A typical job order from a NCR to a NMCB is presented in figure 1-19. The job order form is explained below.

WORK ORDER NUMBER: An assigned accounting number used to control and accumulate charges of materials and labor against the project.

LINE ITEM: The MILCON line item number which identifies the particular project.

JOB TITLE: A short general title of the work to be performed.

DOD CAT CODE: The DOD Facility category code under which the work is being assigned.

QUANTITY: The scope of the facility being constructed in terms of DOD category units of measure.

ESTIMATED MAN-DAYS: An estimate of direct man-days required to do the work described.

ESTIMATED COST: Dollar cost estimated to complete project.

CUSTOMER ACTIVITY: The activity or command for whom the work is to be performed.

REPRESENTATIVE: An official designated to provide liaison between the construction unit and the customer.

TELEPHONE: The telephone number of the representative.

DESIGNATED FOR ACCOMPLISHMENT: Construction unit which is to perform the assigned task.

AUTHORIZED BY: Name and signature of the authorizing official.

GENERAL DESCRIPTION AND REMARKS: A brief, general description of the work and other pertinent data, such as special specifications.

REFERENCE: Identification of reference pertaining to the construction project.

ENCLOSURE: Identification of drawings, specifications, etc., that are being forwarded with the work order.

INSTALL TASK NO.: Numerical identification of sub-tasks to be performed by the construction unit in completing the assigned project.

WORK CLASS: Indication of the predominate ratings involved in the sub-task.

DESCRIPTION OF WORK ACCOMPLISHED: Short description of sub-task.

**WORK REQUEST (MAINTENANCE MANAGEMENT)**
NAVFAC 9-11014/20 (REV. 3-68) S/N-0105-002-7310
Supersedes NAVDOCKS 2331

(PW Department see Instructions in NAVFAC MO-321)

Requester see Instructions on Reverse Side

PART I—REQUEST (Filled out by Requester)

1. FROM
Supply Officer

2. REQUEST NO.
12-711

3. TO
Public Works Officer

4. DATE OF REQUEST
26 June 19 –

5. REQUEST FOR
☐ COST ESTIMATE ☒ PERFORMANCE OF WORK

5a. REQUEST WORK START

6. FOR FURTHER INFORMATION CALL
LTJG L. Moore Bldg. C.
Ext. 891

7. SKETCH/PLAN ATTACHED
☐ YES ☒ NO

8. DESCRIPTION OF WORK AND JUSTIFICATION (Including location, type, size, quantity, etc.)

Fabricate and erect extension to wood storage rack, southwest corner, Bldg. 107. Start from the south wall and extend through bays 3-4 approx: 30' long
2' deep
10' high

Storage rack to be anchored to wall and have 5 shelves spaced approx. 2' apart. Shelves should be capable of storage of material weighing up to 5 lbs. per sq. ft. No paint required.

Extra storage space needed for small shop store items.

9. FUNDS CHARGEABLE
37602 (S&A)

10. SIGNATURE (Requesting Officer)
J. R. Brown
J. R. BROWN, LCDR, USN

PART II—COST ESTIMATE
(Filled out by Maintenance Control Division if estimate requested)

11. TO
Supply Officer

12. ESTIMATE NO.
307

| 13. COST ESTIMATE | |
|---|---|
| a. Labor | $ 140. |
| b. Material | $ 90. |
| c. Overhead and/or Surcharge | $ |
| d. Equipment Rental/Usage | $ |
| e. Contingency | $ 25. |
| f. TOTAL | $ 255. |

14. SKETCH/PLAN ATTACHED
☐ YES ☒ NO

15.
☐ APPROVED. PROGRAMMING TO START IN
☒ APPROVED. BASED ON PRESENT WORKLOAD, THIS JOB CAN BE PROGRAMMED TO START IN 30 days
AUTHORIZED BY 25TH OF July AND FUNDS ARE MADE AVAILABLE.
☐ DISAPPROVED. (See Reverse Side)

16. SIGNATURE
William B. King

17. DATE
3 July 19 –

PART III—ACTION (Filled out by Requester)

18. TO
Public Works Officer

19. AUTHORIZATION TO PROCEED IS ATTACHED (Check one if other than PW funds are involved)
☒ NAVCOMPT 140 ☐ OTHER

20. WORK REQUESTED
☐ HAS BEEN CANCELLED ☐ HAS BEEN DEFERRED ☐ WILL BE PERFORMED BY OTHERS

21. SIGNATURE
J. R. Brown
J. R. BROWN, LCDR, USN

22. DATE
8 July 19 –

(See Part IV on Reverse Side)

117.294

Figure 1-16.—Work Request, NAVFAC 9-11014/20.

JOB ORDER (CONTROLLED MAINTENANCE)

| | | | |
|---|---|---|---|
| | | | Job Order No. 7312011 |
| Activity: Naval Station Anywhere | | Activity Code | Estimate No. 436 |
| 62690 | | 114 | 32 |
| 1721804 | 2515 | 12008 | 46540 |
| | | | ☒ YES ☐ NO |
| | 07 | | 1 May 19 — |

Convert Storehouse, Bldg. 32 into three office areas (60'x30' ea) by installing two partitions, each with center door. Install new lighting with outlets, abandon old concealed wiring. Install steam radiators. Install water coolers. Paint office surfaces including doors, sash and trim, two coats. Lay asphalt tile over present wood floor. Paint Bldg. exterior.

18 BREAKDOWN OF WORK

| Work Center | Description | Est. Hours |
|---|---|---|
| 02 | Construct and erect 60 linear feet of 12' high full partition sheathed with gypsum wall board on both sides, 2"x4" frame studs 16" o.c. 5" baseboard with shoe moulding, shoe moulding to be set loose. 3" cove ceiling moulding. Install 6'-8" x 2'-8" door (flush type) in center of new partition. 4" chair rail to be installed on wall | |

For continuation see Sheets 2 and 3

19 SUMMARY OF ESTIMATES

| Work Center | Labor Hours | Labor $ | Mat'l $ | Total Est $ |
|---|---|---|---|---|
| 02 | 308 | 647 | 484 | 1131 |
| 03 | 406 | 840 | 296 | 1136 |
| 07 | 29 | 60 | 835 | 895 |
| 12 | 153 | 329 | 1,372 | 1,701 |
| 14 | 8 | 13 | 7 | 20 |
| 15 | 74 | 161 | 175 | 336 |
| TOTAL | 978 | 2,050 | 3,169 | 5,219 |
| | | | Grand Total | 5,219 |

20 DISTRIBUTION

| | | | |
|---|---|---|---|
| | 1 | | 1 |
| | 1 | | 12 |
| | 1 | | |
| | 1 | | |

Authorized Work to be Performed: B. W. Wadsworth — Date: 2 Mar 19 —

Sheet 1 of 3

JOB ORDER CONTINUATION SHEET (CONTROLLED MAINTENANCE)

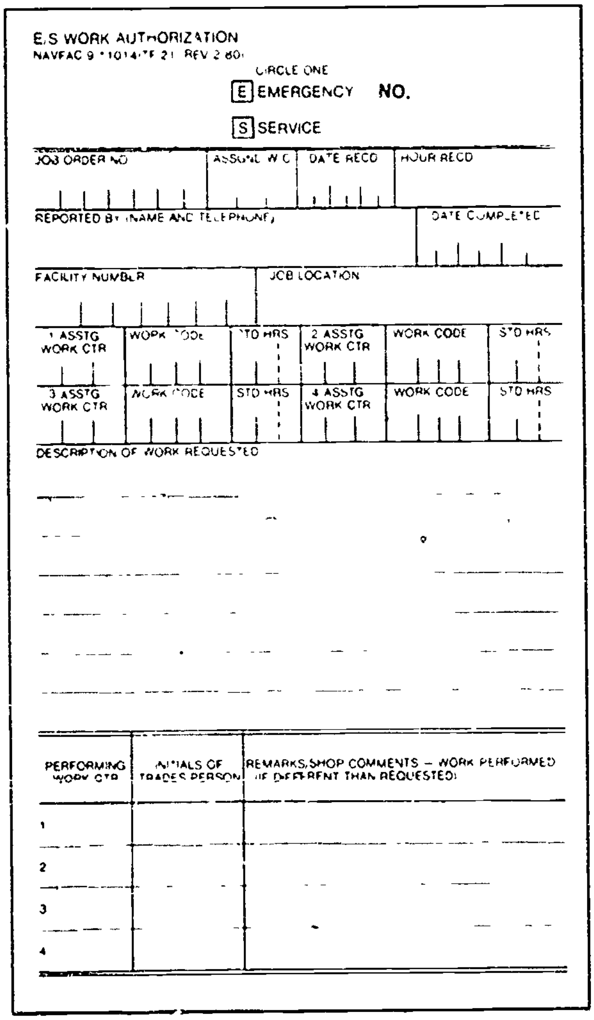
Job Order No. 7312011 — Estimate No. 436

| Work Center | Description of Work | Estimated Hours |
|---|---|---|
| 02 | Lay 5300 sq ft. of 9"x9" asphalt tile with 15# asphalt felt base on existing wood floor. Existing loose floor structure to be renailed and rough sanded before cementing 15# felt. Base board shoe moulding to be reset upon completion of tile application. | 228 |
| 03 | Prepare, prime and paint all partition surfaces. Clean, prime and paint all interior original surfaces in office sections. Paint ceiling, sprinkler pipe, ceiling moulding, door, casing and baseboard flat white. Walls above dado, ceiling moulding, light green. Paint dado walls including chair rail, baseboard, shoe moulding, doors, windows, casing and trim, dark green. Paint for all wall surfaces, trim, etc. to be semi-gloss. Paint exterior of building one coat of existing color. | 406 |
| 12 | Install and connect 52 stem mounted, 4 tube 48" louvered fluorescent light fixtures and 12 duplex convenience flush mounted outlets. Lights to be located 18" below ceiling and outlets to be located 16" above floor. Old lights to be removed, boxes capped, circuits disconnected and abandoned in place. | 39 |
| 15 | Install and connect four sectional type cast iron radiators. Provide traps for each radiator. | 11 |
| 07 | Install and connect three water coolers. Provide traps on new waste lines and valves on new supply lines. | 5 |
| 14 | Remove and properly dispose of debris and extra material discarded in, around and under the building as a result of this work | 8 |

Sheet 2 of 3

87.4

Figure 1-17.—Job Order, NAVDOCKS Forms 2356 and 2357.



E/S WORK AUTHORIZATION
NAVFAC 9-11014/TF-21 (REV 2-80)
CIRCLE ONE
E EMERGENCY NO.
S SERVICE
JOB ORDER NO | ASSGN W C | DATE RECD | HOUR RECD
REPORTED BY (NAME AND TELEPHONE) | DATE COMPLETED
FACILITY NUMBER | JOB LOCATION
1 ASSTG WORK CTR | WORK CODE | STD HRS | 2 ASSTG WORK CTR | WORK CODE | STD HRS
3 ASSTG WORK CTR | WORK CODE | STD HRS | 4 ASSTG WORK CTR | WORK CODE | STD HRS
DESCRIPTION OF WORK REQUESTED
PERFORMING WORK CTR | INITIALS OF TRADES PERSON | REMARKS/SHOP COMMENTS – WORK PERFORMED (IF DIFFERENT THAN REQUESTED)
1
2
3
4

117.295A

Figure 1-18.—Emergency or Service Work Authorization, NAVFAC 9-11014/TF-21.

MAN-DAYS: Estimated or actual number of direct man-days required to complete the sub-task.

BEGIN DATE: Estimated or actual calendar date upon which work on the sub task will commence.

FINISH DATE: Estimated or actual calendar date upon which work on the sub-task will be completed.

SIGNATURE AND DATE: Signature of construction unit representative and date of signature.

When you, as a supervisor, receive a job order, examine it carefully. Make sure you have a clear picture of what is to be done, who is to do it, and when. See that you also have all the information necessary to do the job. If material listings and drawings are listed on enclosures, make sure that they have been included and check them for accuracy. If you have been designated as prime contractor or lead shop, see that the subcontractors or other shops have received the job order, prints and material list as required. Check the availability of the material. The material support will vary greatly. On some jobs, you may not receive the job order until after all the materials necessary for the job have been received. On other jobs, you may have to order the materials yourself through the use of a material yard, shop stores, or the Navy Supply System. If you have any questions, get them answered before starting the job.

See that all the material is properly charged to the correct job order number and that the material is used on the job for which it is drawn. Make sure, also, that the required labor is correctly charged. This will keep you from the embarrassing position of trying to explain how a job was completed without anyone working on it or why some other job exceeded by far the original time estimate.

## DAILY WORK ASSIGNMENTS

The assignment of work is an important matter. On a rush job, you may have to assign the best qualified person available to insure meeting the deadline. When time and workload permit, however, rotate work assignments so that each person will have an opportunity to acquire skills and experience in different phases of the Steelworker's job. When assignments are rotated, the work becomes more interesting for the workers. Another good reason for rotating work assignments is to prevent a particular person from doing all the work of a certain type. It would be a disadvantage in case that person is

THIRTIETH NAVAL CONSTRUCTION REGIMENT

| WORK ORDER NUMBER | JOB TITLE | EST MD 2,000 ESTIMATED COST |
|---|---|---|
| 6PPP69901 | TWENTY FIFTH MOUNTED POLICE BATTALION CANTONMENT, OTTAWA | $26,000 |
| LINE ITEM C-777 | DOD CAT CODE 699 QUANTITY 700 MN | DATE 22 July 19__ |

| CUSTOMER | DESIGNATED FOR ACCOMPLISHMENT |
|---|---|
| ACTIVITY 25th MOUNTED POLICE BATTALION | Naval Mobile Construction Battalion SEVENTY-FIVE |
| REPRESENTATIVE FIELD COPPBOO BOO | AUTHORIZED BY: |
| TELEPHONE OTTAWA 4 | |

GENERAL DESCRIPTION AND REMARKS

Construct the following facilities for customer unit in accordance with reference (a):

(1) Eighty-two (82) 16' x 32' Metal roofed strongbacks.
(2) Three (3) 8 Hole latrines.
(3) One (1) 20' x 48' Shower with concrete deck.
(4) One (1) 500 Man Galley.

Site location as shown by enclosure (1).

| REFERENCE: | ENCLOSURE: |
|---|---|
| (a) 25th MOUNTED POLICE BN LTR DTD 25 MAY 19__ SER 0000. | (1) BASE DEVELOPMENT DWG 732 |

| INSTALL TASK NO. | WORK CLASS | DESCRIPTION OF WORK ACCOMPLISHED | MANDAYS | DATE BEGIN | DATE FINISH |
|---|---|---|---|---|---|
| 82 - 16' x 32' Strongbacks | | | | 25 JUN 19__ | 5 AUG 19__ |
| 1. | EO | Site Preparation | 10 | | |
| 2. | BU | Erection of Strongbacks | 738 | | |
| 3. | CE | Interior/exterior Wiring | 72 | | |
| | | TOTAL | 820 | | |
| 3- 8 Hole latrines | | | | 20 JUL 19__ | 5 AUG 19__ |
| 1. | BU | Erect three structures | 54 | | |
| | | TOTAL | 54 | | |
| 1 - 20' x 48' Shower with concrete deck | | | | 20 JUL 19__ | 5 AUG 19__ |
| 1. | BU | Concrete pour | 10 | | |
| 2. | BU | Erect building | 70 | | |
| 3. | UT | Install piping | 10 | | |
| 4. | CE | Wiring | 10 | | |
| | | TOTAL | 100 | | |
| 1 - 500 Man Galley | | | | 6 JUL 19__ | 5 AUG 19__ |
| 1. | EO | Site preparation | 20 | | |
| 2. | BU | Concrete pour | 80 | | |
| 3. | BU | Building erection | 850 | | |
| 4. | CE | Wiring | 50 | | |
| | | TOTAL | 1000 | | |
| | | GRAND TOTAL | 1974 | | |

SIGNATURE DATE

117.296

Figure 1-19.—NMCB Job Order.

transferred or hospitalized or goes on leave for a long period of time.

Give special consideration to strikers in work assignments. They should be assigned progressively to jobs of ascending levels of difficulty. Strikers may be useful assistants on a complicated job, but may not fully understand the different phases of the job unless they have worked their way up from basic tasks.

When assigning work, be sure to give the worker as much information as necessary. An experienced worker may need only a drawing and a general statement concerning the finished product. A less experienced worker is likely to require more instruction concerning the layout of the job and the procedures to be followed.

Often, you may want to put more workers on a job than it normally takes in order to get the job done sooner. Remember that there is a limit to the number of workers who can put on a job at a given time. But, do not overlook the advantage of assigning more workers to a project when their services can effectively speed up its completion. For instance, to construct a SATS airfield in the shortest time possible, you could assign two crews (instead of one) to lay the matting for the runway. Both crews could work at the same time, one crew laying in each direction. Moreover, if taxiways or parking areas are needed, additional crews could be employed at the same time in laying these areas.

# CHAPTER 2

# SUPERVISION

As a First Class or Chief Petty Officer, you will have many responsibilities added to those which you had at the Second Class level. The higher your paygrade, the more likely it will be that your main duties will consist of supervising rather than doing.

At the First Class and Chief levels, you NOT only must be able to meet the requirements of your rate, you must be familiar with those of the Navy Enlisted Classification (NEC) holders. As you probably know, the NEC holders are individuals who have special skills; therefore, you should be knowledgeable enough in their specialties to be able to explain or supervise their performance on the job. There are other requirements you must meet, if you are to carry out your supervisory responsibilities effectively. You will need to know how to handle your crews to get the most out of them; you must be able to plan projects, make estimates, and set up programs to train your personnel; you must be able to foresee difficulties and devise methods for overcoming them. You must be able to maintain records and reports; and you must be safety conscious, insuring that your personnel observe all safety precautions applicable to their jobs.

## PRINCIPLES OF LEADERSHIP

Supervision or leadership is an art. It requires the ability to organize, delegate, and coordinate operations—techniques, which you, as the supervisor, should employ in your daily supervisory activities. Learning how to organize, delegate, and coordinate the various phases of a project can be developed the same way as any other art. The art of military leadership can be learned, developed, and practiced in varying degrees by anyone motivated who has the mental and physical ability, and the moral integrity expected of either a commissioned or petty officer. Developing this art is a continuing process.

In the ultimate sense, military leadership is NOT inherent; it is based upon the development of traits of the individual personality and upon the understanding and application of sound leadership principles and techniques. Certain rules or principles which have stood the test of time appear to have guided the conduct and action of successful leaders of the past. Throughout military history, these rules—known as Leadership Principles, as given below, have in varying degrees affected the action of every successful leader.

1. Be technically and tactically proficient
2. Know yourself, and seek self-improvement
3. Know your personnel, and look out for their welfare
4. Keep your personnel informed
5. Set an example
6. Insure that the task is understood, supervised, and accomplished
7. Train your personnel as a team
8. Make sound and timely decisions
9. Develop a sense of responsibility in your subordinates
10. Employ your crews in accordance with their capabilities
11. Seek responsibility, and take responsibility for your actions

The ultimate objective of a supervisor is the successful accomplishment of an assigned task

or mission. When properly supervised, this task or mission is carried out with a minimum expenditure of manpower and materials, and with a maximum of harmony, cooperation, and efficiency within the entire work force—from the unskilled helpers to the management and command levels of an organization.

## ORGANIZATION

As a supervisor, you must be able to organize. This means that you should be able to analyze the requirements of a project and plan the sequence of events that will bring about desired results.

You should be able to look at a job and estimate how many man-hours are required to complete it; you will probably have been given a date by which the work is to be completed. Next (or perhaps even before making your estimate of man-hours), plan the sequence of operations. Make sure that you also know the answers to the following questions. What is the size of the job? Is the material on hand? What tools are available, and what is their condition?

Before assigning work, carefully consider the qualifications of your personnel. Are they experienced, or will some training be required? Are any scheduled for leave? Will you need to request additional personnel? After getting answers to these questions, you should be able to assign your crews accordingly and set up tentative schedules. If work shifts are necessary, make arrangements for the smooth transition from one shift to another with a minimum of work interruption. How well you are able to carry out these steps is directly related to your ability to organize.

## DELEGATION

The ability to delegate is an important aspect of good supervisors. Failure to delegate is common in a new supervisor. It is only natural to want to carry out the details of a job yourself, particularly when you know that you can do it better than any of your subordinates. Trying to do too much, however, is one of the quickest ways to get bogged down in details and to slow down a large operation. On some projects, you may have crews working in several different places. Obviously, you cannot be in two places at the same time. There will be times when a crewmember needs assistance or instruction on some problem that arises. If the crew has to wait until you are available, then time will be lost. It is important, therefore, to delegate authority to one or more of your crewmembers to make decisions in certain matters. Here, knowledge of your personnel is important. Some people can handle responsibility well; others cannot. You must know who can make sound decisions in your absence and who cannot. You must also remember that, although you are allowed to delegate authority, you are still responsible for the completion of the project.

## COORDINATION

The ability to coordinate operations is another important aspect of good supervision. When several operations are in progress, it is important to plan them so one can follow another without delay.

Keeping a good interface with your sister companies is also important. Planning to transport rebar cages from the prefab yard to the project site at a certain time and day may be difficult if ALFA Company does not have the trucks scheduled. Coordination is not limited to projects only. You would not want to approve a leave chit for one of your crewmembers then remember a school during the same time period; nor would you want to schedule a crewmember for the rifle range only to find out that the range coaches will not be available at that time.

# SUPERVISORY RESPONSIBILITIES

In effectively performing your supervisory activities, you must be in direct contact with, and have direct control over, the individuals who produce the work. In this regard, the major duties and responsibilities of a supervisor include the following: production; safety, health, and physical welfare of subordinates; development of cooperation; development of morale; and training of subordinates.

## PRODUCTION

The primary responsibility of every supervisor is PRODUCTION. Production can best be obtained by (1) planning and organizing the work to get maximum production with minimum effort and confusion, (2) delegating as much authority as possible, but remaining responsible for the final product, and (3) continuously supervising and controlling to insure that the work is done properly.

## SAFETY, HEALTH, AND PHYSICAL WELFARE OF SUBORDINATES

Safety and production go hand in hand, since the only efficient way to do anything is the safe way. When personnel are absent because of injury, shop equipment is down because of damage, or completed work is destroyed by accident, production will definitely fall. Therefore, you, as a supervisor, must be a constant teacher of safety; you must set examples by constantly observing all safety precautions; you must teach safety as an integral part of each training unit; and you must plan each job with safety in mind.

Showing concern for the health and physical welfare of your subordinates will also payoff production-wise. Remember that a healthy worker is inherently a more efficient worker than one who is not. Besides, concern for these matters is bound to increase the respect with which your subordinates will view you and should motivate them to produce more.

## DEVELOPMENT OF COOPERATION

You can best get the members of your crew to cooperate by willingly telling them the whats and whys of their work. It also helps to develop cooperation among the crewmembers by training them continually in order to prepare them for increased responsibilities and to teach them new skills.

It is essential that you cooperate with your seniors on the project and in the battalion by continually informing them of circumstances which (1) require their decisions or other actions, and (2) what would be unknown to them unless you passed the word. It is often the case that what you, and perhaps your crews as well, imagine to be the indifference of your seniors is actually a result of your NOT keeping them informed.

## DEVELOPMENT OF MORALE

Morale may be defined as an individual's, a team's, or unit's state of mind. It depends upon their attitude toward everything that affects them—their fellow SEABEES, their leaders, Navy life in general, and other things which seem important to them.

Morale is closely related to satisfying a person's basic human needs. If the training, administration, and everyday routine of a unit is conducted to assist in satisfying the crewmembers basic needs, a favorable attitude will be developed. High morale is a positive state of mind which gives the individuals a feeling of confidence and well-being that enable them to face hardship with courage, endurance, and determination.

The state of morale does NOT remain the same; rather, it is constantly changing. Morale of the members of your unit is an important index to the effectiveness of your leadership abilities. You can measure morale by closely observing the personnel in their daily activities, by inspections, by formal and informal interviews, and by evaluating reports. Specific things to watch for include appearance, personal hygiene, military courtesy, personal conduct, use of recreational facilities, excessive quarreling, harmful or irresponsible rumors, condition of mess and quarters, care of equipment, response to orders and directives, job proficiency, and motivation during training.

When properly evaluated, administration reports concerning the status of personnel aid in measuring morale. Particularly valuable are reports which concern the following: military or civil arrest, damage to or loss of equipment through carelessness, family problems, indebtedness, malingerers, absence without leave and desertion, requests for transfer, self-inflicted wounds, sick-call rate, stragglers, and reenlistment rates.

## TRAINING OF SUBORDINATES

The training program of each battalion is formed to provide the personnel with the skills needed to accomplish the battalion's current and mobilization mission. The program is crafted in accordance with the pattern, priority, and tempo established by the commanding officer. The program covers many phases—from orientation courses to special technical courses. Extent of the training depends on operational commitments, policies, and directives from higher authority, experience and previous training of the personnel; training facilities available; and other factors. Although much of the construction training will be provided by class A or C schools, as well as special SEABEE training courses, additional skills and experience must be acquired in the battalion.

As a supervisor, you must emphasize the importance of training to your personnel. At the same time, impress upon them the importance of using the correct terminology and/or technical language common to the Steelworker rating. In so doing, your personnel should learn more readily and also retain a more detailed picture of the functions and operations of their jobs.

## CHAPTER 3

# SHOP AND CONSTRUCTION SITE ORGANIZATION

In the Steelworker rating, you have the opportunity to learn and to become proficient in many skills. You can work toward mastering these skills by attending Navy formal schools, taking SCbT courses, and through on-the-job training. Now as a first class or chief petty officer, you are expected to become the teacher—to pass your knowledges and skills on to the younger Steelworkers. You are now the planner, the organizer, and the supervisor. YOU have become the THEY everyone has talked about and still do.

No one expects you to be the expert in all phases of your rating, but you are expected to be able to find answers or solutions to problems when they arise. This chapter describes ways of setting up shops and fabrication yards and gives helpful suggestions in the supervision of crews engaged in construction operations.

## SHOP LAYOUT

You should be able not only to direct and coordinate the various operations within your shop, but also to plan the layout of equipment and materials needed to set up a new shop from scratch. You will find that certain factors applicable in setting up a new shop can also be applied basically in taking over as a supervisor of a shop already in existence. When taking over a shop already set up, you may often find it worthwhile to make a study of the layout of equipment and materials to determine if some changes would help provide a smoother workflow and higher production.

### PURPOSE OF SHOP

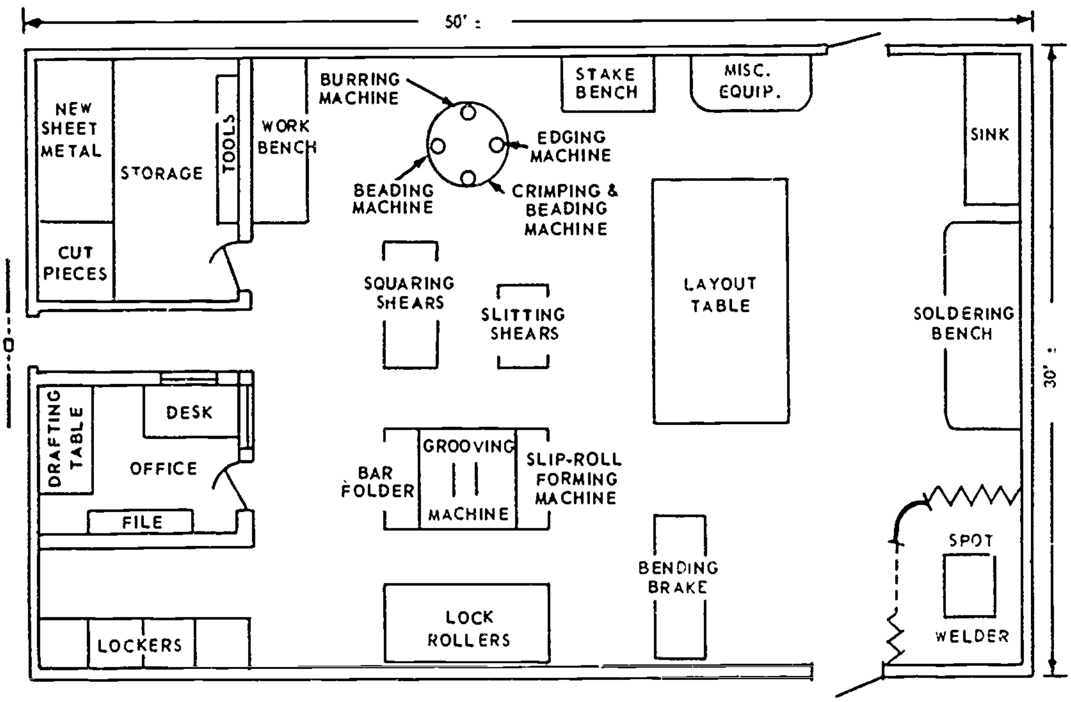
In planning the layout and organization of a shop, carefully analyze the purpose of the shop. What kind of work will be done here? How much work must normally be turned out? Is the shop a specialized shop or a general-purpose shop?

Next, consider the particular advantages and limitations of the proposed shop space. How large is it? How many personnel will be expected to work in the shop at the same time? What kind of tools will be available? Where are the power outlets located? Can good lighting be arranged? What type of ventilation will be readily available?

The function of the shop will have an important bearing on the equipment needed and the minimum space required. At times, you may NOT get the amount of space desired and have to do as best you can with whatever space is available. In some instances, two spaces may be available but one is unacceptable because of major problems that would be encountered. For example, the ideal location for a welding shop may not be used for that purpose if the structural design of the building would cause exhaust duct installation difficulties.

### ARRANGEMENT

Good arrangement is required in all shops, regardless of their function. The arrangement of equipment, layout tables, and so on in a shop should be in the order of the workflow of the project that is most dominant in that shop.




145.1

Figure 3-1.—Layout of a sheet metal shop.

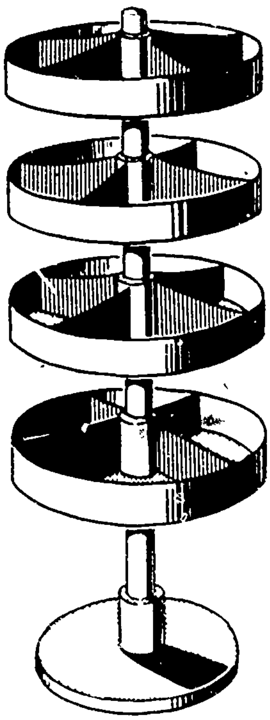
In planning the arrangement of equipment, consider such factors as sequence of operations, working space, clear shop entrance and exit, adequate workbenches, and safety. The positioning of equipment, layout tables, and so on may NOT be the same in one shop as another. The layout in figure 3-1, however, may be used as a guide in laying out a sheet metal shop.

Try to place stationary machines so that the work will flow in an orderly and logical sequence. It is probably easier to do this in a specialized shop than it is in a general-purpose shop where the work differs considerably from one day to another.

In shops where there is a series of operations to be performed, the relative position of the various pieces of equipment has an important bearing on efficient operations. Not only should the equipment be accessible, it should also be arranged to save wasted motion and to reduce walking distance. This will enable your personnel to turn out more work in a shorter time. People unconsciously produce more work when their equipment is close at hand. Clearance between adjacent machines should be such that the operators will NOT get in the way of one another. Allow plenty of space for operations, such as feeding large sizes of sheet metal or bar stock into a machine.

Adequate worktables and workbenches are a necessity for the protection of both personnel and materials. Most shops, especially sheet metal shops, require plenty of flat working surface. Try to have the workbenches positioned with respect to fixed equipment so that the equipment most often used can be quickly and easily reached. Electrical outlets should be readily available to the workbenches. Needless delays are caused by having to rig long connections from poorly located outlets.

Your plans should include adequate means for stowing tools and materials. If considerable amounts of materials must be kept on hand, and if space permits, a special storeroom may be used for stowage of materials; where desirable, a



29.202

Figure 3-2.—Vertical rotor-bin for shop stowage of fittings and miscellaneous items.

portion of the storeroom may also be used for stowage of tools and equipment. When a storeroom is available, however, it may still be advantageous to stow certain materials in the shop near the machines or equipment on which they are used.

The amounts and types of materials stowed in your shop will depend largely upon the space available and the intended purpose of your shop. In most shops, you will probably need facilities for stowing such items as bolts, nuts, screws, and spare parts. In a sheet metal shop, you will need a rack for stowing commonly used gages of metal. In a welding shop, you will need hot lockers for stowing electrodes; the use of hot lockers will help insure that the electrodes are kept dry and that the coated surfaces do NOT get chipped.

Lockers, drawers, bins, cabinets, and the like, are suitable for stowing various types of tools and materials. A vertical rotor-bin, like that shown in figure 3-2, can be used to stow fittings and miscellaneous items in the shop. Whatever the type of shop, make an effort to see that your stowage facilities are arranged to give the greatest possible amount of free working space.

You will also need space for an office. As a rule, try to locate the office in an area of the shop where you will be least disturbed by noise from machines. The shop layout plan should make provision for a bulletin board upon which may be posted safety posters, maintenance posters, instructions and notices, plan-of-the-day, and such other information as is appropriate.

The bulletin board should be located in a prominent place in the shop, preferably near the entrance where personnel will be likely to pass during the day. If necessary, artificial lighting should be provided so that material on the bulletin board can be read with ease. Material on the bulletin board should be changed frequently, expired notices promptly removed, the current plan-of-the-day posted early, and posters and other material rotated periodically. If the same material is presented in the same format every day, it will not be long before the bulletin board will be ignored and the purposes for having it will be defeated. New arrangements are noticed and interest is stimulated with variety.

## SHOP SAFETY

Consider the shop layout from the point of view of SAFETY. Use nonskid flooring in critical areas. Allow adequate space for aisles and passageways. Equipment, storage racks, and the like should be arranged so that the entrance and exit to the building can be kept clear and will be accessible in the event of fire or emergency. Locate stationary machines so that the moving parts will NOT constitute a hazard to either the operator or to other shop personnel. Be certain that your shop layout will allow easy access to fire-fighting equipment, electrical control panels, and junction boxes. Remember that various physical factors, such as lighting and ventilation, also have an effect on safety.

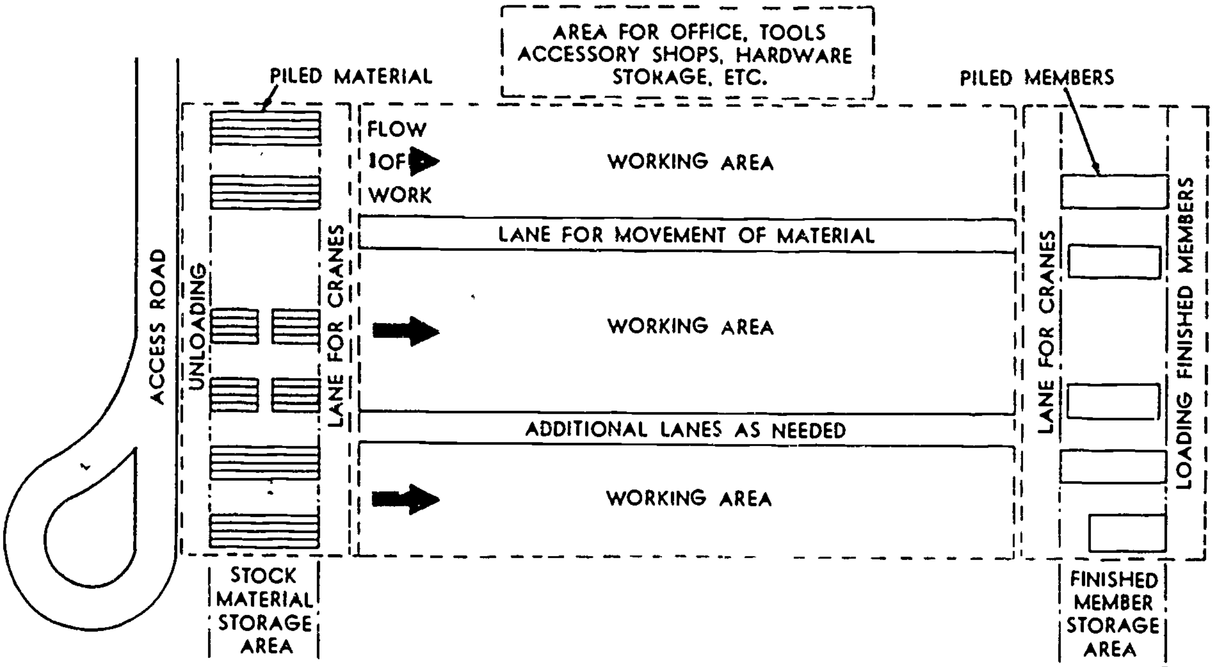



**Figure 3-3.—Plan of typical fabrication yard.**

## LAYOUT OF FABRICATION YARD

In addition to planning the layout of shops, you must also be able to plan the layout of facilities for construction projects in the field. This phase of our discussion will introduce you to some of the major factors to be considered in planning the layout of a fabrication yard. You may often be called upon to plan the layout of a fabrication and erection of steel structures. As a useful hint, remember that the control of fabrication operations depends largely on the planning and organizing that go into them.

A major requirement for jobs concerning the fabrication and erection of steel structures is that the fabrication yard be set up in a manner that will insure a smooth flow of work. The yard should be laid out to suit the fabrication procedure and the size of the operation. If possible, the yard should be located next to the construction site. The ground should be firm and level and ample working space should be provided. A plan showing various subdivisions of a typical fabrication yard is given in figure 3-3.

The layout and arrangement of a fabrication yard may not be the same at one site as at another. A typical fabrication yard, however, would normally include the following main areas:

1. A tool and equipment storage and repair area
2. A material storage area
3. A working area for various operations, such as laying out, cutting, drilling, punching, fitting up, reaming, and bolting
4. A fabricated member storage area

For maximum efficiency, the fabrication yard should be arranged so that work can be carried out in assembly-line order. The arrangement should permit moving heavy pieces of material as little as possible and in a straight line.

It is a good idea for each crew to be held responsible for fabrication of one group or class of member You should try to provide a system of handling that avoids back-tracking or

crossing-over of the material in flow. Lanes for movement of material, cranes, and machines should be located so that materials will pass through each operation with the minimum of handling and the shortest haul. Operation plans and layout should give primary consideration to safeguarding personnel from injuries.

## TOOL AND EQUIPMENT AREA

Numerous types of tools and equipment generally are required in steel fabrication and erection operations. Plans for the layout of a fabrication yard should include adequate space allowance for storage and repair of tools and accessory equipment. An ideal location for such an area is adjacent to the working area. It is suggested that the minimum space requirements listed below be provided for the storage, repair, and maintenance of tools and equipment, as indicated:

| | |
|---|---|
| Handtools and hardware storage | 1/2 square yard per worker, one-half of it under cover |
| Pneumatic tool storage and maintenance shop | 1/4 square yard per worker |
| Machine, blacksmith, and pipefitting shops, including tool sharpening | 30 square yards or more |
| Rigging loft | 20 square yards or more |
| Heavy-equipment storage and maintenance | 50 to 200 square yards |

Tools and equipment requirements may vary from one site to another, depending on factors such as the methods used and the length of time allowed for fabrication. In fabricating typical structures by usual procedures, and under normal site conditions you generally will need a wide variety of ordinary handtools and equipment, for example, C-clamps, center punches, drills, hoists, wrenches, and slings. Often you will need safety equipment and improvised or expedient equipment, such as drill presses, roller tables, push cars, and special lifting hooks. In addition, a crane probably will be needed in the fabrication yard at all times for unloading steel and for moving and turning heavy pieces during fabrication and assembly. For some projects, you may set up small derricks at principal operating sites, or else have additional cranes on hand.

## MATERIAL STORAGE AREA

Careful planning should be given to the location of the material storage area. An ideal location is alongside an access road or railway siding that is on the end of the fabrication yard where the material can be delivered without interfering with other operations. The layout and arrangement should permit easy movement of cranes, trucks, forklifts, and handtrucks in unloading and piling material and in picking it up for transfer to fabrication operations. Insofar as possible, plan for each class of material to be stored in line with the place of its fabrication. A rule of thumb for estimating storage area requirements is one square yard of net area per ton of material. Obviously, hardware, small parts, and tools should be stored under cover and as near the point of use as possible.

When considering the outside storage of material, make sure they will NOT become unduly damaged or deteriorate from exposure to weather. Also, make sure the material will be relatively free from ignition by flying sparks. In a temporary emergency, it may be necessary that material normally requiring inside storage be stored outside. In such cases, see that the necessary precautions are observed and have the material moved inside as soon as possible.

## WORKING AREAS

The working areas of the fabrication yard should be arranged so that all operations of the job will run smoothly and efficiently from start to finish. Areas should be designated for the operations of laying out, cutting, and drilling or punching of individual pieces. Other areas will be needed for fitting up, reaming, bolting, and welding assembled members. Still others, such as a painting area may be necessary, depending upon the requirements of the particular job.

The layout of any particular fabrication yard will depend largely on the size of the structure. For instance, a small structure for which it would not be economical to provide much equipment would probably call for fitting up of members at the point of drilling the main material. But for a large structure, separate areas for drilling main material and for fitting up would appear practical. Incidentally, when an assembling area is required, you probably will find that an ideal place for it is adjacent to the fabricated member storage area.

### FABRICATED MEMBER STORAGE AREA

An area for storage of finished members should be provided adjacent to the last fabrication operation. It should be arranged so that access for cranes and trucks is facilitated. If this area can be located adjacent to the construction site, then the members can be sorted into proper order for erection and stored accordingly, to avoid any extra handling. If necessary to rehandle members before erection, they must be sorted into the most convenient piles for loading on delivery vehicles. An ample access road and turnaround facilities must be provided.

## MATERIAL AND EQUIPMENT

To keep operations running smoothly, you will have to see that the proper materials and equipment are available at the time they are needed. You must try to avoid a big excess in the supply of material. At the same time, make sure that supplies are NOT exhausted before requesting new material. If material or equipment are NOT on hand when needed, it may result in personnel having to stand idle, which could cause delays in meeting production schedules.

### SITE DEPLOYMENT OF MATERIAL AND EQUIPMENT

As a supervisor of construction work, it is important that you be able to handle the deployment of material and equipment at the jobsite. Make it a point to see that the right material and equipment are at the right place and at the right time.

The bill of materials should be checked during the planning stage to make certain that all material is available or is on order. Even with this check, there is sometimes danger of running out of material. This could happen when the rate of progress on the job has been considerably faster than anticipated or when the material has been unusually slow in arriving at the jobsite. If either of these conditions occur, notify the officer in charge (OIC) of the project. The OIC may appoint an expediter to see that material gets to the location when it is needed. Occasionally, you or one of your personnel might serve as expediter; in this case, you might hand-carry a requisition through the supply chain to speed up delivery. Careful advance planning will contribute to an orderly flow of material. Make a special effort to plan deliveries of material to cause the least possible congestion, with a minimum of shifting after it is unloaded at the jobsite.

Where equipment is needed to accomplish a job, make sure in advance that it will be available; and see that it is on hand at the required time. In some cases, you must first determine the method by which a job will be accomplished before determining the types of equipment you will need. This means, for example, determining whether connections for a steel structure will be bolted or welded, or whether layouts will be by template, by scratching, or by marking directly on the metal.

Machine-powered hoisting equipment is a big advantage on jobs that involve the lifting and moving of heavy materials. There may be occasions, however, when you will NOT be able to obtain powered equipment, such as a crane or forklift. In such cases, you will have to use a gin pole, tripod, or other hand-powered hoisting device—one suitable for the job concerned. As a word of advice, remember that you may save time in getting the job done, and also prevent someone getting injured, if you see that the hoisting device is erected at the spot where it will be needed and insure it is properly rigged. (The erection and use of hoisting equipment will be discussed later in this chapter.)

At the jobsite, you may have to arrange for the stowage of material. In doing so, try to have the material as close as possible to the place where it will be used. From previous experience, you should have acquired a knowledge of the safe methods of handling and stowing various types of material commonly used in steelwork. Make sure that your personnel also know and use the safe methods of handling and stowing material used in their work, and see that proper safety apparel is worn on jobs where required.

## SHOP STOWAGE OF MATERIAL

A main objective in stowing material is to put things where you will know where they are and where you can get to them easily. Assign a specific place in which to keep each particular type of material. Whenever possible, material that is used most frequently should be located in the most accessible places.

No matter what type of shop you are supervising, make it a practice to identify all material. A piece of carbon-molybdenum steel looks just like a piece of mild steel, but you cannot use the two materials for the same purposes. Materials should be identified by labels for each bin or rack, by shipping tags attached to the material, by color code markings (when applicable), and by stock number. Keeping the stock number with the material will save you time and trouble when you need to re-order material.

Various methods may be used to control the supply of parts and material which will be kept in the shop. One suggested method is to prepare a set of file cards showing the minimum amount of each item needed, the amount on hand, and the location of the storage area. As the material and parts are received, they are stored in the places designated for those particular items, and the amounts received are added to the inventory on the file cards. When the parts are used, the items are deducted from the inventory.

In determining the minimum number of repair parts to be kept on hand, take into consideration the length of time needed to get these parts after the requisition is forwarded to the Supply Department. At some overseas locations, this period could be from 3 to 6 months.

## SHOP STOWAGE OF TOOLS AND EQUIPMENT

Proper stowage of tools and equipment is an important factor in the management of any type of shop. You should have a place for each tool or piece of equipment, and each should be kept in its place when NOT in use.

Lockers, drawers, cabinets, and the like are suitable for stowing various types of tools. In selecting a place of storage for a given type of tool, you will often have to consider such factors as the size and shape of the tool, its frequency of use, and its value.

To avoid breakage or damage to tools during stowage, you must see that the personnel concerned are familiar with the proper method of placing certain types of tools in stowage. Drill bits, torch tips, combination squares, files, gages, and the like must be stowed so they are protected from contact with other tools. Edged tools and pointed instruments, such as scribers, dividers, and compasses require special stowage to prevent damage to their cutting edges or sharpened points.

Precision tools, such as micrometers, depth gages, surface gages, and squares, must be protected against SHOCK and PRESSURE. All tools made of steel must be protected against CORROSION.

A special bin should be used for the testing equipment. Testing instruments are very delicate, and any rough handling may throw them out of adjustment. Do NOT stow other types of tools or equipment in the same place as testing instruments.

A system is usually set up for checking the tools in and out. The shop personnel should know, or be able to find out from shop records, where all tools are at all times.

Tools, such as screwdrivers, chisels, and hammers, should be checked regularly for damage and wear, for example, dull cutting edges on the chisels and mushroom heads or broken handles on the hammers. Examine all tools when they are issued and again when they are checked back into the shop. Any tool found in bad condition should be put aside until it can be repaired or replaced.

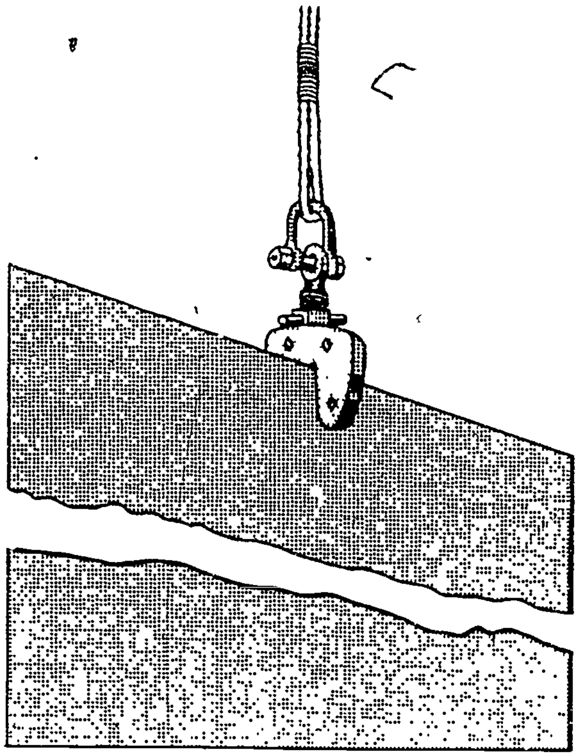


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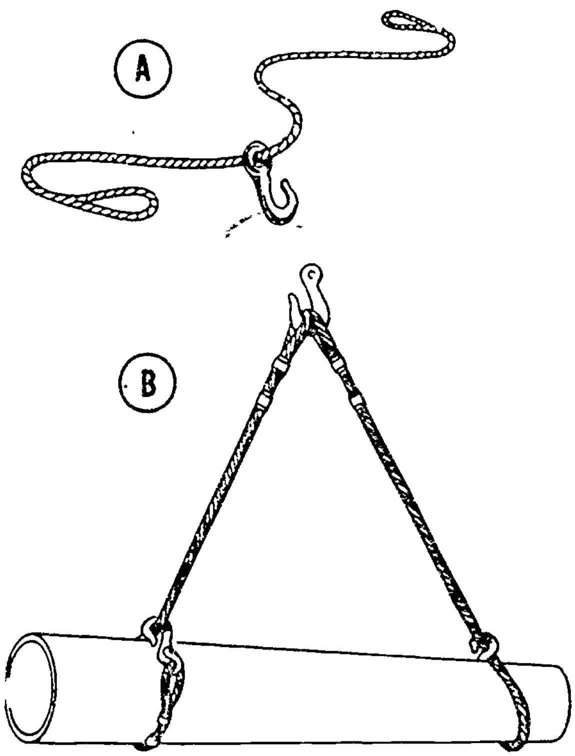
Figure 3-4.—Clamp for handling heavy plate.




80.155
Figure 3-5.—Choker for handling pipe.

If your supply permits, all petty officers should be allowed to have their own toolkit, made up of common handtools ordinarily used in their work. Nobody likes to use a drill bit that someone else has nicked or burnt. Most are better satisfied working with their own tools, and this encourages them to take a special interest in keeping their tools in top shape.

## HANDLING MATERIALS

In supervising the handling of material, you must see that practices are followed which insure the safety of personnel and of the material. Heavy plate is usually handled with wire rope slings, straps, or with an approved plate clamp, such as the one shown in figure 3-4. Note that this clamp should NOT be used for handling bundles of sheet, since the sheets in the middle could slip and cause the entire load to drop. Bulky items, such as reinforcing bar, strap iron, and structural shapes, are usually handled with slings or straps. The choker, shown in view A of figure 3-5, is an effective device for handling pipe and other material which must be gripped tightly. When the hooks are used in pairs, the pull should be from opposite sides of the load, as shown in view B of figure 3-5.

When bundles of reinforcing bars 30 feet or longer in length are being hoisted, it is necessary to use a spreader bar so that the bars will not bend excessively. The length of the spreader bar should be at least one-half the length of the bars in the bundle. The spreader bar may be a fabricated truss assembly, a piece of heavy-duty pipe, or an I-beam.

When bundles of reinforcing bars are being hoisted in congested or limited areas, it may be necessary to apply a tag line to one or both ends of the bundle for the purpose of guiding the load as it is hoisted.

It is very important that chokers and a sling of sufficient strength be selected to lift the load. The stress or tension on each choker depends on

the number of chokers, the angle of the choker, and the total load. The total weight lifted is divided among the supporting chokers and acts straight downward. The greater the angle of the choker from the vertical, the greater is the tension in the choker.

To help prevent injuries to their hands, personnel piling lumber or handling reinforcing steel should wear gloves. Hard hats, safety shoes, and other safety devices should be worn on all jobs where required. In fieldwork, rough-terrain forklifts, cranes, gin poles, and the like are often used in handling heavy construction materials. See that all personnel assigned to jobs on which such devices are used not only know, but also carefully observe, safety precautions applicable to rigging. When materials are moved by hand, warn personnel to use their leg muscles rather than their back muscles. A serious injury may result when an individual attempts to lift or move a load that is too heavy for one person to handle.

When structural steel is stacked or piled, make sure the stack or pile does NOT slide laterally or tip over. Corrugated or flat shapes should NOT be stacked more than 4 feet high. Stacks of pipe are particularly liable to lateral sliding; therefore, such a stack should always be approached from the end, NEVER from the side. Pipe should be segregated by sizes and stacked NOT higher than 5 feet.

Material stacked or piled around the construction site should be located where it will interfere as little as possible with traffic and present the least possible danger to personnel. Barricades and red flags should be placed during the daytime, and red lights at night, on any material which constitutes a hazard to traffic.

## WELDING SHOP

Welding shops may differ in the kind of work being done; one shop may be concerned with vehicle repairs, another with general maintenance, and still another with repairing and fabricating metals. A shop may prepare metals for welding and weld them or it may specialize only in the actual welding operations. Nevertheless, each shop must have on hand material, tools, and equipment needed to do its kind of work.

Whether a shop is permanent or not will also determine the type of tools and equipment in it. A permanent shop, like one that serves as a public works shop, should have a wide variety of tools and equipment. On the other hand, a shop set up by battalion Steelworkers at a construction site is temporary. It should be equipped with only the tools and equipment that are necessary to complete the project.

### MATERIAL

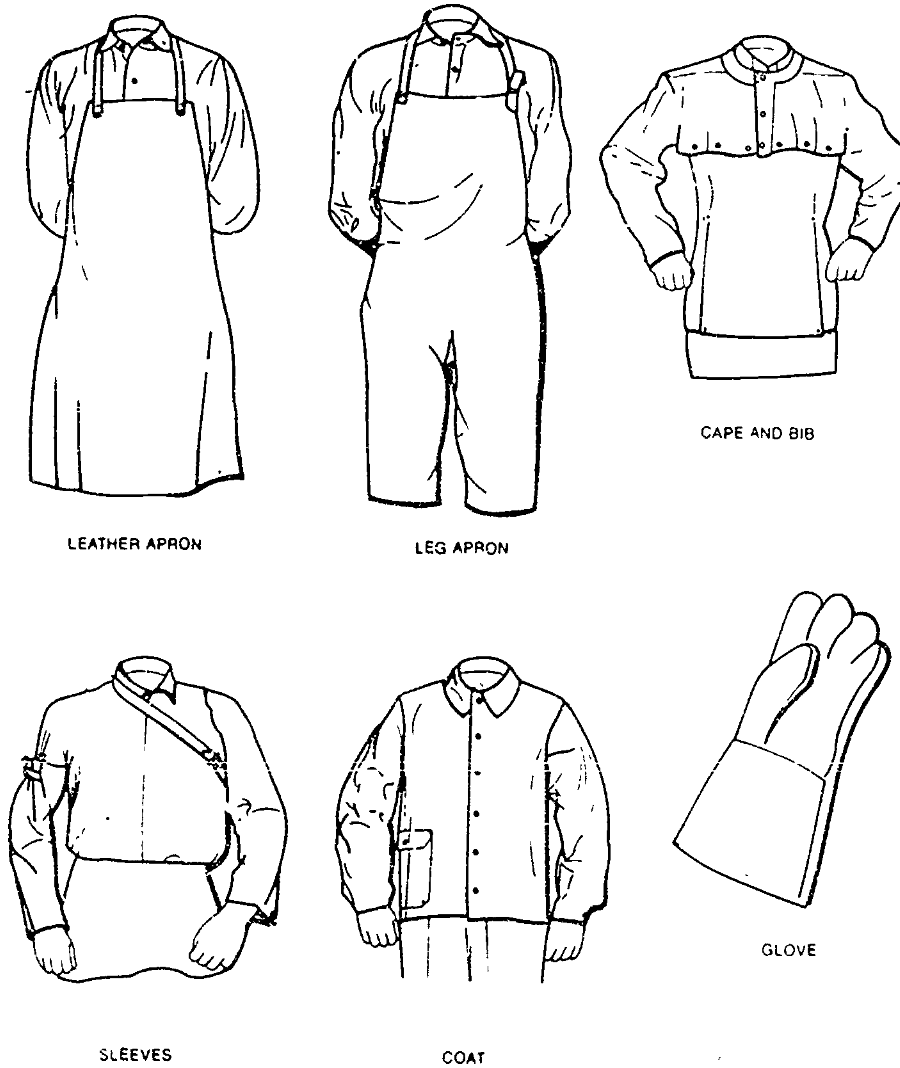
Any well-organized welding shop will have on hand a variety of welding supplies. These include tanks of oxygen and acetylene, electrodes, fluxes, pipe, angle iron, and round, solid rods. Also, standard plate sizes of sheet steel that may be stored in the shop or at the Material Liaison Office (MLO), until needed.

### TOOLS AND EQUIPMENT

Welding shops are equipped with a variety of wrenches, hammers, clamps, screwdrivers and files. Every welding shop regardless of size, must have the cutting equipment needed to accurately shape metal before it is welded. This metal may be cut to size and beveled to specifications by different means. Power hacksaws, metal shears, and power cutoff saws are used to cut standard size stock to the lengths needed. Standard angle cuts are made with either a reciprocating power hacksaw or a band power hacksaw. The portable grinder is used extensively in preparing and finishing the weld areas. It is especially useful for grinding welds on large weldments that cannot be brought to a grinder. Welders wear clothing of leather or other heavy material for body protection and to protect their clothing from molten metal sparks. Appropriate protective clothing, illustrated in figure 3-6, is required for any welding operation. The clothing will vary with the size, nature, and location of the work to be performed. Arc welders wear helmets or face shields with approved lenses to protect their eyes from radiation.

### CUTTING AND WELDING

In directing crews engaged in cutting and welding operations, you will have certain tasks

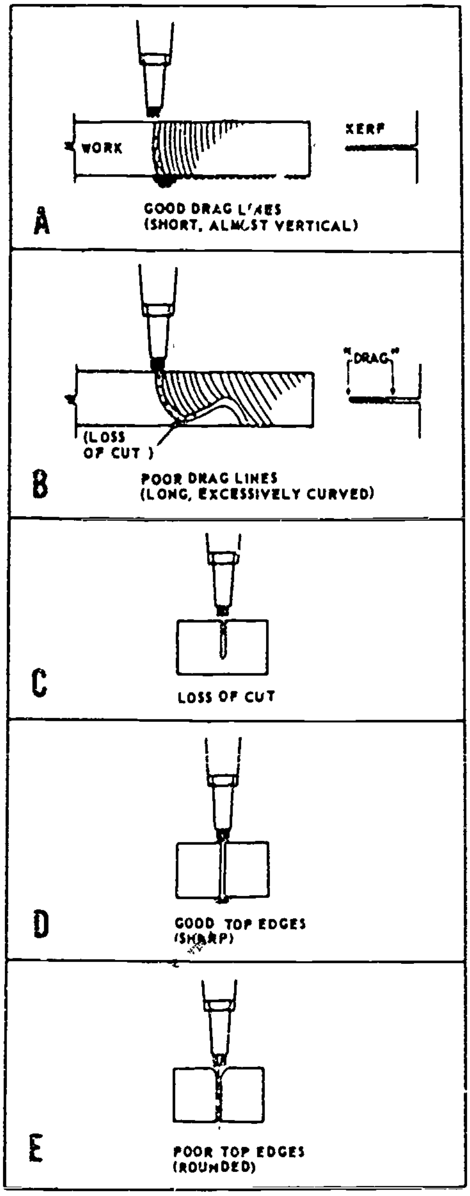



145.369

Figure 3-6.—Protective clothing.

to perform. First, decide which welding process is best suited for a given job. Then select your crew leader and go over the specifications for the job. This means reviewing drawings, sketches, or any other available information. Drawings and sketches convey, by means of welding symbols, all the information needed by the individual who will be fabricating or assembling. Then prepare a bill of materials that will be needed for the job, and submit your requisitions in time to permit delivery so the job can start on time. Depending on the size of the job, you may want to delegate to a crewmember the responsibility for delivery, unloading, checking, and stowage of material.

Before actual welding operations get underway, insure that your crew is preparing for the job. Check the condition of the equipment, and see that it is set up properly. Be sure that all controls are properly adjusted, that all connections are correctly made, and that all safety precau tions are being observed.




11.139

**Figure 3-7.—Effects of correct and incorrect cutting procedures.**

You can control the quality of work by carefully observing the welders. At intervals, make sure they are using the proper techniques and that the proper operating conditions (arc current, arc voltage, and arc speed for each type of electrode and weld size) are being maintained. Observe consumption of the electrode and how it melts down—smoothly or unevenly. Note the size and shape of the weld crater, as well as its surface appearance. Listen to the sound of the arc. Take a close look at the weld bead, noting in particular, its size, shape, and fusion. Correct immediately any faulty techniques that result in defects, such as slag accumulations or cracks; do NOT wait until the job is finished. The most common troubles in welding and their causes and cures are illustrated in table 3-1.

On most Steelworker projects, a cutting torch will be used for beveling plate, cutting and beveling pipe, piercing holes in steel plate, cutting wire rope, and the like. Therefore, learn to recognize a good oxygas cut. In general, the quality of an oxygas cut is judged by (1) the shape and length of the drag lines; (2) the smoothness of the sides; (3) the sharpness and squareness of the top edges; and (4) the amount of slag adhering to the metal and ease of slag removal.

DRAG LINES are the line markings which show on the cut surfaces; they are probably the best single indication of the quality of an oxygas cut. Good drag lines are almost straight up and down, as shown in view A of figure 3-7. On the other hand, poor drag lines are long and irregular or excessively curved, as shown in view B of figure 3-7; they indicate a poor cutting technique which may result in loss of cut (view C of figure 3-7). Also, a grooved, fluted, or ragged-cut surface indicates a cut of poor quality. Where the drag lines are short and almost vertical, you can rely on the sides being smooth, the top edges being sharp and square, and the slag being easy to remove from the metal. Compare views D and E of figure 3-7. Rounded top edges are caused by incorrect preheating or removing the torch too slowly.

## REINFORCING STEEL

The steel used to reinforce concrete structures is hot-rolled in several different strength grades. Most of the reinforcing steel (rebar) is made from new steel billets, but some is rolled from used railroad-car axles or railroad rails that have been cut into rollable shapes.

Table 3-1.—Causes and cures of common welding troubles

### porous welds

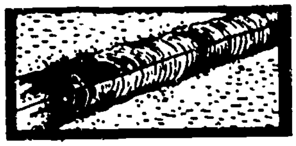
**WHY**

1. Short arc with exception of low hydrogen and stainless
2. Insufficient puddling time
3. Impaired base metal
4. Poor electrode
5. Improper shield coverage

**WHAT TO DO**

1. Check impurities in base metal
2. Allow sufficient puddling time for gases to escape
3. Use proper current
4. Weave your weld to eliminate pin holes
5. Use proper electrode for job
6. Hold longer arc
7. Check shield gas

### cracked welds



**WHY**

1. Wrong electrode
2. Weld and parts sizes unbalanced
3. Faulty welds
4. Faulty preparation
5. Rigid joint

**WHAT TO DO**

1. Design structure to eliminate rigid joints
2. Heat parts before welding
3. Avoid welds in string beads
4. Keep ends free to move as long as possible
5. Make sound welds of good fusion
6. Adjust weld size to parts size
7. Allow joints a proper and uniform gap
8. Work with amperage as low as possible

### poor penetration

**WHY**

1. Speed too fast
2. Electrode too large
3. Current too low
4. Faulty preparation

**WHAT TO DO**

1. Use enough current to obtain desired penetration—weld slowly
2. Select electrode according to welding groove size
3. Leave proper gap at bottom of weld

### poor appearance

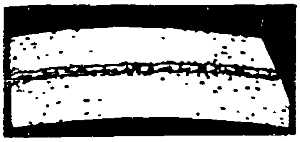
**WHY**

1. Faulty electrode
2. Overhang
3. Improper use of electrode
4. Wrong arc voltage and current

**WHAT TO DO**

1. Use a proper welding technique
2. Avoid overheating
3. Use a uniform weave
4. Avoid overly high current

### warping



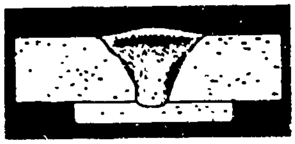
**WHY**

1. Shrinkage of weld metal
2. Faulty clamping of parts
3. Faulty preparation
4. Overheating at joint

**WHAT TO DO**

1. Peen joint edges before welding
2. Weld more rapidly
3. Avoid excessive space between parts
4. Preform parts before welding
5. Use proper sequence
6. Clamp or tack parts properly —back-up to cool
7. Adopt a proper welding procedure
8. Use high speed, moderate penetration process

### poor fusion



**WHY**

1. Wrong speed
2. Current improperly adjusted
3. Faulty preparation
4. Improper electrode size

**WHAT TO DO**

1. Adjust electrode to match joint
2. Weave must be sufficient to melt sides of joint
3. Select proper current and voltage
4. Keep weld metal from flowing away from plates

### undercutting

**WHY**

1. Faulty electrode or gun manipulation
2. Faulty electrode usage
3. Current too high

**WHAT TO DO**

1. Use a uniform weave in butt welding
2. Avoid using an overly large electrode
3. Avoid excessive weaving
4. Use moderate current, weld slowly
5. Hold electrode at safe distance from vertical plane in making horizontal fillet weld

### brittle welds

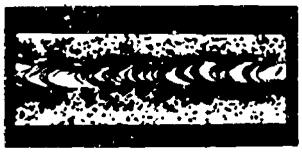
**WHY**

1. Wrong electrode
2. Faulty preheating
3. Metal hardened by air

**WHAT TO DO**

1. Preheat at 300° to 500° F. if welding on medium carbon steel or certain alloy steels
2. Make multiple layer welds
3. Stress relieving after welding
4. Use low hydrogen processes for increased weld ductility

### spatter



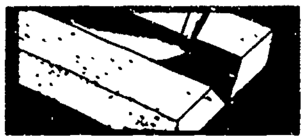
**WHY**

1. Arc blow
2. Current too high
3. Arc too long
4. Faulty electrodes

**WHAT TO DO**

1. Clean parts in weld area
2. Adjust current properly
3. Adjust voltage
4. Pick suitable electrode

### magnetic blow



**WHY**

1. Magnetic fields cause the arc to deviate from its intended course

**WHAT TO DO**

1. Use steel blocks to alter magnetic path around arc
2. Divide the ground into parts
3. Weld in same direction the arc blows
4. Use a short arc length
5. Locate the ground properly on the work
6. Use A-C welding

127.379

Rebar may be round or square. Its surfaces may be smooth, or deformed so that the concrete will adhere better to the bar. The round-deformed bar is produced in a wide range of diameters varying in increments of 1/8 inch. The standard method of calling out a round bar is to give the number of one-eighths contained in the diameter. For example, a 5/8-inch-diameter bar is called a No. 5 bar. All rebar must be placed in accordance with a placing plan of the structure that shows number and length of the rebar as well as the spacing and exact location of each bar.

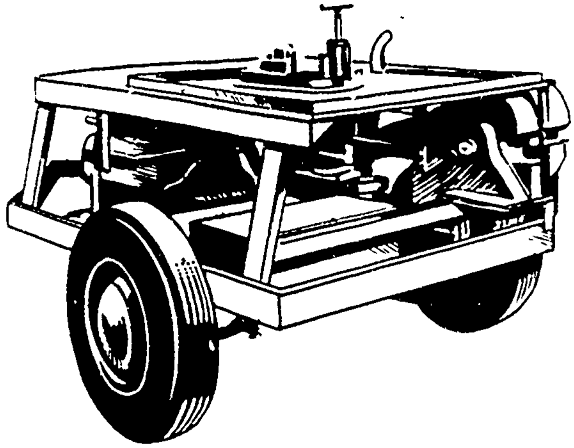
## LAYOUT

The layout of reinforcing steel is essentially the process of accurately measuring and marking the steel for cutting, bending, and placing. You will depend on two principle sets of drawings, engineering and placement, to provide the measurements of the reinforcing steel in a cast-in-place concrete structure. The engineering drawings show the design of the structure, including dimensioned locations of members, sizes of individual members, reinforcing of members, and related information. These drawings are similar to the design drawings prepared for steel structures. The placement drawings show shapes, sizes, and locations of the reinforcing bars in the structure. Also, information on the method of placement and schedules for beams, columns, girders, joints, etc.

## SCHEDULES

The reinforcement of floors and many other parts of structures can best be shown in tabular form commonly referred to as a schedule. The schedule is a compact summary of all the bars in the structure in the order of their use, complete with the number of pieces, sizes, lengths, marks, and bending details from which shop orders can be easily and readily written.

There are many variations of these schedules, but all of them can be included in two basic types which are termed the horizontal type and the vertical type. In the horizontal type the straight or hooked bars, bent bars, and stirrups in each member are listed in a horizontal line while in the vertical type all bars and stirrups are listed under each other.



127.281

**Figure 3-8.—Ironmaster portable hydraulic rod bender and shear.**

## CUTTING AND BENDING

After layout, the rebar is cut to the given measurements with power shears or bolt cutters. Be sure that the crewmembers, who use these tools, wear the proper apparel, such as safety shoes, gloves, and goggles. Rebar is bent with either a power tool or handtool. A power bender (fig. 3-8) works best where many bends have to be made. In the field, a tool like the one shown in figure 3-9 can be used to bend or straighten

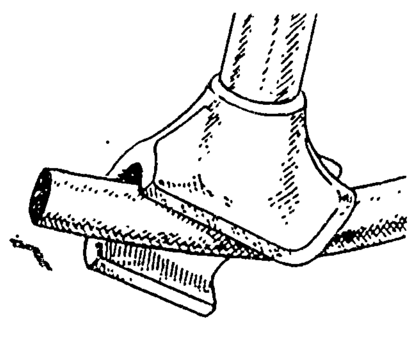


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**Figure 3-9.—Bending tool.**

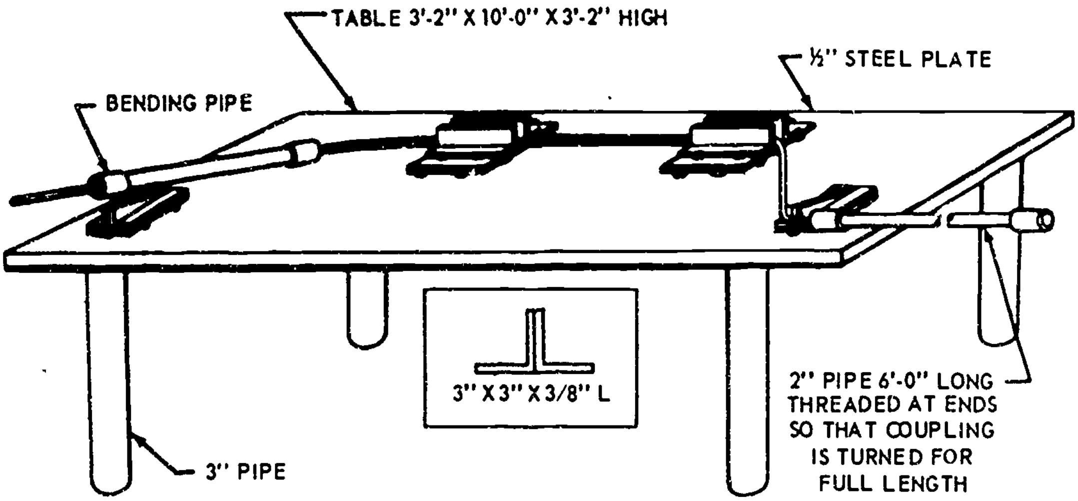


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**Figure 3-10.—Bar-bending table.**

rebar. Another tool that works well in the field fabrication is the bending table (figure 3-10). When secured to the table, a vise makes short radius bending easy. Since all bends must be PRECISE and EXACT (according to specifications and bending schedules), it pays to have a well-qualified power bender operator doing the work and a crew that does NOT hurry when bending rebar.

After the rebar has been cut and bent, it must be bundled and tagged according to size, length, and shape. Using metal or fabric tags or a color coding system will make it easy to identify the bundles. After tagging, the bundles should be placed on cribbing to help keep the rebar clean. For a small job, tagging is not necessary.

## PLACING

When assigned as supervisor of a crew for placing reinforcing bars in structures, you will have your share of responsibilities. One of your major objectives will be to see that bars are placed carefully and accurately to the exact requirements called for on the placing plans, schedules, typical details, and notes, and as suggested by standard practices. You will also have to check the placing schedule and compare it with the bars on hand.

All reinforcing bars, stirrups, hanger bars, wire fabric, spirals, and other reinforcing materials should be provided as indicated on the project drawings or as required by the project specification, together with all necessary wire ties, chairs, spacers, supports, and other devices necessary to install and secure the reinforcing properly. All reinforcement, when placed, must be free from loose, flaky rust and scale, oil, grease, clay, and other coatings and foreign substances that would reduce or destroy the bond. Reinforcement which has bends not shown on the project drawings or on approved shop drawings or is reduced in section must NOT be used.

Reinforcement should be placed accurately and secured. It must be supported by approved chairs or spacers or by metal hangers. When the ends of metal chairs, clips, or supports will be exposed on the concrete surface, this should be permitted only where the surface will NOT be exposed to weathering and where discoloration will not be objectionable; elsewhere, concrete or other approved noncorrodiable material, or other approved means, should be used for supporting the reinforcement.

In many structures that have failed, the primary cause was incorrect placement of

reinforcing bars. Failures cause damage to property and often cost lives. Failures also cost money and time, and cause the job to be done over again. When failures occur, inquiry immediately arises as to whether the placing plans, with all notes and details, were properly followed. Sometimes, what looks like a very small difference in the location or arrangement of bars is the difference between safety and a structure's collapse.

Before starting to place the bars, it is a good practice to make sure you have the latest approved placing plans. Study the placing plans in advance and, if necessary, check them against structural and architectural plans and discuss them with the project officer so as to be quite clear on what is to be done.

After all steel is secured and tied in place, assign a crewmember to check that no bars were displaced during placement of the concrete. Displacement of reinforcing bars happens quite often in floor slabs; this is caused by crewmembers walking on the reinforcing bars or pushing/pulling Georgia buggies loaded with concrete to the pour area.

The proper tying of bars depends upon the amount of abuse to which the mats will be subjected before being buried in concrete. The amount of tying adds nothing to the strength of the finished structure. It is NOT necessary to tie every crossing of bars, NOR is it even necessary to tie every alternate or third crossing. Suggestions for some of the more common cases are given below.

Tie slab bars that are assembled in place as follows:

1. Sufficiently to prevent shifting.
2. At least three times in any bar length.
3. Perhaps every intersection around periphery.
4. At spacings according to bar sizes, about:

| | |
|---|---|
| No. 5 and smaller | 5 feet-0 inches to 6 feet-0 inches |
| No. 6 to No. 9 | 8 feet-0 inches to 10 feet-0 inches |
| No. 10 and No 11 | 10 feet-0 inches to 12 feet-0 inches |

Tie wall bars that are assembled in place as follows:

1. Sufficiently to prevent shifting, even dropping concrete.
2. At least three times in any bar length.
3. Maybe every third or fourth intersection.
4. At spacings according to bar sizes, about:

| | |
|---|---|
| No. 5 and smaller | 3 feet-0 inches to 4 feet-0 inches |
| No. 6 to No. 9 | 4 feet-0 inches to 5 feet-0 inches |
| No. 10 and No. 11 | 6 feet-0 inches to 8 feet-0 inches |

For mats that are being preassembled, use at least the amount of tying called for above, increased, as necessary, to make the mats rigid enough for handling.

## SAFETY

As a supervisor, you are responsible for the safety of your personnel. Encourage them to be safety conscious on the job, and to observe and practice safety in all phases of their work. The following are safe practices for personnel who are working with reinforcing steel.

1. Unload bundles of reinforcing bars so that both ends leave the truck at the same time. (The end of the bundle pushed off the truck last has a tendency to WHIP UP and seriously injure anyone on the truck.)

2. Stand clear several feet from any bundle of reinforcing bars leaving a truck.

3. Wear suitable clothing. Avoid unnecessary belts or pockets, which could become caught on projecting objects.

4. Be careful at stairwells, unprotected areas, openings, etc. Remove all loose, concealing coverings over or near them (or plank over holes securely).

5. Clean or cover with abrasive material all greasy or oily spots on a floor.

6. Never land heavy loads of reinforcing steel on formwork that has NOT been checked for strength.

7. Never raise bundles of reinforcing steel by the bundling wire; use wire rope slings.

8. Be sure that slings are attached to long bundles of reinforcing bars so that they tighten themselves, and the bars cannot slip out of the bundle nor twist within the bundle.

9. Never weld or use an oxyacetylene torch for cutting steel without proper safeguards. Be extra careful to prevent sparks setting fire to tarpaulins.

10. When two crewmembers are carrying lengths of reinforcing steel, both should release the load at exactly the same time to avoid a serious injury.

11. When lifting heavy loads, flex your knees, not your back, in a stooping position to avoid straining your back.

12. Watch out for concrete buggies that could knock a person off the edge of a building or into openings.

13. Think ahead—turn over or bend down projecting nails; report worn or frayed tackle; have everything in first-class condition, ready for use, and use it properly.

14. If an injury does occur, get first aid or medical treatment right away.

Although these safety precautions cannot be considered regulations unless they are issued by competent authority, most of them are common sense measures that will prevent many an accident.

## PREENGINEERED STRUCTURES

Steelworkers must be able to assemble and disassemble the various preengineered structures used by the Armed Forces. These structures are factory built to conform to military specifications. Each preengineered structure is shipped as a complete building kit. This kit contains all the necessary material and instructions to erect it.

### ERECTION PLANNING

Although a preengineered structure is designed to be erected in the shortest time possible, advance planning can insure that the structure is completed on schedule. Planning involves selecting the best method of erection based on type and size of the structure, site conditions, probable weather conditions, capacity of available equipment, skill and experience of personnel, time allowed to complete the project, and other factors. For example, the structure is studied to determine whether or not available equipment can move each assembly or subassembly into place. Also, not having skilled or experienced personnel available will effect a change in the erection procedure. Here a shortage of skilled personnel might call for handling fewer assemblies than planned at first. Or a lack of personnel experienced in working aloft might call for assembling some sections on the ground.

### PREERECTION WORK

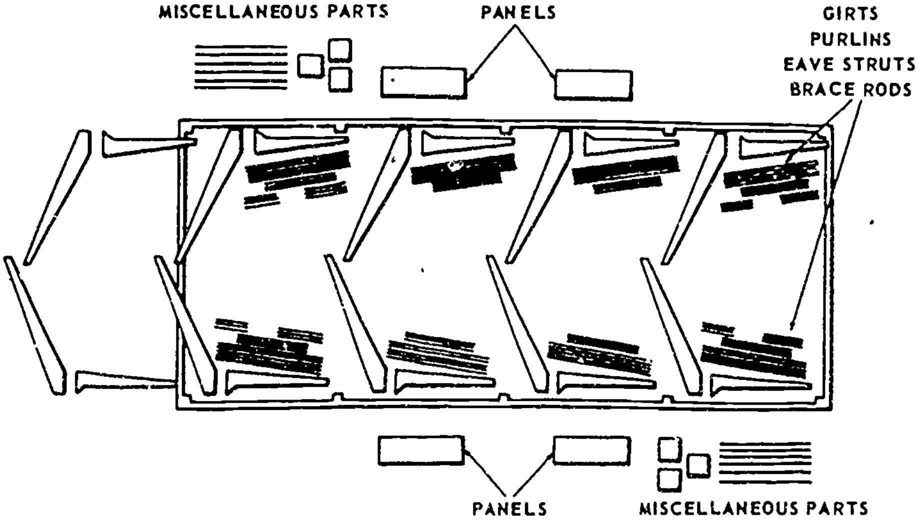
Before a preengineered tructure can be erected, the Equipment Operators and Builders prepare and finish the foundation for it. While this foundation is being constructed, your erecting crew should be unloading the material from the building kit. Make sure the material is unloaded carefully to avoid damage. At the same time, check to see that all material on the shipping list was delivered undamaged to the project site. Next, the material should be uncrated. Look for a list of items inside each crate. Again, check off the items on each list to make sure they had been crated and were not damaged. These items are then moved to the material storage site. Where practicable, they can be placed around the project site, as shown in figure 3-11.

Make sure you have a sound foundation before starting to erect a preengineered structure, such as a tank, tower, or antenna. When the grade or finished foundation is well constructed, problems that could occur in putting up the structure will not. Imagine those that could occur in erection and maintenance of a water tank, for example, if the foundation settles unevenly and throws the steel plates on one side of the tank slightly out of line. Remember that the wall of the tank (consisting of steel plates bolted together) must act as bearing walls to support the roof.

### ERECTION PROCEDURES

Erection involves all the methods of rigging, hoisting or lifting structural members to their proper places, as shown on the engineering drawings, and making the finished connections between members, as shown on the erection plans.

When assemblies are ready to be erected, slings are used to attach the sections to the hoisting apparatus. They are attached to the




127.122X

Figure 3-11.—Material layout.

column sections near the upper end so that the columns will hang vertically and to the horizontal sections so that they will be balanced. All sections must be guided with tag lines by personnel on the ground. Only one member of the crew should be assigned to give the crane operator signals, and the operator should NOT take directions from any other person, EXCEPT FOR EMERGENCY STOP SIGNAL.

After the assemblies are raised and connected temporarily, the structure must be plumbed to bring all of its parts into the correct position and alignment before the connections are finally completed. When all assemblies have been accurately fabricated, little adjustment will be required.

Inspect every section to insure that each one is placed in its proper position in the structure and that all the necessary fillers, shims, and washers are properly used.

## FIELD-ERECTED HOISTING DEVICES

The term FIELD-ERECTED HOISTING DEVICE refers to a device, generally of a temporary nature, which is constructed in the field, using locally available material, for the purpose of hoisting and moving heavy loads. Basically, it consists of a block and tackle system arranged on some form of skeleton structure consisting of wooden poles or steel beams. The tackle system will require some form of machine power or work force to do the actual hoisting. The skeleton structure with attached tackle is held in place and supported by means of guy lines anchored to holdfasts in the ground.

### HOLDFASTS

Gin poles, shear legs, and other rigging devices are held in place by means of guy lines anchored to HOLDFASTS. In fieldwork, the most desirable and economical type of holdfast is natural objects, such as trees, stumps, and rocks. When natural holdfasts of sufficient strength are NOT available, proper anchorage can be provided through the use of manmade holdfasts. These include single picket holdfasts, combination picket holdfast, combination log picket holdfasts, and log deadmen.

#### Natural Types

When using trees or stumps as holdfasts, always attach the guys near ground level. Of

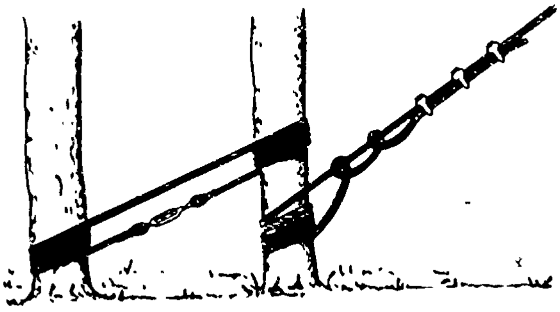


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Figure 3-12.—Use of trees as natural holdfast.

course, the strength of the tree or stump is also an important factor in determining its suitability as a holdfast. With this thought in mind, NEVER use a dead tree or a rotten stump. Such holdfasts are unsafe because they are likely to snap suddenly when a strain is placed on the guy. Make it a practice to lash the first tree or stump to a second one (fig. 3-12). This will provide added support for the guy.

### Single Picket

Pickets used in the construction of picket holdfasts may be made of wood or steel. A wood picket should be at least 3 inches (76.2 mm) in diameter and 5 feet long (1.5 m). A SINGLE PICKET holdfast can be provided by driving a picket 3 to 4 feet (0.9 to 1.2 m) into the ground, slanting it at an angle of 15° opposite to the pull. In securing a single guy line to a picket, take two turns around the picket and then have part of the crew haul in on the guy as you take up the slack. When you have the guy taut, secure it with two half hitches. In undisturbed loam soil, the single picket is strong enough to stand a pull of about 700 pounds (317.5 kg).

### Combination Picket

A COMBINATION PICKET holdfast consists of two or more pickets. Figure 3-13 will give you an idea of how to arrange pickets in constructing a 1-1-1 and a 3-2-1 combination picket holdfast.

In constructing the 1-1-1 combination, drive three single pickets about 3 feet (0.9 m) into the ground, 3 to 6 feet (0.9 to 1.8 m ) apart, and in line with the guy. For a 3-2-1 combination, drive a group of three pickets into the ground, lashing them together before you secure the guy to them. The group of two lashed pickets follows the first group, 3 to 6 feet (0.9 to 1.8 m) apart, and is followed by a single picket. The 1-1-1 combination can stand a pull of about 1,800 pounds (810 kg), while the 3-2-1 combination can stand as much as 4,000 pounds (1800 kg).

The pickets grouped and lashed together, PLUS the use of small stuff secured onto every pair of pickets, are what make the combination picket holdfasts much stronger than the single holdfasts.

The reason for grouping and lashing the first cluster of pickets together is to reinforce the point where the pull is the greatest. The way small stuff links each picket to the next is what divides the force of pull so that the first picket will NOT have to stand all of the strain. Using 12- to 15-thread small stuff, clove hitch it to the top of the first picket. Then, take about four to six turns around the first and second pickets, going from the bottom of the second to the top of the first picket. Repeat this with more small stuff from the second to the third picket, and so on,

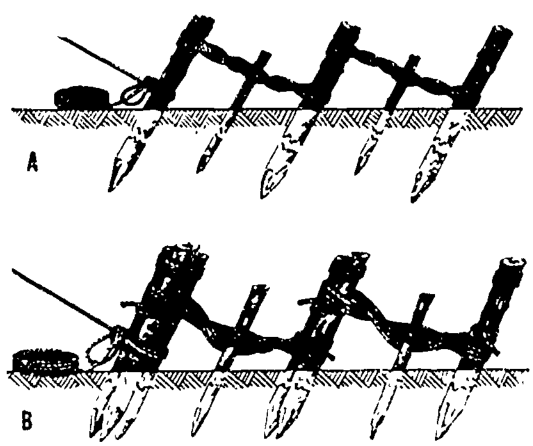


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Figure 3-13.—Combination picket holdfast. (A) 1-1-1 combination. (B) 3-2-1 combination.

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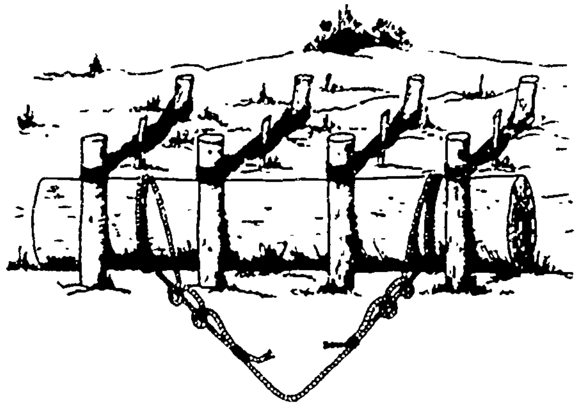

127.62
Figure 3-14.—Combination log picket holdfast.

until the last picket has been secured. After this, pass a stake between the turns of small stuff, between EACH pair of pickets, and then make the small stuff taut by twisting it with the stake. Now, drive the stake into the ground.

If you are going to use a picket holdfast for several days, it is best to use galvanized guy wire in place of the small stuff. Rain will NOT affect galvanized guy wire, but it will cause small stuff to shrink. If the small stuff is already taut, it could break from overstrain. Still, if you MUST use small stuff, be sure to slack it off before leaving it overnight. You do this by pulling the stake up, untwisting the small stuff once, and then replacing the stake.

## Combination Log Picket

For heavy loads or in soft- or wet-earth areas, a COMBINATION LOG PICKET holdfast is frequently used. With this type, the guys are anchored to a log or timber supported against four or six combination picket holdfasts. (See fig. 3-14.) The timber serves as a beam and must be placed so that it bears evenly against the front row of the pickets. Since the holding power of this setup depends on the strength of the timber and anchor line, as well as the holdfast, you must use a timber big enough and an anchor line strong enough to stand the pull.

## Rock Holdfast

ROCK holdfasts are made by inserting pipes, crowbars, or steel pickets in holes drilled in solid rock. Using a star drill, drill holes in the rock 1 1/2 to 3 feet (75 to 90 cm) apart, keeping them in line with the guy. Remember to drill the holes at a slight angle so that the pickets will lean away from the direction of pull. Make the front hole about 1 1/2 to 3 feet (75 to 90 cm) deep and the rear hole 2 feet deep (60 cm) (fig. 3-15). After driving pickets into the holes, secure the guy to the front picket. Then lash the pickets together with chain or wire rope to transmit the load.

## Deadman

A DEADMAN provides the best form of anchorage for heavy loads. It consists of a log, a steel beam, a steel pipe, or a similar object buried in the ground with the guy connected to it at its center. (See fig. 3-16.) Because it is buried, the deadman is suitable for use as a permanent anchorage. When installing a permanent deadman anchorage, it is a good idea to put a turnbuckle in the guy near the ground to permit slackening or tightening the guy when necessary.

In digging the hole in which to bury the deadman, make sure it is deep enough for good bearing on solid ground. The less earth you disturb in digging, the better the bearing surface will be. As indicated in figure 3-16, you should undercut the bank in the direction toward the guy at an angle of about 15° from the vertical. To increase the bearing surface, drive stakes into the bank at several points over the deadman.

A narrow, inclined trench for the guy must be cut through the bank and should lead to the center of the deadman. At the outlet of the

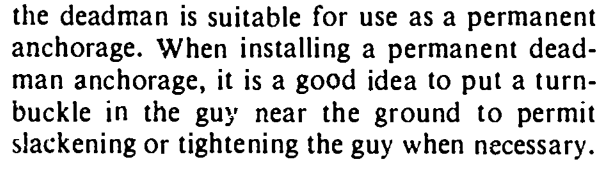


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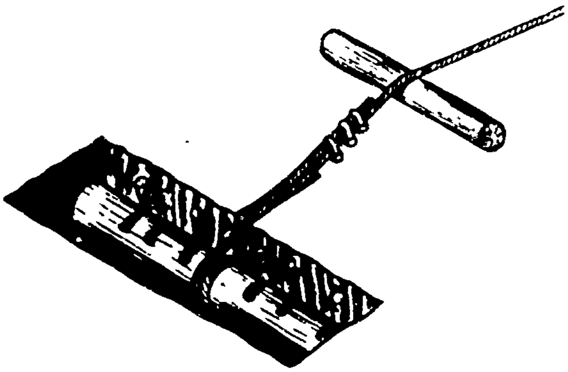
Figure 3-15.—Rock holdfast.



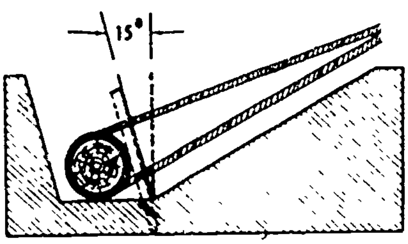



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Figure 3-16.—Log deadman.

trench, place a short beam or log on the ground under the guy (fig. 3-16). In securing the guy to the center of the deadman, see that the standing part—that is, the part on which the pull occurs—leads from the bottom of the log deadman. Thus, if the wire rope clips slip under strain, the standing part will rotate the log in a counterclockwise direction, causing the log to dig into the trench rather than roll up and out. See that the running end of the guy is secured properly to the standing part.

### Steel Picket Holdfast

The STEEL PICKET holdfast shown in figure 3-17 consists of steel box plates with nine holes drilled through each and a steel eye welded on the end for attaching the guy. When installing this holdfast, it is important that you drive steel pickets through the holes in such a manner that will cause them to clinch in the ground. You will find the steel picket holdfast especially useful for anchoring horizontal lines, such as the anchor cable on a pontoon bridge. The use of two or more of the units in combination will provide a stronger anchorage than a single unit.

## GIN POLE

The GIN POLE is a rig constructed from a single pole, square timber, or steel beam. It stands almost vertical and is supported by guys. Loads of medium weight can be lifted from 10 to 50 feet (3 to 16 m) by a block and tackle supported on the gin pole. The hauling part of the tackle leads through a snatch block at the base of the pole to the source of power.

The timber gin pole should NOT be longer than 60 times its minimum thickness because of the tendency to buckle under compression. If the pole is too short and you have to splice two together, place the sections so that the end of one touches the end of the other. This is called BUTT SPLICING. Join the sections together by bolting wooden scabs or metal plates onto them. Sometimes large spikes are used to fasten the wooden scabs. When there is a tendency on the part of a spliced pole to buckle, fasten an additional set of guys at the splice.

Guy lines, incidentally, may be either wire rope or fiber line, although wire rope is usually preferred because of its strength and resistance to corrosion and weathering. Generally, four guys are considered a minimum, with 90° angles between guys. If the pole or spar supported by the guys is very long and slender, it may be

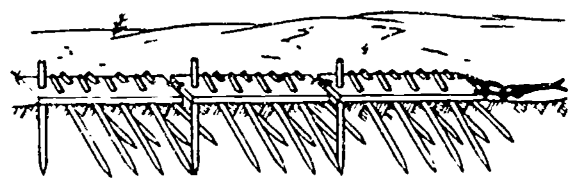

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Figure 3-17.—Steel picket holdfast.

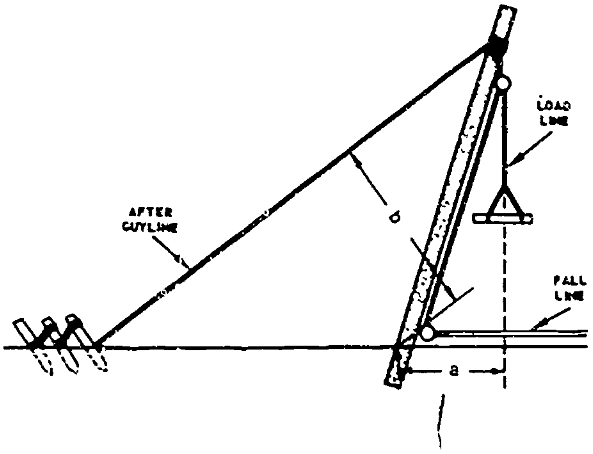


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Figure 3-18.—Stress on after guy, gin pole.

advisable to provide support at several points on the pole, in a tiered effect.

Guy lines should be anchored a considerable distance from the base of the gin pole. The recommended minimum distance from the base of the gin pole to the anchorage of the guy line is twice the height of the pole.

The angle of the pole is especially important in the matter of stress. For instance, if the pole is vertical, the stress on each after guy is practically zero. But, when the angle between the guy and the ground is 45°, the stress on each guy is almost one-half of the total load. That is why you have to figure on using a guy that will stand stress of at least one-half the load.

The weakest point in the gin pole assembly is most likely to be the after guy. If you study figure 3-18, you will see that as the gin pole is slacked outward, distance (b) gets less and distance (a) gets greater. After the pole has reached a certain angle, (a) gets greater than (b), and from then on the guy has a strain on it greater than the weight. This increases so rapidly as the pole approaches the horizontal that the amount of strain is theoretically almost infinite when the pole is lying nearly flat. Obviously, then, the nearer the gin pole is to the vertical, the less the stress on the after guy, and the pole cannot be lowered very far off the perpendicular without setting up dangerous stresses.

The formula for finding the thrust on the pole itself is rather complicated, and involves a value which it would be difficult for you to determine without some knowledge of trigonometry. You can easily see that in the vertical position the pole would be supporting a thrust equal to, but no greater than the weight. As the pole is slacked outward, the thrust on it, like the stress on the guy, increases, reaching fantastic proportions when the pole gets beyond a certain angle.

About the best thing you can do, then, is to remember that a gin pole cannot be slacked to more than a few degrees off the vertical before it begins to take a very heavy strain.

## Rigging

The basic steps in the procedure for rigging a gin pole are given below. Learn each step listed, and study carefully figure 3-19, which shows you how a gin pole is erected and the details of the lashings.

1. Place the pole so that the base is at the spot where it is to be erected.

2. Make a tight lashing of eight or nine turns of fiber line about 1 foot (30 cm) from the top of the pole, with two or more of the center turns engaging the hook of the upper block of the tackle. Secure the ends of the lashing with a square knot, and attach cleats to the pole flush with the lower and upper sides of the lashing, to prevent the lashing from slipping.

3. Lay out guy lines, each one about four times as long as the pole. Each line makes two guys by using a clove hitch in the center which is passed over the top of the pole above the tackle lashing. The guys lead from the pole, opposite each other, to block and tackle arrangements which are attached to an anchorage. Thus, the length of the guy from pole to anchorage is approximately twice the length of the pole.

4. Make another tight lashing (as above) about 2 or 3 feet (60 or 90 cm) from the base of

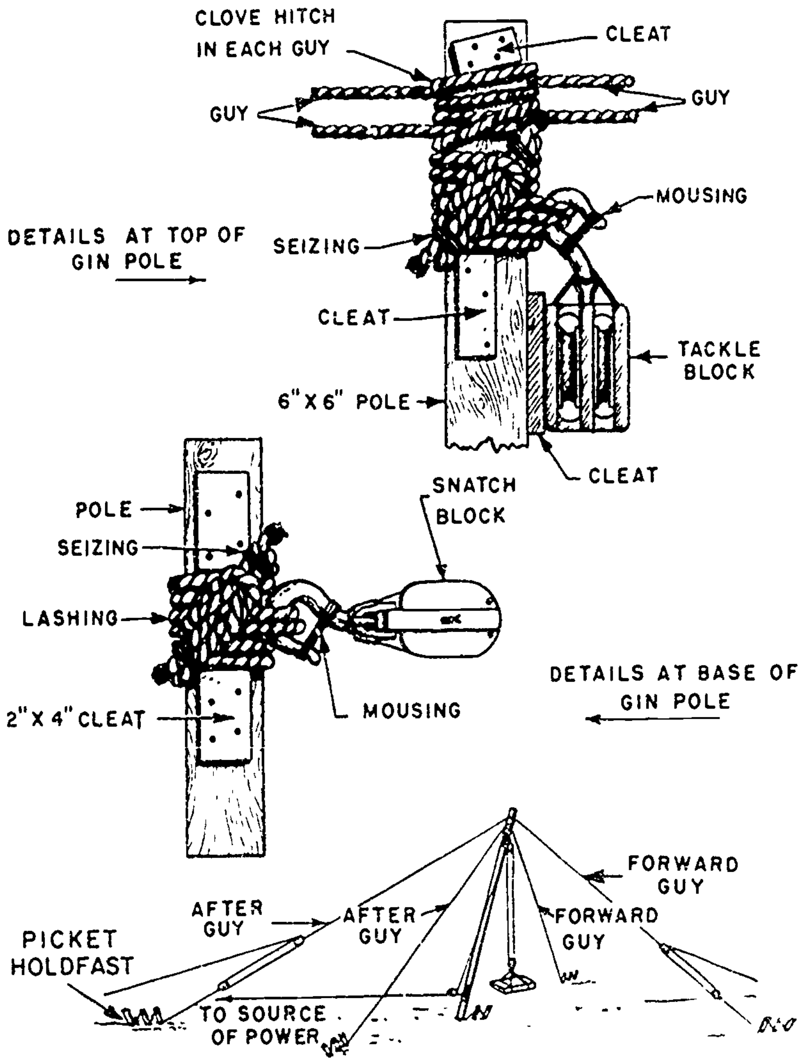


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Figure 3-19.—The gin pole.

the gin pole, and put a cleat above and below this to keep it from slipping. This is where the snatch block is secure.

5. Now, reeve your tackle so that the hauling part passes from the head block, through the snatch block, to the source of power.

6. To keep the pole from skidding while being erected, and to keep it in place while hoisting a load, set up a picket holdfast about 3 feet (90 cm) from the pole base, and tie a line from the holdfast to the pole base.

7. Before erecting the gin pole, make SURE the lashings are made properly and that hooks are moused.

### Erecting

Gin poles NOT over 50 feet (12m) in length may be raised easily by hand, but longer poles

must be raised by supplementary rigging or power equipment. About 10 or more crewmembers may be needed to erect a gin pole properly, the number depending largely on the weight of the pole. Use the following procedure as a guide in erecting the pole.

1. Dig a hole for the base, between 6 inches (15 cm) and 1 foot (30 cm) deep, depending on the type of soil and the weight to be lifted.

2. Lay out each guy as far as its anchorage. If tackle is NOT used on the after guys, one crewmember controls the slack of each, with turns around the anchorage as the pole is raised.

3. You can do one of two things to bring the movable block down within reach. You can tie a line to the hook of the movable block, or you can overhaul the tackle until it is longer than the length of the pole, and secure it to an anchorage opposite the base.

4. To raise the pole easily, start raising it by hand to about 3 or 4 feet (19 or 1.2 m) from the ground. Then, round in the blocks of the after guys. While raising the pole, keep tension on the forward guys, otherwise the pole may swing and throw all the weight to one side.

5. When the pole is upright, make all guys fast.

6. You can move the top of the pole from vertical to 15° forward without moving the base. This is called DRIFTING and should be done only while the pole is NOT loaded, unless you can regulate the tension of all guys by tackle that is secured at the end of each. You will drift the pole forward when lifting the load.

## SHEAR LEGS

The SHEAR LEGS is formed by crossing two timbers, poles, planks, pipes, or steel bars and lashing or bolting them together near the top. A sling is suspended from the lashed intersection and is used as a means of supporting

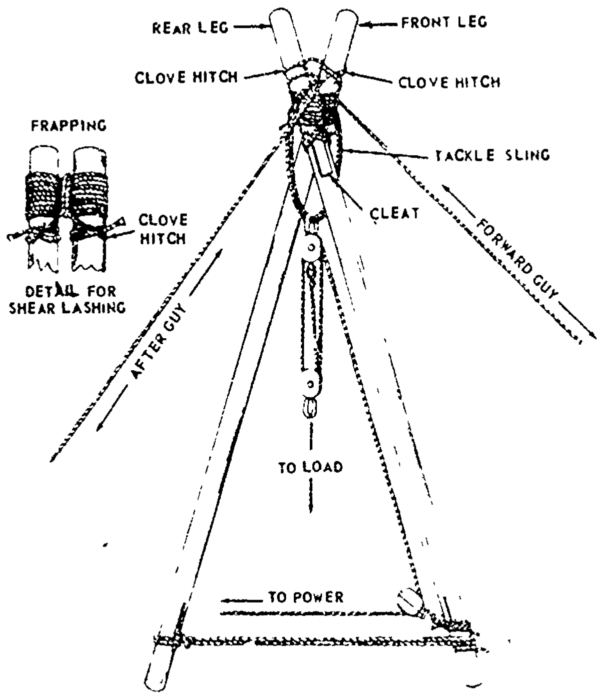


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Figure 3-20.—Shear legs.

the load tackle system. (See fig. 3-20.) In addition to the name SHEAR LEGS, this rig often is referred to simply as a SHEARS. (It has also been called an A-frame.)

The shear legs is used to lift heavy machinery and other bulky objects. It may also be used as end supports of a cableway and highline. The fact that the shears can be quickly assembled and erected is a major reason why it is used in fieldwork.

A shears requires only two guy lines and can be used for working at a forward angle. The forward guy does not have much strain imposed on it during hoisting. This guy is used primarily as an aid in adjusting the drift of the shears and in keeping the top of the rig steady when hoisting or placing a load. The after guy is a very important part of the shears' rigging, as it is under considerable strain when hoisting. It should be designed for a strength equal to one-half the load to be lifted. The same principles for thrust

on the spars apply--that is, the thrust increases drastically as the shear legs go off the perpendicular.

### Rigging

In rigging the shears, place your two spars or poles on the ground parallel to each other and with their butt ends even. Next, put a large block of wood under the tops of the legs just below the point of lashing, and place a small block of wood between the tops at the same point to facilitate handling of the lashing. Now, separate the poles a distance equal to about one-third the diameter of one pole.

For lashing material, use 18- or 21-thread small stuff. In applying the lashing, first make a clove hitch around one of the legs. Then take eight or nine turns around both legs above the hitch, working towards the top of the legs. Remember to wrap the turns tightly so that the finished lashing will be smooth and free of kinks. To apply the frapping (tight lashings), make two or three turns around the lashing between the legs; then, with a clove hitch, secure the end of the line to the other leg just below the lashing (fig. 3-20).

Now, cross the legs of the shears at the top and separate the butt ends of the two legs so that the spread between them is equal to one-half the height of the shears. Dig shallow holes, about 1 foot (30 cm) deep, at the butt end of each leg. The butts of the legs should be placed in these holes in erecting the shears. Placing the legs in the holes will keep them from kicking out in operations where the shears is at an angle other than vertical.

The next step is to form the sling for the hoisting falls. To do this, take a short length of line, pass it a sufficient number of times over the cross at the top of the shear, and tie the ends together.

Now, reeve a set of blocks and place the hook of the upper block through the sling; then secure the hook by mousing. Fasten a snatch block to the lower part of one of the legs, as indicated in figure 3-20.

If you need to move the load horizontally by moving the head of the shears, you must rig a tackle in the after guy—near its anchorage.

The guys—one forward guy and one after guy—are secured next to the top of the shears. Secure the forward guy to the rear leg and the after guy to the front leg, using a clove hitch in both instances. (See fig. 3-20.)

### Erecting

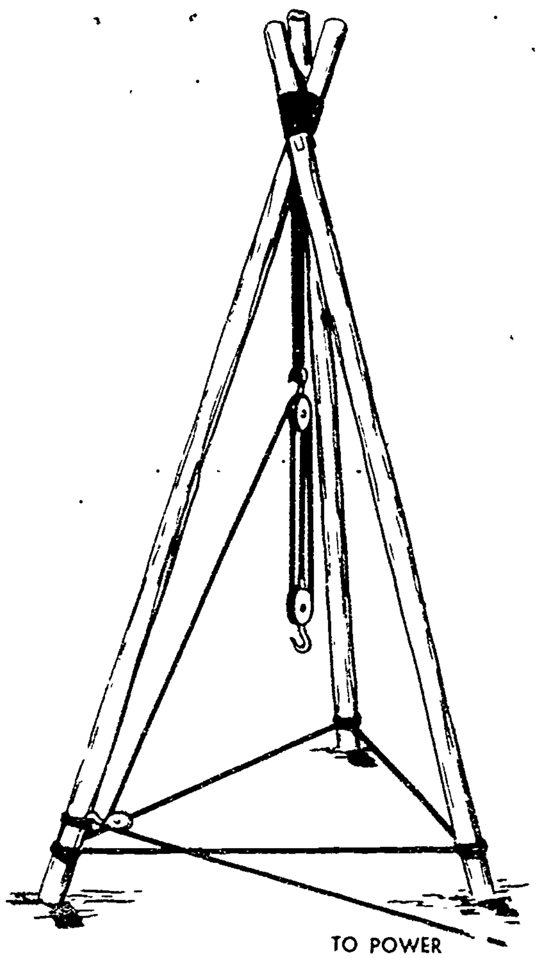
Several crewmembers are needed for safe, efficient erection of the shears, the number being determined largely by the size of the rig. To help insure good results, the erection crew should lift the top of the frame and walk it up by hand until the after guy tackle system takes over the load. When this point is reached, complete the raising of the shears into final position by hauling in on the tackle.

Remember to secure the forward guy to its anchorage before raising the legs, and maintain a slight tension on the line to control the movement. Also, after the shears has been raised, lash the butt ends with chain, line, or boards to keep them from spreading when a load is applied.

## TRIPOD

A tripod consists of three legs of equal length which are lashed together at the top. (See fig. 3-21.) The fact that the tripod can only be used where hoisting is vertical places it at a distinct disadvantage in comparison with other hoisting devices. Its use will be limited primarily to jobs that involve hoisting over wells, mine shafts, or other excavations. A major advantage of the tripod is its great stability. In addition, it requires no guys or anchorages, and its load capacity is approximately 1 1/2 times greater than for shears made of the same size timbers.

The legs of a tripod generally are made of timber poles or pipes. Materials used for lashing include fiber line, wire rope, and chain. Metal rings joined with short chain sections are also available for insertion over the top of the tripod legs.




29.196

Figure 3-21.—Tripod.

## Rigging

The strength of a tripod depends largely on the strength of the material used for lashing, as well as the amount of lashing used. The following procedure for lashing applies to line 3 inches (75 mm) in circumference or smaller. For extra heavy loads, use more turns than specified in the procedure given here; for light loads, use fewer turns than specified here.

As the first step of the procedure, take three spars of equal length and place a mark near the top of each to indicate the center of the lashing. Now, lay two of the spars parallel with their TOPS resting on a skid (or block). Place the third spar between the two, with the BUTT end resting on a skid. Position the spars so that the lashing marks on all three are in line. Leave an interval between the spars equal to about one-half the diameter of the spars. This will keep the lashing from being drawn too tight when the tripod is erected.

With the 3-inch (75 mm) line, make a clove hitch around one of the outside spars; put it about 4 inches (10 cm) above the lashing mark. Then make eight or nine turns with the line around all three spars. (See view A, fig. 3-22.) In making the turns, remember to maintain the proper amount of space between the spars.

Now, make one or two close frapping turns around the lashing between each pair of spars. Do not draw the turns too tight. Finally, secure the end of the line with a clove hitch on the center spar just above the lashing, as shown in view A, figure 3-22.

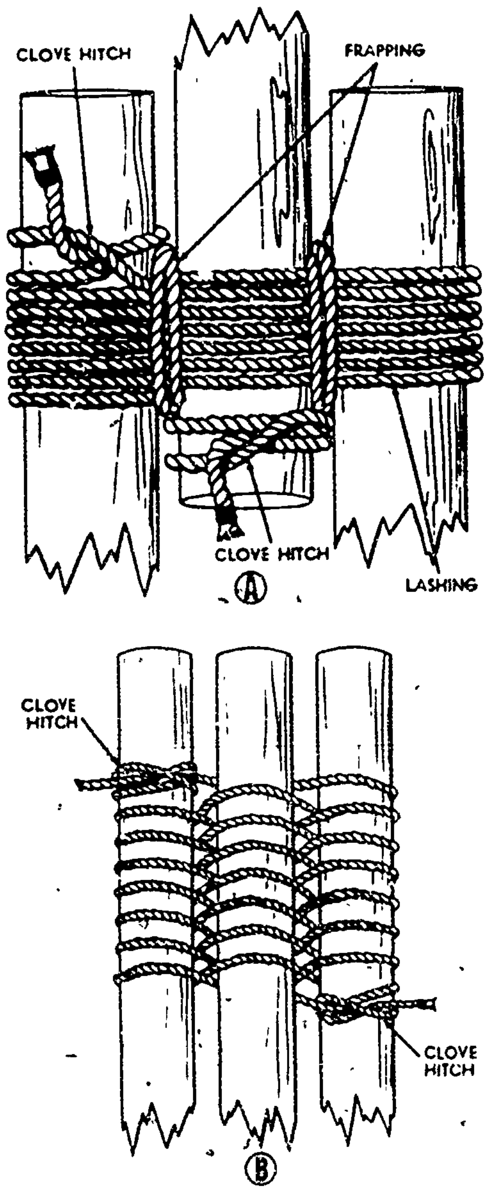
There is another method of lashing a tripod which you may find preferable to the method just given. It may be used in lashing slender poles up to 20 feet (6 m) in length, or when some means other than hand power is available for erection.

First, place the three spars parallel to each other, leaving an interval between them slightly greater than twice the diameter of the line to be used. Rest the top of each pole on a skid so that the end projects about 2 feet (60 cm) over the skid. Then, line up the butts of the three spars, as indicated in view B, figure 3-22.

Next, make a clove hitch on one outside leg at the bottom of the position the lashing will occupy, which is about 2 feet (60 cm) from the end. Now, proceed to weave the line over the middle leg, under and around the other outside leg, under the middle leg, over and around the first leg, and so forth, until completing about eight or nine turns. Finish the lashing by forming a clove hitch on the other outside leg, as shown in view B, fig. 3-22.

## Erecting

In the final position of an erected tripod, it is important that the legs be spread an equal distance apart. The spread between legs must be not more than two-thirds, nor less than




58.10

Figure 3-22.—Lashings for a tripod.

one-half, the length of a leg. Small tripods, or those lashed according to the first procedure given in the preceding section, may be raised by hand. Here are the main steps which make up the hand-erection procedure.

Start by raising the top ends of the three legs about 4 feet (1.2 m), keeping the butt ends of the legs on the ground. Now, cross the tops of the two outer legs, and position the top of the third or center leg so that it rests on top of the cross.

A sling for the hoisting tackle can be attached readily by first passing the sling over the center leg, and then around the two outer legs at the cross. Place the hook of the upper block of a tackle on the sling, and secure the hook by mousing.

The raising operation can now be completed. To raise an ordinary tripod, a crew of about eight members may be required. As the tripod is being lifted, spread the legs so that when it is in the upright position the legs will be spread the proper distance apart. After getting the tripod in its final position, lash the legs near the bottom with line or chain to keep them from shifting. (See fig. 3-21.)

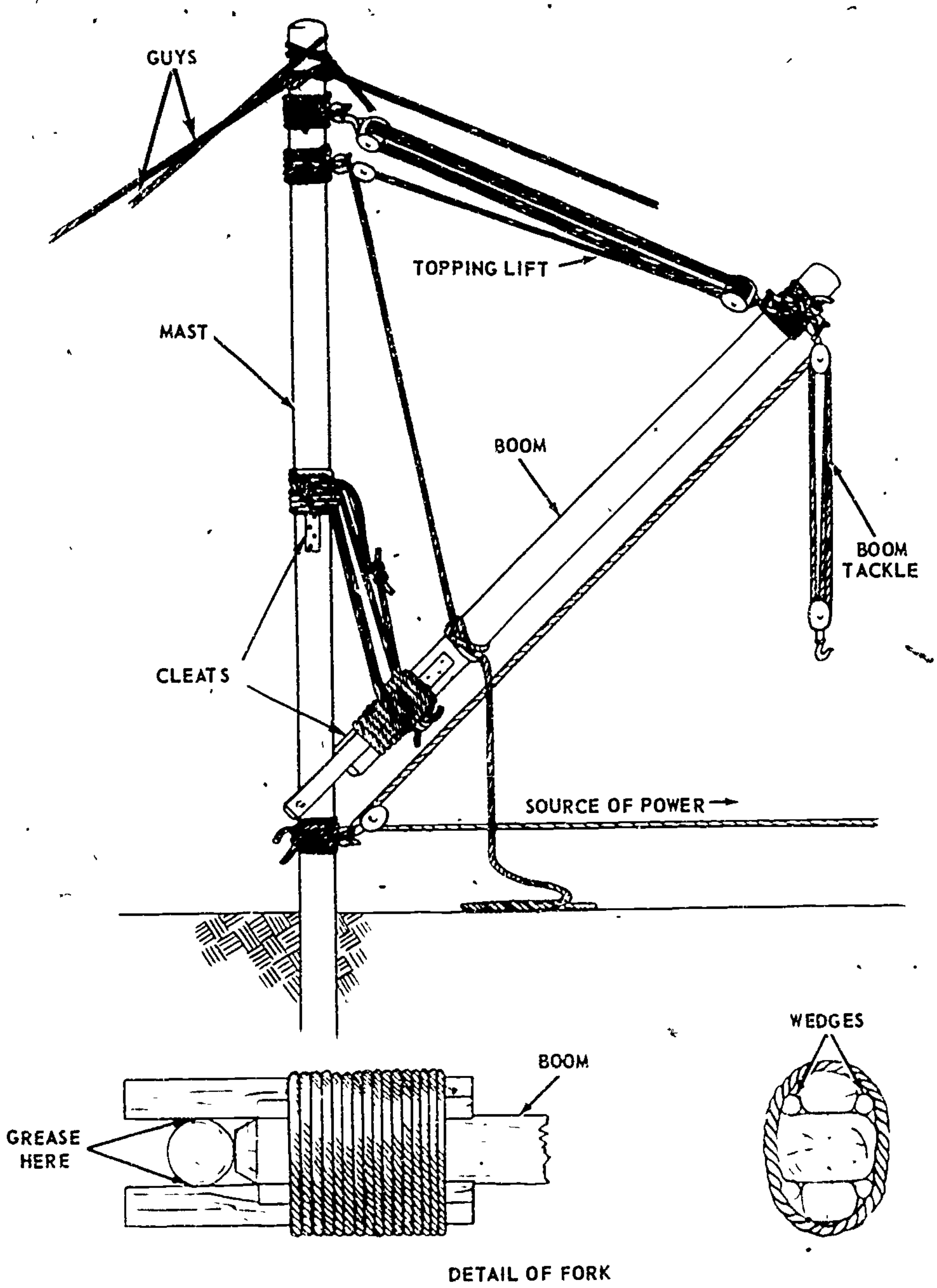
Where desirable, a leading block for the hauling part of the tackle may be lashed to one of the tripod legs, as indicated in figure 3-21.

In erecting a large tripod, you may need a small gin pole to aid in raising the tripod into position. When called on to assist in the erection of a tripod lashed according to the first lashing procedure described in the preceding section, the first thing to do is to raise the tops of the legs far enough from the ground to permit spreading them apart. Use guys or tag lines to help hold the legs steady while they are being raised. Now, with the legs clear of the ground, cross the two outer legs and place the center leg so that it rests on top of the cross. Then, attach the sling for the hoisting tackle. Here, as with a small tripod, simply pass the sling over the center leg and then around the two outer legs at the cross.

## BOOM DERRICK

The BOOM DERRICK consists of a mast with a boom attached, as shown in figure 3-23. It may be used to move weight in any direction. You will find the boom derrick useful for loading and unloading trucks and flat cars when the base of weight-lifting equipment cannot be set close to the objects to be lifted. It is also used to advantage on docks and piers for unloading boats and barges.

For medium loads, the boom may be rigged to swing independently of the mast, as shown in




127.67

Figure 3-23.—Boom derrick.

figure 3-23. For heavy loads, the boom may be set on a turnplate or turnwheel and it and the mast rigged to swing as a unit. On more permanent installations, it is good practice to rig the mast separately and to strap another pole or mast to it. In such a case, one mast is fixed; the boom is rigged to the other mast, which is set on a turnplate. This provides rigid guying, with a swing of more than 180° on the boom.

In case the proper size of line is NOT available, a set of tackle reeved with the same size line as that used in the hoisting tackle may be used as a guy by extending the tackle from the top of the derrick to the anchorage. See that the block attached to the derrick is lashed at that point where the other guys are tied and in the same manner.

**Rigging**

In fieldwork, you may be called on frequently to assist in rigging a boom derrick. For medium loads, follow the rigging procedure given below.

The first step is to rig a mast, and lash the tackle on, which is used as the topping lift. If the hauling part of the topping lift tackle comes from the movable block, lash a fairlead block to the mast 2 or 3 feet (60 or 90 cm) below the topping lift lashing.

For your boom, select a pole, timber, steel pipe, beam, or laminated plank of the same diameter as the mast, but only about two-thirds its length. Attach two cleats to the butt end of the boom and lash them with small stuff to form a fork, as shown in figure 3-23. This fork is to keep the boom from getting away from the mast while moving a load from side to side. Use cleats long enough to extend from the butt end of the boom past the mast. About 4 feet (1.2 m) above the point where boom meets mast, attach two cleats into the mast, and place a lashing of at least four turns of small stuff above the cleats, keeping two ends free.

Using a sling attached to the topping lift, raise the butt end of the boom as high as you want it. With the free ends from the lashing on the mast, make a sling to support the butt end of the boom.

Lash the movable block of the topping lift to the top end of the boom, and lash the fixed block of the boom tackle at the same point. The boom tackled is reeved so that the hauling part comes from the fixed block and passes through a fairlead block lashed at the base of the mast.

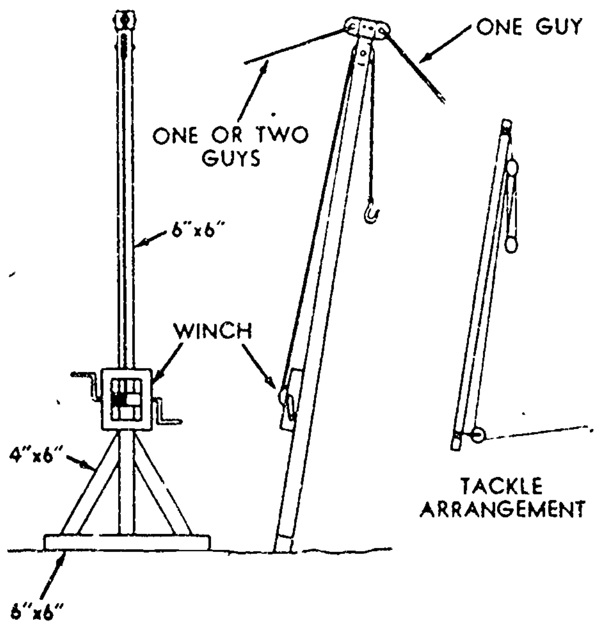
**Erecting**

Raise the boom into position after the above rigging is completed. When working with heavy loads, see that the base of the boom rests on the ground at the foot of the pole. When working with light loads, a more horizontal position may be used, thus providing a greater radius. In no case should the boom bear against any part of the upper two-thirds of the mast.

To swing the boom, push directly on the load, or pull the load with bridle lines or tag lines. The angle of the boom to the mast is adjusted by hauling on the hauling part of the topping lift. The load is raised or lowered by the hauling part of the boom tackle. A fairlead block (snatch block) is usually placed at the base of the mast. The hauling part of the boom tackle is led through this fairlead block to a hand- or power-operated winch for the actual hoisting of the load.

## POLE DERRICK

Various types of light-hoisting equipment are sometimes used on construction projects. A




127.72

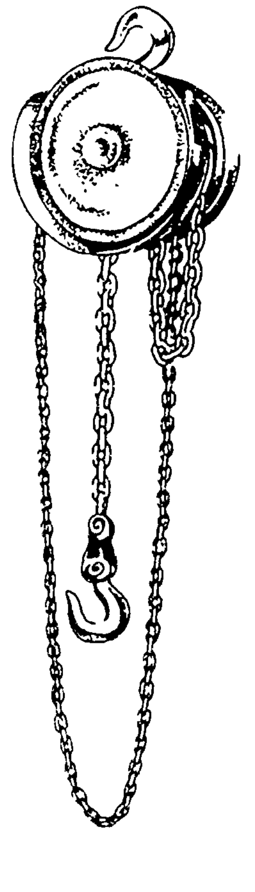
Figure 3-24.—Pole derrick, or Dutchman.

typical example is the POLE DERRICK, also known as a DUTCHMAN, illustrated in figure 3-24. This device is often powered by means of a hand-operated or engine-driven winch. It can be set up readily in the field and moved about from job to job.

The pole derrick is essentially a gin pole constructed with a sill and with knee braces at the bottom. Also, guys usually are installed fore and aft. The pole derrick is suitable for lifting loads of 1 or 2 tons (0.9 or 1.8 metric tons). Since it is light in weight and has few guys, the device can be moved readily from place to place by a small crew

## OTHER HOISTING EQUIPMENT

The two sources of power you will use in hoisting are your work force and machine power.



195.11

Figure 3-25. - Spur gear hoist.

Of the two, machine power is more uniform. On a single vertical line, a crewmember of average weight can pull with a force of 100 pounds (45 kg), while on a single horizontal line the same crewmember can pull with a force of only 60 pounds (27 kg). When you get several crewmembers on a single line, there is no way to measure the actual strength each crewmember puts into the combined pull. When you have to use a lot of crewmembers, you will not be able to get enough personnel on a vertical line because of limited space. In this case, you should change the line to a horizontal pull by using a snatch block as a fairlead.

Machine power is much more predictable. In fact, all cranes have lift tables that show you their lifting capacities on the basis of a single-line pull. The power from winches and other hoists is also figured on a single-line pull.

As you already know, you can change your advantage by reeving different types of purchases. Always make the mechanical advantage fit your source of power. With some purchases, you have the extra feature of being able to increase mechanical advantage without a greater loss of friction. A good example of this is the luff upon luff, which has twice the mechanical advantage of a threefold purchase, while the friction loss of 60 percent is the same with both. Because the friction loss remains the same on a luff upon luff, the use of it saves wear and tear on equipment.

### CHAIN HOISTS

Chain hoists provide a convenient means for hoisting heavy objects. When a chain is used, the load can remain stationary without requiring attention. The slow lifting travel of a chain hoist is also advantageous in that it permits small movements, accurate adjustments of height, and cautious handling of loads.

Chain hoists differ widely in their mechanical advantage, depending upon their rated capacity. The mechanical advantage may vary from 5 to 250—that is, the ratio 5:1 to 250:1. Two types of chain hoists generally used for vertical hoisting operations are the spur gear hoist and the differential chain hoist.

The SPUR GEAR HOIST (See fig. 3-25.) is best for ordinary operations that require

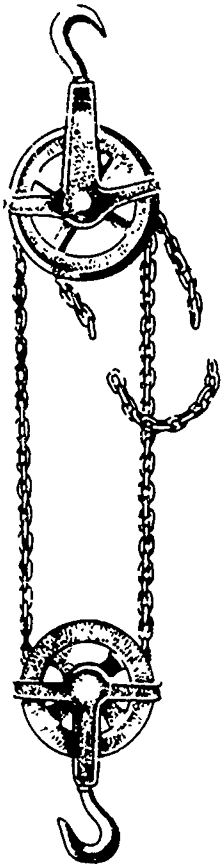


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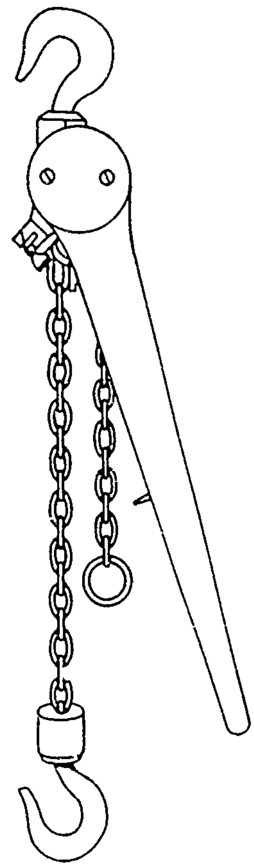
Figure 3-26.—Differential chain hoist.



127.69

Figure 3-27.—Come-along.

frequent use of a hoist and where a minimum number of crewmembers are available to operate it. The spur gear hoist is about 85 percent efficient. In other words, about 85 percent of the energy exerted by the operator is converted into useful work for lifting the load. The remaining 15 percent of the energy is spent in overcoming friction in the gears, bearings, chains, and so on.

The DIFFERENTIAL CHAIN HOISTS (See fig. 3-26.) is suitable for light loads and where only occasional use of the hoist is involved. This hoist is only about 35 percent efficient.

A ratchet-handle pull hoist, commonly called a COME-ALONG, can be obtained and will prove beneficial for making short, horizontal pulls on heavy objects. A typical come-along, having a rated capacity of 1 1/2 tons, is shown in figure 3-27. You will find the come-along to be one of the most useful hoisting devices available. The chain will NOT foul up because it is flexible and cannot kink. The chain is kept in place in the sheave by a hardened steel-load chain guide.

The load capacity of a chain hoist usually is stamped on the shell of the upper block. The rated load capacity of hoists runs from 1/2 ton (0.45 metric tons) upward to 40 tons (36 metric tons).

The lower hook is usually the weakest part in the assembly of a chain hoist. This is intended as a safety measure so that the hook will start to spread open if overloaded. Spreading in a hook is a signal to the operator, warning that the chain hoist is nearing the overload point. Thus, close observance on the part of the

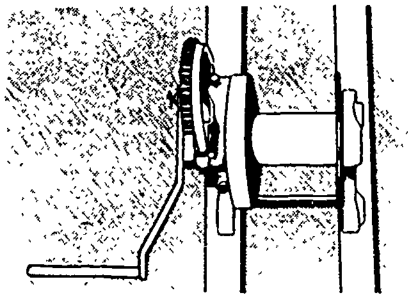


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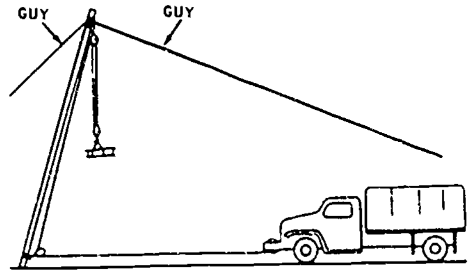
Figure 3-28.—Single drum hand winch.




127.71

Figure 3-29.—Using a vehicular winch for hoisting.

operator is necessary to detect any sign of overloading in time to prevent damage to the chain hoist. Under ordinary circumstances, pull exerted on a chain hoist by one or two crewmembers is NOT enough to overload the hoist.

Frequent inspection of chain hoists is necessary to insure safe operation. A hook that shows signs of spreading or excessive wear should be replaced. If links in the chain are distorted, the chain hoist has probably been overloaded. In such a case, see that the chain hoist is condemned and removed from service immediately.

## WINCHES

Winches are frequently used as a source of power for operating hoisting rigs, particularly gin poles, heavy-duty derricks, and light-hoisting equipment, such as pole derricks. A WINCH, generally speaking, is a device having one or more drums on which line or wire rope is wound and is used for hoisting or hauling of materials or objects. Both hand-operated and engine-driven winches of various types are available.

A single-drum, hand-operated winch similar to the one shown in figure 3-28 is suitable for lifting light loads. Single-drum hand winches are available in various capacities, including 2, 5, 6, and 15 ton (1.8, 4.5, 5.4, 12.5 metric tons) capacities.

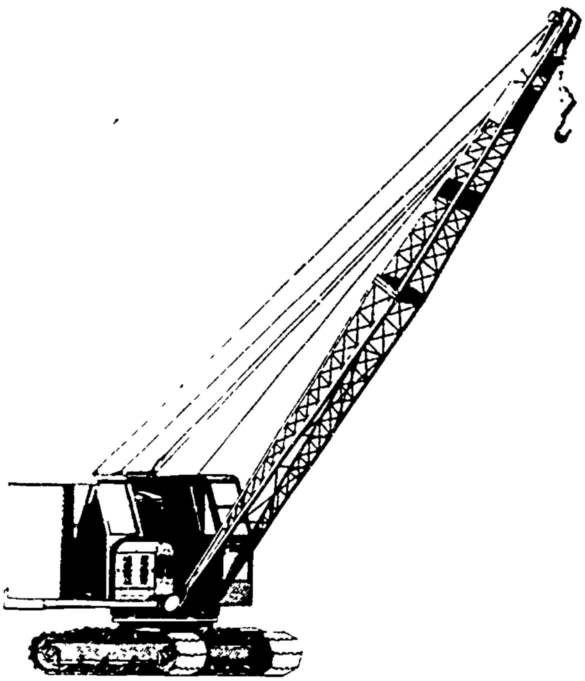
Hand-operated winches are generally mounted near the foot of the rig where they can be operated efficiently; notice the location of the winch on the pole derrick shown in figure 3-24.

In hoisting and moving heavy objects in the field, engine-driven winches may be used with tackle. Vehicular-mounted winches are also widely used (fig. 3-29). Sources of power for power-driven winches include diesel, gasoline, compressed air, or steam engines, as well as electric motors. When vehicular-mounted winches are used, the vehicle should be placed so that the operator can keep a close watch over the load during hoisting.

When setting up a power-driven winch to operate hoisting equipment, make sure you give careful consideration to these two factors: (1) the angle with the ground which the hoisting line makes at the drum of the hoist, and (2) the fleet angle of the hoisting line winding on the drum.

In considering the ground angle, remember that if the hoisting line leaves the drum at an angle upward from the ground, the resulting pull on the winch will tend to lift it clear of the ground. In this case, a leading block should be placed in the system at some distance from the drum in order to change the direction of the hoisting line to a horizontal or downward pull. The hoisting line must be overwound or underwound on the drum—as may be necessary—to prevent a reverse bend.

As for the fleet angle, bear in mind that the distance from the drum to the first sheave of the system is the controlling factor. Place the drum



29.65
Figure 3-30.—Crane rigged with boom and lifting hook.

of the winch so that a line from the last block passing through the center of the drum is at right angles to the axis of the drum. The angle between this line and the hoisting line as it winds on the drum is referred to as the FLEET ANGLE.

As the hoisting lin wound in on the drum, it moves from one fl to the other, causing the fleet angle to chang uring the hoisting process. See that the fleet angle does NOT exceed 2°; and, where possible, keep it below this. A 1 1/2° maximum angle is satisfactory and will be obtained if the distance from the drum to the first sheave is 40 inches (100 cm) for each inch (2.5 cm) from the center of the drum to the flange. The wider the drum of the hoist, the greater the lead distance must be in placing the winch.

Most winches, even those made by the same manufacturer, differ from each other in their operation. If you are not familiar with the operation of a winch to be used on a job, study the operating procedure described in the manufacturer's manual beforehand. The fundamentals of winch operation must be understood to insure safe, efficient handling of materials. The use of hand signals in giving directions to operators of winches is especially important to the safety of both the crewmember and the material being hoisted.

## CRANES

The crane is one of the most useful pieces of construction equipment. It is also one of the most versatile. For instance, by rigging the crane chassis with a boom and lifting hook, you have an excellent device for lifting and moving heavy materials, machinery, and other objects. (See fig. 3-30.) The capacity of the crane for lifting depends on the boom length and angle. The capacity will be noted inside the cab of the crane and this capacity should NOT be exceeded. You will not be required to operate the crane, that is the job of the Equipment Operator. But there are other important jobs, such as that of hook-on man or signalman, and you must be able to handle either of these.

# MANIPULATION OF HOISTING EQUIPMENT

The Steelworker's responsibilities do not end once the hoisting device is rigged and in place. The Steelworker must still be able to attach the load to the hoisting device and direct the movement of the hoisting mechanism in moving and positioning the load.

## HOOK-ON MAN

As a hook-on man, you will be responsible for hooking lines onto loads or slinging loads. Here are some pointers that will help you do this job safely and efficiently.

In using slings to attach lifts to hoisting equipment, always make sure that you use only approved safe methods for fastening the slings to the load and to the hook. There should be no question in your mind as to the load being secured against slipping. It is important, of course, that the load be carefully calculated in

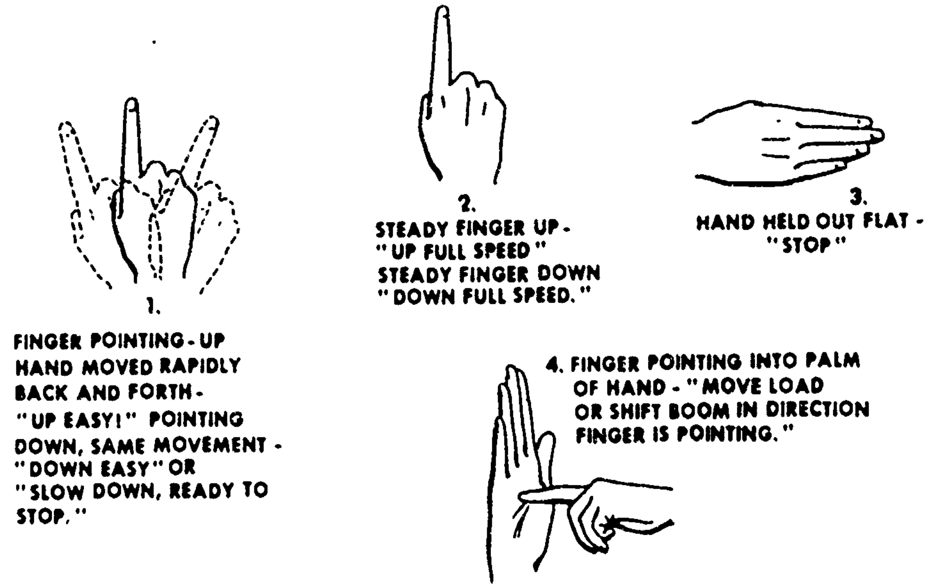



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Figure 3-31.—Suggested system of hand signals to winchmen.

advance, and no attempt should ever be made to lift a load greater than the rated capacity of the hoisting device.

Remember that a load should never be carried on the point of a hook. Box hooks should only be used for raising medium weight boxes and crates to a height to enable placement of slings or dunnage.

When "choking" a load, place the shackle so that the pin will ride in the eye of the pendant—not in the standing part—and not unscrew.

Always exercise special care in hooking up a load to see that wire ropes or chains are kept free of kinks and knots. In addition, make sure that chains or slings do not dangle or drag under a load.

Before a load is hoisted, always check to see that it is properly balanced in the sling. Check the upper block to make sure it is directly over the load to avoid swinging of the load.

When withdrawing slings from underneath a load—after the load has been landed—exercise care to prevent the slings from flying loose and striking someone or catching and tipping the load. For protection of slings, remember to use pieces of rounded wood or old rubber tires on sharp corners, especially in cases where the sling might slide.

The hook-on man should be thoroughly familiar with the hand signals used to direct the operators or hoisting equipment. Appendix I illustrates hand signals which are used for directing crane and derrick operators.

In the case of winches, there is no standard system of signals as with cranes. However, you will probably find the signals shown in figure 3-31 to be clear and effective for all practical purposes. If you can improve on it, do so, but be certain in any event that you have some definite set of signals familiar to all hands and never deviate from it. When winchmen get confused, accidents can easily occur.

## SIGNALMAN

As a signalman, you will probably be in charge of a rigging crew. It is a responsible job and should be filled only by experienced,

qualified personnel. In addition to knowing the technical aspects of the job, the signalman should be a calm, cool-headed, nonexcitable type of person. These characteristics are essential because if something should go wrong in hoisting or moving a heavy load, the safety of personnel, as well as the extent of damage to materials and equipment, may very well depend on the ability of the signalman to take proper action in a HURRY.

NOTE: An important phase of your job as signalman is to give hand signals to the operators of hoisting equipment. Prior to starting the job, it is important that the Steelworker check with the Equipment Operator to make sure that all signals used will be understood.

One person only should be designated as signalman, and the Equipment Operator should accept signals from that person only. One exception to this rule is an EMERGENCY STOP, which may be given by any person and must be obeyed by the Equipment Operator. It is a good idea that the signalman wear some conspicuous article of dress, such as a brightly colored helmet or an armband. This article of dress enables the Equipment Operator to easily distinguish the signalman from other workers.

In addition to giving hand signals, the signalman usually handles various other duties of a responsible nature. As supervisor of the rigging crew, a signalman is responsible for the safe, efficient handling of the loads to be moved, as well as the SAFETY of the crew. Here are some precautions that should be carefully observed in each instance where applicable to the job at hand.

Be sure the Equipment Operator knows what is to be done. Before starting a job, have the Equipment Operator conduct a thorough inspection of all safety devices, such as hoist controls, brakes, and clutches.

Make certain that each member of your crew wears the proper safety apparel.

See that dunnage is placed on the spot where you will place a heavy object. It will be easier to unsling or hook onto again. This also protects the load from moisture and rotting. (Dunnage is scrap material used for temporary platforms under heavy loads, for softening loads, and in some cases for securing loads to keep them from slipping.)

Remember that only a board or crowbar should be used to adjust dunnage under a load, and insure that your personnel keep their hands and feet from under the load at ALL times.

See that tag lines are used to guide loads whenever there is a possibility of the load moving out of control. Tag lines should be of adequate length and kept free of loops and knots.

Before giving a signal for hoisting, check to make certain all members of the crew have removed their hands from the slings, hooks, and the load. In addition, see that all persons are clear of the bights and the snatch block lines, and that all loose parts or objects are properly secured.

Know the load capacity of the rig being used, and see that its capacity is NOT exceeded. When lifting a heavy load, first raise it a few inches and let it hang a moment so you can see if the load is balanced and whether the brakes of the hoist are all right. Also, keep an eye on the load as it is hoisted.

## HOISTING SAFETY

Basically, every hoisting operation involves placing relatively few strength members under the repeated strain of lifting and moving heavy objects. One might think that the primary cause of accidents and injuries incurred in hoisting operations would be material failures. However, analysis of accident reports shows that more than 80 percent of hoisting mishaps and injuries are the direct result of unsafe acts and practices on the part of the personnel involved. Further scrutiny of accident records indicates that the hazardous actions summarized below have been the predominate causes in many of these hoisting accidents.

1. Backing and turning machines, swinging booms, lowering loads, and performing similar operations without looking, giving warning, or signaling.

2. Getting on and off hoisting equipment, such as a crane, while it is in operation, and riding on hoisted loads when not authorized to do so.

3. Operating hoisting equipment with defective brakes, clutches, or other improperly functioning parts.

4. Working under loads hoisted or suspended aloft.

5. Operating cranes too close to powerlines and without adequate watches or supervision.

6. Failure to secure booms or other movable parts of hoisting equipment prior to repairing, leaving, or moving the machine.

7. Failing to use personal protective devices or clothing.

Lowering a hoist line and boom with a load on the hook at the same time is prohibited. The speed of lowering a load should NEVER exceed the hoisting speed. Attempting a sudden or emergency stop while lowering at high speeds will produce dynamic stresses on hoisting gear that are far in excess of the normal static weight of the load. The force may be sufficient to cause sudden and violent failure of the hoisting gear.

Steelworker riggers who work close to cranes should be careful to avoid situations where they might be caught and crushed between some stationary object, such as a wall and the rear of the crane as it is turned.

Nobody should be permitted to ride on the load being hoisted unless unusual circumstances require it, and then only with the permission of the Steelworker rigger in charge and with the appropriate safety belt, lifeline, or similar precautions being used.

Riding of the hoist block or hook should NOT be allowed.

All hoisting chains should be inspected by the signalman at frequent intervals for such defects as stretch of more than 5 percent original length, wear of greater than 25 percent of original thickness, gouge marks, open welds, or fractures as indicated by very fine surface cracks. Any chain found with these defects must be removed from service. In a sense, chains are not as reliable as fiber line or wire rope since they can break without any warning.

Brakes used on cranes and winches are often subject to temporary failure when the linings become wet due to rain or under certain atmospheric conditions. Hoisting crew leaders should have the Equipment Operators check brakes and linings often during adverse weather conditions.

All personnel should be kept clear of areas near or under the boom or suspended load during hoisting operations. It should be remembered that if a boom fails, it will usually swing some distance laterally rather than fall straight down. Therefore, it is NOT adequate to merely clear personnel from the area directly beneath the boom or load. They must be kept clear of areas to either side as well. Thus, riggers should move well clear of the boom or load before a strain is taken on the hoisting line.

If it can be avoided, crane booms should never be operated near high tension powerlines. If work must be done in their vicinity, an effort should first be made to have the powerlines deenergized before starting work. If deenergizing is NOT possible, then a watch should be posted to make sure that the boom or hoisting cable NEVER comes closer than 10 feet (3 m) to the high tension wires. Operators should not be allowed to depend on chains or other grounding devices dragging along the ground to give protection against electrical current discharges through the crane. Such devices cannot safely ground a crane, and they give the operator a false sense of security. If a boom or cable does touch a powerline, ground personnel must not touch any part of the crane or touch the operator until the operator has jumped clear of the equipment. Under no circumstances should the operator dismount from the machine by climbing down the side, thereby permitting his body to come in contact with the machine and the ground at the same time.

When hoisting with a boom derrick and work is temporarily stopped and the derrick is idle, make sure the boom is lowered to a horizontal position or tied in place to prevent wind from blowing it out of control. See that all rigging gear is properly stored when not in use.

Finally, Steelworker riggers must take care to wear the necessary protective clothing; specifically, hard hats, safety shoes, gloves, and work shirts with the sleeves rolled down, or jackets to protect arms and torso from contact with slings.

# CHAPTER 4

# CONSTRUCTION INSPECTIONS AND QUALITY CONTROL

As a Steelworker First Class or Chief, you will be responsible for conducting construction maintenance inspections. This chapter contains information that you can apply in conducting your inspections of new construction, work areas, tools and equipment, welding operations, reinforcing steel erection, and prefabricated structures. Also, it provides technical advice on construction and maintenance techniques, including the safety measures to be taken by personnel engaged in steelworking operations.

## RESPONSIBILITIES OF INSPECTORS

The value of visual inspections depends largely upon the qualifications of the inspector. If inspections are to serve as a tool of quality control, they should be performed only by well-qualified persons. A main requirement of the inspectors is that they have a thorough knowledge of the materials, specifications, techniques, procedures, and so on, commonly used in the work to be inspected. Another major requirement is that they have a keen eye for detecting defects by visual examination of the work. Besides knowing what to look for in the way of defects in the work produced, the inspectors must also be able to observe personnel performing jobs and to recognize any errors in technique, operational conditions, or other phases of workmanship.

The prime function and responsibility of the inspectors of new construction is to assure that the work is performed in all respects in accordance with the drawings and specifications. These requirements are usually—but not always—sufficiently exacting to necessitate high standards of quality, both in materials and workmanship. In the case of temporary or emergency construction, quality requirements may be lowered intentionally. The inspectors, therefore, must be careful to ascertain that the work is of the required quality, and they must also be equally careful not to demand a quality of work superior to that required.

In some cases, the specifications for a project establish definite tolerances over or under the acceptable measurements. Here the inspectors have only to verify that the work is within the specified limits. On most phases of the work, however, specific tolerances cannot be fixed, or at least are not fixed. Then good judgment is necessary in interpreting requirements, such as plumb, true, and level. The intention is that workmanship shall be of the most suitable grade for the purpose. The inspectors, therefore, should have a comprehensive practical knowledge of the grades of workmanship appropriate in the various classes of structures and in the various details of the work.

The degree of the accuracy appropriate is dependent on many factors. Structural framing may have to be true within 1/16 inch, or in some cases within 1/8 inch. Concrete work can seldom be held closer than 1/8 inch, and in some special types of structures, much larger tolerances must be permitted and allowed.

The inspectors must assure themselves that the principal centerlines, column lines, and controlling overall dimensions and elevations are correct; that minor errors are not permitted to accumulate but are compensated continuously; that exposed work is visually acceptable; and that special care is taken when greater than ordinary precision for a type of work is necessary for some special reason.

It is important that the inspectors make clear at the outset of the work what will be expected and make sure that the initial portions of the work fulfill these expectations. It will invariably be found that the standards of accuracy established and enforced during the first few days of work will set the pattern for the rest of the work. The inspectors must be consistent in the standards they exact. They must be reasonable, but they cannot be lenient.

Inspection of temporary construction must be limited to that sufficient to assure that the work is adequate and safe for the purpose. The inspectors should, however, be alert to note any defective construction, unsound materials, possible weaknesses, or hazards and bring any discrepancies to the attention of their superior.

An extremely important and relatively difficult phase of inspection is in the checking of a project as it nears completion to make sure that every item required for completion of the project has actually been provided. It is essential that a checkoff system be used for this purpose and that the system adopted be initiated early enough that ample time will be available for delivery and installation of any items overlooked. This is particularly necessary in times of emergency when long lead time between ordering and delivery is being encountered for many critical items of material and equipment. The inspectors must maintain strict watch over cleanup items, particularly where portions of the work may be concealed in later stages. Because of the inherent tendency of construction projects to drag out to a slow finish, the inspectors will have to exert correspondingly greater pressure to obtain full and expeditious compliance with the requirements in this respect.

The inspectors may be responsible for maintaining accurate and detailed records of the performance of the work and of other pertinent matters.

Since they work with contractors and other persons in private industry as well as with military personnel, inspectors must understand human relations and behave accordingly. This means being tactful, courteous, and absolutely honest, also trustworthy, loyal, diligent, and punctual. In addition, dealing with people requires inspectors to be dignified, steady, and poised. When inspecting their subordinates, inspectors must be firm, but fair. They must avoid showing any favoritism or partiality. In particular, they must also avoid making any statements or taking any action that might discredit another supervisor or foreman in the presence of subordinates. A harmonious relationship is better than one hampered by friction and discord.

## WORK AREAS, TOOLS, AND EQUIPMENT

When work areas, tools, and equipment are inspected, all necessary precautions must be taken to insure the safety of all personnel. Given below are some pointers that should help you in making safety inspections of work areas, tools, and equipment and also in supervising construction operations.

### WORK AREAS

When making a safety inspection of work areas, watch carefully for potential hazards and unsafe conditions. Insure that equipment is arranged to permit working on material with a minimum of handling so that work can flow in an orderly and logical sequence. In addition, see that clearances around the equipment are ample to prevent congestion and avoid interference with the operation of other equipment.

Make sure materials are properly stored and walkways are kept clear. Materials should be piled so that they cannot roll, fall, tumble, or be blown over.

Be especially watchful of housekeeping practices in work areas and insure that potential hazards to personnel or equipment are corrected immediately. Work areas should be kept clean and orderly at all times. Oily rags and other such debris should be disposed of in approved safety containers. See that small parts, tools, or equipment—such as bolts, nuts, and wrenches—are not left lying around where someone may fall over them.

Insure that planks, timbers, or blocks containing projecting nails are removed immediately from the jobsite or placed in orderly piles where personnel are not likely to stumble or fall over them.

Check carefully to see that individuals observe all applicable safety precautions in performing their duties. In doing so, insure that they wear personal protective apparel, such as goggles, safety belts, helmets, gloves, and safety shoes where required. See that safety equipment, such as safety screens, is also used on operations where required.

Make sure that necessary warning signals are placed to provide proper and adequate warning of hazards. These signals should be removed as soon as the hazards have been eliminated.

## HAND AND PORTABLE TOOLS

When inspecting hand and portable tools, insure that they are in safe and proper working condition, and that tools are used only for their proper purpose and in the manner prescribed.

See that handles on handtools are free from slivers or other defects.

NOTE: Defective handles should not be repaired by taping.

Check closely to see that the gripping surfaces of tools are kept free of grease, oil, or other slippery materials.

Insure that defective or damaged tools are not used or that they are repaired or disposed of immediately.

See that power tools are used only when the user is in a secure working position and braced against falling. Sudden cessation of operation, or kicking or bucking of the tool may result in a fall.

Make sure that operators of drills, reamers, and other rotating tools do not wear loose clothing, neckties, or gloves.

See that power machines are operated only by qualified personnel; that guards are kept in place during operation of machines; and that hands, as well as tools, are kept clear of all moving parts of a machine while it is in operation.

Tools left lying around on benches, near machines, and on floors and ladders can cause accidents—and get lost. See that tools are returned to their proper place of storage when not needed on a job.

Mushroomed and burred heads on striking tools can cause serious injury—see that the heads are ground down when required.

Insure that all hand-held power tools are grounded. On three-pronged plugs, this is done automatically when the plug is inserted into an electrical outlet, PROVIDED both the plug and outlet are wired correctly. Tools having a two-pronged plug and distinctively marked "DOUBLE INSULATED," are not required to be grounded. Tools having a two-pronged plug not marked as double insulated must be grounded, either by connecting a built-in third wire to a known ground (cold water pipe, cover plate screw of a grounded outlet, etc.), or by connecting a third wire between the frame of the tool and a known ground. In addition, all tools of the grounded type must be used only on a circuit which is protected by a ground-fault circuit-interrupter device.

## FIBER LINE AND WIRE ROPE

In steelworking operations, such as hoisting and moving heavy loads, you must be concerned with the strength and safety of fiber line and wire rope. Thorough inspections, conducted at regular intervals, are necessary to determine whether fiber line or wire rope is in good condition and of sufficient strength. Rules-of-thumb are used in computing the safe working load of fiber line and wire rope.

The outside appearance of a FIBER LINE is not always a good indication of its internal condition. Fiber line will soften with use. Depending on the manner in which it is handled, it will deteriorate more or less rapidly. Dampness, heavy strain, the fraying and breaking of strands, and chafing on rough edges, all weaken the line considerably. Overloading of a line may cause it to break with possible heavy damage to material and serious injury to personnel. For this reason, inspect the line carefully to determine its exact condition. Untwist the strands slightly to open the line so that the inside can be examined. Mildewed line will have a musty odor, and the inner fibers of the strands will have a dark, stained appearance. Broken strands or broken yarns ordinarily are easy to find. Dirt and sawdust-like material inside the line, caused by chafing, indicate damage. In line having a

central core, the core should not break away in small pieces upon examination. If this happens, it indicates the line has been overstrained. Since any weak point in the line weakens the entire line, examine it at a number of places. If the line appears to be satisfactory in all other respects, pull out two fibers and try to break them. Sound fibers should offer considerable resistance to breakage. When any unsatisfactory condition is found, see that the line is destroyed or cut into short pieces. Make sure none of these pieces are long enough to permit their use in hoisting. The short pieces can be saved for miscellaneous uses.

During an inspection of WIRE ROPE, you should check carefully for fishhooks, kinks, and worn and corroded spots. Usually, breaks in individual wires will be concentrated in the parts of the rope that consistently run over the sheaves or bend onto the drum. Abrasion or reverse and sharp bends cause individual wires to break and bend back. These breaks, as you perhaps know, are known as fishhooks.

Worn spots will show up as shiny flattened spots on the wires. Measure some of these shiny spots. If it appears that the outer wires have been reduced in diameter by one-fourth, the worn spot is unsafe.

There may be several points in the wire rope where broken wires occur. Inspect each point to determine whether it is a single broken wire or several.

If individual wires are broken next to one another, unequal load distribution at this point will make the rope unsafe.

When 4 percent of the total number of wires in the wire rope are found to have breaks within the length of one rope lay, the wire rope is unsafe and should be removed from service.

The wire rope is unsafe and should be removed from service if three broken wires are found in one strand of 6 × 7 wire rope, six broken wires are found in one strand of 6 × 19 wire rope, or nine broken wires are found in one strand of 6 × 37 wire rope.

A wire rope should be removed from service when an inspection reveals widespread corrosion and pitting of the wires. Pay particular attention to signs of corrosion and rust in the valleys or small spaces between the strands. Rope which has had its diameter reduced to less than 75 percent of its original diameter should also be removed from service.

The safe working load (or safe load) of fiber line and wire rope is an important factor. Manufacturers of fiber line and wire rope provide charts and tables listing the safe working load, abbreviated SWL, for different sizes of fiber line or wire rope. But you may not have a chart or table readily available every time you need it, especially in fieldwork. In such instances, you can use a rule-of-thumb for computing the SWL.

For fiber line, the rule-of-thumb for SWL is: SWL (in pounds) = $C^2 \times 150$, where C is the circumference of the line. When line is in good shape, add 30 percent to the SWL arrived at by means of this rule. When the line is in poor shape, subtract 30 percent from the SWL.

The rule-of-thumb for computing the SWL of wire rope, as recommended by NAVFAC is. SWL (in tons) = $D^2 \times 4$, where D represents the diameter of the wire rope in inches.

As a word of caution, remember that these rules for determining SWL are only rules-of-thumb. In computing the SWL of old wire rope, or wire rope which is otherwise in poor condition, you may have to reduce the SWL as much as 50 percent, depending upon the condition of the wire rope.

## CHAINS AND HOOKS

CHAINS are made up of a series of links fastened through each other. Each link is made of a rod of wire bent into an oval shape and welded at one or two points. The weld ordinarily causes a slight bulge in the side or end of the link. Several types of welded chain links are illustrated in figure 4-1. The chain size refers to the diameter, in inches, of the rod used to make the link.

Chains will usually stretch under excessive loading so that the individual links will be bent slightly. Bent links are a warning that the chain has been overloaded and might fail suddenly under load. Wire rope, on the other hand, will fail a strand at a time, giving warning before complete failure occurs. If a chain is equipped with the proper hook, the hook should start to fail first, indicating that the chain is overloaded.

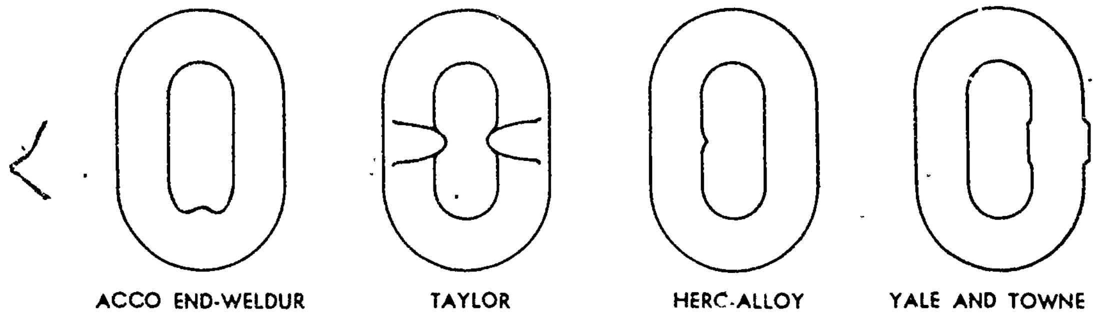


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Figure 4-1.—Types of welded chain links.

Chains are much more resistant to abrasion or corrosion than wire rope and, as a consequence, are used in applications where such factors are a problem. An example is the use of chain for anchor gear in marine work where the chain must withstand the corrosive effects of seawater. Another example is the use of chains for slings to lift heavy objects with sharp edges which would cut wire rope. A number of grades and types of chains are available.

When inspecting chains, make sure that defective links are cut out and replaced. Every link in a chain must be examined, since any single link may be defective in an otherwise satisfactory chain. Small dents, cracks, polished or worn surfaces, and stretched or distorted shapes are indications of possible failure in links. If several links in a chain have been stretched or distorted, the chain should not be used, because there has probably been overloading of the entire chain which does not show in all links. Sharp nicks or cuts in any link may lead to failure of that particular link. This link should be cut open and removed from the chain. Carefully observe the point where each link wears.

Chains, fiber line, or wire rope, when used for lifting loads, can be tied directly to the load. However, for speed and convenience, it is much better to fasten a HOOK to the end of the lifting line. Blocks are ordinarily constructed with a hook. There are two general types of hooks available—the slip hook and the grab hook (fig. 4-2). A SLIP HOOK is made so that the inside curve of the hook is an arc of a circle and may be used with wire rope, chains, or fiber line. Chain links can slip through a slip hook so the loop formed in the chain will tighten under a load. A GRAB HOOK has an inside curve which is nearly U-shaped so the hook will slip over a link of chain edgeways but will not permit the next link to slip through. Grab hooks have a more limited range of use than slip hooks. They are used on chains when the loop formed with the hook is not intended to close up around the load.

When a hook is being inspected, the inspector should pay particular attention to the small

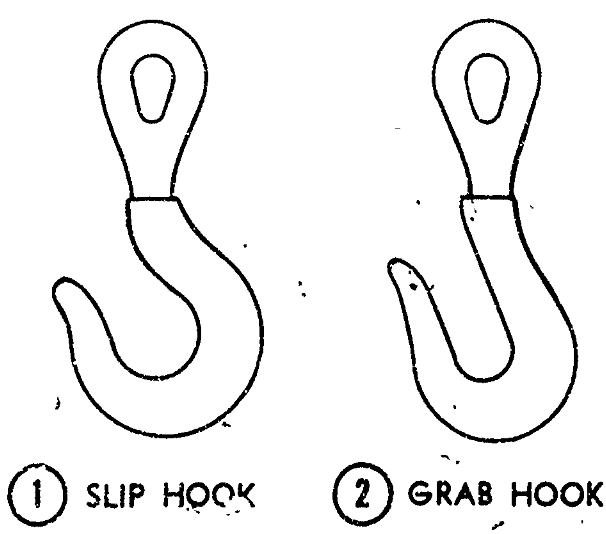


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Figure 4-2.—Types of hooks.

radius fillets at the neck for any deviation from the original inner arc. Also the hook should be checked for indications of overloading or improper hooking. Hooks usually fail by straightening, and thus release the load. Any deviation from the original inner arc indicates that the hook has been overloaded. Since evidence of overloading the hook is easily detected, it is customary to use a hook weaker than the chain to which it is attached. In this way, distortion of the hook (See fig. 4-3.) will occur before overloading of the chain itself occurs. Severely distorted, cracked, or badly worn hooks are dangerous and should be discarded. The safe working load, in tons, of a hook can be determined by the following formula:

$$SWL = 2/3\ D^2 \text{ tons}$$

Example: $D = 2''$

$D^2 = 2 \times 2 = 4$

$2/3 \times 4 = 8/3 = 2\ 2/3$ SWL in tons

$8/3 \times 2000 = 5333$ SWL in pounds

In general, a hook should always be "moused" as a safety measure to prevent slings or lines from jumping off. Mousing is a technique for closing the open section of a hook. Mousing also helps prevent straightening of the hook but should not be considered as an element in the strength of a hook. It serves principally as a safety measure.

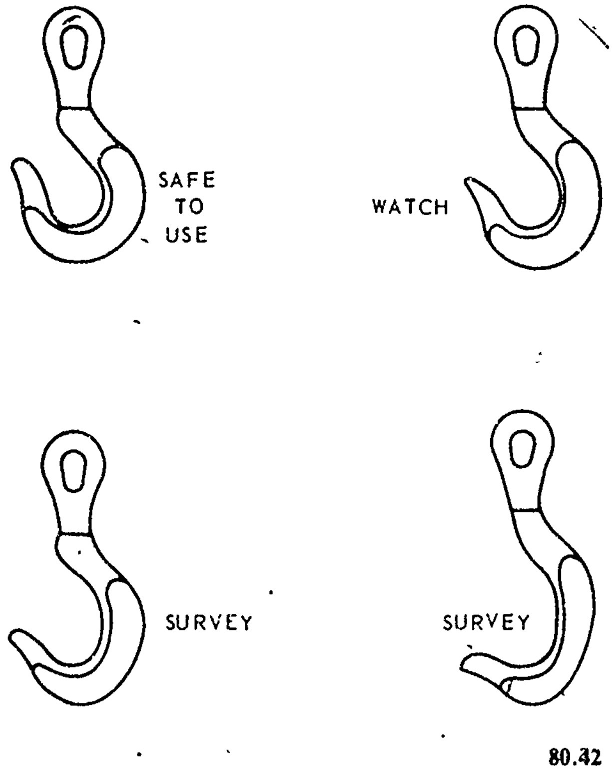


Figure 4-3.—Results of overloading on a hook.

## SLINGS

The term SLING includes a wide variety of designs. A sling may be made up of fiber line, wire rope, or chain. The sling for lifting a given load may be an endless sling, a single sling, or several single slings used together to form a combination sling. The ends of single slings usually are made up into eyes, either with or without thimbles, to go over the hoisting hook. However, they may be made up with end fittings to provide variable service. Spreaders may be added to change the angle of the sling legs. Each type or combination has its particular advantages, and these must be considered when a sling is being selected for a given purpose. Fiber line makes good sling material because of its flexibility, but it is more easily damaged by any sharp edge on the material hoisted than is wire rope or a chain sling. Wire rope is widely used for slings because it has strength combined with flexibility. Chain slings are used for special circumstances where sharp edges of metal would cut wire rope or where pieces of hot metal are lifted, as in foundries or blacksmith shops. Fiber line slings are normally used for lifting comparatively light loads. Properly designed and fabricated wire rope slings are the safest slings. They do not wear away as do slings made of fiber line, nor do they lose their strength from exposure as rapidly. They also are not susceptible to the "weakest link" ailment of chains caused by the uncertainty of the strengths of the welds. Wire rope slings show by inspection their true condition. The appearance of broken wires clearly indicates the fatigue of the metal and the end of the useful life of the sling.

Since all sling legs are subject to damage from cutting by sharp edges or abrasion, all sharp edges on objects to be lifted should be carefully padded to reduce possible damage to the slings. Wood blocking, heavy fabric, or old rubber tires can be used as padding. Slings should be condemned when they are no longer safe. Unsafe slings may seriously injure personnel or damage equipment if they fail under load.

## GUY LINES

Guy lines are lines attached to a gin pole or other structure and secured to an anchor on the ground or to a nearby secured structure which is more stable than the guyed structure. When a load is applied to the structure supported by the guy lines, a portion of the load is passed by each supporting guy line to its anchor. Wire rope is the preferred material for guy lines because it combines strength with resistance to corrosion and weathering. But fiber line can be used for guy lines, particularly on temporary installations.

The number of guys required for a given point on a structure depends on the type and amount of load to be applied to the structure, the size and type of material available for guy lines, and the direction of the pull caused by the load. Four guys are generally considered minimum, with 90-degree angles between guys. (See fig. 4-4.) In a long, slender structure, it is sometimes necessary to provide support at several points of the structure in a tiered effect. In such cases, there might be four guy lines from the center of a long pole to anchors on the ground and four additional guy lines from the top of the pole to anchors on the ground.

The guy line should be anchored a considerable distance from the base of the gin pole so that the distance (y) in figure 4-5 will be a maximum. The guy line should never be anchored closer than a horizontal distance equal to the height of the gin pole. The recommended minimum distance from the base of the gin pole to the anchorage of the guy line is twice the height of the pole. Wire rope clips or clamps can be used to make eyes or loops for securing the

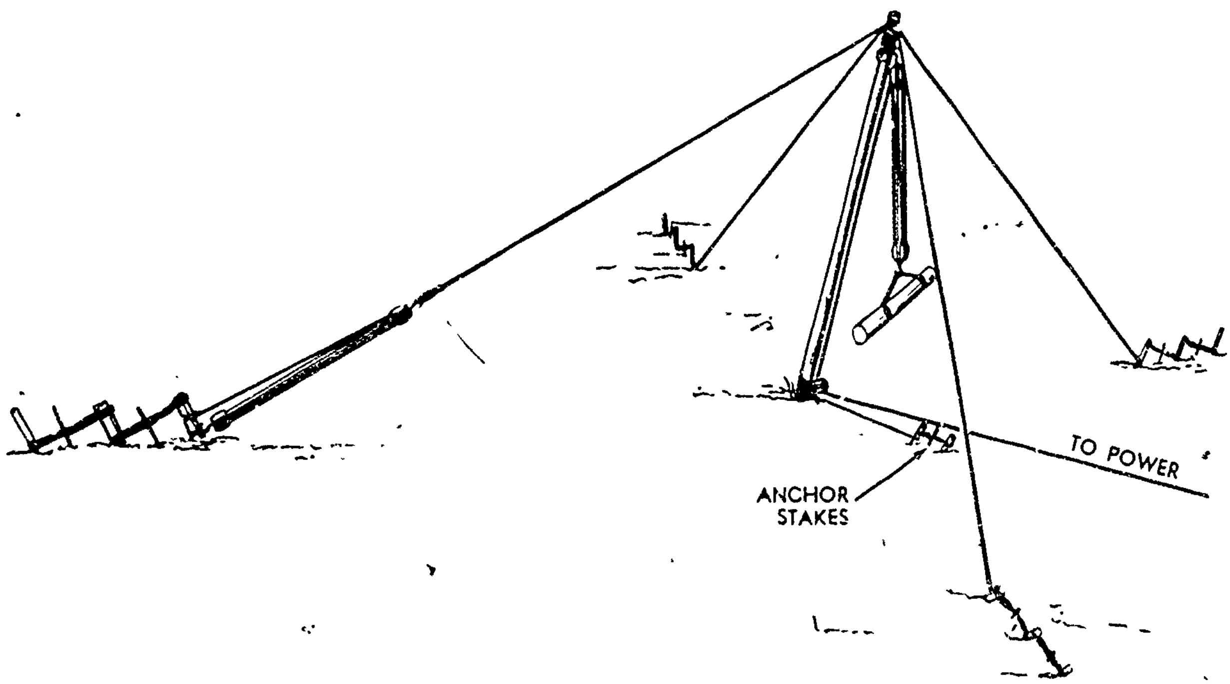


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Figure 4-4.—Typical guy line installations.

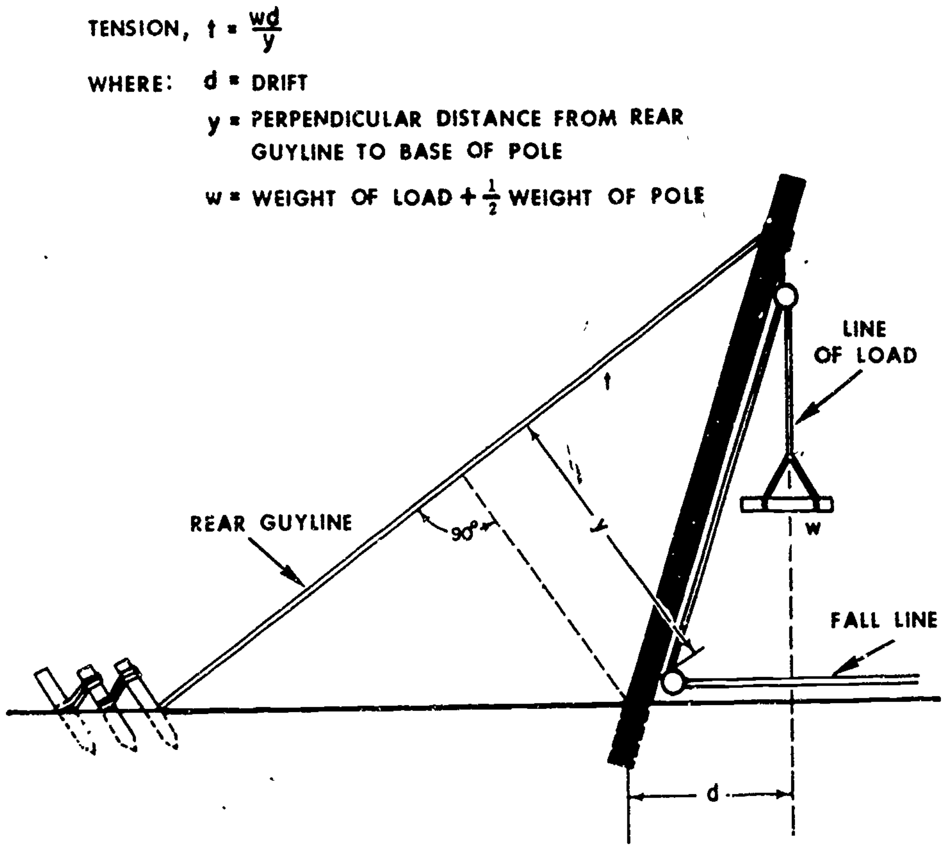


Figure 4-5.—Computing stress in single guylines.

wire rope to the anchorage. It is a very good idea to use a turnbuckle from the anchorage to the eye. If the wire rope is of any length, the turnbuckle can be used to take out the slack.

The anchorages and end fittings of the guys should be checked for evidence of weakened members. In ordinary service, wire rope guys will last indefinitely unless exposed to damp salt air or corrosive fumes. A check should be made also for broken wires in guylines. Broken wires indicate fatigue of the lines.

## PIPE WELDING OPERATIONS

Continuous inspections by well-trained inspectors are important to the production of good quality welds. A major advantage of continuous inspections is that they enforce careful workmanship on the part of the welding operators. Inspectors cannot examine each and every weld during welding; however, careful observation of a selected number of joints will be a great help toward insuring sound quality CONTINUOUSLY in the work produced.

The visual inspection of pipe welds includes three phases—before, during, and after welding. The items covered by a visual inspection will vary somewhat, depending upon such factors as the welding process used, operating conditions, and the type of job concerned. The discussion which follows is mainly concerned with some of the major items generally included in a visual inspection of pipe welding operations, where the metal-arc welding process is used. Proficient pipe weld inspectors will not find it difficult to modify the inspection procedures to meet the

requirements for other types of welding operations.

## PREWELDING INSPECTION

Before the actual welding operations get underway, insure that the welding operator is making the correct preparations for the job. Check the condition of the equipment, and SEE that it is set up properly. Examine the area to be welded for grease, oil, scale, or other foreign matter which would interfere with the welding operation. As part of this preliminary inspection, see that the pipes are correctly alined and the joints properly beveled.

## INSPECTION DURING WELDING

You should be able to control the quality of a weld by carefully observing the welding operator at work. Here it is important to look carefully so you can recognize immediately the results of variations from correct welding procedure. From time to time, make sure each welder uses proper techniques and maintains proper operating conditions. It is good practice to vary operating conditions, one at a time, and to observe the resultant weld. The variable operating conditions are arc current, arc voltage, and arc speed for each type of weld and electrode.

Maintain all of the principal operating conditions except one fixed, then observe the effects brought about by changing that one condition. Observe consumption of the electrode and how it melts down—smoothly or unevenly. Note the size and shape of the weld crater, as well as its surface appearance. Listen to the sound of the arc. Take a close look at the weld bead, noting in particular its size, shape, and fusion. In case of faulty techniques resulting in defects, such as slag accumulations or cracks, make sure that corrections are made then and there—not after the job is finished.

## INSPECTION AFTER WELDING

In checking a completed welding job, watch closely to see whether or not the welds are sound throughout and fused thoroughly. See that the inside of the pipe is free from globules (icicles) of weld metal which might become loose. Check the size, length, and location of the welds, making sure—before passing on the work—that the beads of the deposited metal are of uniform (rather than irregular) size. Examine the welds for undercut, overlap, and other defects which can be detected by visual inspection. If any of these defects are present, make sure that proper corrective measures are taken. Various types of defects (including overlap and undercut) are described in *Steelworker 3 & 2*. A knowledge of these defects plus a clear understanding of certain other weldments described next will help you during inspections of welds made by the metal-arc welding process.

## INSPECTING WELDS

A number of different types of DIMENSIONAL DEFECTS in weldments can be determined by visual inspection. Dimensional defects are those associated with drawing or specification requirements. Examples of dimensional defects are: warpage, incorrect joint preparation, incorrect weld size, and incorrect weld profile.

You must remember that production of satisfactory weldments depends upon, among other things, the maintenance of specified dimensions, whether it be the size and shape of welds or finished dimensions of an assembly. Requirements of this nature are set forth in the drawings and specifications for the job concerned. Departure from the requirements in any respect should be regarded as a dimensional defect. Any such defect must be corrected before final acceptance of the weldment unless a waiver is obtained.

The welding operation involves the application of heat and the fusion of metal in localized sections in the weldment. Stresses of high magnitude may be set up due to thermal expansions and contractions, that persist in the weldment after the structure has cooled. Such stresses tend to cause distortion of the structure. (See fig. 4-6.) By the use of rigid fixtures and careful selection of the welding sequence, positive and negative stresses may be introduced that tend to counteract each other; hence, WARPAGE may be kept to a minimum. Peening also has been used to some extent as a

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**Figure 4-6.—Warpage. Top view shows angular distortion. Bottom view shows correct alinement obtained by use of proper control methods.**

means to keep distortion to a minimum. The correction of this type of defect in a completed weldment usually requires one or more of the following measures:

1. Straightening operation with or without the application of heat.
2. Removal of the weld (or welds) causing the trouble, followed by subsequent rewelding.
3. Either removing metal or adding weld metal where possible.

In checking on JOINT PREPARATION, it should be remembered that good welding practice requires proper joint dimensions for each type of joint consistent with the thickness of the plates being welded. Failure to follow the requirements may result in defects such as porosity, cracking, and surface defects. The joint preparation should be the same as called for in the applicable drawings within specified limits.

Weld deficiencies due to INSUFFICIENT or EXCESSIVE SIZE can be detected by visual examination. (A suitable weld gage also may be used in checking weld size.) The size of a fillet weld is expressed as the length of the shortest leg of the triangular cross section. The size of a groove weld is the depth of the groove, except that where fusion materially exceeds the groove depth, the size of the weld is the depth of the groove plus the depth of fusion.

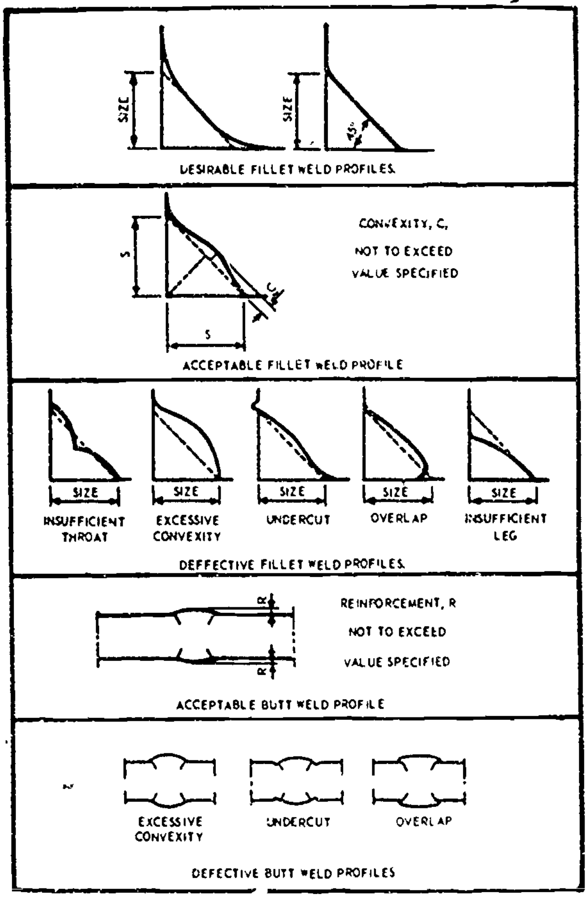


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**Figure 4-7.—Weld profiles. Illustrating acceptable and defective weld profiles.**

The PROFILE of a finished weld may have considerable effect upon its performance under load, whereas the profile of a single pass or layer of a multipass weld may have a considerable effect upon the tendency to produce such defects as lack of fusion or slag inclusion when subsequent layers are applied. Requirements concerning defects of this nature in finished welds are usually provided in the specifications and drawings for the job to be done. Such requirements must be closely adhered to by welders. Figure 4-7 illustrates various types of acceptable and defective weld profiles. Three types of

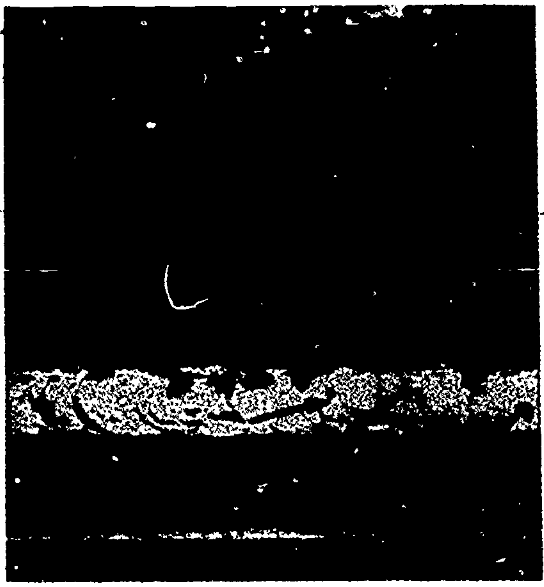

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Figure 4-8.—Surface holes.

defective weld profiles are excess convexity, excess concavity, and excess weld reinforcement.

EXCESS CONVEXITY is a condition that tends to produce notches which are harmful in the case of a fillet weld, owing to the resultant concentration of stress under load. These notches are also harmful in the case of an intermediate pass in a multilayer groove weld because lack of fusion or slag inclusion may occur unless corrected by chipping, grinding, or oxygen grooving before depositing subsequent layers. Excess convexity is usually due to either the use of insufficient current or improper welding techniques. (See fig. 4-8.)

EXCESS CONCAVITY is usually associated with fillet welds. The actual strength of such welds is much less than that of standard size fillet welds, the reason being that the throat is less than normal as measured by the length of the leg. Excess concavity tends to occur primarily in flat position fillet welding and is generally caused by the use of excessive welding current of arc lengths. Note that the only exception to this is that of welding from the top down in making a fillet weld in the vertical position. In the flat position, a remedy can be provided by reducing welding current. However, in the vertical position, there is no cure except to insist that regardless of the size of fillet, as measured by the leg dimensions, the throat of the fillet should be equal to that of the standard fillet required.

The condition of EXCESS WELD REINFORCEMENT is associated with groove welds. It is undesirable since it tends to stiffen the section at that point as well as establish notches, thereby affecting the stress distribution when a load is applied. Excess weld reinforcement may be caused by improper welding techniques or insufficient welding current. (See fig. 4-7.)

In metal-arc welding, a certain class of defects is encountered which has to do with discontinuities within the weld itself. This class of defects may be described as STRUCTURAL DISCONTINUITIES. This term means that there is either lack of weld metal or lack of fusion.

One type of structural discontinuity in welds which can be detected by visual inspection is SURFACE DEFECTS. At times, conditions occur during welding which result in holes in the surface of the deposit. These holes may vary from a single hole every few feet to numerous holes per inch. The atmosphere produced by a given type of electrode is just as important a factor as the slag produced. It not only determines arcing characteristics but also has some effect upon slag composition. You must remember that any change that varies the atmosphere will affect the results obtained. Such a change could be the difference between the air available at the arc when a pass is being deposited at the bottom of a narrow groove as compared to deposition of the top layer of the same weld. Improvement usually results by changing the electrical conditions, such as polarity and arc length; it is possible, however, that the base metal being welded could be a factor. Figure 4-8 illustrates the presence of surface porosity in fillet welds. These are often referred to as pock marks.

A special effort to eliminate this type of defect should be made, keeping in mind that it can result in slag entrapment. When high-quality welding is being done, it is not safe to assume that they will fuse out. They should be

Table 4-1.—Tests for Weld and Base Metal Defects

| Defects | Methods of Testing |
|---|---|
| **Dimensional Defects** | |
| Warpage | Visual inspection with proper mechanical gages and fixtures |
| Incorrect joint preparation | Visual inspection with proper mechanical gages and fixtures |
| Incorrect weld size | Visual inspection with approved weld gage |
| Incorrect weld profile | Visual inspection with approved weld gage |
| **Structural Discontinuities** | |
| Porosity | Radiographic—Fracture—Microscopic—Macroscopic |
| Nonmetallic inclusions | Radiographic—Fracture—Microscopic—Macroscopic |
| Imperfect fusion | Radiographic—Fracture—Microscopic—Macroscopic |
| Undercutting | Visual inspection—Bend tests—Radiographic— |
| Cracking | Visual inspection—Bend tests—Radiographic—Microscopic—Macroscopic—Magnetic particle—Penetrating oil |
| Surface defects | Visual inspection |
| Incomplete penetration | Radiographic—Fracture—Microscopic—Macroscopic |
| **Defective Properties** | |
| Low tensile strength | All-weld-metal tension test—Transverse tension test—Fillet weld shear test—Base metal tension test |
| Low yield strength | All-weld-metal tension test—Transverse tension test—Base metal tension test |
| Low ductility | All-weld-metal tension test—Free bend test—Guided-bend test—Base metal tension test |
| Improper hardness | Hardness tests |
| Impact failure | Impact tests |
| Incorrect composition | Chemical analysis |
| Improper corrosion resistance | Corrosion tests |

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eliminated by clipping or grinding before deposition of succeding layers.

Undercutting and cracking are also structural discontinuities which may be detected by visual inspection. Information on both these defects is given in the *Steelworker 3 & 2* and will not be repeated here. There are a number of other structural discontinuities, such as porosity, imperfect fusion, and incomplete penetration. However, since visual inspection is not used in testing for these defects, they are not covered in this section.

Table 4-1 indicates the usual methods of testing for various weld and base metal defects. Notice that more than one method may be used in testing for some defects.

In table 4-1 also notice that certain defects, such as low tensile strength and low yield strength, are classed as DEFECTIVE PROPERTIES. This class includes defects associated with

properties of the weld metal or of the welded joint. As indicated in the table, a method of testing other than visual inspection is used in testing for defects of this class.

## REINFORCING STEEL

Proper inspection of reinforcing steel operations is necessary to insure the safety and quality of the finished job. The duties of inspectors, particularly on large-sized jobs, are broad in scope. Inspections obviously should be performed by experienced, well-qualified personnel.

### THINGS TO LOOK FOR BEFORE OPERATIONS START

You must see that all details of the plans and specifications are carried out properly. Make sure that all work performed is from the latest issues of specifications, shop drawings, and placing plans. Notify all personnel of any authorized change. In particular, you must insure that:

Reinforcing materials are the kind, type, and quality specified.

All test reports required by the contract documents are received promptly and that materials qualify.

Materials are on hand in advance of job requirements.

Reinforcing steel is well spread out, in convenient locations, readily identified, and not in mud.

Fabricated bars are correctly cut and bent (verified by visual check and occasional measurement).

Bar setters are briefed on just what is to be done and on critical details that require special attention.

### INSPECTION DURING PLACING OPERATIONS

DURING STEEL SETTING, you must see that every footing, wall, slab, beam, girder, and column, before concreting, has the right number of the right type, size, and style of reinforcing bars, bar supports, and welded wire fabric securely fastened in the proper place, especially as regards:

TOTAL DEPTH of member as established by formwork and screeds. Proper amount of COVER or fireproofing to the near surface of the concrete. This should provide the EFFECTIVE DEPTH from center of bar to compression surface of concrete.

Proper setting of dowels for number, size, location, and projection, as well as determination of all points needing dowels.

Type and location of bar supports to hold bars firmly in place until concrete sets.

Correct sizes of bars (because sometimes a bar of the same shape but of a different size than specified would fit into the same space equally well).

Required number of bars (because only close attention by bar setters and inspectors can prevent omission of bars with consequent decrease in safety).

Correct lengths of bars (because a different length bar might go into the space but would not carry out the engineer's intentions).

### INSPECTING THE COMPLETED JOB

You should go back and recheck the entire job before the concrete is placed, using a checkoff list. Having studied the placing plans, you can go over the in-place steel and, by measuring here and there and by comparing one detail with another, eliminate major errors. Since it is the last time the steel can be inspected, pay special attention to:

Proper locations of bars within cross sections of the member, i.e., top bars on the top and bottom bars on the bottom; bottom layer on the bottom and superimposed layer just above the amount called for; outside bars on the outside and inside bars on the inside; stirrups, ties, and spirals enclosing the prescribed longitudinal bars; bars hooked around others as specified; bars hooked in concrete with hooks in proper position at the correct end; all bars securely wired or otherwise held in place, with tops of

all bars the proper amounts below finished concrete, to allow passage of screed and finishing machine.

Proper placement of bars lengthwise of a member, i.e., hooked end of a bar at the end specified, properly embedded in concrete; end of each bar within 2 inches of the location indicated on the placing plans; truss bars, stirrups, and other bent bars right side up as called for (foundations mats and similar members that carry UPWARD pressure require bent bars exactly reversed from slabs and beams carrying DOWNWARD loads); bend-down points and bend-up points within 2 inches longitudinally of where they work out on placing plans; stirrups and ties spaced as scheduled from the exact starting points specified within ± 1 inch; specified overlap in lapped splices and designating welding in welded splices.

Spacing between bars, between layers of bars, and between bars and formwork. For architectural concrete and exposed work, it is usual to provide 1 1/2 inches of cover over bars, with some positive way of maintaining it.

## PREFABRICATED STRUCTURES

Most structures built today are prefabricated; they are erected on the jobsite. Parts are connected to one another by bolting, riveting, or welding. Not being directly concerned with at-the-factory inspections of materials, you must take quality-control measures that will insure that a prefabricated structure is erected in accordance with the project plans and specifications.

### PRELIMINARY INSPECTION

Before delivery of parts to the jobsite, all shop drawings, plans, and specifications should be in the hands of the field manager and all approvals and rejections should have been made by the proper authorities. Anchor bolts to be cast in concrete should arrive on the jobsite in ample time to be incorporated into the work. Templates and the information required to properly locate anchor bolts should be supplied by the building manufacturer along with the bolts.

#### Shop Fabrication

Structural steel is cut, drilled, punched, assembled, riveted, welded, and prime coated to provide subassemblies of manageable and transportable size. These subassemblies can be field erected without further cutting, drilling, punching, or other fabricating, fitting, or altering operations. Sections are cut to fit various locations in the structure and marked for easy identification in accordance with the erection drawings.

#### Jobsite Delivery

Upon delivery of materials to the jobsite, see that they are handled with care and not stored in direct contact with the ground. Remove from the jobsite any part that has been damaged beyond repair and take steps to have it replaced. Compare all parts with approved samples, shop drawings, and other established criteria. Verify metal gages. Verify whether or not fasteners are of the type permitted by the contract documents. Carefully examine all components, hardware, and accessories or speciality items specified to be furnished as part of the structure's package. Verify whether or not dimensions, metal thicknesses, shapes, finishes, quantities, designs, and other requirements in the contract documents are met.

#### Field Erection

Regardless of the type of structure being erected, the condition of the foundation determines whether the construction project progresses smoothly or not. Therefore, the imbedded items must be placed accurately in accordance with the foundation plan. All anchor bolts must be held in place with templates or similar means so they will remain plumb and in the correct location during the placement of the concrete. The projections of all anchor bolts must be held to the dimensions shown. It is next to impossible to erect a prefabricated structure when the anchor bolts are not set correctly. Also, the concrete surface around the anchor bolts must be level and smooth.

Frame subassemblies are generally bolted together on the ground and hoisted into place.

Frames are plumbed, braced temporarily, and secured to anchor bolts.

Erection drawings are the working drawings for the structure and give the exact location of every part in the structure, as well as the directions for the assembly of the structure. Learn as much as you can about these drawings and see that the assembly directions are strictly followed.

### Problem Areas

Many problems in erecting prefabricated structures are associated with welding deficiencies. (Bolted work is easy to inspect, and poor workmanship is difficult to hide.) The erection method and sequence are troublesome too; plans and specifications do not specify them. Here the construction representative should discuss the erection method with the contractor, and an agreement should be reached to assure that all safety requirements are met. The designer should be consulted where questionable methods of erection are suspected.

## IN-PROCESS AND COMPLETION INSPECTION

Joints must be neatly fitted and secured. Make sure that all items are free of distortion, damage, or defect. Where contract documents require, see that sharp corners and edges are eased and that rough edges and welds are ground smooth. Look for breaks in the continuity of the coating of all primed and galvanized surfaces, and see that these breaks are properly repaired. Verify that material is stored out of the weather and in a safe place until installed.

### Structural Steel

Structural steel work must be erected true to line, level, and plumb. To prevent damage, steel members must be properly placed and temporarily braced until the structure is fully self-supporting. Check to see that all bolt holes are mated and bolts of the proper size and clearance tolerance are used at each connection. In addition, do not allow drifting of unfair holes or enlarging of holes by burning. See that all nuts are drawn tight and that proper fillers, shims, and washers required for the types of connections are used.

### Field Erection

In all completed members, compare principal dimensions and connections specifications with those given on the detail drawings. Pay particular attention to dimensions, bevels, matching of holes, and clearances. Check bolted connections for tightness and riveted connections for soundness or other defects. Inspect welds visually for undercut, overlap, surface checks, cracks, and other defects.

# CHAPTER 5

# ADVANCED BASE PLANNING, EMBARKATION, AND PROJECT TURNOVER

This chapter discusses the principles of using the *Facilities Planning Guide* which is an advanced base planning document. Guidelines are provided for a system of preparing material, equipment, and personnel for embarkation. Information also is presented as to how you can best coordinate and supervise the turnover of the company's projects, material, and equipment.

## FACILITIES PLANNING GUIDE

You should consult the *Facilities Planning Guide* (NAVFAC P-437) when tasked to assist in planning the construction of an advanced base. This document identifies the structures and supporting utilities of the Navy Advanced Base Functional Component (ABFC) System. It was developed to make preengineered facility designs and corresponding material lists available to planners at all levels. While these designs relate primarily to expected needs at advanced bases and to the Navy ABFC System, they can be used to satisfy peacetime requirements as well. Facilities, logistic, and construction planners will each find the information required to select and document the material necessary to construct facilities.

NAVFAC P-437 consists of two volumes. Volume I contains reproducible engineering drawings organized as follows: Part 1, Component Site Plans, indexed by component and ABFC designation; Part 2, Facility Drawings, indexed by facility number and DOD category code; Part 3, Assembly Drawings, containing assembly information and indexed by assembly number. Each drawing is a detailed construction drawing that describes and quantifies the facilities, assemblies, or line items required to complete it. A summation of logistic, construction, and cost data is provided for each component, facility, and assembly of the ABFC System. A component is defined as a grouping of personnel and material that has a specific function or mission at an advanced base. Whether located overseas or in CONUS, a component is supported by facilities and assemblies.

Volume II of NAVFAC P-437 contains the detailed data display for each component, facility, and assembly. Also arranged in three parts, Part 1 quantifies and describes by DOD category code the facilities requirement for each component. Part 2 quantifies and describes by assembly number the assembly requirement for each facility. Part 3 quantifies line-item requirements by National Stock Number (NSN) for each assembly. Except for earthwork, material lists in Volume II are complete bills of material.

The P-437 also contains other useful information for planners. For example, crew-sizes, man-hours by skill, land areas and amounts of fuel necessary to make a component, facility, or assembly operational, as well as predesigned facilities and assemblies that are not directly related to components shown in the table of ABFC/s (OPNAV. 41 P3). These facilities and assemblies give the planner alternatives for satisfying contingency requirements when callout of a complete component is not desired. To make the P-437 compatible with other DOD planning guides, NAVFAC P-72 (*Category Codes for Classifying Real Property of the Navy*) is a related publication that establishes the category codes, nomenclature, and required units of measure for identifying, classifying, and

quantifying real property. The cardinal category codes are as follows:

100 Operational and Training
200 Maintenance and Production
300 Research, Development and Evaluation
400 Supply
500 Hospital and Medical
600 Administrative
700 Housing and Community Support
800 Utilities and Ground Improvement
900 Real Estate

If a facility is required for enlisted personnel quarters, for example, it will be found in the 700 series, "Housing and Community Support." The assemblies contained within each facility will consist of a grouping of line items at the National Stock Number Level which when assembled will perform a specific function in support of the facility. An assembly is functionally grouped in such a way that the assembly number relates to the Occupational Field 13 skill required to install it. The groupings are numbered as follows:

| DESCRIPTION | NUMBER SEQUENCE | |
|---|---|---|
| | START | STOP |
| Builder oriented (BU) | 10,000 | 19,999 |
| Utilitiesman oriented (UT) | 20,000 | 29,999 |
| Construction Electrician oriented (CE) | 30,000 | 39,999 |
| Steelworker oriented (SW) | 40,000 | 49,999 |
| Equipment Operator oriented (EO) | 50,000 | 54,999 |
| Water Front Equipment | 55,000 | 57,999 |
| Underwater Const. and Diving Equip. | 58,000 | 59,999 |
| Operational Supplies | 60,000 | 62,499 |
| Operating Consumables | 62,500 | 64,999 |
| NBC Warfare | 65,000 | 67,499 |
| Personnel Related Supplies | 67,500 | 69,999 |
| Unassigned at present | 70,000 | Series |
| Shop Equip. including Maintenance Tools | 80,000 | 80,999 |
| Unique ABFC Tool Kits | 81,000 | 81,999 |
| NCF TOA Const. Tools & Kits (power tools) | 82,000 | 82,099 |
| NCF TOA Const. Tools & Kits (elec.) | 82,500 | 82,599 |
| NCF TOA Const. Tools & Kits (misc.) | 83,000 | 83,199 |
| NCF TOA Const. Tools & Kits (rigging) | 84,000 | 84,099 |
| Shop Equipment (ABFC Unique) | 85,000 | 87,499 |

## TAILORING COMPONENTS AND FACILITIES

It is important to realize, when you are considering tailoring, that the ABFC System contents are based on a set of assumptions. This makes it possible to develop modular elements which can serve similar functions in various locations. The exact requirements for a specific base cannot be defined, economically designed, nor supported within the general system. However, the base development planner knows the specific location, mission, unit composition, and availability of other assets. The planner can then select from the ABFC System components or facilities that satisfy requirements. Tailoring is then applied to the preplanned ABFC assets to come up with what is needed.

Components or facilities can be tailored by (1) deleting or adding facilities or assemblies and (2) specifying requirements for tropical or northern temperate zones. Assemblies required in tropical installations only are coded with the letter "T" in the zone column to the right of the assembly description. Assemblies required in northern temperate installations only are coded with the letter "N". Uncoded assemblies are common to both zones.

## USE AND APPLICATION OF THE FACILITIES PLANNING GUIDE

Although a listing in the P-437 may help you order individual items in general supply, it does NOT replace Stock Lists of System Commands or Bureaus, Offices, Single Managers, or Inventory Control Points. Stock numbers and descriptions can be verified through appropriate Stock Lists. However, you do this automatically in ordering a component, facility, or assembly.

A representative sample of the types of components displayed in Volume II is presented to show the structure and kind of information provided. Figure 5-1 depicts a P-25 component, Naval Mobile Construction Battalion. You can see that a component contains a list of facilities by category code. From this list select a facility, such as Diesel Storage and Dispensing Facility, 200,000-gallon, facility 123-10F. Locate this facility in Part 2 of Volume II. Figure 5-2 shows this facility. Note that within the facility, the necessary assemblies required to perform the defined function are identified. Figure 5-3 depicts an assembly within facility 123-10F. Within assembly 20002, titled 50,000-gallon pillow fuel tank, line items by NSN required to make the assembly operative are displayed. Certain installed equipment and collateral equipment, furniture, and fixtures contributed by others are not furnished with the facilities or the assemblies listed in P-437. They must be requested separately instead. The assembly listings indicate what installed or NAVFAC collateral equipment is provided.

## ADVANCED BASE FUNCTIONAL COMPONENTS

Advanced Base Functional Components (ABFC's) are normally complete entities. However, housing, messing, medical facilities, maintenance facilities, defensive ordnance, communication equipment, and utilities may not be supplied with each component and are themselves service components or facilities to be integrated into an overall base development or augmentation plan. ABFC's are assigned descriptive names to indicate their functions and alpha-numeric designators to facilitate reference. A detailed Advanced Base Initial Outfitting List (ABIOL) is an itemized line item printout of the material in each ABFC. Each System Command or Bureau is responsible for maintaining a detailed listing of that part of the ABIOL assigned to it.

## EMBARKATION

An NMCB, PHIBCB, CBMU, or other unit of the Naval Construction Force (NCF) must be ready to deploy or redeploy by sea, air, or land to complete an assigned mission. To meet the requirements for contingency support of the Naval Task and Fleet Marine Forces, at least two-thirds of the NCF must be capable of redeployment within 10 days. After 60 days in their homeports, NCF units should be able to redeploy within 10 days. While en route to or from a deployment site, the units must be

COMPONENT P25 NAVAL MOBILE CONSTRUCTION BATTALION

PROVIDES PERSONNEL, ADMINISTRATION, HOUSING, SUBSISTANCE, AND EQUIPMENT REQUIRED FOR THE MOBILIZATION OF ONE MOBILE CONSTRUCTION BATTALION.

SITE PLAN 6002580

| FACILITY | DESCRIPTION | FACILITY CAPACITY | QTY | COMPONENT CAPACITY | WEIGHT SHORT TON | CUBE MEAS TON | DOLLAR VALUE | CONST EFFORT MANHOURS |
|---|---|---|---|---|---|---|---|---|
| 111 20B | HELICOPTER LANDING PAD SHALL | 1000 SY | 1 | 1000 SY | 10.4 | 33.9 | 29,291 | 244 |
| 123 10A | MOGAS STOR-DSPNSG FACIL 20000 GAL | 20000 GL | 1 | 20000 GL | 5.6 | 22.6 | 24,258 | 111 |
| 123 10B | DIESEL STOR-DSPNSG FACIL 200000 GAL | 200000 GL | 1 | 200000 GL | 21.7 | 83.6 | 78,820 | 231 |
| 131 15A | COMMUNICATION CENTER | 240 SF | 1 | 240 SF | 10.4 | 14.3 | 9,131 | 558 |
| 141 75C | ARMORY | 210 SF | 2 | 420 SF | 15.4 | 145.2 | 14,940 | 0 |
| 213 41D | CENTRAL TOOL ROOM-SUPPLY ROOM | 4000 SF | 1 | 4000 SF | 3.1 | 9 9 | 15,108 | 74 |
| 214 20H | A CO AUTO VEHICLE SHOP | 4000 SF | 1 | 4000 SF | 7.9 | 10.2 | 13,55[illegible] | 126 |
| 218 20A | A COMPANY CONSTRUCTION EQUIP SHOP | 4000 SF | 1 | 4000 SF | 2.4 | 7.1 | 13,552 | 84 |
| 219 10D | B, C AND D COMPANY SHOP | 7744 SF | 1 | 7744 SF | 5.7 | 17.6 | 26,207 | 212 |
| 421 35A | READY MAGAZINE | 160 SF | 1 | 160 SF | 1.6 | 32.0 | 4,770 | 0 |
| 441 10G | GENERAL WAREHOUSE REPAIR PARTS | 4000 SF | 2 | 8000 SF | 6.2 | 19.8 | 30,217 | 148 |
| 441 10H | GENERAL WAREHOUSE HLO | 4000 SF | 2 | 8000 SF | 6.2 | 1[illegible].8 | 30,217 | 148 |
| 441 10J | GENERAL WAREHOUSE GALLEY | 936 SF | 2 | 1872 SF | 2.4 | [illegible]0 | 7,856 | 54 |
| 441 10K | GENERAL WAREHOUSE SUPPLY | 4000 SF | 2 | 8000 SF | 6.2 | 19.8 | 30,217 | 148 |
| 510 77A | MEDICAL STORAGE | 160 SF | 1 | 160 SF | 1.6 | 32.0 | 4,770 | 0 |
| 540 10J | DENTAL CLINIC | 250 SF | 1 | 250 SF | 10.5 | 87.4 | 52,940 | 0 |
| 550 10C | DISPENSARY | 936 SF | 2 | 1872 SF | 2.4 | 8.2 | 8,605 | 66 |
| 610 10H | ADMINISTRATIVE OFFICE | 936 SF | 10 | 9360 SF | 8.0 | 24.0 | 27,026 | 300 |
| 610 73A | COMPANY HEADQUARTERS (C AND D CO) | 936 SF | 1 | 936 SF | .7 | 2.4 | 2,328 | 24 |
| 610 73E | A COMPANY OFFICE/DISPATCHER | 936 SF | 1 | 936 SF | .7 | 2.4 | 2,328 | 24 |
| 723 10R | GALLEY MESS | 8936 SF | 1 | 8936 SF | 58.1 | 262.6 | 119,842 | 797 |
| 723 20J | LATRINE | 336 SF | 1 | 336 SF | 2.0 | 3.1 | 433 | 112 |
| 723 20K | HEAD/WASHROOM 6 FT X 8 FT | 48 SF | 3 | 144 SF | 2.7 | 6.6 | 2,276 | 339 |
| 723 30G | LAUNDRY | 936 SF | 1 | 936 SF | 11.6 | 61.1 | 38,017 | 47 |
| 725 10S | TROOP HSG EMERG OFF/CPO W/SH-WR | 40 MN | 2 | 80 MN | 23.2 | 78.0 | 43,431 | 1,648 |
| 725 10T | TROOP HSG EMERG W/SHOWER-WASHROOM | 130 MN | 6 | 780 MN | 96.0 | 252.6 | 180,995 | 6,192 |
| 730 30B | BAKERY PLANT FIELD PORTABLE | 936 SF | 1 | 936 SF | 4.3 | 27.4 | 20,569 | 41 |
| 740 07A | EXCHANGE-BARBER SHOP | 936 SF | 1 | 936 SF | 1.9 | 24.0 | 5,697 | 24 |
| 740 33E | SPECIAL SERVICES/POST OFFICE | 936 SF | 1 | 936 SF | .7 | 2.4 | 2,323 | 24 |
| 740 54B | RECREATION FACILITY | 936 SF | 3 | 2808 SF | 2.1 | 7.2 | 6,985 | 72 |
| 740 63A | CLUB ENLISTED MENS | 4000 SF | 1 | 4000 SF | 10.7 | 52.1 | 27,260 | 204 |
| 750 20A | PLAYING FIELD | 1 EA | 1 | 1 EA | .0 | 0 | 0 | 0 |
| 750 50A | OUTDOOR THEATER | 800 SE | 1 | 800 SE | .0 | .0 | 0 | 0 |
| 811 10AU | ELECTRIC PWR PLANT 2-200KW GEN SETS | 500 KV | 2 | 1000 KV | 23 6 | 35.4 | 92,691 | 172 |
| 812 30CX | ELECTRICAL DISTR LINES-UGND 17000LF | 17000 LF | 1 | 17000 LF | 58.2 | 94 5 | 324,396 | 1,128 |
| 812 40A | PERIMETER LIGHTING 1100 LF | 1100 LF | 8 | 8800 LF | 4.8 | 12.8 | 6,885 | 1,344 |
| 831 30A | LEACH FIELD | 1 EA | 3 | 3 EA | 2.4 | 8.1 | 456 | 216 |
| 833 40A | GARBAGE HOUSE | 936 SF | 1 | 936 SF | .7 | 3.3 | 1,944 | 14 |
| 841 10H | WATER TREATMENT FACILITY 1500 GPH | 30 TG | 3 | 90 TG | 16.5 | 27.0 | 31,331 | 78 |
| 841 40E | WATER STORAGE POTABLE 30000 GAL | 30000 GA | 3 | 90000 GA | 14.4 | 31.8 | 36,782 | 168 |
| 842 10J | WATER DISTRIBUTION LINE POTABLE | 7640 LF | 1 | 7640 LF | 14.9 | 27.0 | 20,452 | 324 |
| 851 10A | ROAD WITH DRAINAGE 1 MI | 14000 SY | 2 | 28000 SY | 70.4 | 142.6 | 16,047 | 5,268 |
| 852 10A | PARKING | 200 SY | 4 | 800 SY | 8.4 | 15 6 | 825 | 789 |
| 872 10B | SECURITY FENCING 1980FT | 1980 LF | 5 | 9900 LF | 73.0 | 228.0 | 75,418 | 3,325 |
| 872 20B | GUARD/WATCH TOWER | 4 MN | 4 | 16 MN | 72.0 | 31.2 | 13,796 | 1,440 |
| 872 20C | BUNKER FIGHTING 7FX7FX7F | 2 MN | 40 | 80 MN | 128.0 | 168 0 | 20,556 | 4,560 |
| 872 20D | BUNKER COMMAND POST | 10 MN | 6 | 60 MN | 53.4 | 76.8 | 15,187 | 3,348 |
| 872 20F | SLIT TRENCH | | 36 | | .0 | .0 | 0 | 0 |
| 890 27A | ICEMAKING PLANT | 1 TN | 1 | 1 TN | 1.5 | 4.7 | 6,871 | 4 |
| | | | | TOTAL NORTH | 884.6 | 2,283.9 | 1,542,603 | 34,225 |
| | | | | TOTAL TROPICAL | 856.9 | 2,201.5 | 1,391,535 | 33,301 |

COMPONENT P25

| CONST STD | LAPSED DAYS | LAND ACRES | POWER KVA CONNECTED | POWER KVA DEMAND | WATER GPD | SEWER GPD | FUEL GAL/30DAYS HEATING DSL | FUEL GAL/30DAYS HEATING MOGAS | FUEL GAL/30DAYS PWR GEN DSL |
|---|---|---|---|---|---|---|---|---|---|
| INIT | 21 | 18.5 | 458 | 323 | 305,134 | 0 | 61,056 | 83,778 | 0 |

| SKILLS MANHOURS | BA | BU | UT | CE | SW | EO | UNSKILLED CN |
|---|---|---|---|---|---|---|---|
| | 0 | 7,653 | 6,03[illegible] | 3,657 | 1,767 | 5,428 | 9,627 |

143.298

Figure 5-1.—Component.

prepared for immediate diversion to emergency, contingency, or mobilization assignments.

Staff officers schedule and execute the embarkation in accordance with a time table established by command or higher authority. Before the embarkation, for example, the medical officer sees that personnel have had their innoculations. Also, the dental officer places a hold on personnel who need prolonged dental treatment that would limit their combat readiness. The personnel officer insures that the Record of Emergency Data, NAVPERS 601-2, and other records are current.

Although not part of an embarkation staff, you are involved in the embarkation of your company. Your tasks include making sure that

FACILITY 123 10B          JCE PLANNING FACTOR

DIESEL STORAGE AND DISPENSING FACILITY
200000 GALLON

THIS FACILITY PROVIDES 200000 GALLON OF DIESEL OIL
STORAGE AND RECEIVING-DISPENSING CAPABILITY.

NAVFAC DRAWING NUMBER 6002621

| ASSEMBLY | DESCRIPTION | ZONE | QTY. | WEIGHT POUNDS | CUBIC FEET | DOLLAR VALUE | CONST EFFORT MANHOURS |
|---|---|---|---|---|---|---|---|
| 20002 | TANK FUEL PILLOW 50000 GAL | | 4 | 7,610.8 | 634.4 | 20,805.76 | 112 |
| 20124 | HOSE MANF F/200000 GAL TANK ARR | | 1 | 564.2 | 60.4 | 1,491.61 | 2 |
| 20204 | FUEL TRANSFER ASSEMBLY 350 GPM | | 1 | 3,945.9 | 447.5 | 7,872.64 | 44 |
| 20305 | FUEL DISPENSING ASSY PORTABLE | | 1 | 1,615.9 | 52.9 | 2,519.74 | 8 |
| 20506 | FUEL FILTER AND METER ASSY 600 GPM | | 1 | 3,329.4 | 278.1 | 8,625.71 | 22 |
| 20508 | HEATER FUEL HOT OIL 350 GPM | N | 1 | 25,092.5 | 1,751.9 | 38,859.07 | 24 |
| 30703 | TANK FUEL 275 GAL W/PIPING | | 2 | 758.2 | 91.9 | 319.84 | 16 |
| 29702 | EXTINGUISHER FIRE W/BRKT PKP 20 LB | | 3 | 540.0 | 18.9 | 325.14 | .3 |

| | SHORT TON | MEAS TON | WEIGHT POUNDS | CUBIC FEET | DOLLAR VALUE | CONST EFFORT MANHOURS |
|---|---|---|---|---|---|---|
| TOTAL NORTH | 21.7 | 83.6 | 43,456.9 | 3,344.0 | 78,819.51 | 231 |
| TOTAL TROPICAL | 9.2 | 39.8 | 18,364.4 | 1,592.1 | 41,560.44 | 207 |

FACILITY 123 10B     PRIMARY  200,000 GL     SECONDARY     0

| CONST STD | LAPSED DAYS | LAND ACRES | POWER KVA CONNECTED | POWER KVA DEMAND | VOLTS | PHASE | WATER TOT. GPD | WATER PEAK GPM | SEWER GPD | RECOV. CODE |
|---|---|---|---|---|---|---|---|---|---|---|
| INIT | 0 | 1.28 | 17 | 8 | 208 | 3 | 0 | 0 | 0 | |

| FUEL (GAL/30DAYS) HEATING DSL | MOGAS | PWR GEN DSL | SKILLS MANHOURS EA | BU | UT | CE | SW | EO | UNSKILLED CM |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 490 | 0 | 0 | 6 | 115 | 0 | 0 | 88 | 24 |

143.299

Figure 5-2.—Facility.

ASSEMBLY 20002

TANK FUEL PILLOW 50000 GAL

THIS ASSEMBLY PROVIDES 50000 GALLON OF FUEL STOR-
AGE.

NAVFAC DRAWING NUMBER 6002614

| COG | STOCK NUMBER | DESCRIPTION | UI | QTY | WEIGHT POUNDS | CUBIC FEET | DOLLAR VALUE |
|---|---|---|---|---|---|---|---|
| 9C | 4710-00-639-9445 | PIPE STL BLK 2 | FT | 20 | 75.00 | .7800 | 9.80 |
| 9C | 4710-00-273-1041 | PIPE CULVT NEST 12N ALUM | EA | 4 | 26.40 | 2.1600 | 21.52 |
| 9C | 4720-00-978-[illegible]867 | HOSE ASSY RBR 4X10 SUCT | EA | 3 | 171.00 | 7.5000 | 246.00 |
| 9C | 4730-00-[illegible]-9286 | COUPLING HLF QCPLR 4FX4F | EA | 2 | 16.00 | .4000 | 34.80 |
| 9C | 4730-00-196-2079 | NIPPLE PF SHRT 4X4 | EA | 1 | 3.15 | .0600 | 1.20 |
| 9C | 4820-00-289-9674 | VALVE GATE QUICK 2NPT | EA | 1 | 11.00 | .2000 | 27.70 |
| 9Z | 5330-00-899-4509 | WASHER RBR 4 HSE CPLG | EA | 3 | .15 | .0030 | .42 |
| 2C | 5430-00-999-3739 | TANK FAB COL 50000GL | EA | 1 | 1,600.00 | 150.0000 | 4,860.00 |
| | | ASSEMBLY 20002 | | TOTAL | 1,902.70 | 161.1030 | 5,201.44 |

| FUEL (GAL/30DAYS) HEATING DSL | MOGAS | PWR GEN DSL | SKILLS MANHOURS EA | BU | UT | CE | SW | EO | UNSKILLED CM | CONST EFFORT MANHOURS |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 22 | 4 | 28 |

NOTE - CREW SIZE: 1 EO, 1 UT, 2 CM

143.300

Figure 5-3.—Assembly.

all projects are shut down, tools are cleaned and turned in to the central toolroom, materials are secured on the site or turned in to the Material Liaison Office (MLO), and project sites are cleaned and secured. These tasks are carried out whether the embarkation is a training exercise or an actual movement. Afterwards you direct your efforts to the embarkation itself. Instructions will come from the embarkation staff's office. The embarkation staff relies on the *Tactical Embarkation Manual*, as developed by COMCBLANT and COMCBPAC. This manual is also available to you.

Each company or department that is shipping material designates one officer or petty officer to act as its embarkation representative. The duties of this representative include the following:

1. Keep the NMCB and team embarkation officers informed of shipping requirements.
2. Insure that mount-out box construction, color coding, and numbering are in accordance with established directives.
3. Insure that each box, pallet, or skid required for mount-out is available; new boxes are constructed for additional gear as received.
4. Insure that packing lists are current and accurate; new packing lists are prepared for addition gear as received.
5. Make available box covers and hardware to attach them to their boxes.
6. Insure that unit cargo manifests are maintained, reviewed quarterly, and forwarded to the embarkation officer.

## PROJECT TURNOVER

About 30 days before an NMCB completes its deployment, the advance party of the relieving battalion is sent to the deployment site to arrange for the arrival of the main body of the battalion, and to turn over projects, material, and equipment. As a member of the advance party, you will participate in the on-site proceedings which consist of taking inventory of the camp, supply, material, and equipment to determine shortages or surpluses.

The inventories of camp, supply, and material are conducted by members of both battalions. The items inventoried include administrative and operational machines and consumables, weapons and infantry equipment, toolkits and toolroom supplies, special clothing and bedding, NBC defensive devices, equipment and materials for communications, medical and dental services, damage control and safety, photography and barber supplies, camp facility collateral equipment and supplies, galley and messing equipment, provisions, and camp support-related equipment.

The equipment inventory, better known as the Battalion Equipment Evaluation Program (BEEP), is conducted by assigned personnel of ALFA Company representing both battalions. It is a uniform procedure for evaluating and accounting for all equipment, attachments, collateral equipage, maintenance records, and correspondence.

Your part in a deployment and project turnover is important. It is best to learn or find out as much as you can about your projects. Try to get information about the status of the projects and project materials required. Find out whether or not all materials have been received by supply. If so, are they at the project site or in the MLO yard?

You must have all the information that relates to the amount of work in place. This includes materials expended as well as man-hours. Obtain all updated drawings and specifications for the project, including as-built drawings. In additon, find out whether or not there are problems to solve. If so, what has to be done to solve them?

Make as many contacts as you can with persons who are not attached directly to the battalion, for example, public works shop leaders and supply personnel. Remember, those you are relieving may have had a good working relationship with others who can help you in turning over the project.

# CHAPTER 6

# PLANNING, ESTIMATING, AND SCHEDULING

Good construction planning, estimating, and scheduling procedures are essential to the Naval Construction Force's (NCF) ability to accomplish quality construction that is responsive to Fleet operational requirements. You, as a first class or chief Steelworker, will have many opportunities to test your knowledge in planning, estimating, and scheduling.

PLANNING is the process of determining the requirements and devising the methods and schemes of action for the accomplishment of a certain project. ESTIMATING is the act of determining the size, the duration, and the kind of work to be performed, as well as determining the quantities of work elements, materials, labor, and equipment needed to perform this work. SCHEDULING is the process of determining when a work element should be performed and when the material, the equipment, and the work force will be required.

Another phase of our discussion deals with the critical-path method (CPM) of scheduling. From experience, you may already have learned that CPM is a valuable management tool when it comes to planning, scheduling, and controlling construction operations. If not, you will find the fundamentals of network analysis in this chapter. These include definitions of terms used in connection with the critical-path method and precedence diagraming, and other terms used in network analysis.

## HINTS ON PLANNING

Construction planning is a combination of several factors. In addition to day-to-day planning, the following primary matters should be considered in construction planning: work element estimates, material estimates, equipment estimates, manpower estimates, plant layout, material delivery and storage, work schedules, and progress control. These factors are more or less dependent upon each other, and all are taken into account in any well-planned project. The success of any project depends to a great extent upon the amount of detail and the care taken in planning.

Proper planning saves time and money for the Navy and makes the work easier and more pleasant for your whole group. It can eliminate friction, jealousy, and confusion, and it can free you from many of the details of the work, thus giving you time to carry out other important duties. Proper planning expedites work and eliminates "bottlenecking," (remember that the neck of the bottle is always at its top), and, most important to you personally, it makes your job easier.

As the petty officer in charge, you are responsible for the time of your personnel, as well as for your own time. You must plan so that they will be kept busy doing construction work. This will be to your convenience; a point to remember is: PLAN AHEAD. Having your crews stand around idle each morning while you plan, obviously would be a waste of manpower. At the close of each day, you should confirm planning for the next workday. In doing so, carefully consider factors that have a bearing on the availability and use of the work force equipment and supplies. For effective planning, you may need answers to various questions, such as those listed below.

1. Work force. Who is to do what? How is it to be done? When is it to be finished? Knowing

that idleness may breed discontent, have you arranged to have another job ready for starting as soon as the first one is finished? Is every crewmember fully utilized?

2. Equipment. Are all necessary equipment and tools on hand to do the job? Is safety equipment on hand?

3. Supplies. Are all necessary supplies on hand to start the job? If not, who should take action?

Have a definite work schedule and inspection plan. Set up realistic goals or quotas for the day. Have a definite plan for personally checking at intervals to see that the work is being accomplished and that the goals are going to be met. Spot check for accuracy, quality, and the need for personnel training.

Steelworkers must be trained to do a variety of jobs by means of the rotation method, on-the-job training, or classroom work; allow time for this in your planning for a job. Time must also be allowed for handling personnel problems, records, and military duties. Supervisors must allow time for reports and other paperwork which is necessary for the control of personnel and materials under their charge.

Until petty officers learn to delegate work properly, they can never be much of a success. In delegating authority, they must be sure that the personnel concerned have the training and information necessary to carry out their work. If you, as a supervisor, find that they cannot do the job that is required, they may have to be trained. Remember, you can delegate your authority within reason, to subordinates; but you cannot delegate your responsibility for the final product.

## ESTIMATING PROCEDURES

Estimating is an important part of planning for jobs and/or projects. If you like working with figures, the preparation of estimates should be interesting work. In addition to a knowledge of arithmetic, however, you, as an estimator, should possess a number of other qualifications, some of which are noted below:

Good SEABEE estimators should be able to mentally picture the separate operations of the job as the work progresses through the various stages of construction. They should have previous construction experience and must be able to do careful and accurate work free of errors. SEABEE estimators should possess the ability to use good judgement in determining what effect numerous factors and conditions will have on construction of the project and what allowances should be made for each. They should have information available about material, equipment, and labor required to perform various types of work under the conditions encountered in accomplishing the construction projects. 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 revised frequently. Estimators, working alone or as a member of a team, may often be required to plan construction and prepare estimates for other construction ratings, as well as their own. So, in addition to knowing one particular specialty, estimators must have a working knowledge of other branches of construction for which they will have to draw up estimates.

At this point, let us remind you that various procedures are used in estimating for construction work, and that those described here are suggested procedures, rather than standard procedures. You must use judgment as to when the procedures can be applied effectively; and, in some cases, you may want to make revisions in a procedure to make it more suitable to the particular project being estimated.

### USE OF DRAWINGS AND SPECIFICATIONS

Information provided on drawings is a main basis for measuring quantities of work elements and materials. Accurate estimating requires a thorough examination of the drawings. All notes and references should be read carefully and all detail and reference drawings should be examined. Dimensions shown on drawings

and/or figured dimensions should be used in preference to scaled dimensions. If it becomes necessary to scale dimensions on drawings, a scale rule should be used, and the graphic scale on the drawings should be checked for expansion or shrinkage. When there is disagreement between the plans, elevations, and details, the detail drawing is normally followed, unless it is obviously wrong.

The specifications should be used together with the drawings when quantity estimates are being made. When there is disagreement between the specifications and the drawings, the specifications should normally be followed. If in doubt, consult the OICC, operations officer, or the PW officer for a decision. As the estimator, you should become thoroughly familiar with all the requirements stated in the specifications. Some estimators read the specifications more than once in order to fix these requirements in their minds. Notes made while reading the specifications will prove helpful when the drawings are being examined. These notes should list items of work or materials which are unusual, items NOT familiar to the estimator, and reminders to be used during your examination of the plans.

## NEED FOR ACCURACY

Quantity estimates are used as a basis for purchasing materials and for determining equipment and work force requirements. They are also used in scheduling progress that provides the basis for scheduling the material deliveries, the equipment, and the work force. In view of the widespread use, you can see that accuracy in preparing quantity estimates is very important. To help insure accuracy, quantity estimates should be checked in a manner that will eliminate as many errors as possible. One of the best ways to check a quantity estimate is to have another person make an independent estimate and then compare the two estimates after both are completed.

## WORK ELEMENT ESTIMATES

A work element estimate is a listing of the quantities of each work element, such as lineal feet of pipe to be laid, required to construct a given project. Work element estimates are prepared by computing the quantities of the various items of work shown or referenced by notes on the drawings and described in the specifications. You may sometimes hear work element estimates called quantity surveys or quantity takeoffs. They are used in scheduling progress which provides the basis for scheduling the material deliveries, the equipment, and the work force. Errors in work element estimates can multiply many times through their use in the preparation of these other estimates and schedules.

As an estimator, you should have a good general knowledge of the project to be constructed before performing any actual takeoff of quantities. This knowledge can be obtained by a general study of the drawings, by reading specifications, and by examining all available information about the project site and local conditions. After becoming familiar with the project, you, as the estimator, are ready to begin measuring and recording quantities or materials for the work elements.

In measuring quantities, the normal practice is to begin by measuring work elements on the foundation and footing plan and to proceed through the basement and each succeeding floor plan of the architectural and structural drawings. All reference and detail drawings that refer to a particular plan are examined and worked in conjunction with that plan. After examination of the plans, the elevations and then the details are examined one by one; all material NOT previously taken off are measured and recorded. Often concrete, reinforcing, and structural features are shown on drawings separate from the architectural features. When this is done, it is best to work the concrete and reinforcing drawings first, followed by the architectural drawings. After completing the architectural and structural drawings, the mechanical and then the electrical drawings are worked, and these are followed by any available specialty, civil, or shop drawings.

In measuring quantities on a drawing, it is better to begin at one side and work towards the opposite side, marking with a colored pencil the particular work as it is measured and recorded. Work, such as concrete, reinforcing, and

similar items, can be marked with a simple check (✓), but items, such as conduit and piping, should be marked by tracing over the part measured with a colored pencil. The colored marks NOT only show the estimator what has been taken off, thus preventing duplication, but provides a means of checking a drawing for omissions.

As each work element is measured, the information is recorded and computations are shown on a worksheet. Figure 6-1 illustrates the type of information shown on a typical work element estimate worksheet. The heading of each worksheet should show the following: that it is a work element estimate worksheet, the worksheet number, the estimator's name, date of takeoff,

WORK ELEMENT ESTIMATE WORKSHEET

SHEET NO. 2 OF 6
ESTIMATED BY Kemp DATE 19-
CHECKED BY Bixby DATE 19-

NMCB 3 LOCATION Saipan YEAR 19-
PROJECT 08 Staging-out Warehouse

| WORK ELEMENT | LOCATION | MEASUREMENT AND COMPUTATION | QUANTITY |
|---|---|---|---|
| Footings and foundations (continued) | | | |
| Concrete | Ext. col. | 46 ftgs. 8'-3" sq x 1'-9" deep | |
| | ftgs. | 46x8.25 x 8.25 x 1.75 | 5479 CF |
| | Int. col. | 38 ftgs 7'-3" sq. x 1'-9" deep | |
| | ftgs. | 38x7.25x7.25x 1.75 | 3495 CF |
| | Int. col. | 38 piers 2'4" sq. x 4'6" high | |
| | piers | 38x2.33x2.33 x 4.5 | 928 CF |
| | Grade beam | 2 sides 402'x 4" lg. | |
| | sides | 14" wide, 4'6" hi. | |
| | | 2x402.33 x 1.17 x 4.5 | 4237 CF |
| | Grade beam | 2 ends 100'-3" lg. 14" wide | |
| | ends | 4'6" hi | |
| | | 2 x 100.25 x 1.17 x 4.5 | 1056 CF |
| | | Subtotal | 15,195 CF |

87.1

Figure 6-1.—Work element estimate worksheet.

checker's name, date checked, battalion number, deployment location, year, project number, and project description.

A summary of work element quantities is prepared by transferring the totals on the worksheets to a summary sheet, which becomes the work element estimate. Work elements are arranged in the same sequence as they appear in the standard work element list so they will be in the correct sequence for reporting or recording on work schedules. This summary sheet has the same information in the heading as the worksheet, except that it is shown as a work element estimate summary sheet. The body of the summary sheet shows the description and quantity of the work elements. If decisions have been made as to how the work will be accomplished, they are indicated by an entry. For example, excavation is entered as machine excavation and backfill as machine backfill. A typical work element estimate summary sheet is illustrated in figure 6-2.

SHEET 1 OF 1
ESTIMATED BY Kemp DATE 19-
CHECKED BY Bixby DATE 19-

WORK ELEMENT ESTIMATE
SUMMARY SHEET

NMCB 10 LOCATION Saipan YEAR 19-
PROJECT 08 DESCRIPTION Staging-Out Warehouse

| WORK ELEMENT | QUANTITY |
|---|---|
| Footings and foundations | |
| Machine excavation | 1860 CY |
| Machine backfill | 1277 CY |
| Hand compaction | 1277 CY |
| Spread excess earth-machine | 583 CY |
| Form and strip | 11,083 SFCS |
| Place reinf. steel | 34.6 Tons |
| Place finish & cure concrete | 582.8 CY |
| | |
| | |
| | |
| | |

145.4

Figure 6-2.—Work element estimate summary sheet.

Before proceeding, note that the forms shown in figures 6-1 through 6-6 of this discussion illustrate the minimum amount of information which should appear on such forms and should NOT be considered as standard worksheets. Some estimators may wish to record additional information, or they may desire to record their work in a different manner. A main object to keep in mind is that the recording is to be detailed in such a manner that anyone reviewing the estimate can understand what was taken off and how the computations were made. If this procedure is followed, an independent check can be made without questioning the estimator as to how they arrived at any quantity in the estimate.

## MATERIAL ESTIMATES

A material estimate is a listing and description of the various material and the quantities required to construct a given project. Information for preparing material estimates is obtained from drawings and specifications. A material estimate is sometimes referred to as a materials takeoff.

Material estimates are used as a basis for construction material procurement, and also as a check to determine if sufficient material is available to construct or to complete a project. For example, the operations officer may have some doubt about the availability of material to complete a certain project, so an estimate is prepared listing the quantities of the material that will be required to complete the project. This estimate is compared with the stock of the material on hand to determine any shortage.

The following is a suggested procedure for preparation of a material estimate. First, obtain the work element quantity which is usually done by referring to the work element estimate. Convert this into the quantities of the material required to perform the work. (Conversion units obtained from table 6-1, and from tables supplied by NAVAL CONSTRUCTION TRAINING CENTER, courses should be used whenever possible.) This conversion should be done on a worksheet when the estimator records how each quantity of material was obtained. A typical material estimate worksheet is shown in figure 6-3. It is important that worksheets be sufficiently detailed to be self-explanatory, so that anyone examining them can determine how quantities were computed without consulting the estimator. Sometimes, if desired, a sketch furnished will explain how the estimator planned the takeoff. After computing material quantities on the worksheets, enter them on recap sheets with like material for a project grouped together and totaled. Allowances for waste and loss are added after the quantities are totaled. There are many items, such as reinforcing tie wire, nails, electrodes, gas, solder, flux, form material, and accessories, etc., which are computed by using a material quantity rather than a work element quantity. These computations should appear at the end of the worksheets, using total quantities obtained from the material estimate recap sheet. Notes should be made on the worksheet to remind the estimator that these items are to be compared with the total quantities from recap sheets. The material estimate recap sheet becomes the material estimate. A sample of a typical material estimate recap sheet is shown in figure 6-4.

During construction there is a certain amount of material wasted due to cutting, fitting, and handling. For example, cast-iron pipe comes in standard lengths which seldom can be used without cutting and fitting. Sometimes, the pieces of pipe cut off can be used, but more often it goes into the scrap pile. Allowance must be made in the material estimate for this waste. There is also the possibility of loss due to pilferage, poor work, and weather. An estimator has specific information about the job and is in a position to determine if conditions warrant increasing the waste and loss factor normally used for any material item. Estimators should NOT hesitate to vary this waste and loss factor when job conditions indicate that normal factors are too high.

## EQUIPMENT ESTIMATES

An equipment estimate, for purposes of this discussion, is a listing of the type of equipment, the amount of time, and the number of pieces required to construct a given project. Information from work element estimates, drawings and

**Table 6-1.—Conversion and Waste Factors**

| *Material* | *Conversion* | *% Waste* |
|---|---|---|
| Concrete Construction | | |
| Concrete (1:2:4) | | |
| Cement | 6.0 sk/cy | 10 |
| Fine aggregate | 0.6 cy/cy | 10 |
| Coarse aggregate | 1.0 cy/cy | 10 |
| Curing compound | 0.5 gal/100 sf | 10 |
| Forms | | |
| Footings and piers | | |
| 2 x 4 | 1.5 lf/sfcs | 20 |
| 2 x 8 | 0.2 lf/sfcs | 10 |
| 2 x 12 | 0.7 lf/sfcs | 5 |
| Ground slabs | | |
| 1 x 4 | 0.1 lf/sf area | 20 |
| 2 x 4 | 0.1 lf/sf area | 5 |
| Walls and columns | | |
| 2 x 4 | 1.3 lf/sfcs | 20 |
| Plywood (50% reuse) | 0.5 sf/sfcs | 5 |
| Beams and susp slabs | | |
| 1 x 6 | 0.3 lf/sfcs | 5 |
| 2 x 4 | 0.5 lf/sfcs | 20 |
| 2 x 10 | 0.1 lf/sfcs | 10 |
| 4 x 4 | 0.4 lf/sfcs | 5 |
| 4 x 6 | 0.1 lf/sfcs | 5 |
| Plywood | 0.5 sf/sfcs | 5 |
| Form oil | 0.5 gal/100 sf | 10 |
| Tie wire | 12.0 lb/ton | 10 |
| Snap tie wedges | 0.1 ea/sfcs | 5 |

145.231.1

specifications, and information obtained from inspection of the site provide the basis for preparing the equipment estimate. Figure 6-5 illustrates the type of information shown on an equipment estimate. It is practical to use a form with columns for work quantities, equipment quantities, and operation days when an equipment estimate is being prepared. However, forms with certain information in the heading, such as that shown in the heading of the form in figure 6-5, will save the estimators time.

Equipment estimates are used together with work schedules as a basis for determining the construction equipment requirements of a project as well as total construction equipment requirements of a SEABEE deployment. This estimate includes such items as pipe machines, welding machines, and mortar mixers as well as automotive equipment. They may also be used as a basis for estimating the amount of spare parts, the number of mechanics, the size of shops, and the tools and shop equipment needed to maintain

Table 6-1.—Conversion and Waste Factors—Continued

| *Material* | *Conversion* | *% Waste* |
|---|---|---|
| Concrete Construction (cont'd) | | |
| Snap ties | 0.1 ea/sfcs | 5 |
| She bolts | 0.1 set/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 |
| Reinforcing steel | | |
| #3 | 0.4 lb/lf | 10 |
| #4 | 0.7 lb/lf | 10 |
| #5 | 1.0 lb/lf | 10 |
| #6 | 1.5 lb/lf | 10 |
| #7 | 2.0 lb/lf | 10 |
| #8 | 2.7 lb/lf | 10 |
| Constr joint (bitumen) | 3.0 gal/100 sf | 10 |
| Floor hardner | 3.0 lb/100 sf | 10 |
| Non-slip floor finish | 25.0 lb/100 sf | 10 |
| Masonry construction | | |
| Block (8 x 16) | 1.1 ea/sf | 10 |
| Brick (2¼ x 8) – 3/8 joint | | |
| 4" Wall | 6.6 ea/sf | 10 |
| 8" Wall | 13.1 ea/sf | 10 |
| 12" Wall | 19.6 ea/sf | 10 |

145.231.2

construction equipment in operating condition during a deployment.

In preparing the equipment estimate, the work element estimate should be examined and all work elements requiring equipment for their performance should be listed. For each work element on this list, the type of equipment and method of performing the work should be selected. The production rate per day should

Table 6-1.—Conversion and Waste Factors—Continued

| *Material* | *Conversion* | *% Waste* |
|---|---|---|
| Masonry construction (cont'd) | | |
| Structural face tile (12 x 12) | 1.0 ea/sf | 10 |
| Glazed structural tile | | |
| 5–1/3 x 8 | 3.3 ea/sf | 10 |
| 4 x 12 | 3.0 ea/sf | 10 |
| 5–1/3 x 12 | 2.2 ea/sf | 10 |
| Ceramic and quarry tile | | |
| 3 x 3 | 16.0 ea/sf | 10 |
| 6 x 6 | 4.0 ea/sf | 10 |
| 9 x 9 | 1.7 ea/sf | 10 |
| Mortar | | |
| Block (8 x 16) – 3/8 joint | | |
| 4" Wall | 0.1 cy/100 blocks | 20 |
| 8" Wall | 0.2 cy/100 blocks | 20 |
| 12" Wall | 0.3 cy/100 blocks | 20 |
| Brick (2¼ x 8) – 3/8 joint | | |
| 4" Wall | 0.3 cy/1000 brick | 20 |
| 8" Wall | 0.4 cy/1000 brick | 20 |
| 12" Wall | 0.4 cy/1000 brick | 20 |
| Structure tile (12 x 12) – 3/8 joint | | |
| 4" Wall | 0.2 cy/100 tile | 20 |
| 8" Wall | 0.3 cy/100 tile | 20 |
| 12" Wall | 0.5 cy/100 tile | 20 |
| Tile grout | 20.0 lb/100 sf | 10 |
| Plastering | | |
| Lath | | |
| Channel (¾") | 0.3 lb/lf | 10 |
| Lath | 3.4 lb/sy | 5 |
| Nails (4d) | 0.1 lb/sy | 10 |
| Tie wire | 0.8 lb/sy | 10 |

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be estimated for each piece of equipment. The quantity of work is divided by the production rate per day to find out how many days of operation are required to perform the work. You will be briefed later in this discussion on various factors affecting production and on sources of information used in determining equipment production rates. Some elements of work require several items of equipment to be used as a group rather than individually; in

**Table 6-1.—Conversion and Waste Factors—Continued**

| *Material* | *Conversion* | *% Waste* |
|---|---|---|
| Plastering (cont'd) | | |
| Plaster (¾") | | |
| Scratch coat | 15 cf/100 sy | 10 |
| Brown coat | 20 cf/100 sy | 10 |
| Finish coat | 10 cf/100 sy | 10 |
| Carpentry | | |
| Nails | | |
| Framing | | |
| 8d common | 5 lb/mfbm | 10 |
| 10d common | 15 lb/mfbm | 10 |
| 16d common | 10 lb/mfbm | 10 |
| Sheathing (8d common) | 30 lb/mfbm | 10 |
| Flooring (8d casing) | 30 lb/mfbm | 10 |
| Roofing (8d common) | 30 lb/mfbm | 15 |
| Wall board (6d common) | 15 lb/1000 sf | 10 |
| Trim | | |
| 4d finish | 3 lb/1000 lf | 10 |
| 6d finish | 7 lb/1000 lf | 10 |
| 8d finish | 14 lb/1000 lf | 10 |
| Lumber | | |
| Framing | – | 15 |
| Sheathing | – | 25 |
| Flooring | – | 25 |
| Roofing | – | 25 |
| Wall board | – | 15 |
| Trim | – | 10 |
| Steel erection | | |
| Rivets (field) | 25 ea/ton | 10 |
| Bolts (field | | |
| Temporary | 5 ea/ton | 5 |
| Permanent | 25 ea/ton | 5 |

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these cases, the days of operation should be shown as days of group operation.

After determination of the number of days of equipment operation required, the work schedule should be consulted to find the time allotted for completion of the work element. It may be necessary to work several pieces or groups of equipment at the same time to complete the work within the schedule time. Also, it may be advantageous to use several pieces or

Table 6-1.—Conversion and Waste Factors—Continued

| *Material* | *Conversion* | *% Waste* |
|---|---|---|
| Steel erection (cont'd) | | |
| 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 |
| Gravel | 400 lb/sq | 10 |
| Tiling | | |
| Floor tile | | |
| Asphalt, vinyl, asbestos | – | 10 |
| Primer | 5 gal/1000 sf | 20 |
| Adhesive | 10 gal/1000 sf | 20 |
| Cleaner | 5 gal/1000 sf | 20 |
| Wax | 5 gal/1000 sf | 20 |
| Acoustic tile | | |
| Tile | – | 10 |
| Cement | 25 gal/1000 sf | 20 |

145.231.5

groups of equipment at the same time because it would result in more efficient operation. An equipment schedule should be prepared for the total deployment using the work schedule to determine when the work will be performed. The number of pieces of each type of equipment required at any one time can be determined from this schedule. This schedule will indicate the peak workloads for each equipment type. A study of the peak loads may show that it is desirable to revise the work schedule to more evenly distribute the equipment workload and thereby reduce the amount of equipment required for a deployment. Other alternatives

Table 6-1.—Conversion and Waste Factors—Continued

| *Material* | *Conversion* | *% Waste* |
|---|---|---|
| Glass and glazing | | |
| Glass | | |
| 8 x 12 | 75 panes/box | 10 |
| 10 x 16 | 45 panes/box | 10 |
| 12 x 20 | 30 panes/box | 10 |
| 14 x 24 | 22 panes/box | 10 |
| 16 x 28 | 16 panes/box | 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 gal/1000 lf | 10 |
| Compound (½ x ½) | 13 gal/1000 lf | 10 |
| Painting | | |
| Metal | | |
| Enamel | 0.2 gal/100 sf | 10 |
| Zinc white | 0.2 gal/100 sf | 10 |
| White lead | 0.2 gal/100 sf | 10 |
| Wood | | |
| Enamel | 0.2 gal/100 sf | 10 |
| Zinc white | 0.2 gal/100 sf | 10 |
| White lead | 0.3 gal/100 sf | 10 |
| Varnish | 0.2 gal/100 sf | 10 |
| Flat | 0.2 gal/100 sf | 10 |
| Gloss | 0.3 gal/100 sf | 10 |

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would be considered, such as running two shifts on critical machinery or equipment, or sending an advance party to begin manufacturing, precasting, fabrication, or stockpiling before the arrival of the main construction force.

Following a review of the equipment and work schedules and making all possible adjustments to them, a list of the equipment requirements for the deployment can be prepared. In preparing this list, downtime

MATERIAL ESTIMATE WORKSHEET

SHEET NO. 2 OF 4
ESTIMATED BY Kemp DATE 19-
CHECKED BY Bigby DATE 19-

NMCB 9 LOCATION Bermuda YEAR 19-
PROJECT 01 DESCRIPTION Naval Stores Warehouse

| DESCRIPTION | WORK ELEMENT QUANTITY | CONVERSION UNIT | QUANTITY REQUIRED | REMARKS |
|---|---|---|---|---|
| Concrete Walls | | | | 62 CY |
| Forms-50% reuse | 5000 SFCS | | | |
| Plywood-3/4" | do | .5 | 2500 SF | Fir, form grade |
| 2×4 | do | 1.25 | 6250 LF | S4S #2 XP or equal |
| Form oil | do | 1 gal./200SF | 25 gallons | |
| Snapties 8" wall | do | .125 | 625 each | |
| Snap tie wedges | do | .125 | 625 each | |
| Nails (see | sheet | 4 of 4) | | |
| Reinforcing | | | | |
| Reinf. bars | 12252 lbs. | | 100 #4 × 40', 200 #5 × 40', 21 #6 × 40' | |
| Tie wire (see sheet 4 of 4) | | | | |
| Concrete | 62 CY | | | 6½ pack |
| Portland Cement | do | 6.5 | 403 sks | |
| Fine aggregate | do | .6 | 37 CY | |
| Coarse aggregate | do | 1 | 62 CY | |
| Curing Compound | 5200 SF | 1 gal./200 SF | 26 gallons | |
| Finish-Portland cement | 5000 SF | 2 sks/1000 SF | 10 sks. | |
| Finish-Fine aggregate | do | .0003 | 2 CY | |

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Figure 6-3.—Material estimate worksheet.

MATERIAL ESTIMATE

RECAP SHEET

SHEET NO. 3 OF 5

ESTIMATED BY Kemp DATE 19-

CHECKED BY Bixby DATE 19-

NMCB 9 LOCATION Bermuda YEAR 19-

PROJECT 01 DESCRIPTION Naval Stores Warehouse

| DESCRIPTION | QUANTITY | WASTE & LOSS FACTOR | WASTE & LOSS | QUANTITY TO PROCURE | REMARKS |
|---|---|---|---|---|---|
| #6 Reinf. bars 40' long | — | | | | |
| Walls | 21 pc | | | | |
| Roof slab | 24 pc | | | | |
| | 45 pc. | 10% | 5 | 50 pc. | 2000 LF 3000 lbs. |
| | | | | | |
| Portland cement — | | | | | |
| Slabs on grade | 450 SKS | | | | |
| Walls | 403 SKS | | | | |
| Finishing walls | 10 SKS | | | | |
| Roof slab | 520 SKS | | | | |
| Finishing roof | 8 SKS | | | | |
| | 1391 SKS | 10% | 139 | 1530 SKS | |
| Fine aggregate — | | | | | |
| Slabs on grade | 45 CY | | | | |
| Walls | 37 CY | | | | |
| Finishing walls | 2 CY | | | | |
| Roof slab | 48 CY | | | | |

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Figure 6-4.—Material estimate recap sheet.

SHEET 3 OF 3
ESTIMATED BY Mc Crea DATE 19
CHECKED BY Murphy DATE 19

EQUIPMENT ESTIMATE

MCB 12 LOCATION Guam YEAR 19

PROJECT 01 DESCRIPTION Site Preparation

Equipment Required for Loading and Hauling
3 - 2 1/2 cy Endloaders.
1 - Bulldozer to keep pit in shape.
1 - Grader to keep haul road in shape.
16 - 10 Ton trucks hauling (1 or 2 extra trucks should be added to assure that a truck will always be waiting to be loaded so that endloader will work at full capacity).
2400 cy will be hauled each day.
$\frac{2400}{1200}$ = 2 - tractors & tandem sheepsfoot rollers for compaction.

$\frac{2400}{1200}$ = 2 - Bulldozers to spread earth.
1 - Water truck with sprinkler.
1 - Wobbly wheel roller (standby for sealing top of fill before rains).
Note: this is a more efficient operation as production has been tripled but equipment has not, and total equipment is working about or close to capacity as can be expected.

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Figure 6-5.—Equipment estimate.

should be anticipated. Sufficient equipment should be added so that when the equipment is out of service awaiting repairs, a reserve piece is available for use. This is especially important for automotive equipment.

The number of pieces of equipment required for a deployment is obtained by adding the required reserve equipment of each type to the peak figure indicated by the equipment schedule.

### Factors Affecting Production

In realizing the importance of equipment in getting construction work done, you can see that special care is needed in preparing equipment estimates. You will often have to consider a number of factors before arriving at an estimate of how much work to expect from an individual piece of equipment. Some of the important factors affecting equipment production are the average speed at which the equipment will be operated, the type of materials to be handled, the experience of operators, the age and condition of the equipment, the time allotted for completion, the climate, and safety.

EQUIPMENT SPEED.—Maximum speeds are established either by a governing authority, such as a highway or street speed limit, or by a command, such as an operating limit on the equipment. In either case, the speed limits must be considered when the average hauling speed is being estimated, which, in turn, determines the amount of material the equipment will move in 1 day. The estimator should NOT make the mistake of using the speed limit as the average speed at which the equipment will be operated. Equipment speed will usually average 40 percent to 65 percent of the normal speed limits, depending upon the condition of the road, the number of intersections to be crossed, the amount of traffic, and the length of haul. Longer hauls will usually result in higher average speeds, other conditions being equal.

TYPE OF MATERIALS TO BE HANDLED.—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 dig, load, and dump 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 buckets, beds, or pans and requires little or no jarring or shaking; therefore, the time required for these extra maneuvers is saved. With a clamshell bucket, sand handles easier and quicker than gravel or crushed rock. Bulky, hard-to-rig material and equipment require more time to load and unload when a crane is used for lifting. For example, a large timber or steel beam is easy to handle by simply putting a choker sling around the midpoint and lifting, while a large, bulky piece of equipment would require bridle slings placed so as to balance the equipment as it is lifted. Several trial lifts usually are required, moving the slings after each lift, before the equipment is balanced for safe lifting.

EXPERIENCE OF OPERATORS.—The experience of the operator must be given consideration when the production capabilities of the equipment is being estimated. An experienced operator knows the short cuts and performs work with the minimum of effort and movement, thus getting maximum production from a machine. For example, an experienced operator will spread a load of dirt with less passes than an inexperienced operator will and will also do a better job of spreading. Also, inexperienced operators are likely to forget some of the required maintenance operations and, as a result, tend to have more downtime with their equipment.

AGE AND CONDITION OF EQUIPMENT.—The age and condition of equipment certainly must be considered in estimating the number of days required to perform a project. Old equipment and poorly maintained equipment are more likely to have downtime than new equipment or equipment in good operating condition. Also old and worn equipment respond more slowly to the operator, has less power, and are 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 of the dirt being hauled.

TIME ALLOTTED FOR COMPLETION.—The time allotted for completion affects production if crews must work long hours daily, or if work must be performed under crowded conditions to complete the project within the allotted time. Crews working long hours daily without sufficient rest and relaxation

tend to slow down, especially when this continues for several weeks, causing total production to be lowered. Also when work is performed under crowded conditions, efficiency drops, and the amount of production is lowered. More efficient operation and more production are usually obtained by working two or more shifts per day.

CLIMATE.—Climate, of course, has a considerable effect on production equipment in outside work. Rain slows down the work, and frequently stops it for the remainder of the day and sometimes for several days. In climates having considerable rainfall, as in Okinawa, equipment will 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. Climate also has an adverse effect upon the spare parts required to maintain equipment in operating condition and should be considered when spare part requirements are being determined. Very dry climates with considerable dust cause more rapid wear on parts, such as engines and bearings, while wet climates cause more rapid wear on parts, such as track assemblies, if working in muddy conditions.

SAFETY.—Safety factors sometimes limit the amount of work which can be produced with a machine, and therefore, they must be considered as a production factor. For example, although the manufacturer's crane rating may show it to be capable of lifting 40 tons with a 70-foot boom at a 45° angle, the maximum lifting capacity of that particular crane may have been limited to 85 percent of the manufacturer's rating as a safety precaution. The crane can then only be used to lift 34 tons with a 70-foot boom at a 45° angle. Certain pieces of equipment may have their speed limited because of safety precautions, which would reduce the rate of production as discussed earlier in the section on "Equipment Speed."

### Equipment Production Rates

Numerous sources of information about equipment production rates are available. These sources include manufacturers' tables and diagrams, Government manuals, and estimating books. Production rates are usually available in most SEABEE operations offices. However, it is NOT practical to draw up a production table which would consider the particular combination of factors affecting production on a given project. Production rates found in tables, therefore, must be adjusted to fit the conditions expected on the particular project being estimated. In order to make the adjustment intelligently, the estimator should know on what basis the rate in the table was established. This information is usually contained in the foreword, in notes for the table, or in instructions for using the table.

## MANPOWER ESTIMATES

A manpower estimate is a listing of the number of man-days required to complete the various work elements of a specific project. These estimates may show only the man-days for each work element and the total man-days, or they may be in sufficient detail to show the number of man-days of each rating—such as Steelworker, Builder, Utilitiesman, and so on—for each work element. Manpower estimates are used in determining the size of the work force and the ratings required on a deployment, and to provide the basis for scheduling the work force in relation to the construction's progress. Two types of manpower estimates that you may prepare are preliminary and detailed estimates. A suggested procedure for preparing each type is given in subsections below.

### Preliminary

Preliminary manpower estimates are used to establish costs for budget purposes and to program manpower for succeeding years. They may be used as very rough checks of detailed estimates, but they can be expected to vary as much as 10 to 15 percent from the detailed estimate. Preliminary manpower estimates are prepared from limited information, such as the general descriptions of the projects or preliminary plans and specifications, with little or no detailed information. They are usually prepared on the basis of area, length, or any other suitable measurement.

In preparing preliminary manpower estimates on the basis of area or lineal

measurement, it is first necessary to compute the area or other measurement of the project from the information at hand. Next, the conditions under which it will be constructed must be considered and a suitable man-day per unit figure selected from the tables. The quantity of measurement is then multiplied by the man-day figure selected to obtain the total estimated man-days required for the project.

**Table 6-2.—Housing and Special Services Building Construction**

| Work element description | Unit | Man-days per unit | | |
|---|---|---|---|---|
| | | Adverse condition | Average condition | Favorable condition |
| For preliminary estimates only: | | | | |
| Masonry and concrete construction: | | | | |
| BOQ | SF | 0.95 | 0.60 | 0.40 |
| Barracks | SF | 0.85 | 0.55 | 0.35 |
| Chapel | SF | 1.5 | 1.0 | 0.6 |
| Community center (60% under roof) | SF | 0.45 | 0.30 | 0.20 |
| CPO club | SF | 1.5 | 0.8 | 0.5 |
| Dry cleaning shop | SF | 1.00 | 0.65 | 0.40 |
| EM club | SF | 1.2 | 0.8 | 0.4 |
| Gymnasium | SF | 1.2 | 0.8 | 0.5 |
| Handball court (walls on 3 sides) | Each | 800 | 540 | 350 |
| Housing (family quarters) | SF | 0.60 | 0.40 | 0.25 |
| Library | SF | 0.85 | 0.55 | 0.35 |
| NCO club | SF | 1.5 | 1.0 | 0.6 |
| Officers mess and club | SF | 1.5 | 1.1 | 0.7 |
| Post exchange, ships store, and retail shops | SF | 0.80 | 0.50 | 0.35 |
| Roller skating rink (open sides) | SF | 0.40 | 0.25 | 0.15 |
| School | SF | 1.2 | 0.8 | 0.5 |
| Service station | SF | 1.30 | 0.90 | 0.55 |
| Theater | SF | 2.00 | 1.35 | 0.89 |
| Butler bldg.[1] | SF | 0.15 | 0.10 | 0.06 |
| Butler camp complete[2] | Man | 12 | 8 | 5 |

Note: Man-days per unit are for buildings completely equipped.

[1] Man-days shown do not include interior partition.

[2] Based on a complete camp with messing facilities, all utilities and lavatory facilities, administration buildings. Does not include shops

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For example, an EM club is to be built with reinforced concrete frame and roof, clay tile and plaster walls. The building is to be 60 feet wide by 80 feet long. Then 60 feet by 80 feet = 4800 square feet. Assume the project site is in Spain, and the estimator believes conditions will be favorable for construction. Reference to table 6-2 shows that 0.4 man-days will be required for each square foot of area of this type of construction. So, 4800 square feet by 0.4 man-days per unit = 1920 man-days required for construction of the club complete.

Or, suppose a camp for 500 SEABEES consisting of Butler buildings, with galleys and reefers, complete with sanitary facilities, heat, electric power, water, and communications, is required on an island in the Pacific. Conditions on the island are such that the estimator decides a man-day per unit figure halfway between average and adverse conditions is the correct one to use. Referring to table 6-2, the man-day per unit figures are 12 for adverse and 8 for average. Halfway between this figure is:

$$\frac{8 + 12}{2} = 10 \text{ man-days per unit.}$$

Now, multiplying the 500 SEABEES by 10 man-days per unit = 5,000 man-days required to construct the camp complete.

In preparing manpower estimates, you may have occasion to use table 6-3. This table may be used in the preparation of preliminary estimates for warehouse and magazine construction.

In using tables, such as those presented in table 6-2 and table 6-3, the estimator should select the man-days per unit figure to be used from the table after considering the various factors which might affect production at the site. Factors that should be weighed and considered, in making both preliminary and detailed manpower estimates, include: the weather outlook during the construction period, the skill and

**Table 6-3.—Warehouse and Magazine Construction**

| Work element description | Unit | Man-days per unit | | |
|---|---|---|---|---|
| | | Adverse Condition | Average Condition | Favorable Condition |
| For preliminary estimates only: Masonry and concrete construction: | | | | |
| Flammable storage | SF | 0.70 | 0.45 | 0.30 |
| Magazine, small arms | SF | 1.10 | 0.75 | 0.45 |
| Storage shed | SF | 0.50 | 0.35 | 0.20 |
| Warehouse | SF | 0.60 | 0.40 | 0.25 |
| Prefabricated structure: | | | | |
| Butler warehouse | SF | 0.12 | 0.08 | 0.05 |
| Earth covered concrete magazine | SF | 0.5 | 0.3 | 0.2 |

Note: Man-days per unit are for building completely equipped.

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experience of the SEABEES who 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.

Remember that tables 6-2 and 6-3 are designed for the preparation of preliminary estimates and may be used to obtain a quick estimate of the work force needed. They will NOT give nearly as accurate results as detailed estimates which attempt to adjust for all of the factors which affect the number of man-days required to construct a project.

**Detailed**

Detailed manpower estimates are used to determine the work force required for construction of a given project. They are also used to determine total direct labor requirements of a SEABEE deployment.

In preparing detailed manpower estimates, first obtain the work element quantity from the work element estimates worksheet. Using the appropriate table as a starting point, select the man-days per unit figure; adjust it, as necessary, to compensate for new tools, equipment, methods, and previously maintained factors, and then multiply by the quantity to obtain the total man-days required for the work element. If a work element estimate summary is prepared, a copy of this summary sheet can be used as a manpower estimate worksheet by adding two columns—one headed "Man-days per Unit" and the other "Man-days Required." The man-days per unit figure should be entered in the appropriate column. Extensions are then made by multiplying the figure in the quantity column by the figure in the man-days per unit column, the result being the man-days required. An example of a work element estimate summary sheet used as a worksheet for manpower estimates is shown in figure 6 6. If the summary sheet is NOT used, worksheets should be prepared listing the work elements and their quantities. Otherwise, the procedure is the same as indicated above, with the worksheet substituted in place of the summary sheet. These worksheets record the manpower estimate when progress control is to be exercised to the extent detailed in the tables. If lesser control is desired, a summary sheet should be prepared with the work elements detailed to the extent desired.

Table 6-4 illustrates the type of table which you might use in preparing detailed manpower estimates of structural steel erection. As an example in the use of this table, suppose that a gymnasium is to be erected on an island in the Pacific, using structural steel frame and steel roof trusses with high-strength bolted field connections. The work element estimate lists the following quantities of steel to be erected:

| | |
|---|---|
| Columns and beams .... | 46.5 tons |
| Trusses ............... | 18.5 tons |
| Purlins ............... | 15.8 tons |
| High-strength bolting... | 1,800 bolts |

## USES OF A CONSTRUCTION SCHEDULE

Before, during, and after construction, the schedule serves as an operational guide for all managerial and supervisory personnel. Without the schedule, coordination and teamwork would be difficult to achieve.

### BEFORE CONSTRUCTION

Before work actually begins, the schedule insures that the person in charge has an idea of the time required for construction. It shows clearly the sequence in which the personnel, materials, and equipment are required, thus allowing one job to be integrated with another and insuring maximum utilization of the constructing units capability.

### DURING CONSTRUCTION

During construction, the schedule serves as a basis upon which to issue orders to

SHEET 1 OF 1

ESTIMATED BY Cato DATE 19-

CHECKED BY Stiles DATE 19-

**WORK ELEMENT ESTIMATE**
**SUMMARY SHEET**

NMCB 15 LOCATION Saipan YEAR 19-

PROJECT 08 DESCRIPTION Staging - Out Warehouse

| WORK ELEMENT | QUANTITY | MAN-DAYS PER UNIT | MAN-DAYS REQUIRED |
|---|---|---|---|
| Footings and foundations | | | |
| Machine excavation | 1860 cy | 40/1000 cy | 74.4 |
| Machine backfill | 1277 cy | 6/1000 cy | 7.7 |
| Hand compaction | 1277 cy | .30/cy | 383.1 |
| Spread spoil earth-machine | 583 cy | 3/1000 cy | 1.75 |
| Form and strip | 11,083 SFCS | 44/1000 SFCS | 487.7 |
| Place reinf. steel | 34.6 Ton | 10/Ton | 346.0 |
| Place finish & cure concrete | 582.8 cy | .75/cy | 437.1 |
| | | | |
| | | | |
| | | | |
| | Total man-days | | 1,737.75 |
| | | | |
| | | | |
| | | | |

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Figure 6-6.—Manpower estimate worksheet.

subordinates. It insures that equipment is NOT tied up longer than necessary, and that large numbers of personnel are NOT brought on the job before they can be employed efficiently. Such a situation is NOT only wasteful, but is quickly interpreted as lack of organization, and will have an extremely adverse effect on the units morale. The schedule enables the supervisor to prepare checklists to see exactly what jobs should be in operation at a given time, rather

Table 6-4.—Structural Steel Erection

| Work element description | Unit | Man-days per unit | | |
|---|---|---|---|---|
| | | Adverse condition | Average condition | Favorable condition |
| Unload, erect, plumb, and level: | | | | |
| Columns and beams | Ton | 4.2 | 2.8 | 1.4 |
| Girders | Ton | 3 | 2 | 1 |
| Trusses | Ton | 6.3 | 4.2 | 2.1 |
| Girts and purlins | Ton | 4.2 | 2.8 | 1.4 |
| Window and door frames | Ton | 8.4 | 5.6 | 2.8 |
| High-strength bolting | 1000 Bolts | 40 | 25 | 15 |
| Welding structural steel connections (1/4" weld) | 1000 LF | 100 | 63 | 38 |
| For quick estimates: | | | | |
| Structural steel erection, complete | Ton | 5.7 | 3.8 | 1.9 |

Typical crew: 1 crew leader, 1 crane operator, 4 to 6 workers unloading, plumbing and connecting, and 2 to 4 workers bolting and welding.

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than to assume "everyone is working, so everything must be all right." The schedule is a means of insuring that material is NOT produced or delivered long before it is required, and that storage facilities are utilized efficiently, and that effort is NOT expended needlessly in rehandling materials.

When field changes occur or production is slowed down, the schedule serves as a basis by which a supervisor can evaluate the effects upon related work items and devise solutions which will cope with the changes in scheduled operations.

Up-to-date actual progress, plotted upon the schedule at regular and frequent intervals, reveals work items that are falling behind schedule in time to apply corrective action. The schedule also serves as the basis for preparation of progress reports to higher command levels.

## AFTER CONSTRUCTION

After the project is completed, an analysis of the schedule can be useful in isolating information for future reference. Noting which items fell behind or were completed ahead of schedule will enable estimators to re-evaluate their time rates and modify them for future use based on new experience.

## ELEMENTS OF SCHEDULING

The elements used in scheduling work include the work item number, the item description, the unit of measurement (cubic yard, square yard, ton, each, etc.), the quantity of work to be performed, the relations of each item to the whole in terms of work to be performed, such as percentage of the total work required for each item, units of time to be used in the

schedule, the starting date, the time required for each item, and the completion date. The elements of scheduling equipment and the work force are similar to those of scheduling work, but in addition, the number of pieces of equipment and the number of personnel are included.

## PRINCIPLES OF SCHEDULING

The development of a schedule is governed by four principles which remain fixed, even though the type of schedule is changed.

SCHEDULED OPERATIONS CANNOT EXCEED THE CAPABILITY TO ACCOMPLISH THE WORK. For example, if only five welding machines are available, the maximum which can be scheduled at any given time is five.

SCHEDULED OPERATIONS MUST FOLLOW THE SEQUENCE OF THE WORK REQUIRED FOR THE PARTICULAR JOB. For instance, the same part of a road cannot be surfaced while the base course is being constructed, nor can a roof be put on a building before the foundation and walls are up.

These two principles may appear so obvious as to merit little attention, yet the most common errors in scheduling involve violations of both. If a schedule is made which does NOT violate either of these principles, it will be a workable schedule, but it will NOT necessarily be a good schedule. Two other principles must be observed to develop a good schedule.

CRITICAL ITEMS MUST BE SCHEDULED AS SOON AS POSSIBLE. Maximum speed in completion of a project is most frequently the aim in advanced base construction. This is usually achieved by scheduling those items which take the longest, or upon which many other operations are based, to begin as early as possible.

SCHEDULING MUST INSURE CONTINUITY OF WORK EFFORT Maximum efficiency in accomplishing a particular work item is best achieved if the time for accomplishing that item is as continuous as possible. For example, a crewmember on a project should NOT be required to change from cutting and tying rebar to installing duct work or doing some other type of work. This reduces the output, and requires more supervisory personnel. These last two principles are often in opposition to one another and a balance must be made between them to obtain the best schedule.

## TYPES OF SCHEDULES

Work schedules are usually prepared for the deployment as a whole and for each project of the deployment. Manpower and equipment schedules are normally prepared at the same time, because the information they contain is required for the preparation of the work schedules. The separate projects of a deployment are scheduled in the deployment schedule; the separate work elements of a project are scheduled in a project schedule.

A typical deployment work schedule is shown in figure 6-7. The deployment will accomplish three projects: (1) the construction of 22 replacement housing units, (2) the laying of 12,600 linear feet of a POL (petroleum, oil, and lubricant) system, and (3) the construction of 28,000 square yards of road. It is estimated that, of the total work time allotted, 58.7 percent will be required for the replacement housing, 23.9 percent for the POL system, and 17.4 percent for the roads.

Project 1 will begin in March and end in October; project 2 will begin in April and end in October; and project 3 will begin in March and end in July. The estimated percentage of completion of each project for each month is as shown. These monthly figures are used to determine the estimated percentage of completion of the total project (deployment), shown at the bottom of the page. For example, in May, 34 percent of 58.7 percent, 18 percent of 23.9 percent, and 58 percent of 17.4 percent of the work will be accomplished. This amounts to 34 percent of the total work.

| DEPLOYMENT WORK SCHEDULE | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NMCB 40 LOCATION -- DIEGO GARCIA YEAR -- 19– PREPARED 1-4– BY G. SMITH | | | | | | | | | | | | |
| PROJECT NO. | DESCRIPTION | UNIT | QUANTITY | WEIGHTED VALUE [1] | MONTHLY PRODUCTION – EST. AND ACT. | | | | | | | |
| | | | | | MAR | APR | MAY | JUN | JUL | AUG | SEPT | OCT |
| 1 | REPLACEMENT HOUSING | UNITS | 22 | 58.7 | 10 | 25 | 34 | 43 | 52 | 66 | 85 | 100 |
| 2 | POL SYSTEM | LF | 12,600 | 23.9 | | 2 | 18 | 39 | 58 | 80 | 91 | 100 |
| 3 | ROADS | SY | 28,000 | 17.4 | 8 | 31 | 58 | 75 | 100 | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | TOTAL PROJECT | | | 100.0 | 7 | 21 | 34 | 48 | 62 | 76 | 89 | 100 |

[1] WEIGHTED VALUE IS THE PERCENTAGE OF THE TOTAL MAN-DAYS ALLOCATED TO EACH PROJECT.

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**Figure 6-7.—Deployment work schedule.**

| PROJECT WORK SCHEDULE | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NMCB 40 LOCATION -- DIEGO GARCIA YEAR -- 19– PREPARED 1-4– BY G SMITH<br>PROJECT -- POL SYSTEM | | | | | | | | | | | | |
| ITEM NO. | DESCRIPTION | UNIT | QUANTITY | WEIGHTED VALUE | MONTHLY PRODUCTION – EST. AND ACT. | | | | | | | |
| | | | | | MAR | APR | MAY | JUN | JUL | AUG | SEPT | OCT |
| 2A11 | TRENCHING, DITCHING, & BACKFILLING | CY | 2,200 | 9.1 | | 10 | 27 | 44 | 61 | 78 | 95 | 100 |
| 2M2 | INSTALL VALVES | EACH | 25 | 0.9 | | | | | 15 | 50 | 80 | 100 |
| 2M4 | CONSTRUCTION VALVE PITS | EACH | 10 | 10.9 | | | 10 | 40 | 65 | 90 | 100 | |
| 2M13 | INSTALL 12 PIPE | LF | 12,600 | 58.2 | | | 20 | 39 | 58 | 77 | 95 | 100 |
| 2R9 | PUMP HOUSE | EACH | 1 | 15.4 | | | 15 | 40 | 65 | 85 | 100 | |
| 2Q3 | WORK NOT COVERED ABOVE | L/S | 1 | 5.5 | | 5 | 20 | 40 | 55 | 70 | 90 | 100 |
| | | | | | | | | | | | | |
| | TOTAL PROJECT | | | 100.0 | | 1 | 18 | 39 | 60 | 79 | 96 | 100 |

82.92

**Figure 6-8.—Project work schedule.**

Figure 6-8 shows the work schedule for one of the projects shown in figure 6-7. Figure 6-9 shows the deployment manpower schedule for 1 month of deployment. The total man-days per month figure at the bottom is the sum of the total per day full-day figures, plus half the sum total per day half-day figures. Figure 6-10 shows a 1-month manpower schedule for one of the projects shown in figure 6-9.

Figure 6-11 shows the equipment schedule for the deployment. The interval during which each item of equipment will be required is indicated by a BAR at the right. In figure 6-12, a similar chart, called a BAR CHART, shows the 1-month equipment schedule for one of the projects. Figure 6-13 shows a simple tabular type of the project work schedule.

## TECHNIQUES OF SCHEDULING

In scheduling a project, the first procedure is to list the work elements. Next, determine the construction sequences; obviously, excavating must come before foundation placement, building completion before the base course and paving materials can be placed, etc. The starting date for the project is the starting date for the work element which is first in the construction sequence.

The time required for each work element is determined by dividing the estimated man-days required by the number of persons expected to be assigned to constructing that element. Each work element is scheduled in its proper construction sequence, showing starting and completion dates. Often, of course, it is NOT economical to wait until one element is finished before starting another. For example, concrete foundations can be started at one end of a building while excavating is still going on at the other end, or paving can begin at one end of a road while grading is still going on at the other.

DEPLOYMENT MANPOWER SCHEDULE

NMCB 40 LOCATION DIEGO GARCIA YEAR -- 19— PREPARED 1 4- BY G SMITH

PROJECT · POL SYSTEM

| PR NO | DESCRIPTION | DATE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | JULY | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | REPLACEMENT HOUSING | E | 47 | 47 | 49 | X | 49 | X | 49 | 41 | 48 | 48 | 48 | 50 | X | 46 | 54 | 54 | 50 | 54 | 54 | X | 54 | 47 | 47 | 43 | 50 | 47 | X | 47 | 47 | 42 | 42 |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | POL SYSTEM | E | 50 | 50 | 48 | X | 48 | X | 48 | 56 | 49 | 49 | 49 | 47 | X | 51 | 43 | 43 | 47 | 43 | 43 | X | 43 | 50 | 50 | 54 | 47 | 50 | X | 50 | 50 | 55 | 55 |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | ROADS | E | 40 | 40 | 40 | X | 40 | X | 40 | 40 | 40 | 40 | 40 | 40 | X | 40 | 40 | 40 | 40 | 40 | 40 | X | 40 | 40 | 40 | 40 | 40 | 40 | X | 40 | 40 | 40 | 40 |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | E | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | E | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | E | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | E | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| TOTAL PERSONS PER DAY | | E | 137 | 137 | 137 | X | 137 | X | 137 | 137 | 137 | 137 | 137 | 137 | X | 137 | 137 | 137 | 137 | 137 | 137 | X | 137 | 137 | 137 | 137 | 137 | 137 | X | 137 | 137 | 137 | 137 |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| TOTAL MAN-DAYS PER MONTH | | E | 3288 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

X DENOTES SUNDAYS AND HOLIDAYS WHEN NO WORK IS SCHEDULED.

/ DENOTES SATURDAYS WHEN HALF DAY'S WORK IS SCHEDULED.

82.93

Figure 6-9.—Deployment manpower schedule.

PROJECT MANPOWER SCHEDULE

NMCG 40 LOCATION -- DIEGO GARCIA YEAR -- 19 — PREPARED 1-4 — BY G. SMITH

PROJECT -- POL SYSTEM

| IT. NO. | DESCRIPTION | DATE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2A11 | TRENCHING, DITCHING, BACKFILL | E | 2 | 2 | 2 | | 2 | | 2 | 2 | 2 | 2 | 2 | 2 | | 2 | 2 | 2 | 2 | 2 | 2 | | 7 | 7 | 7 | 7 | 7 | 7 | | 7 | 7 | 7 | 7 |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2M2 | INSTALL VALVES | E | | | 2 | | 2 | | 2 | 2 | | | | | | | | | | | | | 2 | 2 | 2 | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2M4 | CONSTRUCT VALVES PITS | E | 6 | 6 | 6 | | 6 | | 6 | 10 | 5 | 5 | 5 | 6 | | 10 | 6 | 6 | 10 | 6 | 6 | | 6 | 6 | 10 | 5 | 5 | 5 | | 5 | 5 | 10 | 10 |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2M13 | INSTALL 12" PIPE | E | 26 | 26 | 26 | | 26 | | 26 | 26 | 26 | 26 | 26 | 26 | | 26 | 26 | 26 | 26 | 26 | 26 | | 19 | 26 | 22 | 33 | 25 | 26 | | 26 | 26 | 26 | 26 |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2R9 | PUMP HOUSE | E | 12 | 12 | 12 | | 12 | | 12 | 12 | 12 | 12 | 12 | 9 | | 9 | 9 | 9 | 9 | 9 | 9 | | 7 | 7 | 7 | 7 | 10 | 10 | | 10 | 10 | 10 | 10 |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2Q3 | WORK NOT COVERED ABOVE | E | 4 | 4 | | | | | | 4 | 4 | 4 | 4 | 4 | | 4 | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | | 2 | 2 | 2 | 2 |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | E | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| TOTAL PERSONS PER DAY | | E | 50 | 50 | 48 | | 50 | | 48 | 56 | 49 | 49 | 49 | [illegible] | | 51 | 43 | 43 | 47 | 43 | 43 | | 43 | 50 | 50 | 54 | 47 | 50 | | 50 | 50 | 55 | 55 |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| TOTAL MAN-DAYS PER MONTH | | E | 1174 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Figure 6-10.—Project manpower schedule. 82.94

DEPLOYMENT EQUIPMENT SCHEDULE

NMCB 40 LOCATION -- DIEGO GARCIA YEAR -- 19 — PREPARED 1-4 — BY G. SMITH

| PROJECT NO. & DESCRIP. | EQUIPMENT | NO. REQ. | MAR | APR | MAY | JUN | JUL | AUG | SEPT | OCT |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 REPLACEM'T HOUSING | AIR COMPRESSOR, 210 CFM | 1 | | | | | | | | |
| | BULLDOZER, 113/130 DBHP | 1 | | | | | | | | |
| | CRAWLER CRANE, 45 TON | 1 | | | | | | | | |
| | MORTAR MIXER, 6 CF | 2 | | | | | | | | |
| | MOTOR GRADER, 12' BLADE | 1 | | | | | | | | |
| | TRUCKS, 2 TON, STAKE | 3 | | | | | | | | |
| 2 POL SYSTEM | BULLDOZER, 113/130 DBHP | 1 | | | | | | | | |
| | MORTAR MIXER, 6 CF | 1 | | | | | | | | |
| | MOTOR CRANE, 20 TON | 2 | | | | | | | | |
| | TRENCHING MACHINE | 1 | | | | | | | | |
| 3 ROADS | ASPHALT DISTRIBUTOR, 24' WIDTH | 1 | | | | | | | | |
| | ASPHALT FINISHER, 10' - 14' WIDTH | 1 | | | | | | | | |
| | ASPHALT PLANT, COMPLETE, 100 TON | 1 | | | | | | | | |
| | BULLDOZER, 110/113 DBHP | 2 | | | | | | | | |
| | MOTOR GRADER, 12' BLADE | 1 | | | | | | | | |
| | SCRAPERS, SELF-PROPELLED, 12 CY | 3 | | | | | | | | |
| | TANDEM ROLLER, SELF-PROPELLED | 1 | | | | | | | | |
| | TRACTOR, PUSHER, 113/130 DBHP | 1 | | | | | | | | |
| | TRUCKS, 10 TON, DUMP | 3 | | | | | | | | |
| | VIBRATING COMPACTOR | 1 | | | | | | | | |
| ALL PROJECTS | CONCRETE BATCH PLANT, COMPLETE | 1 | | | | | | | | |
| | TRANSIT-MIX TRUCKS, 5½ CY | 3 | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

Figure 6-11.—Deployment equipment schedule. 82.95

PROJECT EQUIPMENT SCHEDULE

NMCB 40 LOCATION -- DIEGO GARCIA YEAR -- 19 — PREPARED 1-4 — BY G. SMITH
PROJECT -- POL SYSTEM

| ITEM NO. & DESCRIPTION | EQUIPMENT | NO. REQ. | MAR | APR | MAY | JUN | JUL | AUG | SEPT | OCT |
|---|---|---|---|---|---|---|---|---|---|---|
| 2A11 TRENCH & BF | TRENCHING MACHINE | 1 | | | | | | | | |
| | BULLDOZER, 130 DBHP | 1 | | | | | | | | |
| 2M2 INST VALVES | MOTOR CRANE, 20 TON | 1 | | | | | | | | |
| | | | Work in conjunction with 12" Pipe | | | | | | | |
| 2M13 INST 12" PIPE | MOTOR CRANE, 20 TON | 2 | | | | | | | | |
| | BULLDOZER, 130 DBHP | 1 | | | | | | | | |
| 2R9 PUMP HOUSE | MOTOR CRANE, 20 TON | 1 | | | | | | | | |
| | MORTAR MIXER, 6 CF | 1 | | | | | | | | |

82.96

Figure 6-12.—Project equipment schedule.

PROJECT WORK SCHEDULE

NMCB 40 LOCATION -- DIEGO GARCIA YEAR -- 19 — PREPARED 1-4 — BY G. SMITH
PROJECT -- POL SYSTEM

| ITEM NO. | DESCRIPTION | UNIT | QUANTITY | WEIGHTED VALUE | ESTIMATED | | ACTUAL | |
|---|---|---|---|---|---|---|---|---|
| | | | | | START | FINISH | START | FINISH |
| 2A11 | TRENCHING, DITCHING, & BACKFILLING | CY | 2,200 | 9.1 | 4-16 — | 10-18 — | | |
| 2M2 | INSTALL VALVES | EACH | 25 | 0.9 | 7-16 — | 10-16 — | | |
| 2M4 | CONSTRUCT VALVE PITS | EACH | 10 | 10.9 | 5-14 — | 9-20 — | | |
| 2M13 | INSTALL 12" PIPE | LF | 12,600 | 58.2 | 4-30 — | 10-16 — | | |
| 2R9 | PUMP HOUSE | EACH | 1 | 15.4 | 5-14 — | 9-29 — | | |
| 2Q3 | WORK NOT COVERED ABOVE | L/S | 1 | 5.5 | 4-16 — | 10-18 — | | |
| | TOTAL PROJECT | | | 100.0 | 4-16 — | 10-18 — | | |

82.97

Figure 6-13.—Project work schedule.

## PROGRESS CONTROL

Progress control is exercised by:

1. Measuring actual production against planned production.
2. Determining causes of discrepancies, if there are any.
3. Taking remedial action to correct deficiencies in production and to balance activities in order to attain overall objectives.

## REPORTING PROGRESS

Work accomplished should be reported on daily labor reports. However, in some types of work, it is more convenient to report work quantities as portions are completed, rather than to attempt to report partial completion of portions. For example, if 2,000 cubic feet of earth must be excavated before a section of runway paving is to be placed, it is difficult to estimate partial progress of the excavation, and NO report is usually made until the excavation is completed, ready for paving.

Items suitable for daily reporting are those which may reasonably be expected to show a fairly steady production rate per man-hour, such as placing concrete or asphalt paving or excavating and/or hauling of large quantities of cut and fill. For such items, daily reports provide a continuous, running check on progress.

A daily report should show the man-hours expended on each work element. Preparation of weekly or monthly reports is accomplished by recording daily reports in ledger form and totaling for a week or month.

Monthly progress reports are usually made in narrative form, with a progress chart (explained later) included in the report. Major problems affecting progress should be described, and any unusual construction methods should be reported in detail with sketches included if necessary. If progress is behind schedule, the report should describe what measures are being taken to bring it back on schedule, or explain why the completion date cannot be met and what extension of time is needed for completion.

## CHARTING PROGRESS

A common way of charting progress is to insert percentages of actual work completed in spaces left adjacent to the figures for estimated completion percentages on work schedules.

## THE CRITICAL PATH METHOD

In past years, a network analysis system of project planning, scheduling, and control, called the CRITICAL PATH METHOD (CPM) has come into existence and widespread use in the construction industry. The object of CPM is to combine all the information relevant to the planning and scheduling of project functions into a single master plan—a plan that coordinates all of the many different efforts required to accomplish a single objective, that shows the interrelationship of all of these efforts, that shows which efforts are critical to timely completion, and hence promotes the most efficient use of equipment and manpower.

The Critical Path Method of scheduling was one of the outgrowths of the Program Evaluation Review Technique (PERT) developed in the Special Projects Office, BuWeps, Navy Department and a project planning and scheduling technique based on network analysis called Critical Path Planning and Scheduling (CPPS).

While CPM has been most widely applied in the construction field, other possible applications are almost unlimited. A shop supervisor, for instance, may often find CPM, useful in planning work to obtain the most economical manpower utilization.

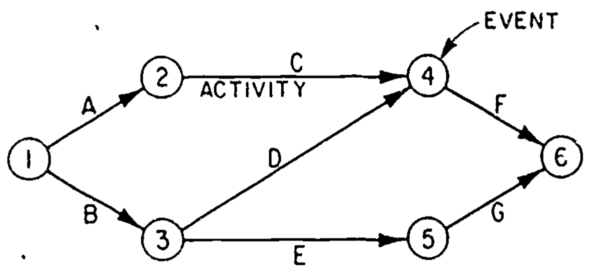
There is a lot to know about CPM and you may not find all the information you need on the subject in this training course. Sufficient coverage is provided, however, to assist you in preparing arrow diagrams, interpreting critical path schedules drawn up for jobs under your supervision, and in developing critical path schedules for future construction projects. More detailed information on the CPM can be found in the *SEABEE Planner's and Estimator's Handbook*, NAVFAC P-405.

## PREPARING THE ARROW DIAGRAM

The arrow diagram is the single most important piece of input information. It must be drawn to identify, in a graphic form, the individual items of work, services, or tasks—referred to in network analysis as ACTIVITIES—that are involved in constructing the project. Also, of equal importance, the arrow diagram must show how each ACTIVITY depends upon others during the sequence of construction.

In substance, the arrow diagram graphically describes the sequence of ACTIVITIES as well as the interrelationship of ACTIVITIES within the project. Instead of an arrow diagram, the graphic technique is sometimes referred to as an ARROW NETWORK, a DEPENDENCY DIAGRAM, a DEPENDENCY NETWORK, or a LOGIC NETWORK.

In an arrow diagram, both arrows and circles are used to describe the sequence of work. An arrow represents an ACTIVITY, and a circle represents an EVENT. An EVENT is the starting point of an ACTIVITY and occurs only when all the ACTIVITIES preceding it, which means all the arrows leading to the circle, have been completed.




117.308X

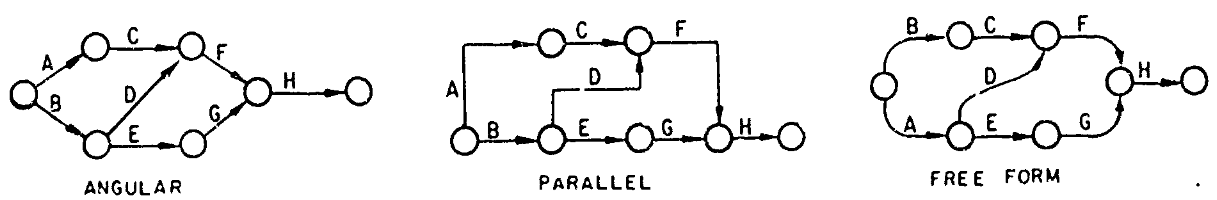
Figure 6-14.—Activities and events.

In figure 6-14, the starting point for activity C is the occurence of EVENT NO. (2). Event NO. (4) does NOT occur until the work represented by activity C and the work represented by activity D had been completed—and this means entirely completed. This indicates then, that the work represented by the activity F cannot start until activities C and D have been finished. If this does NOT accurately describe the situation, the arrow diagram must be redrawn. The graphic form used to illustrate the arrow diagram is a matter of battalion preference. NAVFAC and COMCBPAC/COMCBLANT are somewhat liberal about the form or specific technique used. Three of the more common graphic forms used in arrow diagraming are shown in figure 6-15.

Because everything that happens in network analysis is activity dependent, one activity is dependent upon others. The arrow diagram must be a meaningful description of the project. If it is NOT, results from the network analysis will be less than satisfactory. In almost every case of difficulty or dissatisfaction with network analysis, the cause can be traced to a faulty or unrealistic arrow diagram. Since everything in an arrow diagram is significant, the basic principles must be understood and applied completely.

### Principle Number 1

The first principle of arrow diagram development is that everything in the diagram has




117.309X

Figure 6-15.—Graphics forms used in arrow diagraming.

meaning. Within this principle, the following rules apply.

1. Every arrow represents an item of work and is referred to as an ACTIVITY. (See view A of fig. 6-16.)

2. An EVENT is the starting point of an ACTIVITY, shown as a circle. (See view B of fig. 6-16.)

3. An ACTIVITY depends upon and cannot begin until the completion of all preceding ACTIVITIES. (See view C of fig. 6-16.)

As illustrated in view D of figure 6-16, POUR FOOTINGS depends upon the completion of DIG & INSPECT FOOTINGS and ORDER & DELIVER REBARS.

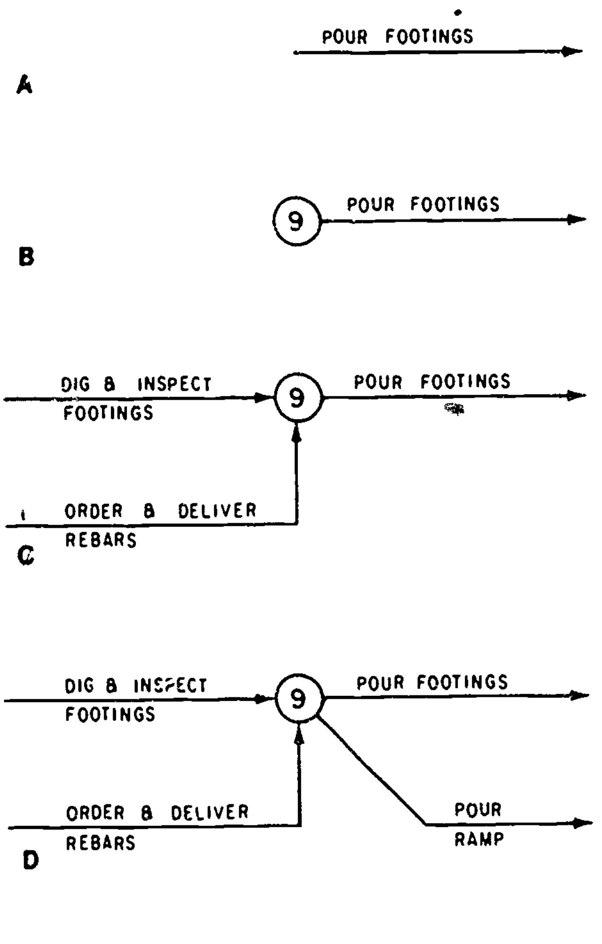
4. All activities that start with the same event depend upon and cannot begin until the completion of all activities that enter that event.

As illustrated in view D of figure 6-16, POUR FOOTINGS and POUR RAMP depend upon the completion of the two activities that enter their common starting event. In other words, it is impossible to POUR FOOTINGS or to POUR RAMP until DIG & INSPECT FOOTINGS, and ORDER & DELIVER REBARS have both been completed. The diagram indicates that all the footings, not just a few, must be dug and inspected, and all necessary rebars must be on hand, before either of the two activities starting with event (9) can begin.

In figure 6-17, all three activities that start with event (10) must wait until all activities that enter event (10) have been entirely completed. None of the three can possibly start until both OBTAIN PERMITS and the PRELIMINARY SURVEY have been finished. If one of the three leaving (10) does NOT depend upon the completion of both those entering (10), the arrow diagram is misdrawn and the schedules produced from it will NOT be realistic.

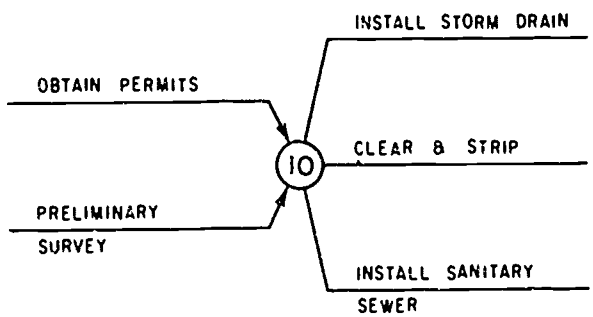
### Principle Number 2

A second principle is that an activity has a single definite starting point and a single



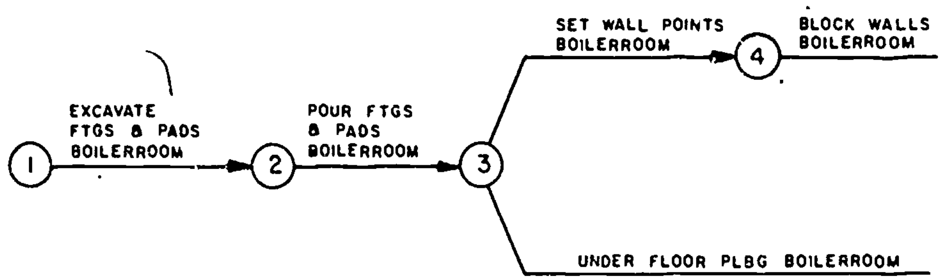

143.290X

**Figure 6-16.—Diagram development for principle number 1.**




117.314X

**Figure 6-17.—Three activities starting at a common event.**




117.315X

Figure 6-18.—Diagram development.

definite ending point. Placing an arrow in a diagram must satisfy two basic questions:

1. "What activities must be completed before this one can start?" This indicates the event from which to start the activity.

2. "What activities cannot be started if this one is NOT completed?" This indicates into which event the activity should enter.

Suppose, for example, the following arrow diagram (fig. 6-18) had been drawn.

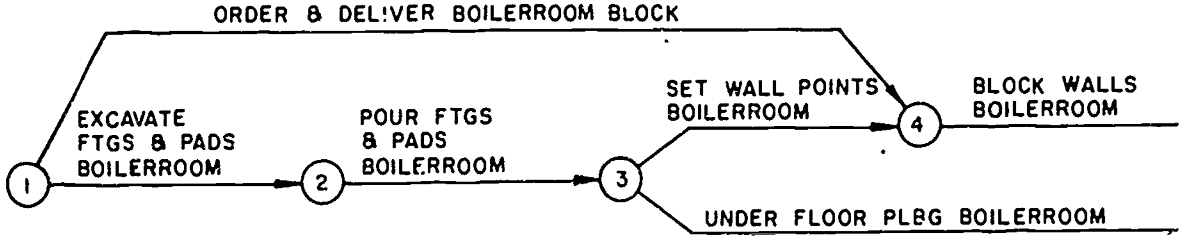
As shown, excavating for the footings and pads for the boilerroom is the first activity, followed by placing the concrete footings and pads. At event (3), and as a result of the completion of the previous activities, several independent work items then can commence.

Suppose, however, that it is desired to add an activity to indicate delivery of concrete block for the walls of the boilerroom. The first question asked about this new activity should be, "What must be finished before the block can be ordered and delivered?" Actually, there is nothing in the diagram that—if NOT accomplished—would hold up the ordering and delivery of block. The starting point for this activity would then be event (1).

The second question to be asked about the new activity is, "What cannot proceed until this activity is completed?" The answer is, of course, BLOCK WALLS, and the BOILERROOM. The termination point for this new activity then is event (4), and the results of the analysis described above would appear as illustrated in figure 6-19.

**Principle Number 3**

A third principle is that the arrow diagram does NOT describe time relationships, but rather describes dependency relationships. Generally, the arrow diagram is NOT drawn on a time



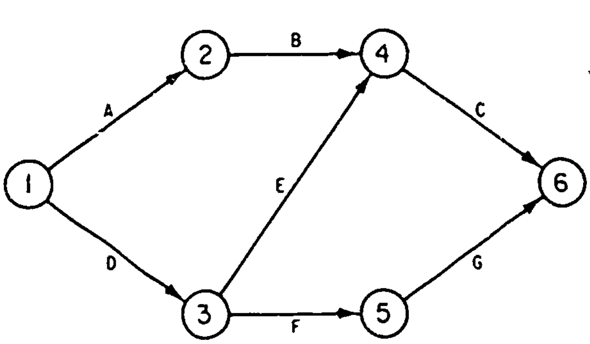

117.316X

Figure 6-19.—Adding an activity.

scale. That is, the length and direction of an activity arrow has no relationship to the amount of time required to accomplish the work represented by it. Likewise, two activities starting with the same event do NOT necessarily occur at the same time. In figure 6-20, the only thing known about activities A and D is that they are independent. They may or may NOT go on at the same time. The time that an activity takes place is decided in the scheduling phase, NOT by the arrow diagram. The arrow diagram merely defines the dependency situations that exist. In the illustration involving the concrete block for the boilerroom walls, for example, the activity ORDER & DELIVER BOILERROOM BLOCK starts with event (1), as does EXCAVATE FOOTINGS & PADS, etc. This does NOT mean that both activities must be conducted at the same time. They might but probably will not. The only thing indicated is that these two activities are independent.

### Principle Number 4

It is important to realize that the arrow diagram is seldom drawn by a single person. Because the accomplishment of the schedule produced from the arrow diagram is affected by many persons, all who have anything to do with the project must be consulted when the arrow diagram is created. All crew leaders should be asked to review the arrow diagram carefully to make certain that the activities pertaining to their work are accurately and realistically described. Also this principle applies equally to the production of duration estimates for the activities.




117.317X

Figure 6-20.—Dependency relationship.

## OTHER RULES AND CONVENTIONS

Notice in the illustrations thus far, that the events are all numbered. Numbering makes it possible to uniquely identify an activity and its position in the diagram. An activity is identified by using the event number at its tail, called the activity's "I", and the event number at its head, called the activity's "J". In the boilerroom illustration, POUR FOOTINGS & PADS-BOILERROOM could be referred to or identified as activity (2)-(3).

So that an activity can be uniquely identified by its "I" and "J" numbers, a rule must be established and observed in the creation of the arrow diagram. The rule can be stated as follows:

> "NOT MORE THAN ONE ACTIVITY MAY HAVE THE SAME "I" AND THE SAME "J."

To help observe this rule, it is sometimes necessary to use a "connector" type activity that does not really represent work. This type of activity, usually referred to as a DUMMY, is drawn as a dotted line. It indicates that NO work is involved in that activity.

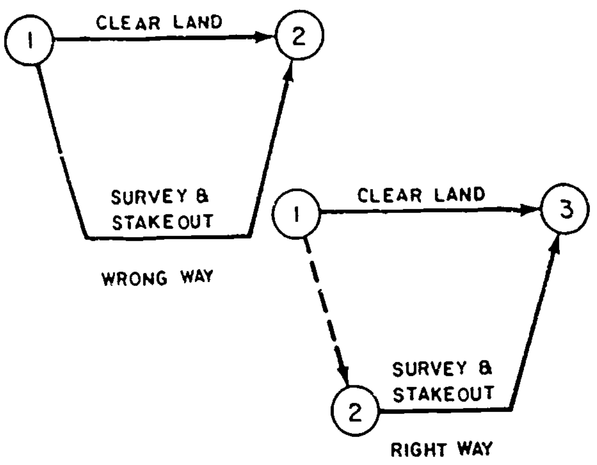
Figure 6-21 illustrates this rule and the use of the dotted-line (dummy) activity. The dotted-line activity represents the dummy and involves no duration and no cost. It serves only as a dependency connector or sequence indicator.

Dummies have purposes in addition to the one mentioned above and will be discussed in more detail later.

To produce a schedule by hand, you must make sure of two things that concern the numbering of events: (1) every number must be used, and (2) the number at the tail of an arrow must be less than the number at the head of that arrow.

It is always wise to refrain from numbering the diagram until it has been completed, reviewed, and approved.

Another rule governing the creation of the arrow diagram is that a project will have only




117.318X

Figure 6-21.—Activity identification.

one starting event and only one ending event. When nothing must be done prior to the start of an activity, the arrow representing that activity starts with the project's starting event. When nothing depends upon the accomplishment of an activity, its arrow ends with the project's ending event. Because of this rule, you always know where an activity belongs in the network. Furthermore, restricting the arrow diagram to one starting event and one ending event does NOT limit the number of starting or ending activities.

## ARROW DIAGRAM CONSTRUCTION PROBLEMS

This section is devoted to the solution of problems by network analysis with arrow diagraming. In problem solving, it is vital to draw properly the arrow diagram upon which network analysis is based. To do so, you must apply the basic principles of diagram preparation that are repeated here:

- Everything in the arrow diagram has significant meaning.
- An activity has a single definite starting point and a single definite ending point.
- The arrow diagram describes dependency relationships rather than time relationships.

Moreover, in applying the second principle above, you must ask two questions and know the answers to both What activities must be completed before this one can start? What activities cannot start until this one has been completed. The answer to the first question determines the event that starts the activity, whereas the answer to the second indicates at what event the activity ends.

## PROBLEM 1

To illustrate the arrow diagram with an actual problem, suppose that it was desired to install a drainage ditch in the backyard of a house. Assume for this problem that only one person was going to work on this project. Draw a diagram for this project including only the following activities:

1. DIG DITCH
2. PLACE GRAVEL IN BOTTOM OF DITCH
3. OBTAIN DRAINTILE
4. INSTALL DRAINTILE AND BACKFILL

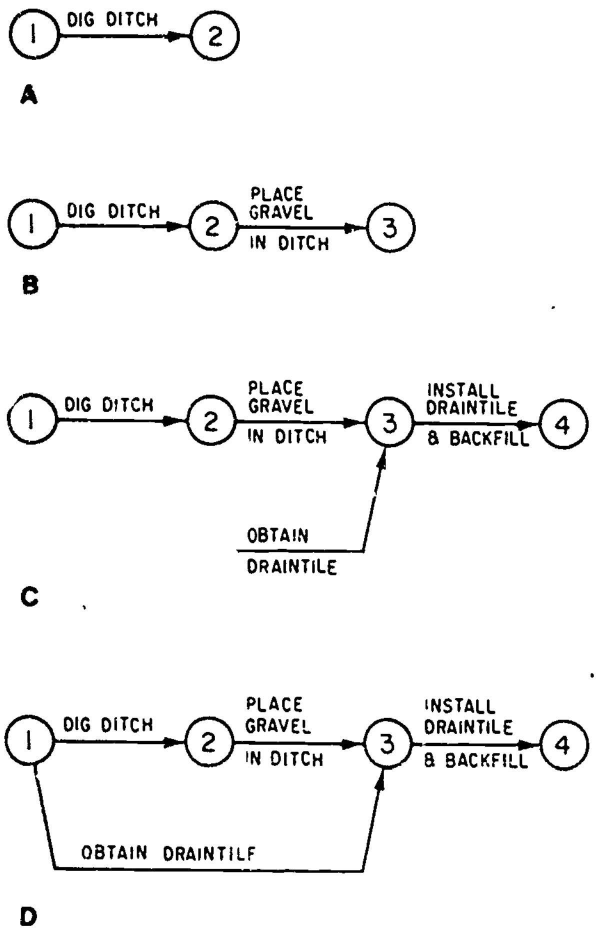
Make the following assumptions about these activities:

A. There is no need to order or deliver gravel. There is a supply in the driveway.

B. OBTAIN DRAINTILE does not require the effort of the one person doing this project. It is a "delivery" type activity.

The first activity possible in this project is DIG DITCH—so an activity indicating this would be drawn as illustrated in view A of figure 6-22.

After the ditch had been dug, the placing of the gravel would be next and the diagram would look like view B of figure 6-22.




143.291
**Figure 6-22.—Diagram development for problem 1.**

After the gravel is in, the draintile could be installed. However, in order for this to happen, the draintile must have been obtained. This means that the activity, OBTAIN DRAINTILE, must end at the beginning of INSTALL DRAINTILE AND BACKFILL. This will be at event (3) and the diagram would look like view C of figure 6-22.

The question remaining is where does OBTAIN DRAINTILE start? One must further ask what activities must be accomplished before this one can start. It turns out that nothing need be done in order to start this activity and it starts with event (1). The completed solution is illustrated in view D of figure 6-22.

**PROBLEM 2**

To create a slightly more complicated problem, consider the situation that would exist if the work described in problem 1 had been performed in the street in front of the house rather than in the backyard.

If this were the case, it would be necessary to add to the list of activities given for 1, the following:

5. OBTAIN PERMIT TO BLOCK STREET

6. BLOCK STREET

7. OBTAIN TRENCHER.

8. ORDER AND DELIVER PAVING MATERIAL

9. PAVE STREET

For this problem, the following assumptions are made in addition to A and B already mentioned in problem 1:

C. The permit is only necessary to block the street. There is no doubt that it will be obtained.

D. OBTAIN TRENCHER is a delivery type activity just as OBTAIN DRAINTILE was in problem 1.

The solution to this problem would start with the first activity that can take place. In this problem, four independent activities can be shown as starting the project. (See view A of fig. 6-23.) Which one goes where is not at all important. In the beginning, it may appear that all four activities are expected to start or take place at the same time. This is definitely NOT the case. The person drawing the diagram must realize and remember at all times that the arrow diagram does NOT describe time relationships but rather only dependencies. This diagram, so far states only that OBTAIN TRENCHER, OBTAIN PERMIT, OBTAIN DRAINTILE, and ORDER AND DELIVER PAVING MATERIAL are independent—that is, they can start at any time whether the activities have

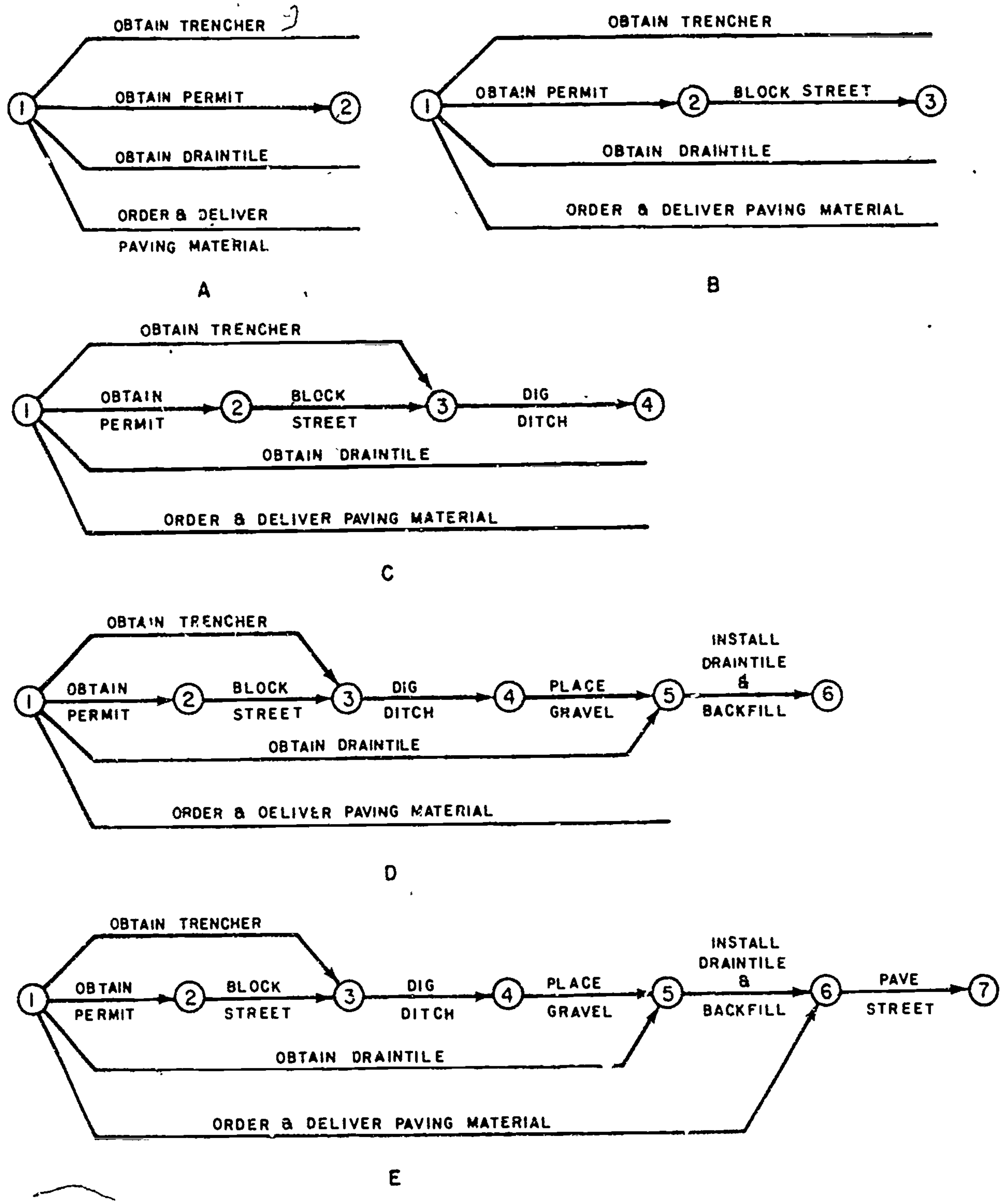



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Figure 6-23.—Diagram development for problem 2.

started or NOT. "When" these activities take place will be determined in the scheduling phase.

The next item that can be placed into the diagram is BLOCK STREET. The only thing that must be done before this activity can start is OBTAIN PERMIT. This new activity then starts with event (2) as shown in view B of figure 6-23.

The assumption that obtaining the permit was only a formality makes it possible to show OBTAIN TRENCHER, OBTAIN DRAINTILE and the PAVING MATERIAL ACTIVITY as starting with event (1). If this assumption had not been made, a prudent decision would have been to start these activities at event (2) so as to avoid spending money without being sure of the result.

After the street had been blocked, DIG DITCH could start. However, because the ditch is to be dug through the pavement, the trencher would have to be on hand. The arrow diagram indicating this would appear as shown in view C of figure 6-23.

From this point until the final activity, the diagram would be constructed as it was for problem 1, as shown in view D of figure 6-23.

The final activity would be the repair to the damage caused by tearing up the street. In order to pave, however, the paving materials would have to be on hand. This situation is described by making the event that starts PAVE STREET (6) and making the same event the end point for ORDER AND DELIVER PAVING MATERIAL. The final solution to this problem is illustrated in view E of figure 6-23.

An important point to remember about arrow diagrams is that the assumptions made about the activities are as important as the activities themselves. They should always be written down, so as to be remembered.

**PROBLEM 3**

Create an arrow diagram for a reinforced concrete equipment foundation project to be built partially below ground level. Assume that all necessary tools, equipment, and materials (including concrete are on the jobsite, and that there is no limit to the number of workers. A backhoe is used to excavate. Use only the following activities:

1. LAY OUT AND EXCAVATE
2. FINE GRADE
3. PREFABRICATE FORMS
4. PREFABRICATE REBAR
5. SET FORMS
6. SET REBAR AND ANCHOR BOLTS
7. ADVISE AVAILABILITY OF BACKHOE
8. POUR CONCRETE

For this problem, assume that FINE GRADE must be done before the forms are set.

One would start the arrow diagram with three independent activities, as indicated in view A of figure 6-24. Remember that the diagram does NOT indicate that these three items go on at the same time. It only shows that they are NOT dependent on the completion of any other activities.

After the layout and excavation had been completed, two activities could be started. FINE GRADE would depend upon the completion of this activity, and of course, the backhoe could NOT be returned until the completion of this phase of work. At this point, the diagram would appear as indicated in view B of figure 6-24.

Again, the diagram is NOT stating that FINE GRADE and that ADVISE AVAILABILITY OF BACKHOE occur simultaneously, but rather that they both depend upon—cannot start until—the completion of LAYOUT AND EXCAVATE.

After FINE GRADE had been completed, and when PREFAB FORMS was finished, SET FORMS could start. At its conclusion, and after PREFAB REBAR had been completed, it would be possible to SET REBAR and ANCHOR BOLTS and then finally POUR. The final arrow diagram would look like view C of figure 6-24.

## DUMMIES

Occasionally, it is necessary to use a "connector" type activity to indicate a dependency relationship without causing confusion. This type of activity, which does NOT represent work and which has a duration of zero, is called a DUMMY activity and is shown on the arrow diagram as a dotted line.

There are two reasons for using dummies. These two reasons can be illustrated by altering problem 3 above. Suppose that instead of having a single activity called SET REBAR AND ANCHOR BOLTS, it was desired to make two activities: one called SET REBAR and the other called SET ANCHOR BOLTS. Suppose that both depended upon PREFAB REBAR, and SET FORMS, and that both had to be completed before the POUR. The affected part of the diagram would appear as illustrated in view A of figure 6-25.

From a dependency point of view, there is nothing wrong with this kind of description. However, confusion results from having more than one activity with the same I – J numbers. It is NOT clear which is activity (4) – (5). Earlier in this chapter, a rule was

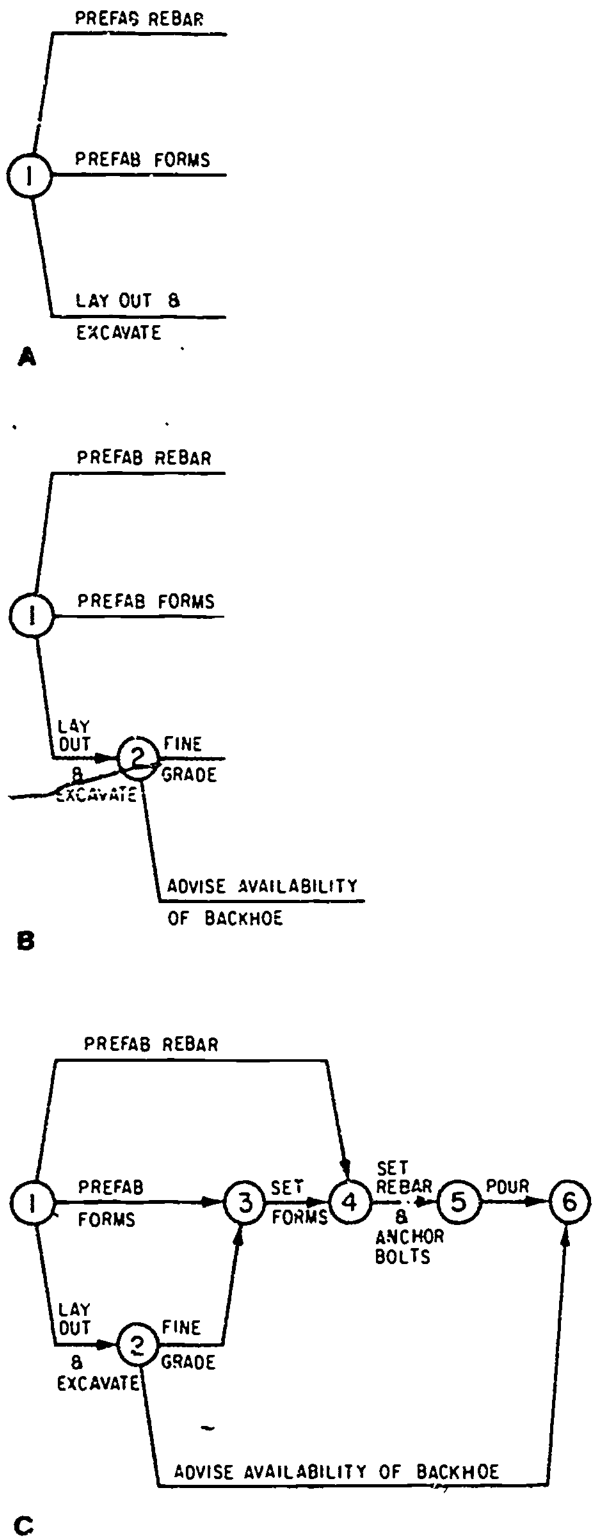


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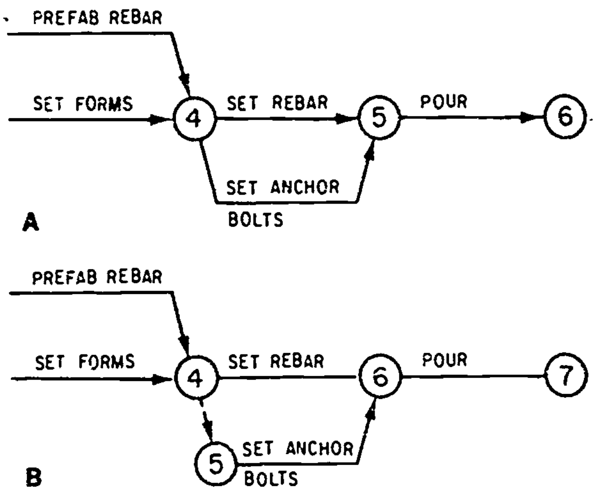
Figure 6-24.—Diagram development for problem 3.




117.325X
Figure 6-25.—Using a dummy to maintain the uniqueness of the I – J identification system.

established to solve this problem. It was stated that not more than one activity may have the same "I" and the same "J." So as NOT to break this rule, one of the two "nonunique" activities must be changed into two, one of which is a dummy. The affected part of the diagram would now appear as illustrated in view B of figure 6-25.

If view B of figure 6-25 is examined closely, the following points become clear:

1. Event (6) occurs when SET REBAR and SET ANCHOR BOLTS have been completed.

2. Since the DUMMY from (4) to (5) activity has zero duration, it is completed at the same point in time that event (4) occurs.

3. For this reason, event (5) occurs when SET FORMS is finished and PREFAB REBARS is finished, and SET ANCHOR BOLTS can start at this time.

4. This is exactly the same dependency statement that was made in the incorrect solution illustrated in view A of figure 6-25, in which two activities from (4) – (5) appeared.

The first reason for using a dummy then is to maintain the uniqueness of the I – J identification system.

The second reason for using a dummy is somewhat more complex. A connector type activity is sometimes needed to describe dependencies in such a way that nondependent activities are NOT shown as dependent. This can be illustrated also with the diagram from problem 3.

If the problem were changed by eliminating the assumption that FINE GRADE had to precede the setting of the forms, one would be tempted to produce an arrow diagram that looked like view A of figure 6-26.

This approach, however, is incorrect because it is NOT possible to set forms unless at least the excavating has been completed. Another solution—which is also incorrect—might be to combine event number (2) and event (3). Event (3) would then appear as in view B of figure 6-26.

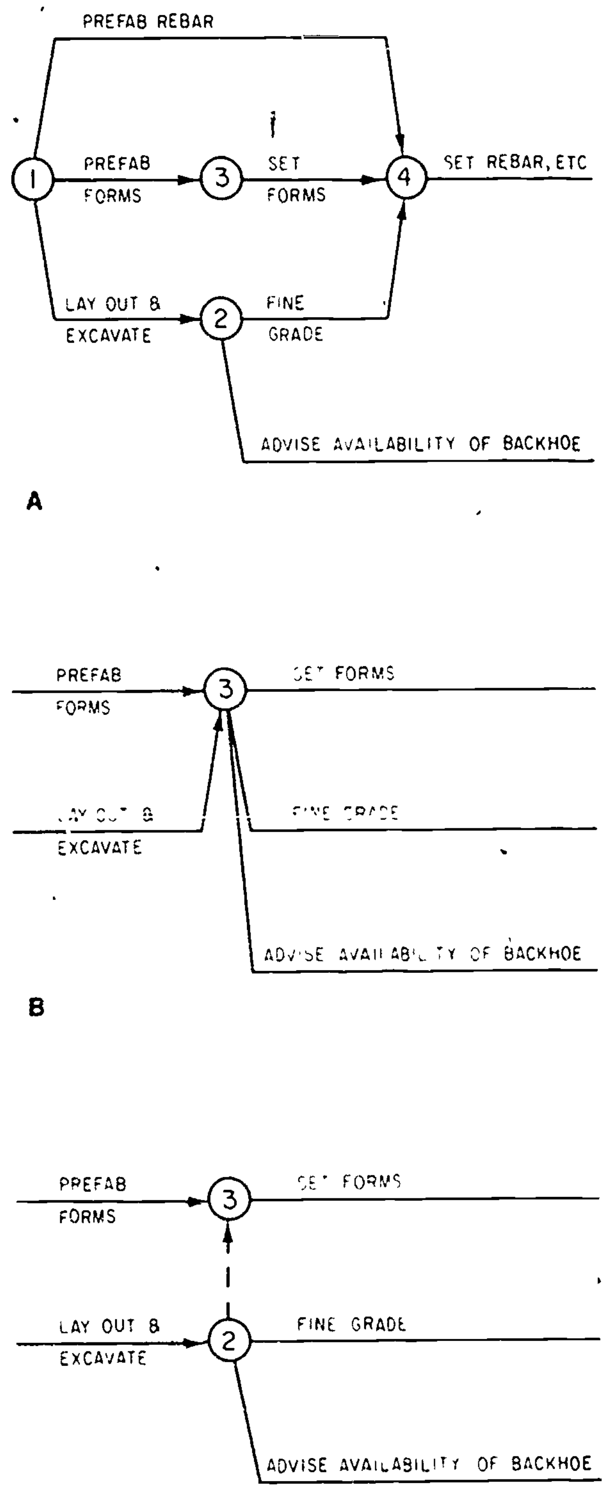



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**Figure 6-26.—Using a dummy to establish a dependency or sequence without confusing nondependent activities.**

The error in this arrow diagram exists because FINE GRADE and ADVISE AVAILABILITY OF BACKHOE do NOT depend upon the completion of PREFAB FORMS as indicated, but rather only on LAY OUT AND EXCAVATE.

The correct solution is one in which set forms is indicated as depending upon both PREFAB FORMS as well as on LAY OUT AND EXCAVATE, and in which FINE GRADE and ADVISE AVAILABILITY OF BACKHOE depend only on LAY OUT AND EXCAVATE. The proper way to show this situation is by using the first solution with a DUMMY from (2) to (3), as illustrated in view of C of figure 6-26.

Because the DUMMY from (2) to (3) has a zero duration, it is finished when event (2) occurs. It merely transfers, then the dependency relationship—the sequence—desired to event (3).

The second reason for using a DUMMY is to establish a dependency or sequence without confusing nondependent activities.

### DUMMY PROBLEM

Go back to the very first problem in this section. There it was assumed that only one person would work on the job. If the job is broken into segments to show how several crews would get the job done, the activity list could be almost doubled. Assume for this problem that each of those original activities will now be done in two phases. That is, approximately half the ditch will be dug before the "gravel crew" will start placing gravel, and the gravel will be in half the ditch before the crew installing the draintile can start work. The activity list would then consist of the following items:

1. OBTAIN DRAINTILE
2. DIG DITCH FIRST HALF
3. DIG DITCH SECOND HALF
4. PLACE GRAVEL FIRST HALF
5. PLACE GRAVEL SECOND HALF
6. INSTALL DRAINTILE FIRST HALF
7. INSTALL DRAINTILE SECOND HALF

It must be assumed for this problem that the first half of each job will be finished before the second half starts. Assumed also is that OBTAIN DRAINTILE is a delivery type of activity and that the ditch will be backfilled as part of the INSTALL DRAINTILE operation.

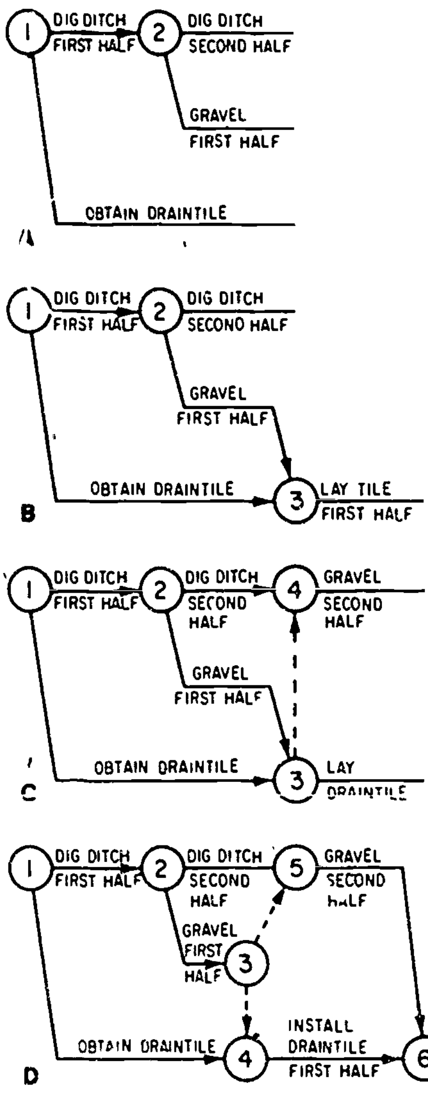
The initial activities would be drawn in as illustrated in view A of figure 6-27.

This arrangement of activities indicates that when DIG DITCH FIRST HALF is complete, two activities can start—DIG DITCH SECOND HALF and GRAVEL FIRST HALF. Independently, OBTAIN DRAINTILE can occur any time after the start of the project.

When the gravel is in the first half of the ditch, if the draintile is on hand, the draintile can be installed. The diagram would grow to look like view B of figure 6-27.

When the second half of the ditch had been dug, the gravel could be placed. However, the assumption was made that the first half of any job would have to be completed before starting the second half. This causes a problem insofar as the present version of the diagram is concerned. It is desired to show that GRAVEL SECOND HALF depends upon DIG DITCH SECOND HALF and GRAVEL FIRST HALF. Tying this new activity to the ditch digging operation is no problem but difficulties arise when GRAVEL FIRST HALF is considered. The problem is caused by the fact that GRAVEL FIRST HALF has been tied into event (3). If the end of GRAVEL FIRST HALF is connected to the beginning of GRAVEL SECOND HALF, and a dummy is about the only way this could be done, a serious sequence error is committed.

The diagram, as it appears in view C of figure 6-27, indicates that GRAVEL SECOND HALF cannot start until OBTAIN DRAINTILE has been completed. That is, the diagram states




143.292

**Figure 6-27.—Diagram development for expanded drainage ditch problem.**

that it is impossible to place gravel unless draintile is on hand. No such assumption was made, so this is incorrect.

The problem is solved by rearranging the diagram as originally created and splitting GRAVEL FIRST HALF into two paths. Dummy activities are required to do this. The final solution to this expanded drainage ditch problem appears in view D of figure 6-27.

## NETWORK ANALYSIS SCHEDULING

After a project has been planned on an arrow diagram, the next phase is to schedule the project—that is, place it on a working timetable. This makes it possible to determine when each of the various activities must be performed, when deliveries must take place, how much, if any spare time there is for each activity, and when completion of the project may be expected. It will also be possible to determine which activities are critical and to what extent a delay in one activity will affect succeeding activities. The steps taken in this phase determine whether or NOT network analysis will be used successfully.

## DURATION ESTIMATES

Developing a schedule for a project involves estimating the time it will take to complete each activity, called the duration time. Duration time estimates are also used to identify activities that control the time needed to finish the project. These are the critical activities that collectively make up the "critical path," which is the longest path—in terms of time—through the network. Since duration times of critical activities are added to determine the duration of the project, delaying a critical activity will increase the total duration time. Conversely, speeding up a critical activity will decrease the total duration time.

Duration estimates can be made in several ways, but always on an individual activity basis. The simplest way is to determine the "normal" amount of time needed to finish the activity, and assuming that the usual number of crewmembers or pieces of equipment are available.

In the arrow diagram of figure 6-28, duration times have been assigned to each of the activities. This diagram contains three paths, one of which consists of activities A, B, and C. It indicates that A, a 12-day activity, must be finished before 4-day activity B can begin, and that B must be finished before 8-day activity C can start. The time required to complete these

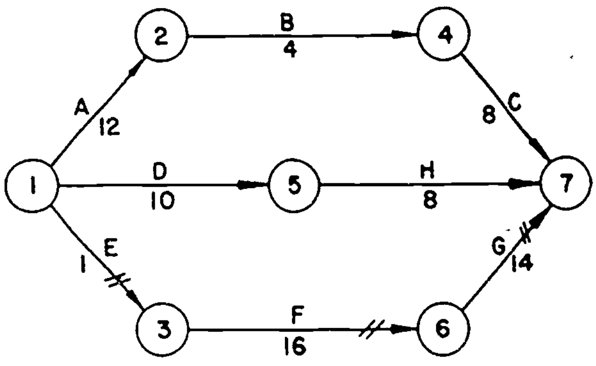



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Figure 6-28.—Determining the critical path.

activities equals the total of their duration times (12 + 4 + 8) or 24 days.

A second path through this network is made up of activities E, F, and G. This path requires a total of 31 days to finish, (1 + 15 + 14).

A third path in the network is also possible. It is made up of activities D and H. The duration of this path is 10 + 8, or 18 days.

The longest path in time through the network illustrated is thus E, F, and G. This then is the critical path and is indicated by small double slants on the arrows. If it is desired or required that the amount of time needed to complete the project be shortened, these are the activities upon which to concentrate. Noncritical activities are strictly dependent upon the completion of the critical items, so speeding up noncritical activities is of NO value at all, in terms of project duration.

It turns out generally that a very small number of activities make up the critical path—usually less than 30 percent of the total activities. This means that a large percentage of the activities in a project have extra time available—since they are, in a sense, waiting for the critical items to be completed. A project manager can adjust noncritical activities to take best advantage of weather conditions, manpower and equipment availabilities, and other items, without delaying the project.

An important point to remember in network analysis is that there is NOT necessarily only one critical path. There may be several. Also, remember that if a critical path is shortened, a new "parallel" path will most likely become critical. In the simplified example illustrated in figure 6-29, the critical path goes through the top activities. If these are shortened by only one day, however, the bottom path becomes a parallel critical path. Any further reducing of the amount of time required to get the project finished would have to be done on both critical paths.

In studying an arrow diagram, project managers and others want to pick out important or significant conditions or events quickly. To enable them to do this, you may be asked to identify the key events as "milestones." A MILESTONE may be indicated by the use of a slightly different symbol, or may be shown as a regular event with a special notation on the diagram as to its significance, such as "interior wiring completed" or "roof completed."

## EARLIEST EVENT TIMES

The earliest time at which an event can occur is the sum of the durations of the activities on the LONGEST PATH leading up to the event. This time is entered in a box next to the event on the arrow diagram, as shown in figure 6-30.

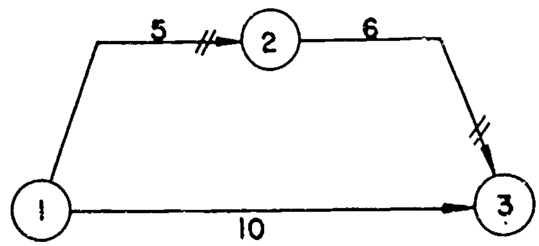


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Figure 6-29.—Simplified example.

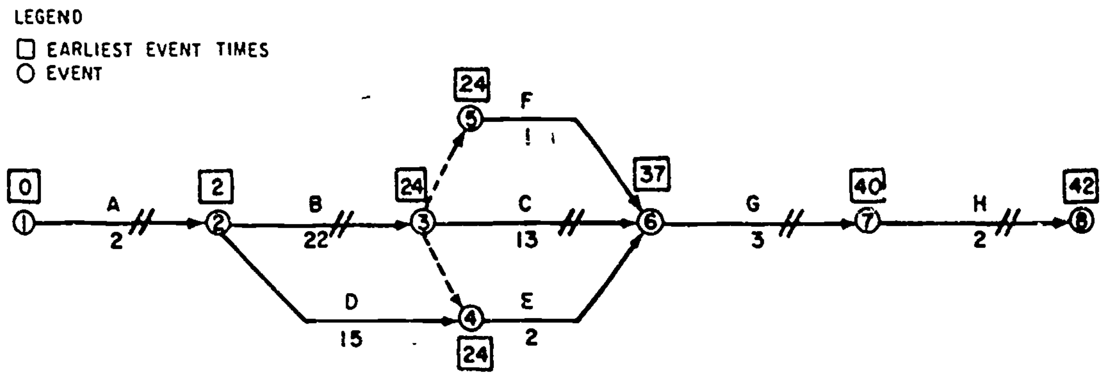


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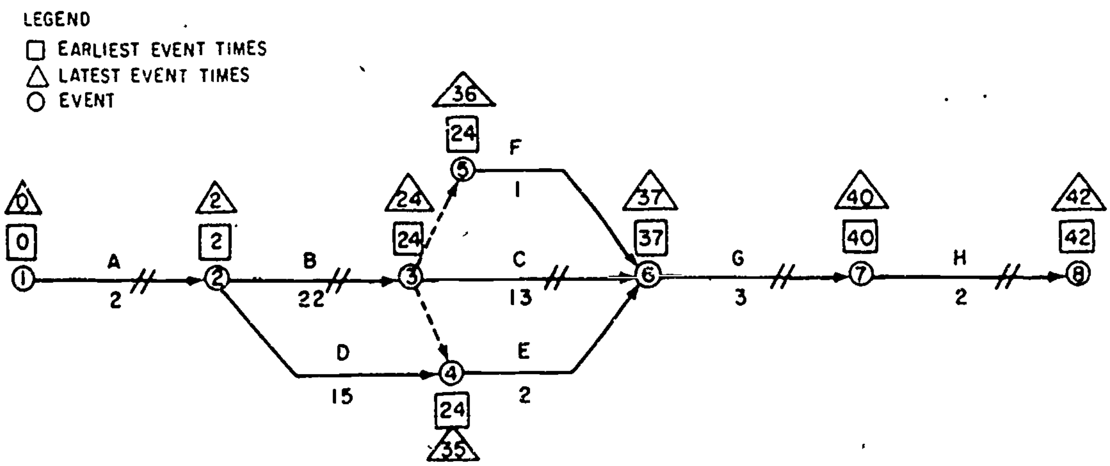
Figure 6-30.—Earliest event times on arrow diagram.

The times shown are project times—that is, successive WORKING DAYS, NOT successive calendar days, reckoned from 0 at the tail of the first arrow. The duration of the first activity in figure 6-30, is 2 days; therefore, event (2) occurs at project time 2. The time for event (3) is the sum of the duration times of activities (1) – (2) and (2) – (3) or 24. However, there are two paths leading to event (4): one from event (1) through (2) and (3) for a total of 24. Following the rule of selecting the longest path, the earliest event time for event (4) is 24. Similarly, three paths lead to event (6), and the longest from event (1) through (2) and (3) is selected, giving an earliest event time for event (6) of 37.

## LATEST EVENT TIMES

To calculate latest event times, you start with the last event on the arrow diagram and work from right to left. First, determine the latest time at which the last




82.107

Figure 6-31.—Latest event times on arrow diagram.

event can occur. This is the same as the earliest time for that event, which you already found. For example, the latest time for event (8), the last event in figure 6-31, is 42 since the earliest time for this event is 42. (See fig. 6-30.) Next, find the latest times at which other events on the diagram can occur. Do so for each of these events by subtracting the duration of an activity from the latest time at which the immediately following event can occur. For example, the latest time for event (7) in figure 6-31 is found by subtracting the duration of activity (7) – (8), which is 2, from the latest time of event (8), which is 42, to get 40. Likewise, the latest time for event (6) is 40 – 3 or 37.

To continue, the latest time for event (5) equals the latest time for event (6) minus the duration of activity (5) – (6). The result is 37 – 1 or 36. You find the latest time for event (4) in the same way, except that the duration of activity (4) – (6) is subtracted from the latest time of event (6). In this case, 37 – 2 or 35 is the latest time of event (4). And so on for events (2) and (1).

Note that for an activity on the critical path the earliest event time and the latest event time are the same; it is only for activities NOT on the critical path that these event times differ. It follows that identical earliest and latest event times are another means of identifying activities on the critical path.

## EARLIEST AND LATEST JOB START AND FINISH TIMES

Figure 6-32 shows a fully developed arrow diagram for the project of building an arch-type magazine with all activities included, with earliest and latest event times inscribed. With earliest and latest event times established, earliest and latest starts and finishes for activities can be determined.

In figure 6-32, for example, what are the latest and the earliest days on which waterproofing of the topside of the arch can be started? What are the earliest and latest days on which the installation of the ventilator can be started?

Before either of these jobs can begin, the stripping of the arch forms, which is activity (9) – (10), must be completed. This activity is on the critical path, and it will be completed at project time 24. The waterproofing of the arch and the installation of the ventilator must be completed by project time 37, if the project is NOT to be delayed.

The waterproofing is a 2-day job. It can begin as early as day 25 (day of completion of stripping of arch forms plus 1), or as late as day 36 (final deadline for completion minus 2 plus 1). It can be completed as early as day 26 or as late as day 37. Similarly, the installation of the ventilator can begin as early as day 25 or as late as day 37, and can end as early as day 25 or as late as day 37.

The rules for calculating start and finish days for an activity, then are as follows:

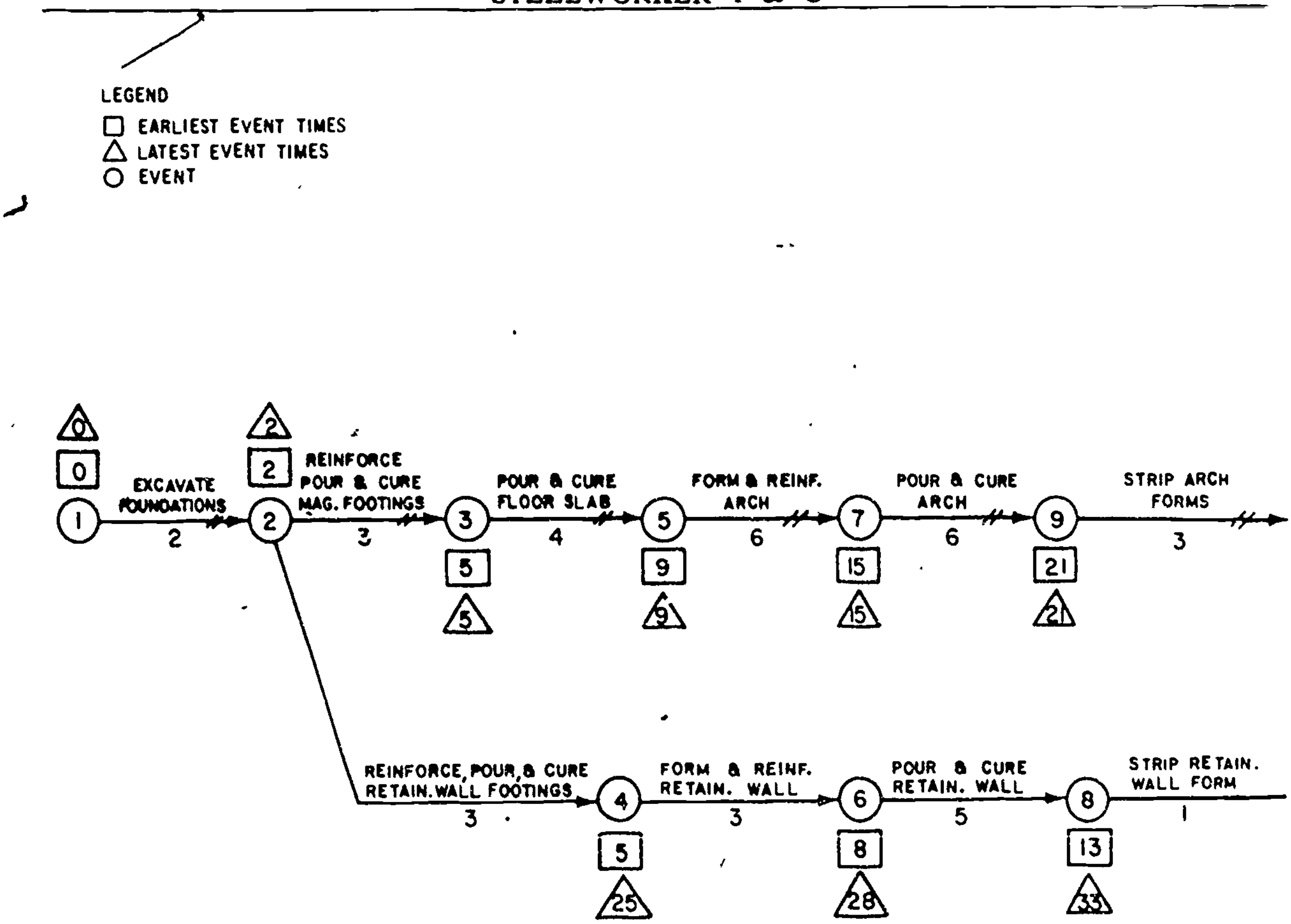
Earliest start day: earliest event time at the tail of the arrow plus 1.

Earliest finish day: earliest start time plus job duration.

Latest start day: latest event time at the head of the arrow minus job duration plus 1.

Latest finish day: latest event time at the head of the arrow.

To calculate earliest finish days, you work from left to right of the diagram, adding job durations to earliest event times. To calculate latest start times, you work from right to left, subtracting job duration from preceding latest event time.




Results are entered in a schedule as shown in figure 6-33. This schedule assumes that all jobs will be started as early as possible.

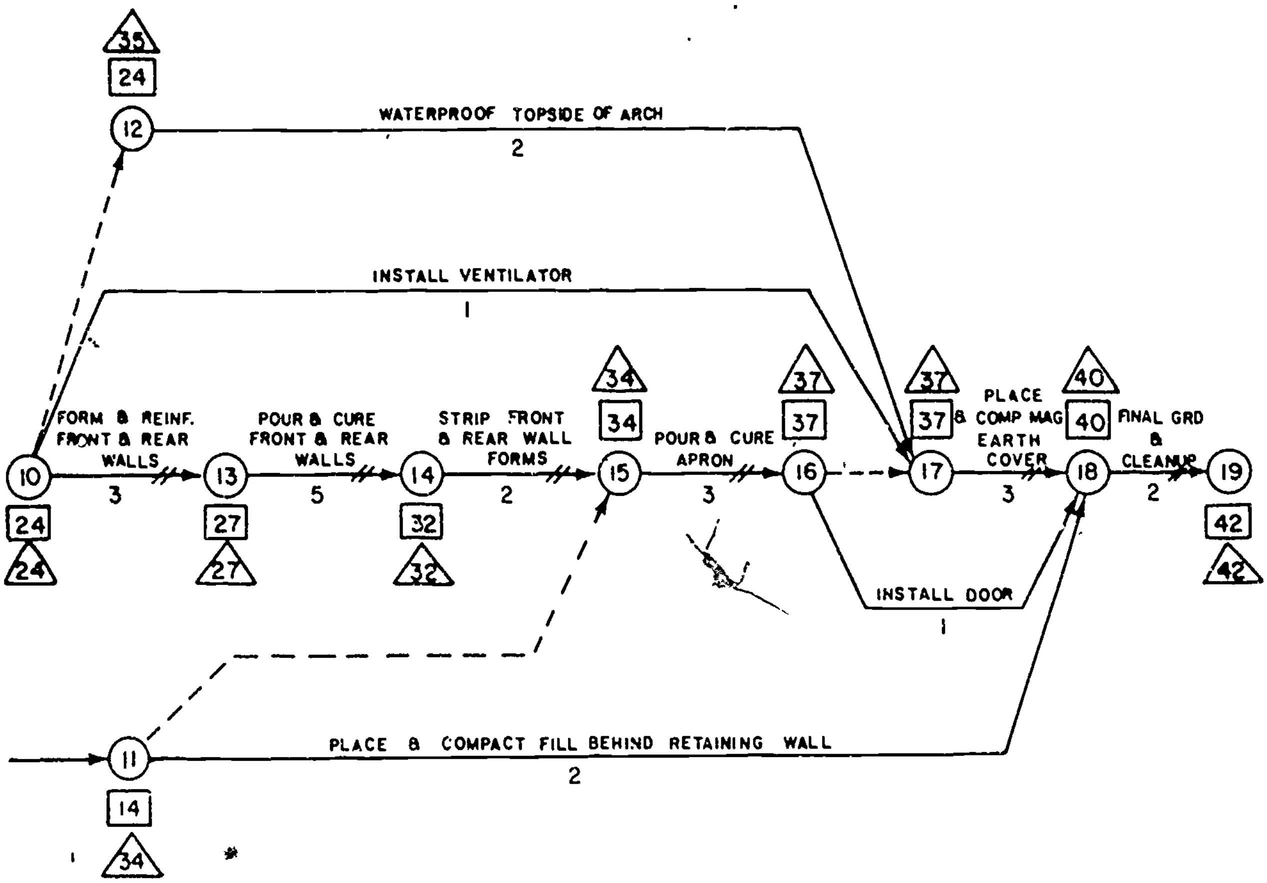
## CONCEPT OF SLACK

The spare time available to perform a task, such as the installation of a ventilator, is called slack. Properly controlled, the manipulation of slack is valuable in determining the most efficient use of the work force, equipment, and material. The existence of slack allows latitude in the time of the jobs with which it is associated. On the other hand, a job having NO slack is inflexible; it must start and end precisely at specific times or the completion of the project will be affected.

### Rule for Calculating Slack

In figure 6-32, the task of installing the ventilator has 12 days of slack, because it is a 1-day job and there are 13 days available in which it may be performed. Similarly, the waterproofing task in the same figure has 11 days of slack. To calculate slack, subtract both the duration and the earliest event time at the tail of the arrow from the latest event time at the head of the arrow. For activity (6) – (8), for example, the slack come to 33 – 8 – 5, or 20.

Each of the noncritical activities along the path from event (2) to event (11) has 20 days of slack when considered independently. However, there are only 20 days of slack




82.108.1

Figure 6-32.—Diagram for high-explosive magazine.

available for the whole chain, calculated as follows:

34 − 2 − (3 + 5 + 1) = 34 − 2 − 12 = 20.

The reason that when slack calculated independently for each separate activity, it is assumed that all the preceding activities were started as early as possible. However, as soon as any slack is used, the slack available to subsequent activities is correspondingly reduced.

Suppose, for example, that activity (4) − (6) was delayed for 3 days. The succeeding activity (6) − (8) would have 3 days added to its earliest event time and subtracted from its slack. The slack for activity (6) − (8) would then be 33 − 11 − 5, or 17.

### Use of Slack in Allocation of Manpower and Equipment

In the construction of the high-explosives magazine diagramed in figure 6-32, there are three jobs of form stripping to be done. The stripping of the arch is critical, and must be performed between project times 21 and 24. Similarly, the stripping of the front and rear wall forms must be done between day 32 and day 34. However, the stripping of the retaining wall forms is a 1-day job which may be done at any time between project time 13 and project time 34. Obviously, the crew should be scheduled to strip the retaining wall at a time when they are not busy with the arch or front and rear wall forms. Similarly, the pouring and curing should

| JOB | PROJECT DAY | | | | REMARKS |
|---|---|---|---|---|---|
| | START | | FINISH | | |
| | EARLIEST | LATEST | EARLIEST | LATEST | |
| (1, 2) | 1 | 1 | 2 | 2 | critical |
| (2, 3) | 3 | 3 | 5 | 5 | critical |
| (2, 4) | 3 | 23 | [illegible] | 25 | |
| (3, 5) | 6 | 6 | 9 | 9 | critical |
| (4, 6) | 6 | 26 | 8 | 28 | |
| (5, 7) | 10 | 10 | 15 | 15 | critical |
| (6, 8) | 9 | 29 | 13 | 33 | |
| (7, 9) | 16 | 16 | 21 | 21 | critical |
| (8, 11) | 14 | 34 | 14 | 34 | |
| (9, 10) | 22 | 22 | 24 | 24 | critical |
| (10, 13) | 25 | 25 | 27 | 27 | critical |
| (10, 12) | 25 | 37 | 25 | 37 | |
| (11, 18) | 15 | 39 | 16 | 40 | |
| (12, 17) | 25 | 36 | 26 | 37 | |
| (13, 14) | 28 | 28 | 32 | 32 | critical |
| (14, 15) | 33 | 33 | 34 | 34 | critical |
| (15, 16) | 35 | 35 | 37 | 37 | critical |
| (16, 18) | 38 | 40 | 38 | 40 | |
| (17, 18) | 38 | 38 | 40 | 40 | critical |
| (18, 19) | 41 | 41 | 42 | 42 | critical |

82.109

Figure 6-33.—Project schedule for arrow diagram shown in figure 6-32.

be scheduled so as to take advantage of the slack in activity (6) – (8). By starting activity (6) – (8) 1 day after its earliest start time, it can be performed concurrently with activity (5) – (7). Thus, by using up a day of slack, more efficient use is made of the crew and equipment.

### Adjustment of Slack

Earliest and latest event times shown in the arrow diagram (fig. 6-32) were changed to reflect the days dropped out as a result of weekend curing. A check was then made to insure that the critical path was still the same, since shortening the original critical path might cause another to take its place. Next, the slack was recalculated, and the new slack values were entered in the timetable (fig. 6-34). Notice that on the timetable, activity (11) – (18) and activity (17) – (18), both of which consist of placing and compacting fill (see fig. 6-32), are scheduled about a month apart. Since activity (11) – (18) shows 20 days of slack, however, and since the same equipment will be used for both activities, activity (11) – (18) should be scheduled to end the day before the critical activity (17) – (18) begins.

## PREPARING A TIMETABLE

After the arrow diagram has been completed and the slack has been calculated, a timetable

| JOB | PROJECT DAYS | | CALENDAR DAYS | | SLACK |
|---|---|---|---|---|---|
| | START | DURATION | START | FINISH | |
| ( 1, 2) | 1 | 2 | March 1, Thurs. | March 2, Fri. | 0 |
| ( 2, 3) | 3 | 3 | March 5, Mon. | March 7, Wed. | 0 |
| ( 2, 4) | 3 | 3 | March 5, Mon. | March 7, Wed. | 16[2] |
| ( 3, 5)[1] | 6 | 4 | March 8, Thurs. | March 11, Sun. | 0 |
| ( 4, 6) | 6 | 3 | March 8, Thurs. | March 12, Mon. | 16[2] |
| ( 5, 7) | 10 | 6 | March 12, Mon. | March 19, Mon. | 0 |
| ( 6, 8) | 9 | 5 | March 13, Tues. | March 17, Sat. | 16[2] |
| ( 7, 9) | 16 | 6 | March 20, Tues. | March 25, Sun. | 0 |
| ( 8, 11) | 14 | 1 | March 19, Mon. | March 19, Mon. | 16[2] |
| ( 9, 10) | 22 | 3 | March 26, Mon. | March 28, Wed. | 0 |
| (10, 12) | — | 0 | — | — | 0 |
| (10, 13) | 25 | 3 | March 29, Thurs. | April 2, Mon. | 0 |
| (10, 17) | 25 | 1 | March 29, Thurs. | March 29, Thurs. | 11[2] |
| (11, 15) | — | 0 | — | — | 0 |
| (11, 18) | 15 | 2 | March 20, Tues. | March 21, Wed. | 20[2] |
| (12, 17) | 25 | 2 | March 29, Thurs. | March 30, Fri. | 10[2] |
| (13, 14)[1] | 28 | 5 | April 3, Tues. | April 7, Sat. | 0 |
| (14, 15) | 33 | 2 | April 9, Mon. | April 10, Tues. | 0 |
| (15, 16) | 35 | 3 | April 11, Wed. | April 13, Fri. | 0 |
| (16, 18) | 38 | 1 | April 16, Mon. | April 16, Mon. | 2 |
| (17, 18) | 38 | 3 | April 16, Mon. | April 18, Wed. | 0 |
| (18, 19) | 41 | 2 | April 19, Thurs. | April 20, Fri. | 0 |

[1]Curing scheduled for weekend.

[2]Adjusted to reflect weekend curing.

82.110

Figure 6-34.—Timetable from arrow diagram shown in figure 6-32.

like the one shown in figure 6-34 can be prepared. This is a timetable derived from the arrow diagram shown in figure 6-32. Obviously, project day 1 falls on 1 March, a Thursday. No work is done on Saturdays or Sundays; therefore, though project days 1 and 2 fall on Thursday and Friday, 1 and 2 March, project day 3 falls on Monday, 5 March. As you can see, however, Saturdays and Sundays are included in the calendar when they can be utilized as curing time for concrete jobs. When this is done, such a Saturday or Sunday becomes a project day, and if the day relates to a job on the critical path, the effect is to gain time by cutting a day from the schedule. In figure 6-34, 5 days were cut from the critical path by scheduling concrete work so that curing could occur on weekends.

For example, activity (3) – (5) consisted of placing and curing the magazine footings. It was started on Thursday, so that curing could be scheduled for Saturday and Sunday. Since this job was on the critical path, the use of Saturday and Sunday for curing cut 2 days from the schedule.

## MONITORING AND CONTROL

The arrow diagram produced at the beginning of a project should NEVER be considered as fixed for the duration of the project. If the full benefit of the critical-path method is to be realized, the diagram must be updated regularly in accordance with circumstances, generally weekly or every other week, but even oftener than weekly for high-priority complex projects

A feedback system must be established to provide the operations officer with changed information about current job progress. As a project proceeds, it may be discovered that the original estimates of the times required to complete activities were NOT accurate or that deliveries cannot be made on time, or that anticipated work force will NOT be available. Correction of the arrow diagram to reflect the true picture will induce change, such as changes in completion date, critical path, intermediate target dates, slack for noncritical activities, and critical manpower or equipment schedules.

Occasionally, there may be design changes which may lead to the addition of new activities, the cancellation of previously planned activities, or the necessity for making a more detailed breakdown of work elements on the arrow diagram. Such changes may result in a shift of the critical path, or in new target dates; or they may make it necessary for certain parts of the project to be expedited in order to keep on schedule.

Crew leaders should report regularly on current work in progress. A WORK PROGRESS REPORT should include:

The completion date of each activity
The beginning date of each activity
Significant delays in current activities
Estimated number of man-days required to complete current activities

This information enables the operations officer to spot trouble areas immediately and to take corrective action. A suggested work progress report is shown in figure 6-35.

## RESOURCES ALLOCATION

Until now, it has been assumed that whatever personnel, materials, and equipment were required would be available to perform an activity in the allotted time. In practice, this is seldom the case, and it is often necessary to plan for the best allocation of a resource which is in short supply. An example of such a resource is the work force.

One person is often NOT qualified to do another's job—or, at least, a person NOT qualified to do another's job will do it less efficiently than the fully qualified person. Therefore, the work force must be considered in terms of the qualifications or ratings of available personnel. As an example, take the erection of a temporary steel and timber warehouse. The arrow diagram for this job is shown in figure 6-36. For the sake of simplicity, it is assumed that only Builders, Equipment Operators, and Steelworkers will be used on the job.

PROJECT STATUS REPORT

| ACTIV, ITY (I, J) | BRIEF DESCRIPTION | DURA-TION | SCH. STAR. | ACT. STAR. | SCH. COMP. | TIME TO DATE | TIME REQ. TO COMP. | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
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REPORT DATE ____________

SHEET ______ OF ______

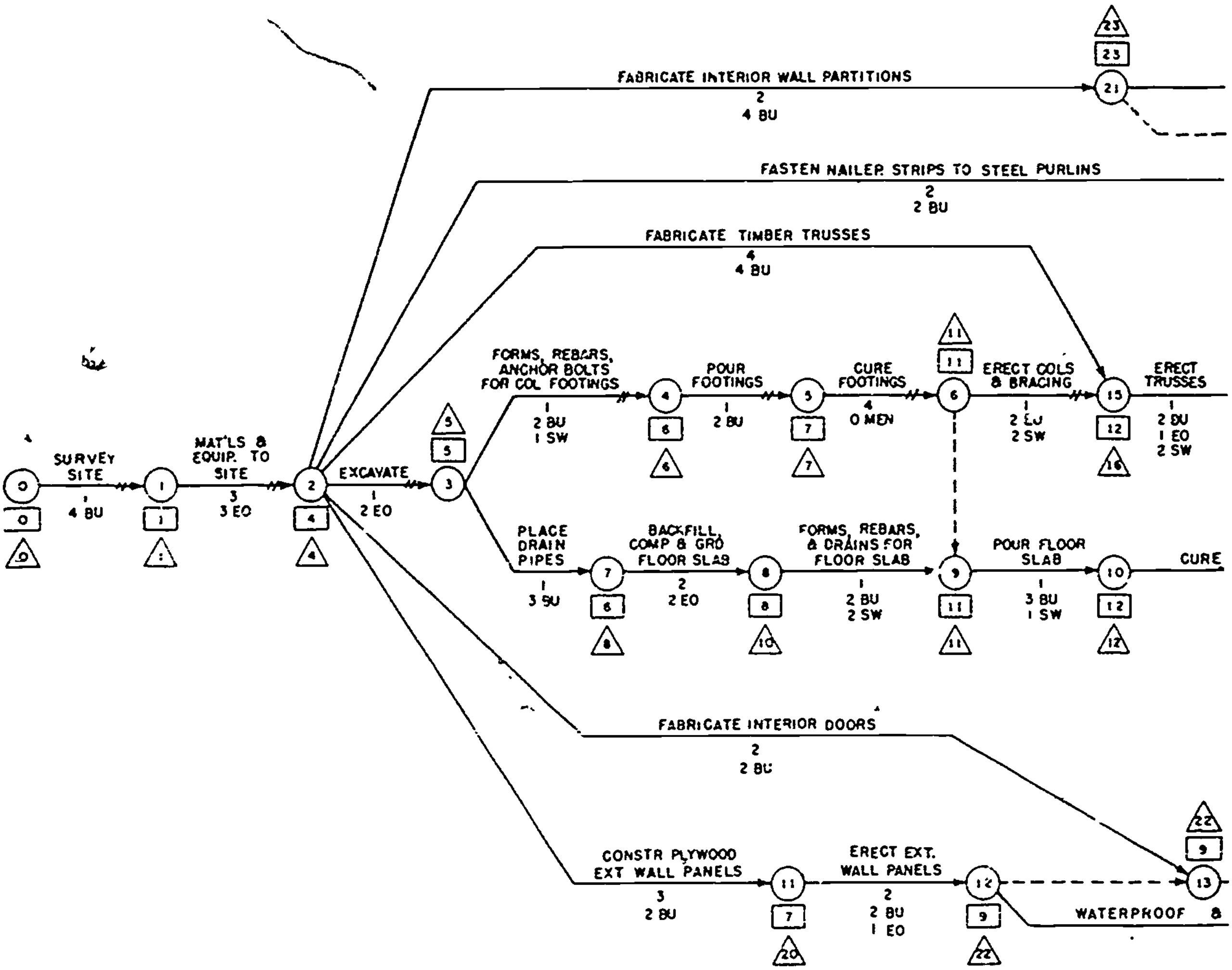
82.111

Figure 6-35.—Suggested work progress report form.

There must be some sort of schedule as a point of departure. Referring to the arrow diagram, you list all of the activities in the order in which they can begin, as shown in figure 6-37. When several activities can begin on the same day, list them secondarily in order of the amount of slack they contain. If two or more activities have the same amount of slack and start on the same day, it does not matter which is placed first. The easiest way to arrange the activities in order for copying on the schedule is to list each activity on a 3 by 5 card and sort the cards into proper order.

Next you transfer the values shown in this preliminary schedule to a bar chart like the one shown in figure 6-38. The broken lines indicate slack. The bar graph is a schedule for the project, but based on the assumption that available work force is unlimited.

At this point, or previously, you enter on the arrow diagram the work force requirements shown already entered in figure 6-39. These are, of course, based on estimates of how many persons of each rating it will take to do each of the activities shown in the diagram. By referring to these figures and to the bar chart (fig. 6-38)




you can now make a work force schedule, as shown in figure 6-39.

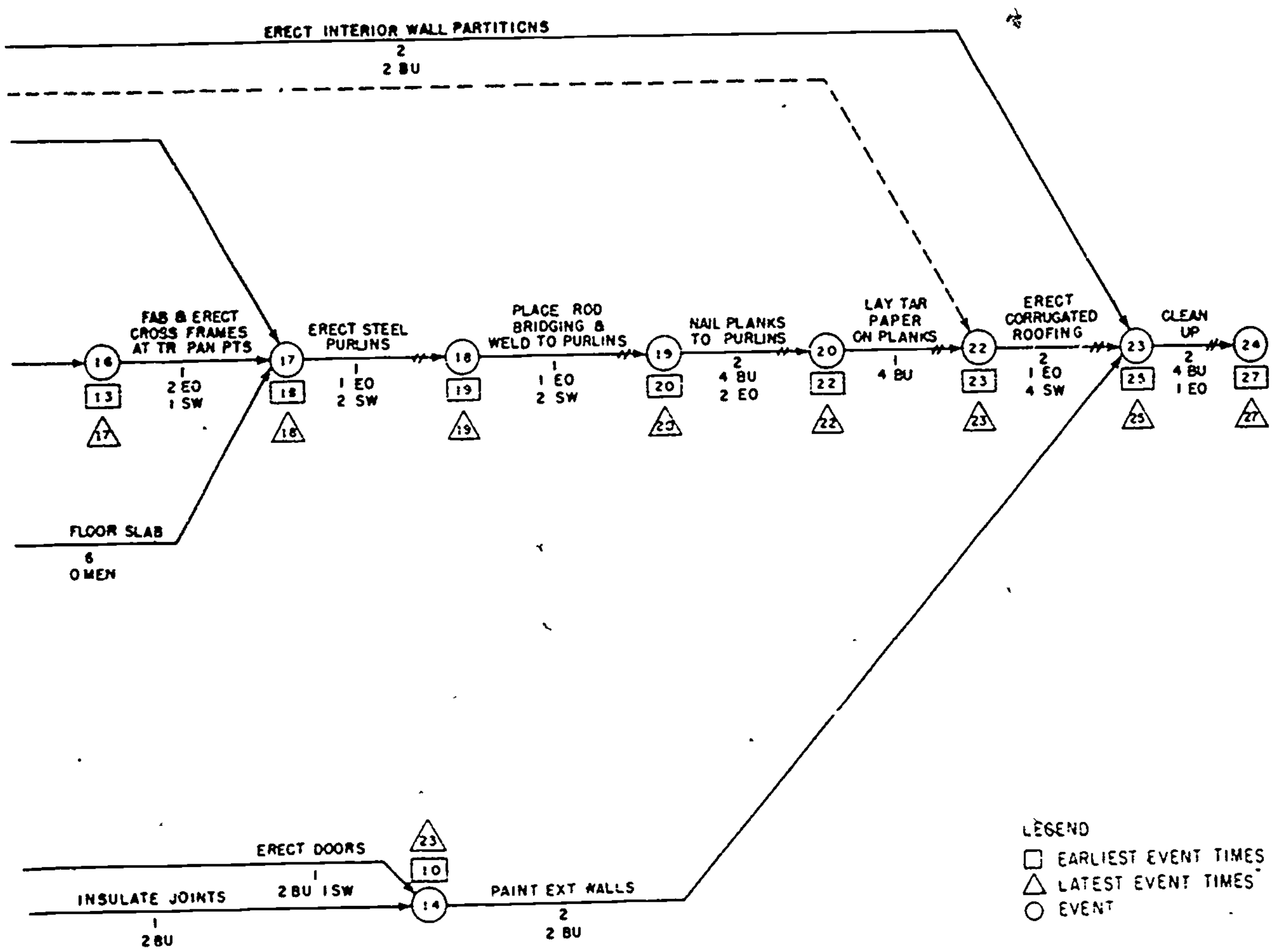
Examination of the work force totals in figure 6-39 shows undesirable peaks in the Builder requirements—14 called for on day 5, 19 on day 6, 8 on day 7, and so on. To correct this situation, you would decide what the maximum available number of Builders would be for a day, and rework the chart on the basis of this limitation. The general procedure is as follows:

1. List all activities in the same order as before (fig. 6-36).

2. Enter the critical activities in the same places as before; these cannot be displaced.

3. Use slack time on noncritical activities to shift activities using Builders to days on which, on the previous chart, Builders were NOT shown employed. For example, activity (2) – (15) in figure 6-39 could be shifted to days 13 through 16, since the chart shows only two Builders working on day 13 and none on days 14, 15, and 16.

4. After every adjustment of this kind, refer back to the arrow diagram and the schedule,




82.112

Figure 6-36.—Arrow diagram—temporary steel and timber warehouse.

to see whether in rescheduling activities you have moved back the times at which subsequent activities can start.

In practice, it is often possible to split work elements—to do part of the work on the fabrication of doors (for example) on one day, then drop this and pick it up at a later day when Builders are available.

Remember that when you make this or any other type of adjustment, you must immediately check the arrow diagram for the effect on subsequent activities. On even a small project, the possibility for improving efficiency through adjustments in scheduling or through job splitting nearly always exists,—or, at any rate, exists until the most efficient schedule is found. Because of the interrelationship between work elements and the affect they have on each other, much experimentation and readjustment may be required to attain the most efficient and economical schedule.

The schedule that stays completely accurate through the entire life of a project, as originally

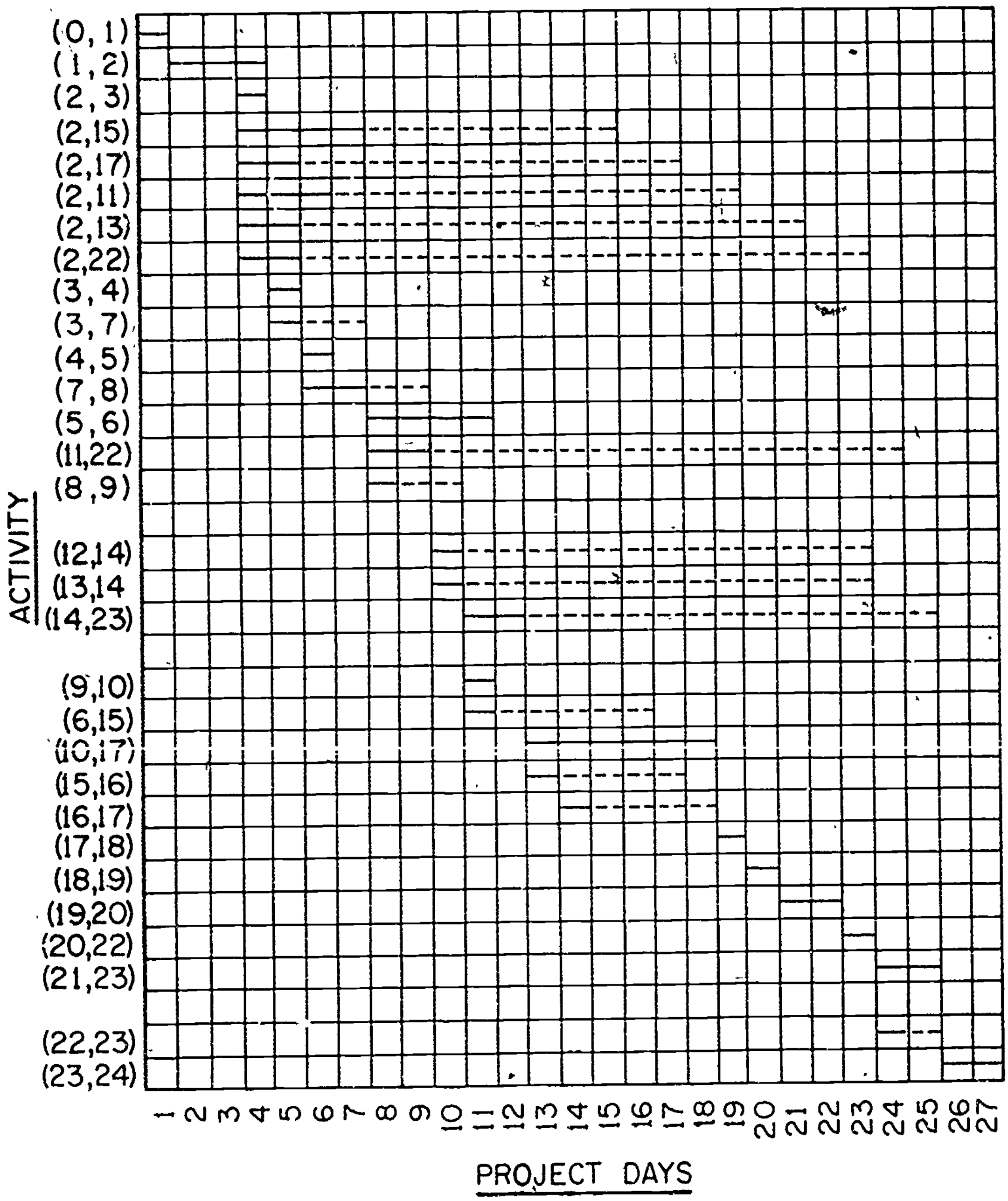
| EARLIEST EVENT AT TAIL OF ARROW | ACTIVITY (I, J) | DURATION | LATEST EVENT AT HEAD OF ARROW | SLACK |
|---|---|---|---|---|
| 0 | ( 0, 1) | 1 | 1 | 0 |
| 1 | ( 1, 2) | 3 | 4 | 0 |
| 4 | ( 2, 3) | 1 | 5 | 0 |
| 4 | ( 2, 15) | 4 | 16 | 8 |
| 4 | ( 2, 17) | 2 | 18 | 12 |
| 4 | ( 2, 11) | 3 | 20 | 13 |
| 4 | ( 2, 13) | 2 | 22 | 16 |
| 4 | ( 2, 22) | 2 | 24 | 18 |
| 5 | ( 3, 4) | 1 | 6 | 0 |
| 5 | ( 3, 7) | 1 | 8 | 2 |
| 6 | ( 4, 5) | 1 | 7 | 0 |
| 6 | ( 7, 8) | 2 | 10 | 2 |
| 7 | ( 5, 6) | 4 | 11 | 0 |
| 7 | (11, 12) | 2 | 22 | 13 |
| 8 | ( 8, 9) | 1 | 11 | 2 |
| 9 | (12, 13) | 0 | 22 | 13 |
| 9 | (12, 14) | 1 | 23 | 13 |
| 9 | (13, 14) | 1 | 23 | 13 |
| 10 | (14, 23) | 2 | 25 | 13 |
| 11 | ( 6, 9) | 0 | 11 | 0 |
| 11 | ( 9, 10) | 1 | 12 | 0 |
| 11 | ( 6, 15) | 1 | 16 | 4 |
| 12 | (10, 17) | 6 | 18 | 0 |
| 12 | (15, 16) | 1 | 17 | 4 |
| 13 | (16, 17) | 1 | 18 | 4 |
| 18 | (17, 18) | 1 | 19 | 0 |
| 19 | (18, 19) | 1 | 20 | 0 |
| 20 | (19, 20) | 2 | 22 | 0 |
| 22 | (20, 21) | 1 | 23 | 0 |
| 23 | (21, 23) | 2 | 25 | 0 |
| 23 | (21, 22) | 0 | 24 | 1 |
| 23 | (22, 23) | 1 | 25 | 1 |
| 25 | (23, 24) | 2 | 27 | 0 |

82.113

Figure 6-37.—List of activities in figure 6-36 in order of earliest events (tail of arrows).

developed, is extremely rare. Periodic revision and refinement is a necessary and a valuable part of network analysis. It is up to the network analysis user to analyze the schedule to make certain that is is meaningful and accurate and to enforce the accomplishment of it.

Since many services, trades, and supplies are required during the course of construction, the leading petty officers responsible for the various activities should be consulted. Network analysis requires a team effort on the part of all participants to make it work effectively.




82.114

Figure 6-38.—Bar chart—preliminary schedule of activities listed in figure 6-37.

## PRECEDENCE DIAGRAMING

Although precedence diagraming is becoming the preferred method, arrow diagraming is the method most often used in the NCF community. Precedence diagraming does NOT require the use of dummy activities, is easier to draw, and has greater applications and advantages when networks are put on the computer. In precedence diagraming, the activity is in the

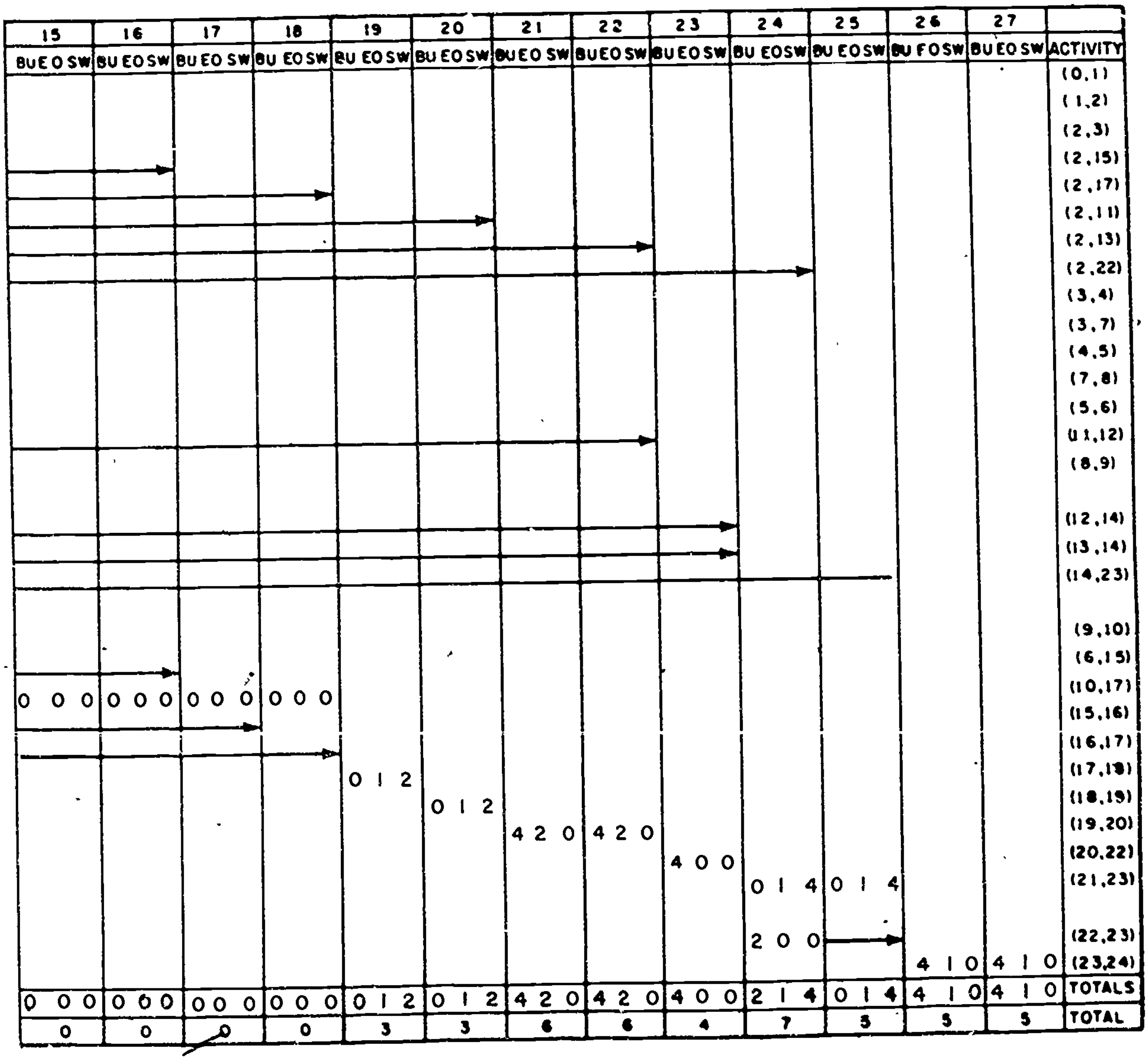
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ACTIVITY | BU EO SW | BU EO SW | BU EO SW | BU EO SW | BU EO SW | BU EO SW | BU EO SW | BU EO SW | BU EO SW | BU EO SW | BU EO SW | BU EO SW | BU EO SW | BU EO SW |
| (0,1) | 4 0 0 | | | | | | | | | | | | | |
| (1,2) | | 0 3 0 | 0 3 0 | 0 3 0 | | | | | | | | | | |
| (2,3) | | | | | 0 2 0 | | | | | | | | | |
| (2,15) | | | | | 4 0 0 | 4 0 0 | 4 0 0 | 4 0 0 | | | | | | |
| (2,17) | | | | | 2 0 0 | 2 0 0 | | | | | | | | |
| (2,11) | | | | | 2 0 0 | 2 0 0 | 2 0 0 | | | | | | | |
| (2,13) | | | | | 2 0 0 | 2 0 0 | | | | | | | | |
| (2,22) | | | | | 4 0 0 | 4 0 0 | | | | | | | | |
| (3,4) | | | | | | 2 0 1 | | | | | | | | |
| (3,7) | | | | | | 3 0 0 | | | | | | | | |
| (4,5) | | | | | | | 2 0 0 | | | | | | | |
| (7,8) | | | | | | | 0 2 0 | 0 2 0 | | | | | | |
| (5,6) | | | | | | | | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | | | |
| (11,12) | | | | | | | | 2 1 0 | 2 1 0 | | | | | |
| (8,9) | | | | | | | | | 2 0 1 | | | | | |
| (12,14) | | | | | | | | | | 2 0 0 | | | | |
| (13,14) | | | | | | | | | | 2 0 1 | | | | |
| (14,23) | | | | | | | | | | | 2 0 0 | 2 0 0 | | |
| (9,10) | | | | | | | | | | | | 3 0 1 | | |
| (6,15) | | | | | | | | | | | | 0 2 2 | | |
| (10,17) | | | | | | | | | | | | | 0 0 0 | 0 0 0 |
| (15,16) | | | | | | | | | | | | | 2 1 2 | |
| (16,17) | | | | | | | | | | | | | | 0 2 1 |
| (17,18) | | | | | | | | | | | | | | |
| (18,19) | | | | | | | | | | | | | | |
| (19,22) | | | | | | | | | | | | | | |
| (20,21) | | | | | | | | | | | | | | |
| (21,23) | | | | | | | | | | | | | | |
| (22,23) | | | | | | | | | | | | | | |
| (23,24) | | | | | | | | | | | | | | |
| TOTALS | 4 0 0 | 0 3 0 | 0 3 0 | 0 3 0 | 14 2 0 | 19 0 1 | 8 2 0 | 6 3 0 | 4 1 1 | 4 0 1 | 2 0 0 | 5 2 3 | 2 1 2 | 0 2 1 |
| TOTAL | 4 | 3 | 3 | 3 | 16 | 20 | 10 | 9 | 6 | 5 | 2 | 10 | 5 | 3 |

node, as illustrated in figure 6-40, NOT on the arrow, as is the case with arrow diagraming.

## REPRESENTATION OF ACTIVITIES AND EVENTS

An activity in a precedence diagram is represented by a rectangular box and is identified by an activity number, and NOT the start and finish nodes as in an arrow diagram. This eliminates the need for additional activities, called dummies, for the purpose of achieving positive identification, as shown in views A and B, figure 6-41.

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 "connectors" and the general direction of the flow is evident in the connectors themselves, and arrows are NOT necessary.




82.115

Figure 6-39.—Manpower schedule—temporary timber and steel warehouse (considering three ratings).

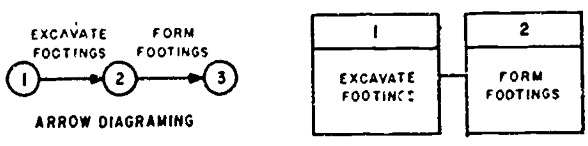
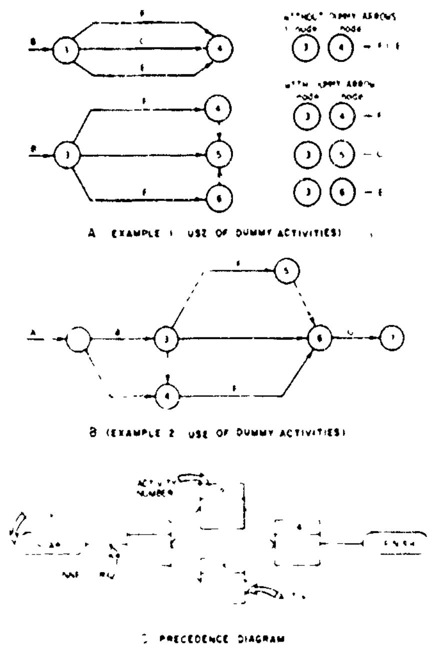



Figure 6-40.—Representation of arrow and precedence diagrams.

The network might also contain certain precise, definable points in time, called "events." Examples of events are the start and finish of the project as a whole which should always be entered in the network diagram. Events have NO duration and are represented by oval boxes on a network. A precedence network is illustrated in view C of figure 6-41.

The rule governing the drawing of a network is that the start of an activity must be linked to



145.370

Figure 6-41.—Representation of activities and events.

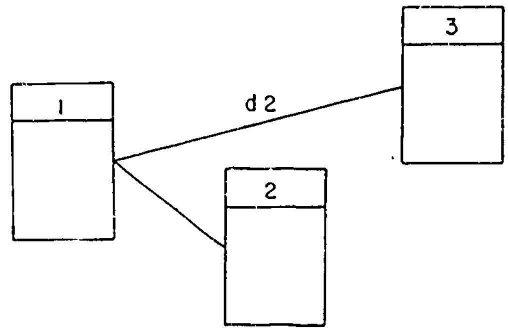



Figure 6-42.—Representation of delay.

the ends of all completed activities before the start may take place. Activities taking place at the same time are NOT linked in any way. In view C, figure 6-41, both activities 2 and 3 start as soon as activity 1 is completed. Activity 4 requires the completion of both activities 2 and 3 before it (4) can start.

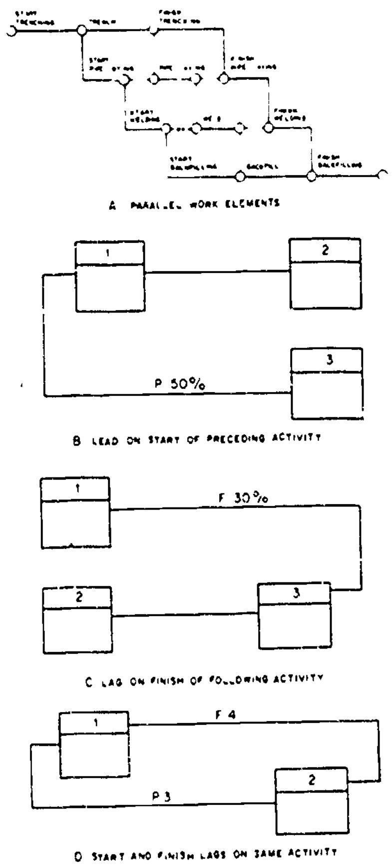
## REPRESENTING A DELAY

In certain cases, there might be a delay between the start of one activity and the start of another. In this case, the delay might be ndicated on the connector itself, preceded by the letter "d," as shown in figure 6-42. Here, activity 2 may start as soon as activity 1 is completed, but activity 3 must wait 2 days. The delay is started in the basic time units of the project in which case the word "days" can be omitted.

## REPRESENTING PARALLEL ACTIVITIES

Some activities might parallel others, as illustrated with arrow networks in view A, figure 6-43. This can be achieved in precedence diagrams without increasing the number of activities. For instance, it is possible to start laying a long pipeline before the excavations are completed. This type of overlap is known as a "lead." It is possible to start a job independently, but NOT to complete it before another is completed. This type of overlap is a "lag." (It is also a common occurrence that both start and finish of two activities may be linked, but this case is accommodated by a combination of lead and lag.) The letter "p" on the connector indicates a lead of the start of the preceding activity, and an "f" on the connector indicates a lag on the finish of the following activity.

As seen in views B and C of figure 6-43, a lead, or "partial start" is indicated by drawing the connector from the start of the preceding activity, and a lag or "partial finish" is indicated by drawing the connector from the end of the following activity. The value may be given in the basic time units of the project, as with a delay, or as a percentage overlap, as shown in views B and C, figure 6-43. In certain circumstances, it could also be started as a quantity if the performance of the activity can be measured on




145.371

**Figure 6-43.—Representing parallel activities.**

a quantitative basis. The indication of the type and amount of delay, lead, or lag is generally referred to as a "lag factor."

In view B, figure 6-43, activity 3 may start when activity 2 is 50 percent complete, although activity 2 must wait for the final completion of activity 1. In view C, figure 6-43, activity 3 may start when activity 2 is complete, but will still have 30 percent to go when activity 1 is complete. The last 30 percent of activity 3 may NOT begin until activity 1 has been completed. In view D, figure 6-43, activity 2 may start when activity 1 is advanced three days, but will still have 4 days of work left when activity 2 is completed.

## SPLITTING CONNECTORS

The number of sequencing connectors becomes very large when a network is of a great size. When two activities are remote from each other and have to be connected, the lines tend to become "lost" or difficult to follow. In such cases, it is NOT necessary to draw a continuous line between the two activities. To show their relationship, circles are used with the following-activity number in one, and the preceding-activity in the other. In figure 6-44, both activities 2 and 6 are dependent upon activity 1.

## DIRECT LINKING USING AN EVENT

When the number of common preceding and succeeding activities in a particular complex is

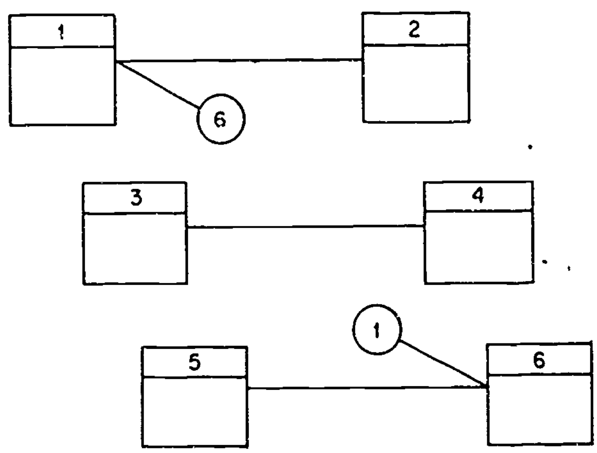
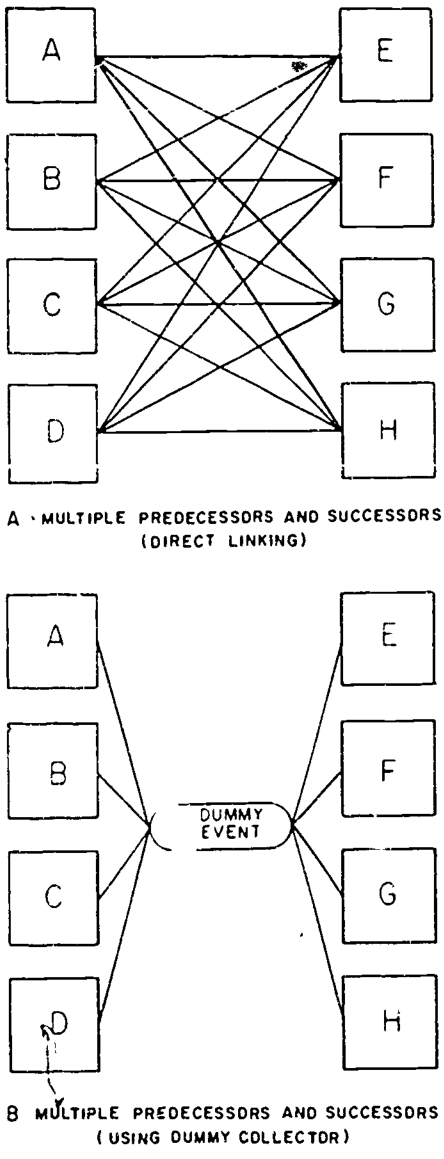



**Figure 6-44.—Splitting connectors.**

large, as in view A, figure 6-45, a dummy event or focal activity of zero duration may be introduced to simplify the network. The use of such a dummy event is shown in view B, figure 6-45, which is a simplification of view A, figure 6-45. The effect in terms of scheduling is the same, but it can be seen that the introduction of the dummy has improved the clarity of the diagram.

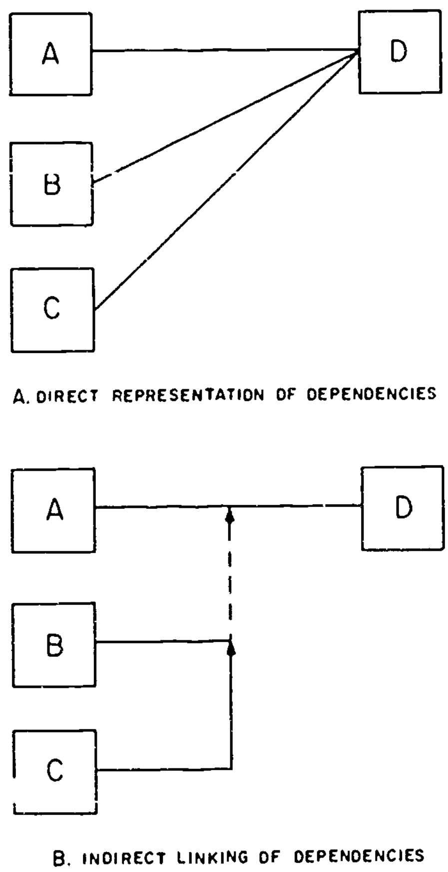



145.372

Figure 6-45.—Use of a dummy event.

## AVOID JOINING CONNECTORS

In many instances, opportunities are present for joining several connectors going to a common point to reduce the congestion of the drawing. The diagrams in views A and B, figure 6-46, have precisely the same interpretation. Several connectors have been joined in view B, figure 6-46. When the network is coded for the computer, the fact that activity D has three preceding activities with only one line actually entering D may be overlooked. This form of representation must be discouraged for this reason.




145.373

Figure 6-46.—Avoid joining connectors.

## SCHEDULING PRECEDENCE DIAGRAMS

Scheduling, or putting the network on a working timetable, is calculated the same as arrow diagrams. The information is represented differently, being contained within the activity box as illustrated in figure 6-47.

## ADVANTAGE OF PRECEDENCE

Precedence networks eliminate many of the complicating factors of arrow networks. Most construction management programs for computers are limited by the number of activities the computer can accommodate. Arrow networks contain as much or more than 30 percent of dummy activities or split activities and are therefore very costly to run on computers.

Precedence networks are easier to draw because all of the activities can be placed on small cards, laid out on a flat surface, and manipulated easily until a realistic logic is achieved. Draw lines (connectors) to each of the activities to show the relationship between the activities.

## EQUIPMENT MAINTENANCE

To achieve both quantity and quality in work output, it is important that you have the right kind of tools and equipment, as well as qualified personnel to operate them. It is equally important that the tools and equipment receive the preventive maintenance and upkeep necessary to keep them operating at peak efficiency.

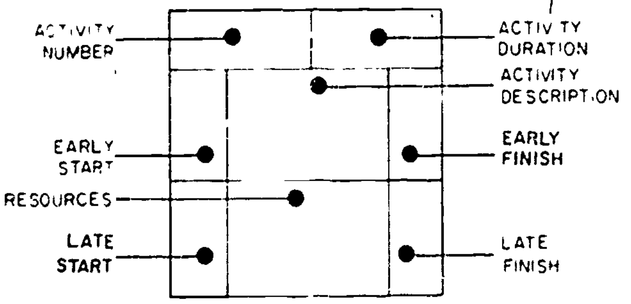



Figure 6-47.—Information for a precedence activity.

Preventive maintenance pays off in many ways. It aids in promoting safe working conditions and safe working habits. Among other advantages, preventive maintenance means fewer breakdowns and the maximum length of useful life for the equipment.

Equipment maintenance includes a number of routine tasks, such as cleaning, adjusting, and lubricating. Some workers regard these tasks as unimportant, but as every experienced Steelworker knows, they have an important bearing on the operating condition of the equipment. Certain maintenance duties may be required daily or weekly; certain others are performed monthly, quarterly, or at even longer intervals. The type and frequency of maintenance depend largely upon the type and make of the individual piece of equipment. The maintenance requirements for a given piece of equipment generally will be prescribed by the manufacturer; this information usually will be included with the equipment when it is received by your activity. For each piece of equipment, be sure and follow the maintenance instructions prescribed by the equipment manufacturer.

CAUTION: Leave the maintenance of all electrical equipment, such as motors, generators, and transformers to the Construction Electrician. They should be around at regular intervals to inspect and service all of the electrical equipment. The maintenance duties that should be handled by experienced electricians include lubricating, adjusting, and cleaning the equipment.

It is not our purpose here to describe the many tasks included in equipment maintenance. You are probably familiar, anyway, with the common types of equipment used in welding, rigging, sheet metal work, and other operations performed by Steelworkers; also, you most likely have had much experience in lubricating, operating, cleaning, and adjusting this equipment.

As a supervisor, you can help insure that equipment receives the proper care and upkeep by establishing a good maintenance program and then, seeing to it that the program is

carried out. In setting up a maintenance program, it may be helpful to prepare a chart listing each piece of equipment and its maintenance requirements, such as method of cleaning, frequency of lubrication, and the like, for each type or make of equipment. In making up the maintenance chart, refer to the manufacturer's instruction manual to determine the types, frequency, and other maintenance requirements for a particular make of tool or machine.

Make it a practice to maintain a file of all instruction manuals received with the various pieces of equipment. If possible, use a filing cabinet for filing the manuals. The manuals can be filed alphabetically by the name of the equipment or manufacturer, or any other method which will allow easy access to a manual when needed. If you do NOT have a system for filing the manuals, a great deal of time may be lost while you hunt through a stack of papers to find a particular manual.

Another technique which may prove useful to you in carrying out an equipment maintenance program is a material history of individual pieces of equipment. A material history is a chronological record describing the events in the service life of a given machine. The entries are made on a file card and include such items as the following: (1) results of all tests and measurements; (2) difficulties or troubles encountered; (3) methods used to repair or restore the equipment to service; (4) dates when grease or oil was changed; and (5) any other information that may be of value to a complete understanding of the machine. All such data should be entered opposite the date on which an incident occurred. If there is a complete history on a particular machine, any interested person can get a picture of what has been done to remedy troubles that may have arisen in the past as well as the care it has received.

## AS-BUILT DRAWINGS

The best laid plans have a way of going wrong. No amount of preplanning can change this. The only thing to do is make corrective changes and continue the project. When these corrections involve the actual construction of your project, you must also show this change in the form of a AS-BUILT DRAWINGS. You should contact your operations officer to get approval to make any changes on a project. When the decision has been made, show the changes on your drawing As-built drawings consist of the original construction drawings, corrected to show additions, omissions, or changes made during construction. Changes made on the original construction drawings are drawn in red on the working drawings. The drawings are then turned into engineering where the final record drawings are completed.

## CHAPTER 7

# METALS IDENTIFICATION AND TESTING

Many tests have been developed for determining the physical properties of metals. Two important physical properties of special concern to the Steelworker are hardness and tensile strength. Hardness may be measured by file testing, or preferably, by machine testing with a Rockwell, Brinell, or other type of tester. The tensile strength of a metal can be determined by a tension test. Although you may only make these tests occasionally, knowing the physical properties of metals is important. In many instances, you may use tables or charts which show information obtained from tests for hardness and tensile strength. Weld defects in metals can be detected by magnetic particle inspection or liquid penetrant inspection. Other tests described in this chapter include tests of sample welds and metal identification.

### HARDNESS TESTS

Most metals possess some degree of hardness—that is, the ability to resist penetration by another material. Many tests for hardness are used; the simplest one is the file hardness test. While fair estimates of hardness can be made by an experienced Steelworker, more consistent quantitative measurements are obtained with standard hardness testing equipment. This equipment eliminates the variables of size, shape, and hardness of the file selected, and of the speed, pressure, and angles of the file used during a test.

HARDNESS can be defined as resistance to penetration, resistance to abrasion, resistance to machine tool cutting, or resistance to bending (stiffness) by wrought products. Except for resistance to penetration, the characteristics of hardness are not readily measurable. Consequently, most hardness tests are based on the principle that a hard material will penetrate a softer one. In a scientific sense, hardness is a measure of the resistance of a material to penetration or indentation by an indenter of fixed size and geometrical shape, under a specific load.

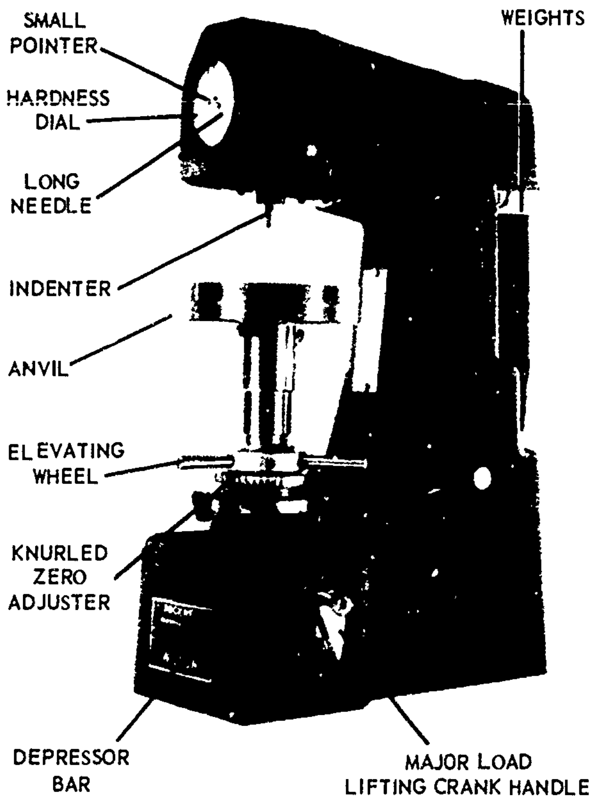
The information obtained from a hardness test may be used to compare alloys and the effects of various heat treatments on them. Hardness tests are also useful as a rapid, nondestructive method for inspecting and controlling certain materials and processes, and to insure that heat-treated objects have developed the hardness desired or specified. The results of hardness tests are useful not only for comparative purposes, but also for estimating other properties. For example, the tensile strength of carbon and low-alloy steels can be estimated from the hardness test number. There is also a relationship between hardness and endurance or fatigue characteristics of certain steels.

Hardness is most often measured with the Rockwell and Brinell hardness testers. Other hardness testers include the Vickers, Eberbach, Monotron, Tukon, and Scleroscope. Since there are many tests and the hardness numbers derived are not equivalent, it is essential that the hardness number be designated according to the test and the scale employed in the test. Since you are more likely to have access to a Rockwell tester than to any other, the Rockwell test is described in greater detail. The essential differences between the Rockwell and Brinell tests are also pointed out.

## ROCKWELL HARDNESS TEST

Of all the hardness tests, the Rockwell is the one most frequently mentioned. The basic principle of the Rockwell test (like that of the Brinell, Vickers, Eberbach, Tukon, and Monotron tests) is that a hard material will penetrate a softer one. This test operates on the principle of measuring the indentation, in a test piece of metal, made by a ball or cone of a specified size which is being forced against the test piece of metal with specified pressure. In the Rockwell tester shown in figure 7-1, the hardness number is obtained by measuring the depression made by a hardened steel ball or a spheroconical diamond penetrator of a given size under a given pressure.

With the normal Rockwell tester shown, the 120° spheroconical penetrator is used in conjunction with a 150-kilogram load to make impressions in hard metals. The hardness number obtained is designated Rockwell C (Rc). For softer metals, the penetrator is a 1/16-inch steel ball in conjunction with a 100-kilogram load. A hardness number obtained under these conditions is designated Rockwell B (Rb). Figure 7-2 illustrates the principle of indenter hardness tests. Although the conical penetrator is shown, the princip'` is the same for a ball penetrator. (The geometry of the indentions would, of course, differ slightly.)



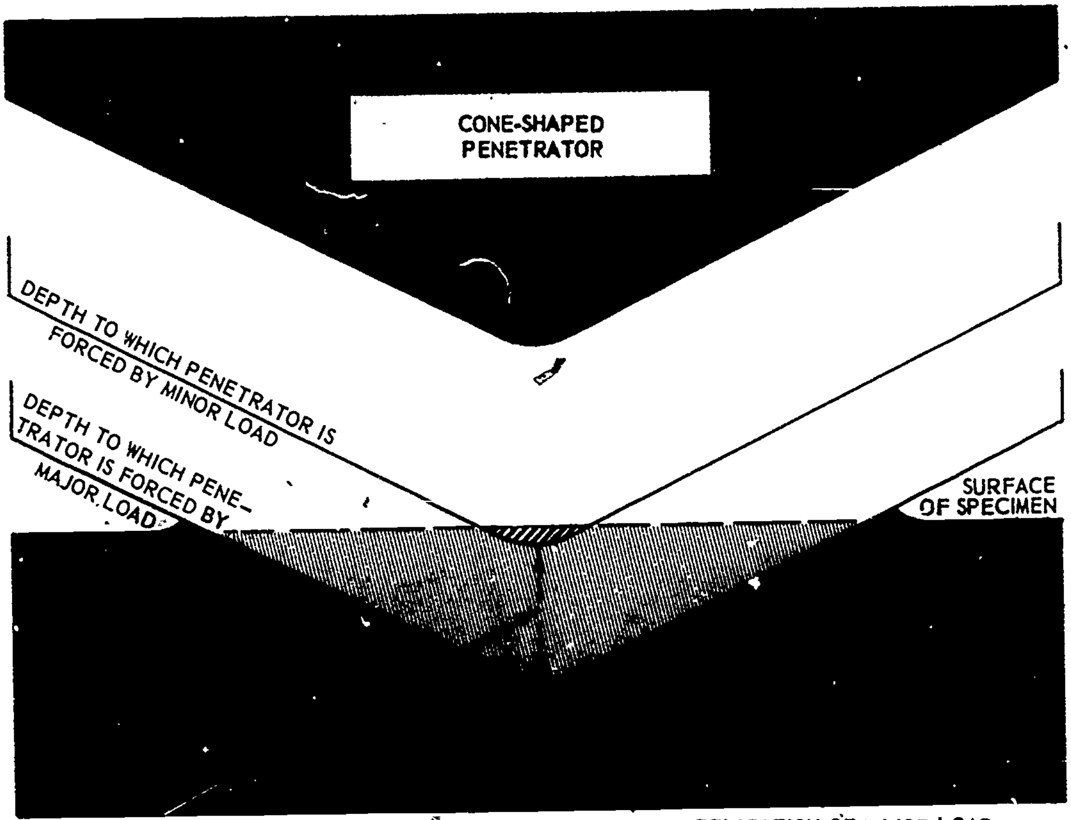

102.90X

**Figure 7-1.—Standard Rockwell hardness testing machine.**

With the Rockwell tester, a deadweight, acting through a series of levers, is used to press the ball or cone into the surface of the metal to be tested. Then the depth of penetration is measured. The softer the metal being tested, the deeper the penetration will be under a given load. The average depth of penetration on samples of very soft steel is only about 0.008 inch. The hardness is indicated on a dial, calibrated in the Rockwell B and the Rockwell C hardness scales. The harder the metal, the higher the Rockwell number will be. Ferrous metals are usually tested with the spheroconical penetrator, with the hardness numbers being read from the Rockwell C scale. Nonferrous metals are tested with the steel ball; results are read on the B scale.

With most indenter-type hardness tests, the metal being tested must be thick enough to avoid bulging or marking the opposite side. The specimen thickness should be at least 10 times the depth of penetration. It is also essential that the surface of the specimen be flat and clean. When hardness tests are necessary on thin material, a superficial Rockwell tester should be employed.

The Rockwell superficial tester differs from the normal Rockwell tester in the amount of load applied to perform the test and in the kind of scale used to interpret the results. Where the major loads on the normal tester are 100 and 150 kilograms, the major loads on the superficial tester are 15, 30, and 45 kilograms. One division on the dial gage of the normal tester represents a vertical displacement of the indenter of 0.002 millimeter. Hardness scales for the Rockwell superficial tester are the N and T scales. The N scale is used for materials of such hardness that, were they of sufficient thickness, they would be tested with the normal tester using the C scale. The T scale is comparable to the B scale used




126.87X

**Figure 7-2.—Principle of Rockwell hardness test.**

with the normal tester. In other respects, the normal and superficial Rockwell testers are much alike.

Assuming the sample is properly prepared and the appropriate penetrator and loads are selected, the following step-by-step procedure indicates how a Rockwell tester is used:

1. Place the piece to be tested on the testing table, or anvil.

2. Turn the wheel for elevating the testing table until the piece to be tested comes in contact with the testing cone or ball. Continue to turn the elevating wheel until the small pointer on the indicating gage is nearly vertical and slightly to the right of the dot.

3. Watch the long pointer on the gage, and continue raising the work with the elevating wheel until the long pointer is nearly upright—within approximately five divisions, plus or minus, on the scale. This step of the procedure sets the minor load.

4. Turn the zero adjuster, located below the elevating wheel, to set the dial zero behind the pointer.

5. Tap the depressor bar downward to release the loads and apply the major load. Watch the pointer until it comes to rest.

6. Turn the crank handle upward and forward, thereby removing the major but not the minor load. This will leave the penetrator in contact with the specimen but not under pressure.

7. Observe where the pointer now comes to rest, and read the Rockwell hardness number on the dial. If the test has been made with the 1/16-inch ball and a 100-kilogram load, the reading is taken from the red, or B, scale. If the test has been made with the spheroconical penetrator and a load of 150 kilograms, the reading is taken from the black, or C, scale. (In the first example, the number is prefixed by Rb, and in the latter instance by Rc.)

8. Turn the handwheel to lower the testing table, then remove the test specimen.

## BRINELL HARDNESS TEST

The Brinell hardness testing machine provides a convenient and reliable hardness test. The machine is not suitable, however, for thin or small pieces. This machine has vertical hydraulic press design and is generally hand operated, a lever being used to apply the load which forces a 10-millimeter diameter hardened steel or tungsten-carbide ball into the test specimen. For ferrous metals, a 3,000-kilogram load is applied. For nonferrous metals, the load is 500 kilograms. In general, pressure is applied to ferrous metals for 10 seconds, while 30 seconds are required for nonferrous metals. After the pressure has been applied for the appropriate time, the diameter of the depression produced is measured with a microscope having an ocular scale.

The Brinell hardness number (Bhn) is the ratio of the load in kilograms to the impressed surface area is square millimeters. This number is found by measuring the distance the ball is forced, under a specified pressure, into the test piece. The greater the distance, the softer the metal, and the lower the Brinell hardness number will be. The diameter of the impression is measured, using the calibrated microscope furnished with the tester. Figure 7-3 illustrates an impression as seen through the microscope. After measuring the diameter of the impression, the measurement is converted into the Brinell hardness number, using the conversion table furnished with the tester. A portion of the conversion table is shown in table 7-1.

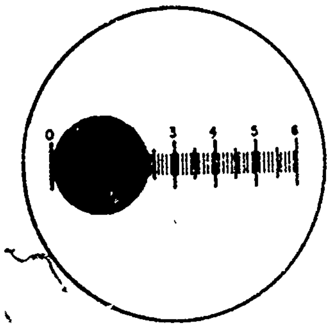



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Figure 7-3.—Microscopic view of impression.

The Brinell hardness machine is of greatest value in testing soft and medium-hard metals and in testing large pieces. On hard steel, the imprint of the ball is so small that is is difficult to read.

Table 7-1.—Portion of Conversion Table Furnished with Brinell Tester

| Diameter of ball impression (mm) | Hardness number for load of kg | |
|---|---|---|
| | 500 | 3000 |
| 2.0 | 158 | 945 |
| 2.05 | 150 | 899 |
| 2.10 | 143 | 856 |
| 2.15 | 136 | 817 |
| 2.20 | 130 | 780 |
| 2.25 | 124 | 745 |
| 2.30 | 119 | 712 |
| 2.35 | 114 | 682 |
| 2.40 | 109 | 653 |
| 2.45 | 100 | 627 |

145.229

## TENSION TEST

You must be familiar with the principles of metal testing for tensile strength, as well as for hardness. The term TENSILE STRENGTH may be defined as resistance to longitudinal stress or pull, or as the amount of stress resisted by the metal in pounds per square inch of cross section. The test is made by a tensile testing machine, either of the portable or stationary type.

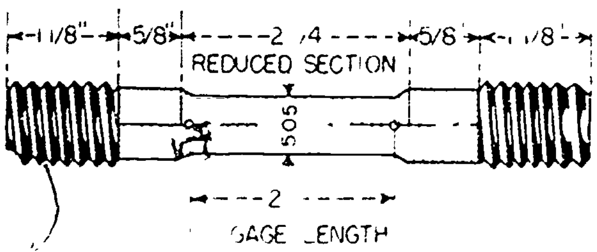
Two essential features of a tension testing machine are a device for straining the test specimen and a device for measuring the resistance of the specimen to this straining. Another instrument, known as the extensometer or strain gage, is clamped to the specimen to measure strain in that part of the specimen where strain is essentially uniform. With some equipment, a device is used to record and plot the stress-strain curve.

The tension test is a destructive test since the specimen must be loaded or stressed until it fails in order to obtain the desired information; moreover, there are few parts which would fit the tension testing machine. These factors explain why the test is made on a standard specimen rather than on the part itself. It is obviously important that the test specimen truly represents the part; for instance, not only must the specimen be given the same heat treatment as the part, but it must also be heat treated at the same time.

There are a number of standard types of tensile test specimens; figure 7-4 shows you one standard type of specimen in common use.

The standard test piece is an accurately machined specimen. Overall length is not particularly critical, but the diameter and gage length are. The 0.505-inch-diameter (0.2 square inch area) cross section of the reduced portion provides an easy factor to manipulate arithmetically; for example, to divide into the load, as read from the machine, to determine tensile strength in pounds per square inch (psi). The 2-inch gage length is the distance between strain-measuring points. This is the portion of the specimen to which the extensometer is attached. In addition, the gage length is used to determine percent elongation.

The tension test amounts to applying a smooth, steadily increasing load (or pull) on a test specimen and measuring the resistance of the specimen until it breaks. When recording equipment is not used, the test is not difficult to perform. During the test, the behavior of the specimen is observed, and the extensometer and gage readings are recorded at regular intervals. After the specimen fractures and the fracturing load is recorded, the specimen is measured with calipers to determine the percent elongation and the percent reduction in area. In addition, a stress-strain curve is plotted. From the data thus obtained, you can determine tensile strength, yield point, elastic limit, modulus of elasticity, and other properties of the material.




11.367

Figure 7-4.—Standard tension test specimen.

## TESTING PROCEDURES

Specific details for conducting the tension test vary with the purpose of the test and the kind of metal concerned. Before starting the test, however, make sure you measure the specimen accurately, using a micrometer, and compute the load. This is important because you compute tensile strength by dividing the maximum load in pounds applied during the tension test by the original cross-sectional area of the specimen in square inches; that is

$$\text{Tensile Strength} = \frac{\text{Load}}{\text{Area}}$$

Assuming a steel specimen has been properly set up in the equipment, with an extensometer attached, the tension test procedures is generally as follows. Apply a steadily increasing load. At

first apply a load well below the specimen's suspected elastic limit. At frequent intervals, release the load, read, and record the values indicated by the extensometer and the load-indicating gage.

With loading, the extensometer needle moves, indicating that the metal is elongating or stretching: first elastically and later plastically. Frequent loading, releasing, reading, and recording are necessary to establish that point where elastic stretching stops and permanent stretching begins. Consequently, it is necessary to repeat this procedure at frequent intervals, increasing the load in small amounts, until permanent deformation occurs; that is, the specimen does not return to its original size when the load is released. As long as the applied load is not too great, the extensometer needle returns to zero when the load is released. This indicates that the specimen has returned to its original length because of its elasticity. It also indicates that permanent deformation has not occurred and, therefore, that the elastic limit of the material has not been exceeded.

Unless automatic equipment is employed, the process of obtaining data needed to determine the elastic limit and the yield point require skillful manipulation of the loading controls and careful observation of the behavior of the specimen. At a certain point in the tension test of soft steel, for example, a definite increase in specimen length occurs with no increase in load. For this reason, it is necessary to apply, release, and increase loads repeatedly, being careful to avoid overshooting the load which is just enough to cause permanent deformation. When permanent deformation or yielding begins the straining load is released and the extensometer removed from the test specimen (unless an electronic-type extensometer is employed which measures strain up to the breaking point of the metal).

With the extensometer removed, a more rapidly applied, steadily increasing load may be employed. At first, the test metal continues to stretch. The NECKING IN is observed, and, finally, the specimen breaks. The load at the breaking point is recorded along with values obtained earlier in the test. Remember that the behavior of the metal specimen during the test varies with the kind of material involved and the condition of the material after working or heat treating. This is demonstrated by the test specimens shown in figure 7-5. In this illustration, A is a fractured specimen of a brittle metal; B is a ductile metal. Curves shown in views B, C, and D of figure 7-6 demonstrate the effect the condition of the material has on tension test results.

After fracturing the specimen and removing it from the tension tester, match the two parts of the specimen together at the point of fracture, and measure the distance between the 2-inch gage marks. The difference in gage length before

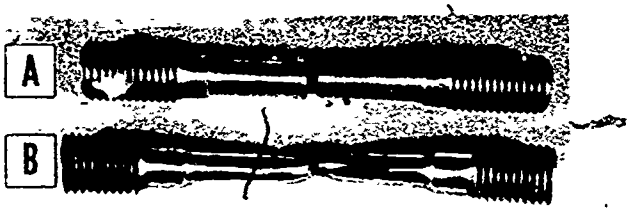



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Figure 7-5.—Comparison of tension test specimen fractures of (A) brittle, and (B) ductile metals.

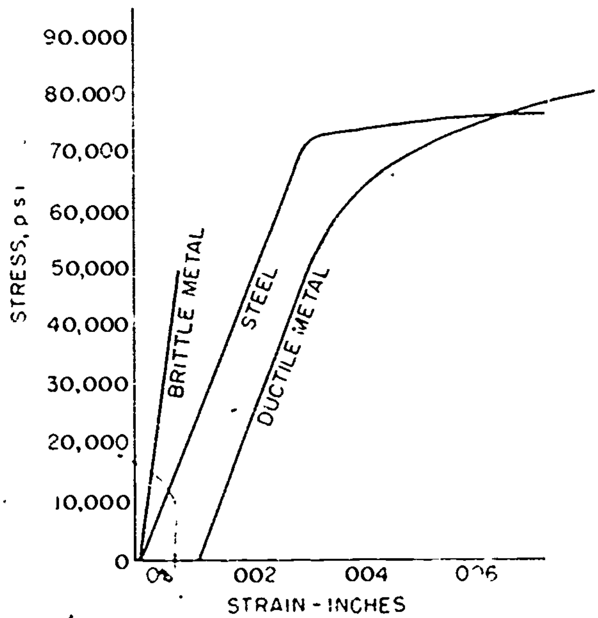


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Figure 7-6.—Stress-strain curve for typical metals.

and after testing is the elongation in 2 inches. The difference between the original gage length and the gage length after fracture divided by the original gage length (2 inches) times 100 is the percent of elongation. A similar measurement of the change in diameter of the specimen is made to determine the percent reduction in area. Both percentages are taken as measures of ductility.

## STRESS-STRAIN CURVES

The extensometer readings and the load data associated with those readings, taken during the tension test, are plotted on a graph to produce a stress-strain curve. Extensometer or strain values are plotted as abscissas (horizontal axis); stress or load values, as ordinates (vertical axis). The shape of the plotted curve varies with the kind of material involved. This is demonstrated by the stress-strain curves shown in figure 7-7. Note that the curve for a brittle metal has a steep slope. In fact, it is almost a straight line with fracture occuring at maximum stress. On the other hand, the curve for a very ductile material has practically no straight-line portion. Almost as soon as a load is applied, the material begins to stretch and continues to do so until the specimen fractures. The angle of slope and the straight (or nonstraight) line characteristics of the curve are suggestive of the properties of a metal in tension and indicate the extent of brittleness or ductility. The straight-line portion of the curve can be used to determine the modulus of elasticity. The area under the curve is a measure of toughness. Since the area under the curve is much greater for the ductile than for the brittle specimen, the former is, obviously, considerably tougher than the latter.

The more important features of a stress-strain curve plotted from data obtained during a tension test are illustrated in view A, figure 7-6. The material involved is a soft low-carbon steel. The straight-line portion of the curve from a to b indicates that the internal fiber stress (stress = applied load-cross-sectional area) is proportional to the strain as measured by the extensometer. The point b indicates the proportional limit; that is, stress is no longer proportional to strain, and stretching begins. Somewhere between b and c is the elastic limit, while c is the yield point. The highest point on the curve, e, is the tensile strength or the greatest stress the material can withstand without rupture.

The curves illustrated were obtained with testing machines equipped with autographic recorders. Curves obtained without such equipment would have a different shape from point d to e. It would drop downward, giving the appearance that the stress at fracture is less than the ultimate strength of the material. Such a curve gives this impression because stress is calculated as load divided by the original cross-sectional area, rather than the true cross-sectional area, actually related to the load after the specimen begins to neck down. Were the curve plotted in terms of the true stress, that is, the load divided by the actual cross-sectional area, the curve would rise to the point of fracture like those illustrated in figure 7-7.

## SCRIBE METHOD OF DETERMINING ELASTIC LIMIT

The most difficult properties of a metal to determine are its elastic limit and yield point. This is especially true for nonferrous metals and certain steels like the stainless group. Even with ordinary steel, they are difficult to establish without expensive autographic recorders and electronic strain gages. If the requirements are not too exacting, the elastic limit of ordinary steel can be determined by the scribe method.

In the SCRIBE METHOD for determining elastic limit, a pair of dividers is adjusted to 2 inches between points. Then, centering one leg in the lower 2-inch-gage-length punch mark, scribe a light line with the other divider leg point. When the load approaches that suspected to be in the region of the elastic limit of the material, the straining load is released and another mark inscribed with the dividers in the same manner as before. If this mark coincides with the first, the elastic limit has not been reached. If the first line thickens, the elastic limit has just been reached. If two distinct lines result, the elastic limit has been exceeded. Unless you are merely attempting to establish that a specific

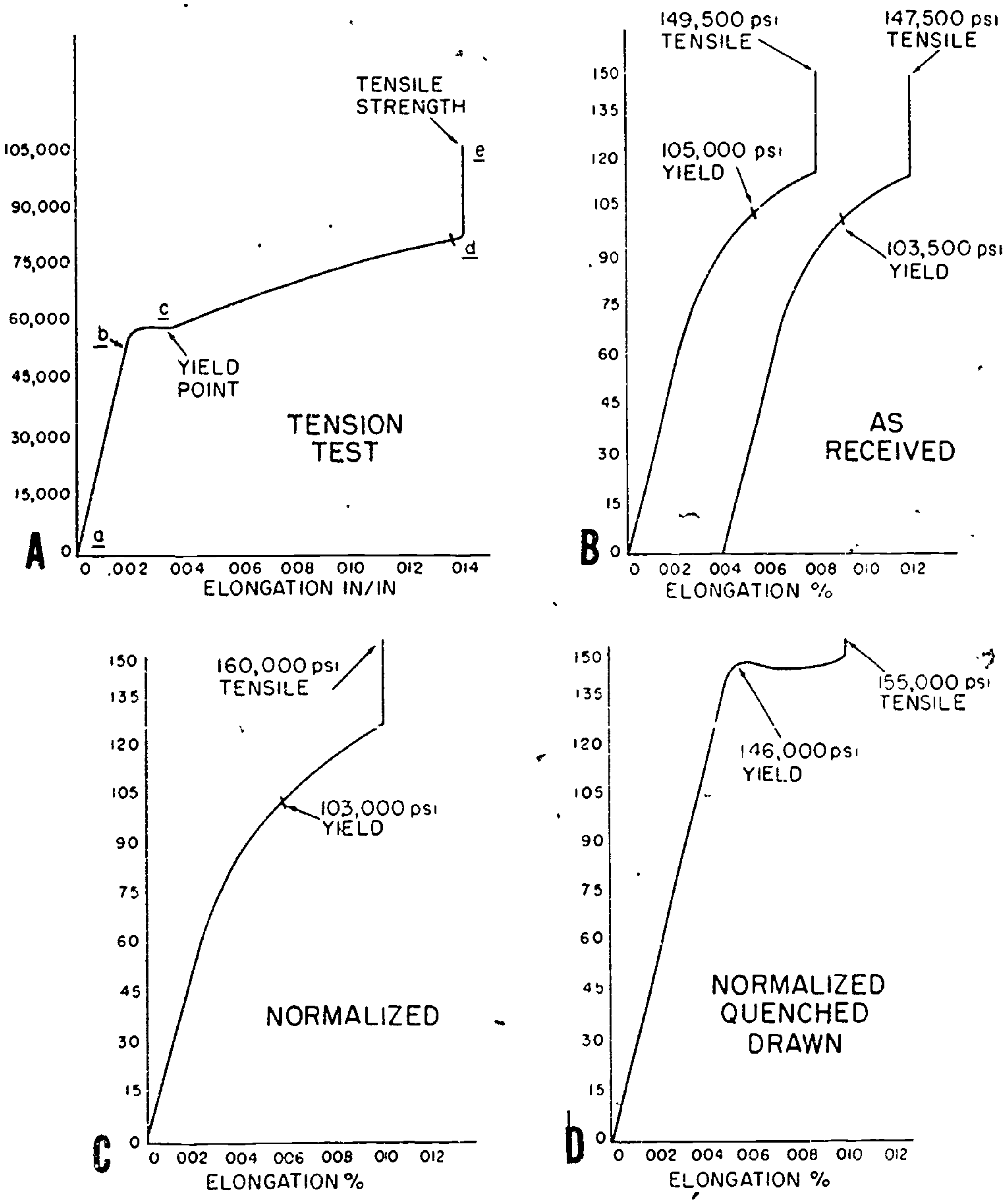


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Figure 7-7.—Stress-strain curve for low-carbon steel of medium ductility.

load does not develop stresses exceeding a given elastic limit of a material, the loading and comparing scribe marks will probably have to be done repeatedly to establish the load that just causes the scribe mark to thicken.

## OFFSET METHOD OF DETERMINING PROOF STRESS AND YIELD STRENGTH

With ductile metals having a ductile fracture like the one shown in view B of figure 7-5, or a

stress-strain curve similar to that presented in figure 7-8, the departure of the curve from a straight line is so gradual that it is difficult to determine just where deviation (the elastic limit) occurs. For such materials, the acceptable procedure is the OFFSET METHOD shown in figure 7-8. Here, a straight-dash line, whose point of origin on the abscissa is offset (set off) 0.01 percent from the point of origin of the stress strain curve itself. 's drawn parallel to the lower straight portion of the curve. As shown in figure 7-8, the point at which the 0.01 percent offset parallel intersects the stress-strain curve is taken as the value corresponding to elastic limit; with the offset method, this value is called PROOF STRESS. The point of intersection on the stress-strain curve of a second parallel line originating at 0.2 percent is taken as the yield strength (in contrast with yield point) value. For certain purposes, other percent offset values

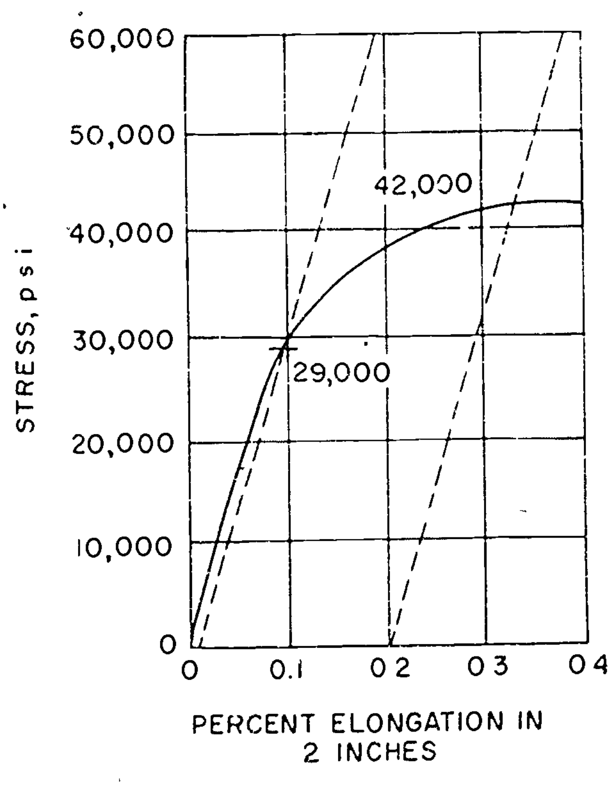


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Figure 7-8.—Offset method of determining proof stress (elastic limit) and yield strength from stress-strain curves.

may be used. Consequently, when the offset method for determining the elastic limit or proof stress and the yield strength is employed, it is essential that the amount of offset be specified.

## MAGNETIC PARTICLE INSPECTION

Magnetic particle inspection can be used for the detection of weld defects in metals or alloys in which magnetism can be induced. While the test piece is magnetized, finely divided iron powder is applied to it. As long as the magnetic field is not disturbed, the iron particles will form a regular pattern on the surface of the test piece. If the magnetic field is disturbed by a crack or some other defect in the metal, the pattern is interrupted and the particles cluster around the defect.

The test piece may be magnetized either by having an electric current pass through it, as shown in figure 7-9, or by having an electric current pass through a coil of wire that surrounds the test piece, as shown in figure 7-10. When an electric current flows in a straight line from one contact point to the other, magnetic lines of force are in a circular direction, as shown in view A of figure 7-9. When the current flow is through a coil around the test piece, as shown in view A of figure 7-10, the magnetic lines of force are longitudinal through the test piece.

If a defect is to show up as a disturbance in the pattern of the iron particles, the direction of the magnetic field must be at right angles to the major axis of the defect. A magnetic field having the necessary direction is established when the current flow is parallel to the major axis of the defect. Since the orientation of the defect is unknown, different current directions must be used during the test. As shown in figure 7-9, circular magnetism is induced in the test piece so that the piece may be inspected for lengthwise cracks, while longitudinal magnetism, as shown in figure 7-10, is induced so that the piece may be inspected for transverse cracks. In general, magnetic particle inspection is satisfactory for detecting surface cracks and subsurface cracks that are not more than 1/4 inch below the surface.

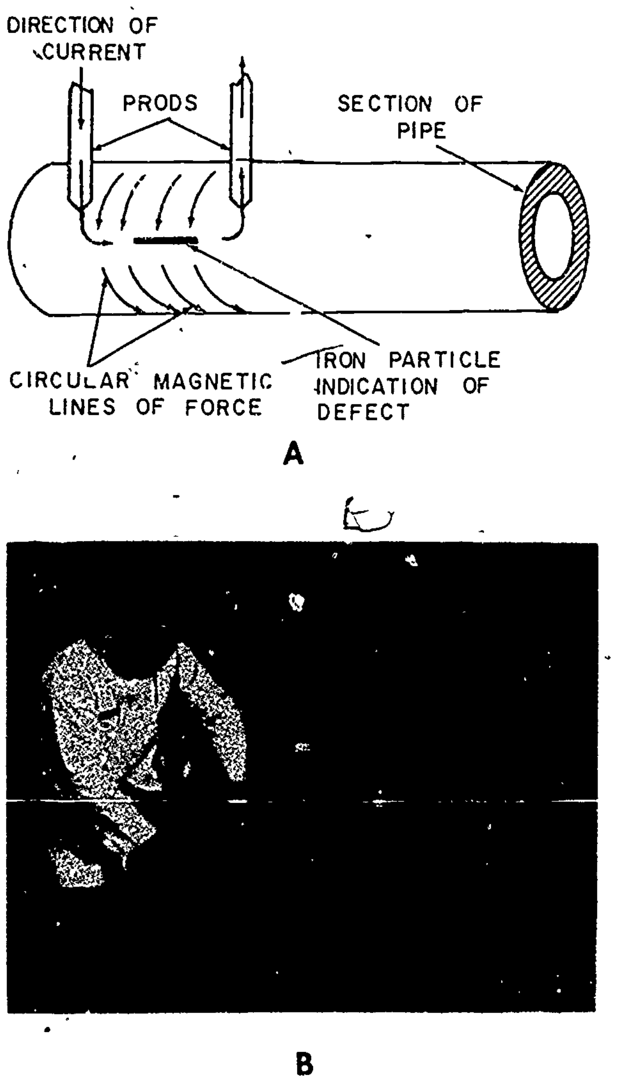


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**Figure 7-9.—Circular magnetization (prod method).**

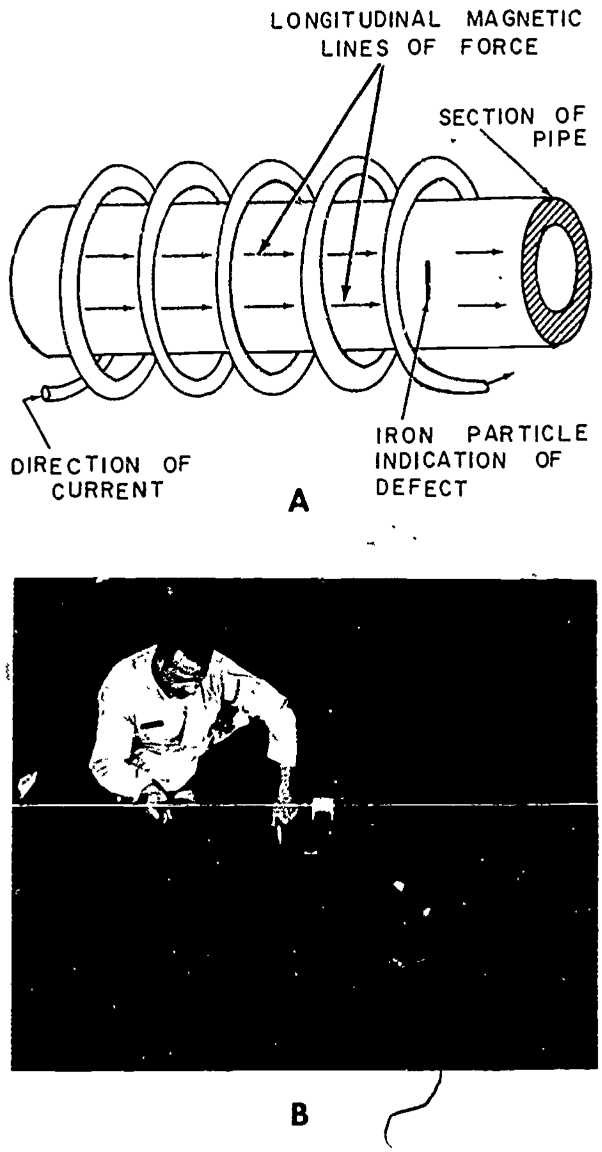


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**Figure 7-10.—Longitudinal magnetization (coil method).**

The type of magnetic particle inspection unit most commonly used in the Navy is the portable unit shown in figures 7-9 and 7-10. It is a high-amperage, low-voltage unit having a maximum magnetizing output of 1,000 amperes, either alternating or direct current. It is ready to operate when plugged into the voltage supply specified by the manufacturer. The unit consists of a magnetizing current source, controls, indicating meters, three 10-foot lengths of flexible cable for carrying the current to the test piece and a prod kit. The prod kit includes an insulated prod grip fitted with an ON-OFF relay or current control switch, a pair of heavy copper contact prods, and two 5-foot lengths of flexible cable. Cable fittings are so designed that either end of any cable may be fitted to the unit, to the prods, or to any other cable. The unit has three outlets on the front which make it easy to change from alternating to direct current or vice versa. The outlet on the left is labeled a.c., the center is COMMON, and the right is d.c. One cable will

always be plugged into the COMMON outlet, and the other cable is plugged into the a.c. or d.c. outlet, depending upon what type of current the test requires. For most work, alternating current magnetization effectively locates fatigue cracks and similar defects extending through to the surface. When more sensitive inspection is required to detect defects below the surface, direct current is used.

The unit can be used with alternating or direct current in either of two ways: (1) with prods attached to the flexible cable and used as contacts through which current is passed into and out of a portion of the test piece, setting up circular magnetization in a local area between the prod contact points, as shown in view B of figure 7-9, or (2) with flexible cable wrapped around the work, as shown in view B of figure 7-10, to form a coil, which with the passage of current, induces longitudinal magnetism in the part of the work piece that is surrounded by the coiled cable.

Although either of these two methods may be used, the prod method is probably the easier to apply. In most instances, it effectively serves to detect surface defects. With the prods, however, only a relatively small area of the test piece can be magnetized at any one time. This magnetized area is limited to the distance between prod contact points and to a few inches on each side of the current path. To check the entire surface, it is necessary to successively test adjacent areas by changing the location of the prod contact points after a given area has been tested. Each area of the test piece must be inspected twice—once with the current passing through the metal in one direction and once with the current passing through the metal in a direction at right angles to the direction of the first test. One of the advantages of the prod method of magnetic particle inspection is that the current can be easily passed through the metal in any desired direction. Thus, if a given area is suspected of being defective, magnetic fields of various orientations can be established during the test.

The prod method is accomplished by adjusting the unit for a current output suitable for the magnetizing and testing to be performed for any particular kind of metal. The current setting required depends on the distance between prod contact points. With the prod kit supplied with the unit, the space between prod contact points is 4 to 6 inches. For this space, with a material thickness less than 3/4 inch, a current setting between 300 and 400 amperes is satisfactory. With a material thickness of 3/4 inch and over, use 400 to 600 amperes. To obtain the same magnetic field force, less current is required if the prod contact points are closer together. With prods constantly at the same spacing, more current will induce a field of greater strength.

After adjusting the unit, place the prods in position. Hold them in firm contact with the metal and turn on the current. Then apply magnetic particles to the test area with the duster bulb and observe any indicator patterns. With the current still on, remove the excess particles from the test area with a blower bulb and complete the inspection. Do not move the prods until after the current has been turned off. To do so would cause the current to arc, resulting in a flash similar to that occurring in arc welding.

Through the use of magnetic particle inspection, hairline cracks that are otherwise invisible are readily detected, since the particles form an unmistakable outline of the defect. Large voids beneath the surface are more easily detected than small voids, but any defect below the surface is more difficult to detect than one which extends through to the surface. Since false indications occur frequently, the inspectors must be able to accurately interpret the particle indications they observe.

Factors that help the inspectors to interpret the test results include the amount of magnetizing current applied, the shape of the indication, the sharpness of the outline, the width of the pattern, and the height or buildup of the particles. Although these characteristics do not determine the seriousness of the indication, they do serve to identify the kind of defect indicated.

The indication of a crack is a sharp, well-defined pattern of magnetic particles having a

definite buildup. This indication is produced by a relatively low-magnetizing current. Seams are revealed by a straight, sharp, fine indication. The buildup of particles is relatively weak, and the magnetizing current must be higher than that required to detect cracks. Small porosity and rounded indentations or similar defects are difficult to detect for inexperienced inspectors. A high magnetizing current continuously applied is usually required. The particle patterns for these defects are fuzzy in outline and have a medium buildup.

Whether or not an indicated defect is to be chipped or ground out and repaired by welding depends on the specifications governing the job. Surface cracks are always removed and repaired. Indications of subsurface defects detected by magnetic particle inspection are evaluated by the inspector. If the indication is positive, it is usually best to grind or chip down to solid metal and make the repair. Unless the inspector can differentiate accurately between true and false indications, it is best to restrict the application of magnetic particle inspection to the detection of surface defects. For this application, magnetic particle inspection is almost foolproof.

After indicated defects have been repaired, the areas should be reinspected to insure that the repair is sound. The final step in magnetic particle inspection is to demagnetize the workpiece. This is especially important when the workpiece is made of ' h-carbon steel. Demagnetization is essential w direct current has been used to induce the r etic field. It is not as necessary when altern ig current has been employed in the test. In fact, the usual demagnetization procedures involves placing the workpiece in an a.c. coil or solenoid and slowly withdrawing it while the current passes through the coil.

Demagnetization can be done with the portable unit, if a special demagnetizer is not available. To demagnetize with the portable unit, form a coil of flexible cable around the workpiece. Be sure that the cable is plugged into the unit for the delivery of alternating current. Set the current regulator to deliver a current identical to that used for the inspection and turn on the unit. Then gradually decrease the current until the ammeter indicates zero. If the piece is large, it may be necessary to demagnetize a small portion of the work at a time.

A check for the presence of a magnetic field (and thus a check on the need for demagnetization) may be made by using small compass. A deviation of the needle from its normal position, when the compass is held near the work piece, is an indication that a magnetic field is present. An instrument called a field indicator may also be used to check for the presence of a magnetic field. This instrument will usually come with the magnetic particle inspection unit.

## LIQUID PENETRANT INSPECTION

Liquid penetrant methods are used to inspect metals for surface defects similar to those revealed by magnetic particle inspection. Unlike magnetic particle inspection, which can reveal subsurface defects, liquid penetrant inspection reveals only those defects that are open to the surface. In general, the only metals that are inspected by liquid penetrant methods are nonferrous metals and nonmagnetic steels.

Four groups of liquid penetrants are used. Group I is a dye penetrant which is nonwater washable. Group II is a water-washable dye penetrant. Group III and Group IV are fluorescent penetrants. The instructions prescribed for each penetrant should be followed carefully, since there are some differences in procedure and some differences in safety precautions required for the various penetrants.

Before using a liquid penetrant to inspect a weld, remove all slag from the surface. Except where a specific finish is required, it is not necessary to grind the weld surface as long as the weld surface is in accordance with applicable specifications and as long as the weld contour blends into the base metal without undercutting. If a specific finish is required, liquid penetrant inspections may be performed before the finish is made, in order to detect defects that extend beyond the final dimensions; but a final liquid penetrant inspection must be made AFTER the specified finish has been given.

Before using a liquid penetrant, clean the surface of the material—including the areas adjacent to the inspection area—very carefully. You can clean the surface by swabbing it with a clean, lint-free cloth saturated in a nonvolatile solvent or by dipping the entire piece into a solvent. After the surface has been cleaned, all trace of the cleaning materials must be removed. It is extremely important to remove all dirt, grease, scale, lint, salts, or other materials, and to make sure that the surface is entirely dry before the liquid penetrant is used.

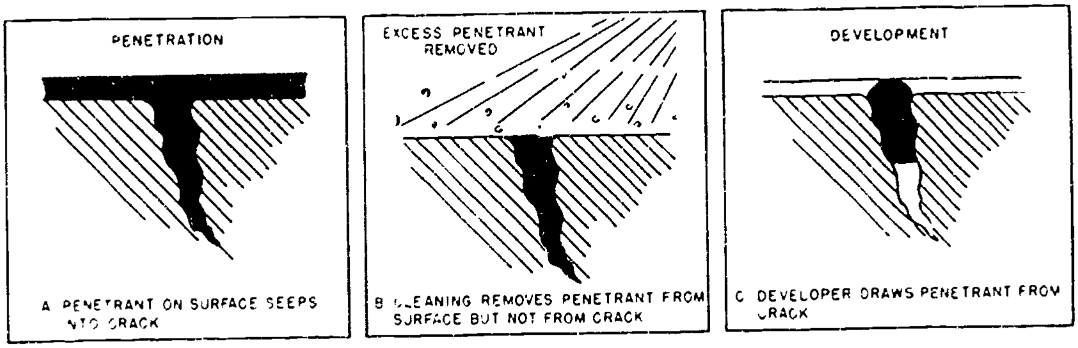
The temperature of the liquid penetrant and of the piece to be inspected MUST be maintained in the temperature range of 50° to 100°F. Do NOT attempt to use liquid penetrant when this temperature range cannot be maintained. Do NOT use an open flame to increase the temperature since the liquid penetrant materials are flammable.

After thoroughly cleaning and drying the surface, coat the surface with the liquid penetrant. Spray or brush on the penetrant or dip the entire piece in the penetrant. To allow time for the penetrant to get into all cracks, crevices, or other defects that are open to the surface, keep the surface of the piece wet with the penetrant for a minimum of either 15 minutes or 30 minutes, depending upon the penetrant being used.

After keeping the surface wet with the penetrant for the required length of time, remove the excess penetrant from the surface with a clean, dry cloth, or absorbent paper towel. Then, dampen a clean, lint-free cloth, or absorbent paper towel with penetrant remover and wipe the remaining excess penetrant from the test surface. Next, allow the test surface to dry by normal evaporation or wipe it dry with the clean, lint-free cloth, or absorbent paper towel. In drying the surface, avoid contaminating it with oil, lint, dust, or other materials that would interfere with the inspection.

After the surface has dried, apply another substance, called a developer. Allow the developer (powder or liquid) to stay on the surface for a minimum of 7 minutes before starting the inspection. Leave it on no longer than 30 minutes, thus allowing a total of 23 minutes to evaluate the indications.

Do you know what takes place when these penetrant materials are applied? First of all, the penetrant applied to the surface of the material will seep into any passageway open to the surface, as illustrated in view A of figure 7-11. The penetrant is normally red in color, and like penetrating oil, it seeps into any crack or crevice that is open to the surface. Next, the excess penetrant is removed from the surface of the metal with the penetrant remover and a lint-free absorbent material. Only the penetrant on top of the metal surface is removed (view B, fig. 7-11); thus, only the penetrant that has seeped into the defect is left.




C 18.81X

Figure 7-11. Principles of liquid penetrant inspection.

Finally, the white developer is applied to the surface of the metal. (See view C, fig. 7-11.) The developer, an absorbing material, will actually draw the penetrant from the defect. Therefore, the red penetrant indications in the white developer represent the defective areas. The amount of red penetrant drawn from the defective areas will give an indication of the size and sometimes the type of defect. When dye penetrants are used, the lighting in the test area must be bright enough to enable you to see any indications of defects on the test surface.

The indications you see during a liquid penetrant inspection must be carefully interpreted and evaluated. In almost any inspection, some insignificant indications are present. Most of these are caused by failure to remove all excess penetrant from the surface. At least 10 percent of all indications must be removed from the surface to determine whether defects are actually present or whether the indications are merely caused by excess penetrant. If a second liquid penetrant inspection does not reveal indications in the same locations, it is usually safe to assume that the first indications were not really indications of defects.

All penetrant inspection materials must be removed as soon as possible after the final inspection has been made. Use water or solvents, as appropriate.

Since the liquid penetrant materials are flammable, do not use them near open flames, and do not apply them to any surface which is at a temperature higher than 100°F. In addition to being flammable, many solvents are poisonous in the vapor form and highly irritating to the skin in the liquid form.

## OTHER TESTS

Different types of tests are used for testing sample welds made on the job. Three tests which may be performed without elaborate equipment are the free-bend test, the guided-bend test, and the nick-break test.

### FREE-BEND TEST

The FREE-BEND TEST is designed to measure the ductility of the weld deposit and heat-affected area adjacent to the weld. It is also used to determine the weld metal's percentage of elongation. (Ductility, as you perhaps recall, is that property of a metal which makes it capable of being drawn out or hammered thin.)

As the first step in preparing a welded specimen for the free-bend test, machine the welded reinforcement crown flush with the surface of the test plate. Whenever the weld area of a test plate is machined, as is the case of the guided-bend as well as in the free-bend test, the machining operation must be performed opposite the direction in which the weld was deposited.

The next step in the free-bend test is to scribe two lines on the face of the filler deposit. Locate these lines 1/16 inch from each edge of the weld metal. (See view B, fig. 7-12.) Measure the distance, in inches, between the lines to the nearest 0.01 inch and let the resulting measurement equal (x). Then bend the ends of the test specimen so that each leg forms an angle of 30° to the original centerline.

With the scribed lines on the outside, and the piece placed so that all the bending will occur in the weld, bend the test piece by using a hydraulic press or similar machine. (If the proper precautions are observed, a blacksmith's forging press or hammer can be used to complete the bending operation.) If a crack in excess of 1/16 inch develops during the test, stop the bending; the weld is a failure. Otherwise, the specimen is bent flat. After completing the test, measure the distance between the scribed lines and designate that measurement (y). The percentage of elongation is then determined by the formula:

$$\frac{y - x}{x} \times 100 = \% \text{ of elongation}$$

Requirements for a satisfactory test are a minimum elongation of 15 percent, and no cracks greater than 1/16 inch on the face of the weld.

### GUIDED-BEND TEST

The GUIDED-BEND TEST is used to determine the quality of weld metal at the face and root of a welded joint. This test is made in a jig.

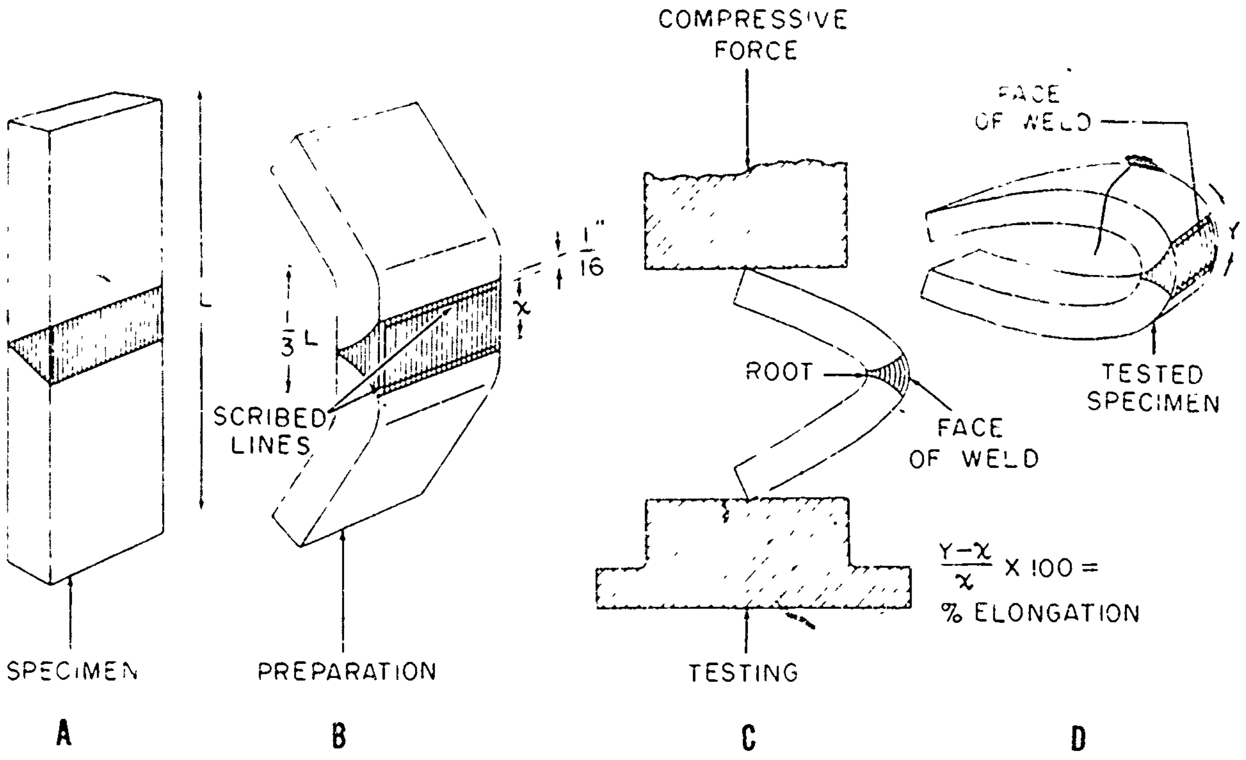
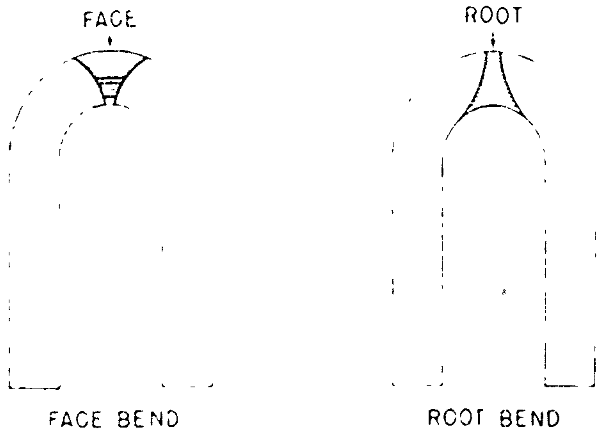


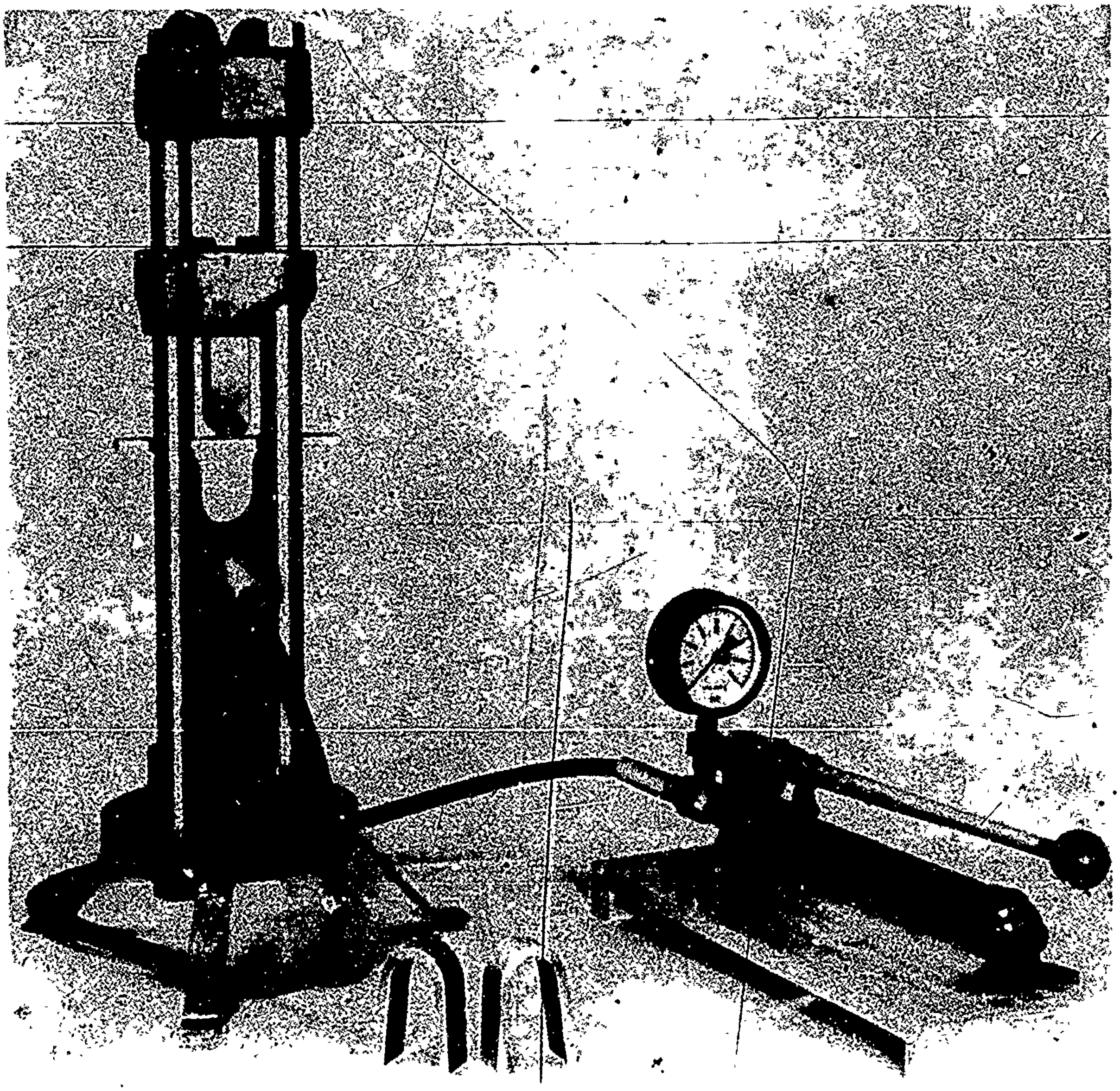

Figure 7-12.—Free-bend test. 98.63X

The test specimen is placed across the supports of the die. A plunger, operated from above by hydraulic pressure, forces the specimen into the die. To fulfill the requirements of this test, the specimen must bend to the capacity of the jig of 180°. No cracks should appear on the surface greater than 1/8 inch. The face-bend tests are made in this jig with the face of the weld in tension (outside), as shown in figure 7-13. The root-bend tests are made with the root of the weld in tension (outside), also as shown in figure 7-13.




98.64X
Figure 7-13.—Guided-bend test specimens.

Figure 7-14 shows a machine used for making the guided-bend test. This machine is used in many welding schools and testing laboratories for the daily testing of specimens. Simple in construction and easy to use, it works by hydraulic pressure and can apply a direct load up to 40,000 pounds, and even more on small specimens. When making the test, position the specimen in the machine as previously indicated and pump the lever of the pump. Keep your eye on the large gage and watch the load grow. You will know actual load under which the test piece fails by the position of an auxiliary hand which is carried along by the gage pointer. The hand remains at the point of maximum load after the pointer returns to zero.



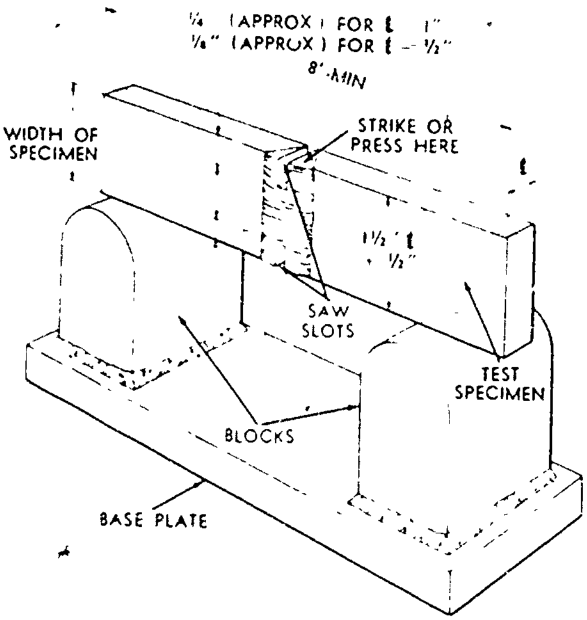
145.171X

Figure 7-14.—Testing machine for making guided-bend tests.

## NICK-BREAK TEST

The NICK-BREAK TEST is useful for determining the internal quality of the weld metal. This test reveals various internal defects (if present), such as slag inclusions, gas pockets, lack of fusion, and oxidized or burned metal. The nick-break test for soundness of a butt weld is performed as follows:

First, flame cut the test specimens from a sample weld. (See fig. 7-15.) Make a saw cut at each edge through the center of the weld. The depth of cut should be about 1/4 inch.




145.172

Figure 7-15.—Nick-break test of butt weld.

Next, place the saw-nicked specimen on two steel supports, as shown in figure 7-15; also, break the specimen by using a heavy hammer. Weld metal exposed in the break should be completely fused, free from slag inclusions, and contain no gas pockets greater than 1/16 inch across their greatest dimension. There should not be more than six pores or gas pockets per square inch of exposed broken surface of the weld.

## METAL IDENTIFICATION

A number of methods are available to help identify a piece of metal. The metal must be identified before it can be welded or used in fabrication. Common methods of identification include surface appearance, the spark test, and the chip test, which are described in *Steelworker 3 & 2*. Other methods are described below.

### CHEMICAL TEST

A chemical test identifies metals by their reaction with certain chemicals; it is not a chemical analysis. This test should be performed very carefully since a metal may be completely destroyed by the reacting chemicals. In addition, poisonous or explosive gases may be given off. Always perform the test in a ventilated room.

#### Aluminum and Its Alloys

To tell whether a metal is aluminum or an alloy of aluminum, start by putting a 10-percent solution of caustic soda and water in a glass beaker. Then dip the metal in this solution for a few minutes. If the metal is pure aluminum, it will not be discolored. If it is aluminum alloy, it will have darkened.

#### Stainless Steel

To prepare a test solution for stainless steel, start by dissolving 10 grams of cupric chloride in 100 cubic centimeters of hydrochloric acid. Place one drop of this solution on the metal's surface. Allow to stand for 2 minutes, then add 3 drops of water slowly. Next, wash and dry the surface. Finally, examine the spot tested. If the spot is brown, the steel consists of 18 percent chromium and 8 percent or more nickel. It is known as 18-8 stainless steel.

#### Nickel-Chromium-Iron Alloy

In the test for nickel-chromium-iron alloy, the test solution is the same as that for stainless steel, and it is applied in the same manner. If the test spot is white, the metal is a nickel-chromium-iron alloy.

### TEST FOR MAGNETIC PROPERTIES

Magnetic and nonmagnetic metals can easily be distinguished by testing them with a permanent magnet. If attracted by the magnet, the metal is usually iron or steel; if not attracted, it is nonferrous. But there are exceptions. Some nickel alloys are magnetic, whereas austenitic steel is nonmagnetic. With the spark test, however, the magnetic nonferrous metals can easily be told from the nonmagnetic ferrous metals.

## FIRE TEST

To identify a metal as magnesium or aluminum, try cutting off a small piece and heating it with a torch. If the metal is magnesium or magnesium alloy, it will ignite and burn violently. Aluminum or aluminum alloy will merely melt.

## HEAT-AND-QUENCH TEST

The heat-and-quench test is used to distinguish steel that can be hardened from that which cannot. In this test, the steel is heated to a bright red heat and quenched in cold water. Then an attempt is made to bend it. If the steel bends, it is low-carbon steel; if it breaks, it is an alloy steel or high-carbon steel. Make sure the steel is at least 1/16 inch thick. To further distinguish high-carbon steel from alloy steel, try the spark test.

## TORCH TEST

Some metals can be identified by heating samples with an oxyacetylene torch and observing the behavior of the metals. A list of these metals includes copper-nickel alloy, aluminum, copper, brass, bronze, lead, zinc, tin, magnesium, and their alloys.

### Copper-Nickel Alloy

An alloy consisting of 70 percent copper and 30 percent nickel flows freely when it is melted. As the alloy cools, a heavy, black scale forms on its surface.

### Aluminum and Its Alloys

When aluminum or an aluminum alloy is heated, the metal holds its shape until just before it melts and then suddenly collapses. A heavy, white scale forms immediately on the surface of the molten metal. Aluminum does not turn red when it is heated as some metals do.

### Copper

More heat is required to melt copper than most other metals. Like aluminum, copper tends to hold its shape until nearly molten and then suddenly collapses. It solidifies rapidly when the torch is removed. Copper alloys melt at lower temperatures and solidify more slowly than pure copper.

### Brass and Bronze

Brass gives off white fumes on melting due to the zinc in brass that changes to a vapor. When melted, tin bronze flows very freely and may fume slightly. As aluminum bronze melts, a heavy scum forms on its surface and mixes with the molten metal.

### Lead and Its Alloys

Lead and lead alloys melt at low temperatures. Usually, the molten metal is covered with a thin, dull-colored slag.

### Zinc and Its Alloys

When zinc or a zinc alloy is heated with an oxyacetylene torch, the metal melts at a low temperature and boils when it is melted.

### Tin and Its Alloys

Tin and tin alloys collapse quickly when they melt. They flow freely when molten and solidify rapidly when the torch flame is removed. Practically no scale is formed when these metals are heated.

### Magnesium and Its Alloys

When magnesium or a magnesium alloy is heated to near its melting point, the metal catches fire. Once the metal starts to burn, the fire gathers momentum rapidly. Enough heat is generated to melt steel. If the fire appears to be getting out of hand, smother it with sand. Magnesium fires cannot be extinguished by ordinary methods.

# CHAPTER 8

# COMPANY CHIEF

The senior enlisted person in the company may be assigned the duties of Company Chief, who serves as the principal enlisted assistant to the Company Commander. This chapter describes most of the important duties as well as the principles that you, as Company Chief, can apply in supervising or managing a project, carrying out the military functions of the company, training your personnel, or supervising the clerical administrative details of the company.

## PROJECT MANAGEMENT

Productivity on company projects will depend on the level of training of personnel, teamwork, condition and availability of equipment, status of material, and other factors. To be an effective Company Chief, you must recognize the problems that exist or are likely to develop so they can be solved before production is affected. Base your actions or decisions on personal knowledge and all available information. Keep in mind that the more complete this knowledge and information, the better are your chances of taking the right action or making the right decision.

You can accomplish little in the company unless responsibilities are specified for all levels of supervision. One of your duties is to insure that areas of responsibility and levels of authority are clearly defined for all enlisted personnel in the company. Also, establish good communications with the platoon leaders and the company commander in all matters pertaining to the efficient operation and effective working relations of the company. Make frequent inspections of all company projects to insure good working practices and proper use of manpower, equipment, and material. You will report the results of these ins[illegible]ons to the company commander, including the status of all matters pertaining to the projects. In addition, you will be expected to make recommendations that will improve working conditions or efficiency, as well as help the company commander maintain good working relations with other companies or units.

Besides ceremonies, briefings, and conferences, you will assist the company commander in the assignment of personnel to weapons and positions in the military organization of the company. For this assignment, it will pay you to study the battalion defensive plans and assist in laying out and coordinating the construction of company defensive positions. You can help insure the readiness of the company by inspecting its material, equipment, and personnel.

## BATTALION TRAINING

Most training for the company will be administered through the battalion organization, under the direction of the S-2 officer. To develop the necessary construction-combat skills within the battalion, the training officer utilizes training facilities, such as service schools, fleet schools, civilian schools, disaster recovery training units, and military training units, as well as battalion-formulated training programs. As Company Chief, you assist the company commander by contacting S 2 personnel and coordinating the assignment of company personnel to training designed to establish the company capability at the required level.

The commanders, Naval Construction Battalions, Atlantic/Pacific Fleet (COMCBLANT/COMCBPAC) have established the manpower skill level capability requirements for each Naval Mobile Construction Battalion (NMCB). The differences between the desired and actual capability are the training requirements in terms of skills and levels of proficiency. To assist in determining the state of readiness and capability of a SEABEE unit at any time and to plan for training and personnel support, the Personnel Readiness Capability Program (PRCP) was developed. The PRCP answers many basic questions. For example: How many Steelworkers can weld? How many of them will complete the next deployment? You can find other questions that the PRCP answers by reviewing a copy of the Personnel Readiness Capabilities Program, Volume II 6, *Standards and Guides for Steelworkers*. NAVFAC P-458. The information gathered through the PRCP system goes into a training plan to insure that the unit is capable of performing its functions during the next deployment.

## COMPANY TRAINING

The primary objective of the battalion-administered training program is the overall readiness of the battalion. Responsibility for the education, training, and resultant progress of each individual in the company remains with the company commander. The training officer may direct that certain training functions be at the company level and that a training program be administered by the company. If so, you as Company Chief, will assist the company commander in setting up an effective training program.

The enlisted advancement system assumes that enlisted personnel are provided adequate training. Although selected individuals receive training in service schools, it is neither intended nor desired that formal schooling provide all the training needed. Rather, the advancement system depends on the in-service training and support provided by individual commands. Responsibility for this training in an NMCB rests with the company commander.

Objectives of the company program should include (1) developing in all candidates for advancement, the skills necessary for the rate to which they aspire, (2) imparting the knowledge related to these skills, (3) developing petty officer attributes with emphasis on the quality of leadership, and (4) providing items that contribute to the overall efficiency of the company (safety instructions, new work methods, and so on).

The company commander has five major functions in the enlisted advancement system: (1) to encourage all personnel to qualify for advancement; (2) to give exact information on requirements for advancement, schools available, and eligibility requirements for these schools; (3) to recommend for advancement those who have met the qualifications; (4) to establish procedures for training and advancement; and (5) to maintain an effective training program.

The company commander normally outlines the course of instruction applicable to the company and delegates the responsibility for instruction, recordkeeping, and checking on individual progress in completing study assignments and advancement requirements.

### ORGANIZATION

The content, timing, and organization of the company training program depends on location, operational commitments and experience of the company petty officers, training aids and training facilities available, requirements of higher authority, and other factors. Therefore, the training program has to be tailored to meet the requirements of each company.

The following example may be useful as a guide for delegating responsibility for a training program. DELTA Company, NMCB 901, is organized with three platoons. The first platoon consists of a Chief Builder as a platoon leader, with rated Builders and Builder strikers. The second platoon consists of a Chief Builder as platoon leader, with two squads of rated Builders and Builder strikers and one squad of Steelworkers and Steelworker strikers. The third platoon consists of a Chief Steelworker as platoon leader, with rated Steelworkers and Steelworker strikers. The training

responsibilities for the company may be organized as follows:

1. The platoon leader (BUC) of the first platoon is responsible for the development of skills and knowledge of the Builder rating for all Builders in the company. Using the petty officers of the platoon as instructors, the platoon leader directs a training program that is designed to (1) prepare Builders at all levels for advancement (including advancement requirements), (2) improve working practices or efficiency of the Builders, and (3) prepare the Builders for any upcoming project. The platoon leader then must turn in reports of instructions and progress to the company clerk.

2. The platoon leader (BUC) of the second platoon is responsible for the leadership program, instructor training, and safety training of the company. The platoon leader directs a training program that is designed to (1) develop leadership, (2) provide qualified instructors for the company, and (3) insure safe working practices. Due to the nature of subjects, the platoon leader calls on various qualified petty officers in the company to serve as instructors for the training program. The platoon leader must turn in reports of instructions and progress to the company clerk.

3. The platoon leader (SWC) of the third platoon is responsible for the developing of skills and knowledge of the Steelworker rating for all Steelworkers in the company. Using the petty officers of the platoon as instructors, the platoon leader directs a training program that is designed to (1) prepare Steelworkers at all levels for advancement (including advancement requirements), (2) improve working practices or efficiency of the Steelworkers, and (3) prepare the Steelworkers for any upcoming project. The platoon leader must turn in reports of instructions and progress to the company clerk.

4. The company clerk collects training information from the platoon leaders and prepares company records and reports. The company records may be designed to include (1) each individual's progress toward advancement, (2) each skill in which an individual has received instruction, and (3) other information deemed necessary by the company commander.

5. The Company Chief is responsible for the preparation of training schedules; helping the platoon leaders obtain training publications, training aids, and training facilities; helping the company commander review lesson plans, records, and reports and evaluate the training program.

6. The company commander directs the company in ground defense and disaster control exercises; organizes and directs the training program of the company; assists in formulating NMCB training at meetings with the executive officer; reviews each individual's progress toward advancement; evaluates the effectiveness of the company training program; and reviews and signs company training reports that are submitted to S-2, S-3, and so on.

## INSTRUCTORS

The petty officers of the company are the instructors in the company training program. Although teaching ability is included among the naval standards for enlisted personnel in pay grades E-5 and above, most petty officers will have had little experience as instructors. A petty officer may be expert and knowledgeable in a given field—which is important in teaching—but there are other qualifications that the petty officer instructor should possess. For example, familiarity with the latest methods and techniques of teaching, and ability to motivate students to learn. Among other things, the instructors should take their jobs seriously and be pleasant. Few petty officers will be able to teach effectively without some training. Therefore, in the company training program, the development of instructors becomes a primary objective.

Chances are that several senior petty officers of the company will have had a tour of instructor duty and are good instructors for the instructor training program. *The Manual for Navy Instructors*, NAVEDTRA 107, is the basic text for use in instructor training.

A valuable source of already prepared training courses are the NCTC's. Many of the

SCBT courses are short and directed at one skill. There is a good possibility that the NCTC already has prepared lesson plans, instructors' guides, list of tools, equipment, references, etc., required to teach the subject, so before launching out to prepare your own, contact the local NCTC and find out what they already have available.

## ON-THE-JOB TRAINING

Construction projects assigned to the company are usually suitable for one of the many forms of on-the-job training. It may be an especially tailored, well-organized program, such as one designed to help Steelworkers acquire advanced skills in welding. Then again, on-the-job training may be in the form of simple instruction, like explaining and showing someone how to replace the cutting tip on a welding torch. In each case, one person helps another learn a job or task and makes sure the trainee learns to do it correctly. Therefore, on-the-job training has come to mean "helping an individual acquire the necessary knowledge, skill, and habits to perform a specific job." This training applies not only to the new personnel in an organization, but also to persons who are assigned new jobs. Since no person can be regarded as completely trained, on-the-job training is a continuous process.

### Setting Up and Implementing an On-The-Job Training Program

One of the first steps in setting up an on-the-job training program is to determine the need for training. In determining this need, it is often a good idea to interview the trainees. By proper questioning, you can get a summary of their previously acquired skills and knowledge. Next, compare jobs the trainees know how to do with those they will be doing. The training needs can then be determined on the basis of required knowledge and skills minus knowledge and skills already possessed.

Knowing the type of training required, you can then determine the subject matter to be taught and how much to teach at one time. Many new instructors try to teach too much at a time. They forget that what seems simple to them may be very difficult for a trainee. Bear in mind that beginners need to get their learning in small doses. So break down the job into small parts and teach these small parts one at a time. You may also have to establish lesson sequence, determine lesson objectives, analyze reference materials, prepare lesson plans, and so on.

Determine the method or methods which will be most effective in conducting the training. The number of trainees, time available, facilities required, nature of training, and individual capabilities are determining factors. (A section on methods of on-the-job training is presented later.)

Carefully select those who will actually conduct the training. By all means try to select instructors who know their job and are efficient, effective workers. They should also be dependable, patient, and keenly aware of how people learn. Among other things, the instructors should be able to make learning interesting and motivate the trainees to learn. Do not expect a high level of achievement from trainees whose instructor is dull, does not know the job, and does not seem to care whether they learn or not.

Before getting underway with instruction, the instructor should have equipment and materials ready and have the work place properly arranged. It is difficult to learn a new job at a bench which is cluttered up with tools, nuts and bolts, scrap material, and so on. Have only what is needed for the immediate job. Give the trainees a fresh start!

Prior to starting a job, the instructor should explain the purpose of the job and give directions on how to accomplish the job SAFELY, easily, and economically. The instructor should also explain the techniques that will improve the skills of the trainees. The importance of each operation in the job should be stressed. The technical terms relating to the job should also be explained.

The instructor and trainees should discuss the problems that arise in doing a job, and try to clear up any questions. The instructor should point out to the trainees any similarity in different operations of the job so knowledge or training may be transferred. Relationship of procedures in a particular job, to things with which the trainee is acquainted, should also be

discussed. This allows the trainee to learn through association with past experiences.

At frequent intervals, the instructor should let the trainees know how well they are doing, individually and collectively. The instructor should encourage them to keep trying, by stressing the value of the training.

By turning out well-trained workers, the instructors contribute to Navy training. An instructor's job is not easy, but a reputation for doing an outstanding job of training subordinates is well deserved.

### Methods of On-the-Job Training

In on-the-job training, you must be prepared to use a combination of training methods, depending upon the nature of the subject, time available, and the capabilities of the trainee. The following methods of training are basic to any well-planned unit training program.

No other method of training is as effective as intelligent, interested COACH-PUPIL INSTRUCTION. In addition to being a quick way of fitting a new worker into the operation of a unit, it serves as one of the best methods of training. Without specific directions and guidance in learning to perform the necessary duties, a worker is likely to waste time and material, and form bad work habits. Many organizations in private industry have apprenticeship courses which are designed to train workers in a trade or skill. Their training consists of coach-pupil supervision under skilled workers with periodic group instruction when it is advantageous.

SELF-STUDY should be encouraged. Skilled and semiskilled jobs require a considerable amount of job knowledge and judgment ability. Even in simple jobs, there is much basic information that the worker must acquire. The more complicated technical jobs involve both basic and highly specialized technical knowledges and related skills, which must be taught.

GROUP INSTRUCTION is a practical adjunct to direct supervision and self-study. It saves time when several workers are to be instructed in the same job knowledge or procedures. It affords an opportunity for the instructor to check the progress of training and to clarify matters which are difficult for the trainees to understand. Group instruction, if intelligently used, can expedite production. For example, suppose six trainees are learning the same job. Four of the trainees are having trouble with a certain job element, while the other two have it "knocked".

The four trainees having trouble can be brought over to the other two, and in a short time the difficulty will probably be solved. In on-the-job training, this is an example of group instruction; and, as can be seen, group instruction is not the same as classroom or so-called "academic-type" instruction.

Another type of on-the-job training is PIECEMEAL INSTRUCTION. For instance, trainees ask for information which the instructor then supplies. A crew leader's orders to crew are piecemeal in a sense because the leader lets a crew know what, when, where, and, perhaps, how and why. Some other examples of piecemeal instruction are: explaining regulations, procedures, and orders; holding special meetings; indoctrinating new personnel, and organized or unorganized on-the-job instruction.

### Expand Knowledge of Training

There is a lot to training and extensive coverage on the subject that is not given here. Training is essential to continued progress and success of the Navy, so make a continuing effort to expand your knowledge of training. Additional information on training can be found in the *Manual for Navy Instructors*, and *Military Requirements for Petty Officer 1 & C*. *CAMPUS*, the Magazine of Naval Training, will also help keep you posted on current developments in training in today's Navy. Remember that you owe it to your personnel at all times to give them the best training possible.

## ADMINISTRATIVE SUPERVISION

As Company Chief, you supervise the clerical administrative details of the company. You are responsible for maintaining company records and supervising the preparation of company reports (daily musters, time sheets, and so

on). You must insure that all pertinent directives and information are disseminated to enlisted personnel of the company.

## PERSONNEL ADMINISTRATION

The Company Chief must pay particular attention to items that may influence morale, discipline, or espirit de corps. As Company Chief, you are generally in a better position than the company commander to influence the enlisted personnel of the company. You should, therefore, counsel enlisted personnel on any pertinent professional and personal matter which may affect their efficiency or effectiveness. Although it may be necessary to refer some problems to the company commander, there are many matters that you can take action on. For example, suppose CN Pardines is unable to obtain a pair of boots of the correct size from the greens issue. You can tell this person where they may be obtained. Such a problem is small, but it happens often and should be solved promptly.

You will have many other specific duties in regard to company personnel. They are listed below. greet, interview, and indoctrinate new personnel to the company; insure that the company commander's personnel data cards and PRCP cards are prepared and kept current according to existing instructions; assign or insure the assignment of all company personnel within a platoon, work crew, berthing space, duty section, etc.; insure assignment and fair rotation of mess personnel, compartment cleaners, shore patrol, and the like; recommend to the company commander personnel who are eligible for advancement; supervise and coordinate the preparation of enlisted evaluation sheets and insure that they are fair and accurate; direct the expeditious handling of special request slips, insure the prompt delivery of personal mail and see that such mail is immediately forwarded to personnel on detachment, in hospitals, etc.; assist the company commander in disciplinary matters, insure satisfactory scheduling of personnel going on annual leave and R and R leave; encourage individual study and motivate eligible personnel to take advantage of programs for which they may qualify (i.e., SCORE and LDO); and coordinate company recreation projects, such as parties and athletic teams.

Several books have been written on the subject of military leadership and you have probably read some of them. One book that may be of particular interest to you, as Company Chief, is *The Armed Forces Officer*, NAVEDTRA 46905.

## COMMUNICATION

Passing the word is an important part of the Company Chief's job. The battalion's commanding officer, your company commander, and other higher authority frequently issue orders or directives which you should pass on to your personnel. You should be familiar with all instructions and notices that affect your work and the work of your personnel, and make certain that all this information has been passed down within your command.

Orders and directives from higher authority may pertain to a particular job, recreation, liberty, military requirements, or safety. When the information is of the type you can pass orally, you should determine the best time to do so. Morning quarters and special musters are often suitable times.

You will need to put certain types of information into writing in the form of a written directive. Considerable personnel turnovers exist in most units, and it takes new personnel several weeks or months to learn about all the policies they should know. Their tasks are even harder if there are no written directives to which they can refer. Safety requirements, local policies with respect to the use of Government material, tools and equipment, and local shop rules are examples of information which should normally be in written form.

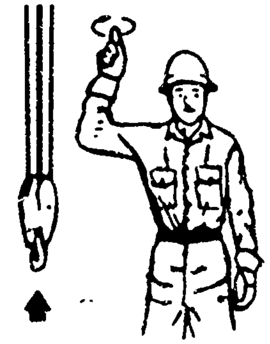
Remember, communication is the process of conveying information and understanding to others. Never minimize the importance of good communication. It leads to better human relations and higher individual and company morale. Money, time, and lives can be saved if communication is accurate and fast. Obviously, no military organization can be truly effective without good communication.

Be a good listener—an important part of communications and one most frequently ignored is listening to what the other person has to say. Careful listening will frequently reveal just how well the word is being passed down the chain of command. Communication is a two-way street, listening and speaking. Also, good listening reveals just how much the other person knows or does not know and thus the listener is better prepared to take corrective action.

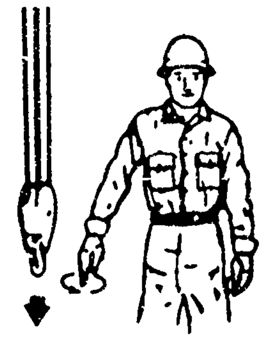
Bulletin boards are a convenient means of passing along information the personnel need. Keep the boards clear of extraneous information. One Company Chief was very successful in assuring that the personnel would read the bulletin board by putting little cartoons on it.

One obvious method of attracting attention toward the bulletin boards is to place the duty-section list there. Preparing the duty section rosters and posting them on the bulletin board as far in advance as possible is a morale booster. It enables the personnel to make plans well in advance and at the same time helps you anticipate your own manpower requirements more readily. C-O-M-M-U-N-I-C-A-T-E.

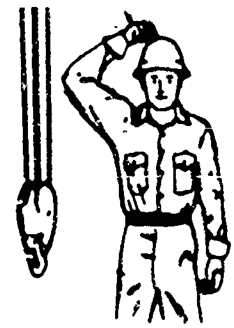
## Appendix I
# HAND SIGNALS



HOIST: WITH FOREARM VERTICAL, FOREFINGER POINTING UP, MOVE HAND IN SMALL HORIZONTAL CIRCLES.

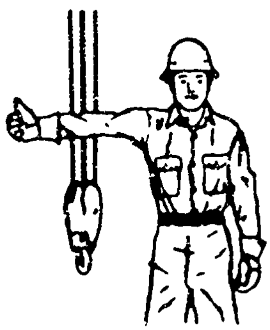


LOWER: WITH ARM EXTENDED DOWNWARD, FOREFINGER POINTING DOWN, MOVE HAND IN SMALL HORIZONTAL CIRCLES.

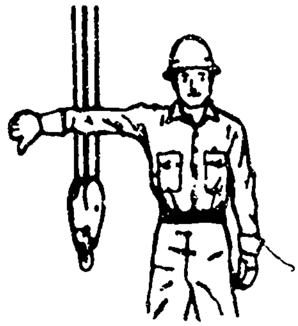


USE MAIN HOIST: TAP FIST ON HEAD, THEN USE REGULAR SIGNALS.

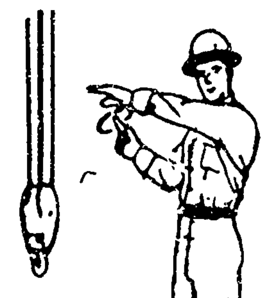
USE WHIP LINE: (AUXILIARY HOIST) TAP ELBOW WITH ONE HAND, THEN USE REGULAR SIGNALS.



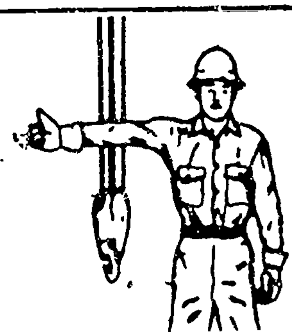
RAISE BOOM: ARM EXTENDED, FINGERS CLOSED, THUMB POINTING UPWARD.



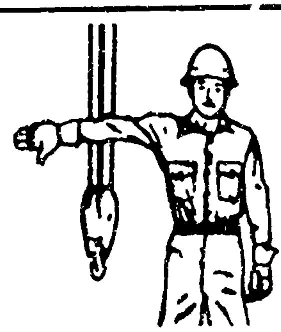
LOWER BOOM: ARM EXTENDED, FINGERS CLOSED, THUMB POINTING DOWNWARD.



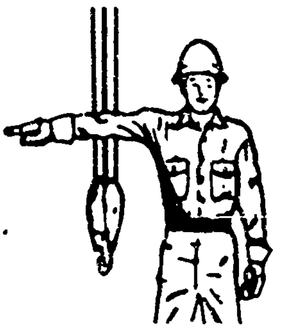
MOVE SLOWLY: USE ONE HAND TO GIVE ANY MOTION SIGNAL AND PLACE OTHER HAND MOTIONLESS IN FRONT OF HAND GIVING THE MOTION SIGNAL. (HOIST SLOWLY SHOWN AS EXAMPLE).



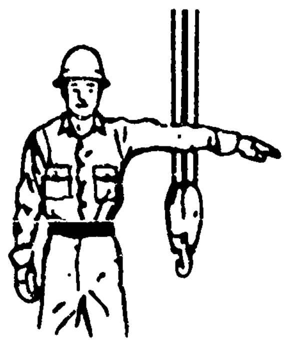
RAISE THE BOOM AND LOWER THE LOAD: WITH ARM EXTENDED THUMB POINTING UP, FLEX FINGERS IN AND OUT AS LONG AS LOAD MOVEMENT IS DESIRED.



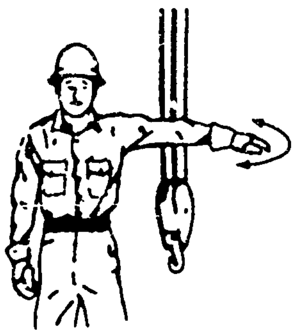
LOWER THE BOOM AND RAISE THE LOAD: WITH ARM EXTENDED, THUMB POINTING DOWN, FLEX FINGERS IN AND OUT AS LONG AS LOAD MOVEMENT IS DESIRED.



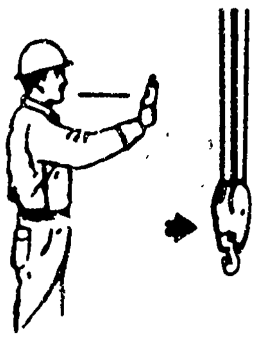
SWING: ARM EXTENDED POINT WITH FINGER IN DIRECTION OF SWING OF BOOM.



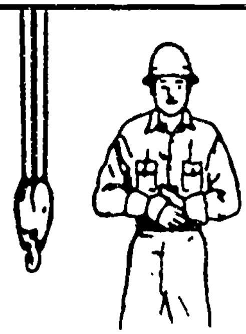
STOP: ARM EXTENDED, PALM DOWN, HOLD POSITION RIGIDLY.



EMERGENCY STOP: ARM EXTENDED, PALM DOWN, MOVE HAND RAPIDLY RIGHT AND LEFT.

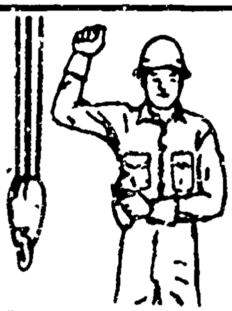


TRAVEL: ARM EXTENDED FORWARD, HAND OPEN AND SLIGHTLY RAISED, MAKE PUSHING MOTION IN DIRECTION OF TRAVEL.

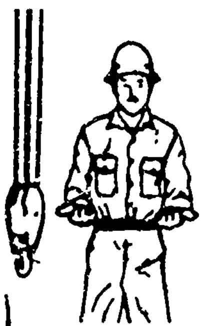


DOG EVERYTHING CLASP HANDS IN FRONT OF BODY.

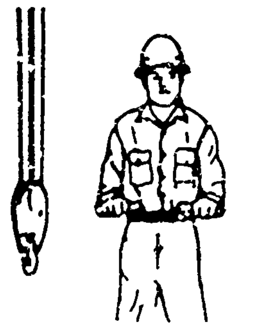
TRAVEL: (BOTH TRACKS) USE BOTH FISTS, IN FRONT OF BODY, MAKING A CIRCULAR MOTION, ABOVE EACH OTHER, INDICATING DIRECTION OF TRAVEL, FORWARD OR BACKWARD (FOR CRAWLER CRANES ONLY).



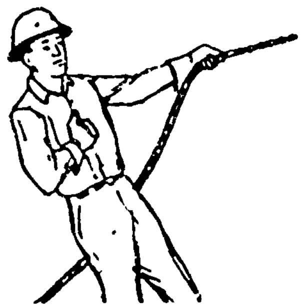
TRAVEL: (ONE TRACK) LOCK THE TRACK ON SIDE INDICATED BY RAISED FIST. TRAVEL OPPOSITE TRACK IN DIRECTION INDICATED BY CIRCULAR MOTION OF OTHER FIST, ROTATED VERTICALLY IN FRONT OF BODY (FOR CRAWLER CRANES ONLY).



EXTEND BOOM: (TELESCOPING BOOM) BOTH FISTS IN FRONT OF BODY WITH THUMBS POINTING OUTWARD.



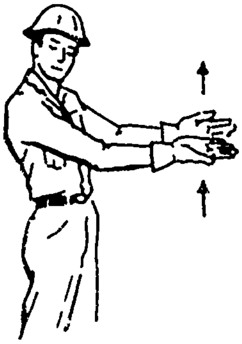
RETRACT BOOM: (TELESCOPING BOOM) BOTH FISTS IN FRONT OF BODY WITH THUMBS POINTING TOWARD EACH OTHER.



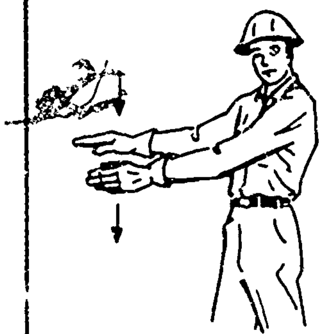
EXTEND BOOM: (TELESCOPING BOOM) ONE HAND SIGNAL. ONE FIST IN FRONT OF CHEST WITH THUMB TAPPING CHEST.

RETRACT BOOM: (TELESCOPING BOOM) ONE HAND SIGNAL. ONE FIST IN FRONT OF CHEST, THUMB POINTING OUTWARD AND HEEL OF FIST TAPPING CHEST.

WHEN CUT, FILL OR HAUL ROAD IS TO BE DRAGGED OR BLADED, POINT TO THE AREA, THEN RUB PALMS OF HANDS TOGETHER INDICATING A SMOOTHING MOTION. APPLIES TO SCRAPERS, MOTOR GRADERS AND BULLDOZERS.



RAISE A LITTLE



LOWER A LITTLE

DUMP LOAD NOW: (START DUMPING AND SPREADING LOAD TO PROPER DEPTH IF GIVEN.)

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# STEELWORKER 1 &C

## NAVEDTRA 10654-E

Prepared by the Naval Education and Training Program Development Center, Pensacola, Florida

Your NRCC contains a set of assignments and perforated answer sheets. The Rate Training Manual, Steelworker 1&C, NAVEDTRA 10654-E , is your textbook for the NRCC. If an errata sheet comes with the NRCC, make all indicated changes or corrections. Do not change or correct the textbook or assignments in any other way.

### HOW TO COMPLETE THIS COURSE SUCCESSFULLY

Study the textbook pages given at the beginning of each assignment before trying to answer the items. Pay attention to tables and illustrations as they contain a lot of information. Making your own drawings can help you understand the subject matter. Also, read the learning objectives that precede the sets of items. The learning objectives and items are based on the subject matter or study material in the textbook. The objectives tell you what you should be able to do by studying assigned textual material and answering the items.

At this point you should be ready to answer the items in the assignment. Read each item carefully. Select the BEST ANSWER for each item, consulting your textbook when necessary. Be sure to select the BEST ANSWER from the subject matter in the textbook. You may discuss difficult points in the course with others. However, the answer you select must be your own. Remove a perforated answer sheet from the back of this text, write in the proper assignment number, and enter your answer for each item.

Your NRCC will be administered by your command or, in the case of small commands, by the Naval Education and Training Program Development Center. No matter who administers your course you can complete it successfully by earning a 3.2 for each assignment. The unit breakdown of the course, if any, is shown later under Naval Reserve Retirement Credit.

### WHEN YOUR COURSE IS ADMINISTERED BY LOCAL COMMAND

As soon as you have finished an assignment, submit the completed answer sheet to the officer designated to grade it. The graded answer sheet will not be returned to you.

If you are completing this NRCC to become eligible to take the fleetwide advancement examination, follow a schedule that will enable you to complete all assignments in time. Your schedule should call for the completion of at least one assignment per month.

Although you complete the course successfully, the Naval Education and Training Program Development Center will not issue you a letter satisfactory completion. Your command will ..e an entry in your service record, giving you credit for your work.

### WHEN YOUR COURSE IS ADMINISTERED BY THE NAVAL EDUCATION AND TRAINING PROGRAM DEVELOPMENT CENTER

After finishing an assignment, go on to the next. Retain each completed answer sheet until you finish all the assignments in a unit (or in the course if it is not divided into units). Using the envelopes provided, mail your completed answer sheets to the Naval Education and Training Program Development Center where they will be graded and the score recorded. Make sure all blanks at the top of each answer sheet are filled in. Unless you furnish all the information required, it will be impossible to give you credit for your work. The graded answer sheets will not be returned.

The Naval Education and Training Program Development Center will issue a letter of satisfactory completion to certify successful completion of the course (or a creditable unit of the course). To receive a course-completion letter, follow the directions given on the course-completion form in the back of this NRCC.

You may keep the textbook and assignments for this course. Return them only in the event you disenroll from the course or otherwise fail to complete the course. Directions for returning the textbook and assignments are given on the book-return form in the back of this NRCC.

## PREPARING FOR YOUR ADVANCEMENT EXAMINATION

Your examination for advancement is based on the Occupational Standards for your rating as found in the MANUAL OF NAVY ENLISTED MANPOWER AND PERSONNEL CLASSIFICATIONS AND OCCUPATIONAL STANDARDS (NAVPERS 18068). These Occupational Standards define the minimum tasks required of your rating. The sources of questions in your advancement examination are listed in the BIBLIOGRAPHY FOR ADVANCEMENT STUDY (NAVEDTRA 10052). For your convenience, the Occupational Standards and the sources of questions for your rating are combined in a single pamphlet for the series of examinations for each year. These OCCUPATIONAL STANDARDS AND BIBLIOGRAPHY SHEETS (called Bib Sheets), are available from your ESO. Since your textbook and NRCC are among the sources listed in the bibliography, be sure to study both as you take the course. The qualifications for your rating may have changed since your course and textbook were printed, so refer to the latest edition of the Bib Sheets.

## NAVAL RESERVE RETIREMENT CREDIT

This course is evaluated at 12 Naval Reserve retirement points, which will be credited upon satisfactory completion of the entire course. These points are creditable to personnel eligible to receive them under current directives governing retirement of Naval Reserve personnel. Credit cannot be given again for this course if the student has previously received credit for completing another Steelworker 1&C NRCC or ECC.

## COURSE OBJECTIVE

In completing this NRCC, you will demonstrate a knowledge of the subject matter by correctly answering items on the following: administrating an accident prevention program; organizing a battalion training program; managing the Personnel Readiness Capability Program; advanced base planning, embarkation, and project turnover, construction scheduling; supervisory of, safety precautions of, and detailed elements of reinforcing concrete with steel; fundamentals and procedures of aluminum, gas tungsten-arc, and gas metal-arc welding processes using various metals and alloys; techniques of metal cutting by carbon-arc and air-arc processes; safety principles of operating and handling of welding tools and techniques; various methods of testing metal strength; and duties and responsibilities of the construction inspector and the company chief.

While working on this correspondence course, you may refer freely to the text. You may seek advice and instruction from others on problems arising in the course, but the solutions submitted must be the result of your own work and decisions. You are prohibited from referring to or copying the solutions of others, or giving completed solutions to anyone else taking the same course.

Naval courses may include a variety of questions -- multiple-choice, true-false, matching, etc. The questions are not grouped by type; regardless of type, they are presented in the same general sequence as the textbook material upon which they are based. This presentation is designed to preserve continuity of thought, permitting step-by-step development of ideas. Some courses use many types of questions, others only a few. The student can readily identify the type of each question (and the action required) through inspection of the samples given below.

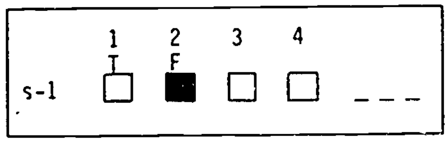
## MULTIPLE-CHOICE QUESTIONS

Each question contains several alternatives, one of which provides the best answer to the question. Select the best alternative, and blacken the appropriate box on the answer sheet.

### SAMPLE

s-1. The first person to be appointed Secretary of Defense under the National Security Act of 1947 was
1. George Marshall
2. James Forrestal
3. Chester Nimitz
4. William Halsey

Indicate in this way on the answer sheet:



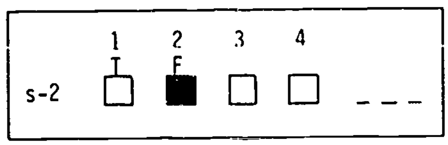

## TRUE-FALSE QUESTIONS

Mark each statement true or false as indicated below. If any part of the statement is false the statement is to be considered false. Make the decision, and blacken the appropriate box on the answer sheet.

### SAMPLE

s-2. Any naval officer is authorized to correspond officially with any systems command of the Department of the Navy without his commanding officer's endorsement.

Indicate in this way on the answer sheet:




## MATCHING QUESTIONS

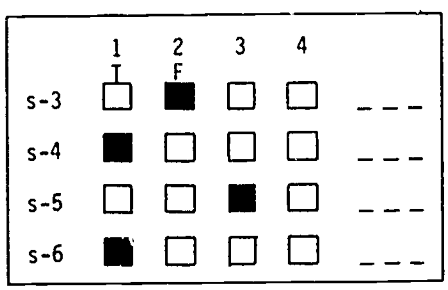
Each set of questions consists of two columns, each listing words, phrases or sentences. The task is to select the item in column B which is the best match for the item in column A that is being considered. Items in column B may be used once, more than once, or not at all. Specific instructions are given with each set of questions. Select the numbers identifying the answers and blacken the appropriate boxes on the answer sheet.

### SAMPLE

In questions s-3 through s-6, match the name of the shipboard officer in column A by selecting from column B the name of the department in which the officer functions.

| A | B |
|---|---|
| s-3. Damage Control Assistant | 1. Operations Department |
| s-4. CIC Officer | 2. Engineering Department |
| s-5. Disbursing Officer | 3. Supply Department |
| s-6. Communications Officer | |

Indicate in this way on the answer sheet:



# Assignment 1

Administration

Textbook Assignment: Pages 1-1 through 1-32

In this course you will demonstrate that learning has taken place by correctly answering training items. The mere physical act of indicating a choice on an answer sheet is not in itself important; it is the mental achievement, in whatever form it may take, prior to the physical act that is important and toward which course learning objectives are directed. The selection of the correct choice for a course training item indicates that you have fulfilled, at least in part, the stated objective(s).

The accomplishment of certain objectives, for example, a physical act such as drafting a memo, cannot readily be determined by means of objective type course items; however, you can demonstrate by means of answers to training items that you have acquired the requisite knowledge to perform the physical act. The accomplishment of certain other learning objectives, for example, the mental acts of comparing, recognizing, evaluating, choosing, selecting, etc., may be readily demonstrated in a course by indicating the correct answers to training items.

The comprehensive objective for this course has already been given. It states the purpose of the course in terms of what you will be able to do as you complete the course.

The detailed objectives in each assignment state what you should accomplish as you progress through the course. They may appear singly or in clusters of closely related objectives, as appropriate; they are followed by items which will enable you to indicate your accomplishment.

All objectives in this course are learning objectives and items are teaching items. They point out important things, they assist in learning, and they should enable you to do a better job for the Navy.

This self-study course is only one part of the total Navy training program; by its very nature it can take you only part of the way to a training goal. Practical experience, schools, selected reading, and the desire to accomplish are also necessary to round out a fully meaningful training program.

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Learning Objective: Describe reports, records, and forms that show job progress, man-hours, and material expended.

---

1-1. As a supervisor, why is it advantageous to keep up-to-date records and reports on projects?
1. To keep a close check on the project, crewmembers, and equipment
2. To check accomplished job progress against the planned job progress
3. To plan and schedule future projects
4. Each of the above

1-2. Which of the following data is NOT found in the work progress log?
1. Date the job order was received and the job order number assigned
2. Date the material is received and amount of material received
3. Brief description of the job
4. Number of man-hours required and names of personnel assigned

1-3. The job progress log is used to determine the percentage of work completed on a project at any given time.

1-4. Of the following data, which is found on the material expended record?
1. Date and amount of material received
2. Date and amount of material expended
3. Order number of the project on which the material is used
4. Each of the above

1-5. The equipment log is used to locate tools and to assist in making periodic inventories.

1-6. Refer to textbook figure 1-3. How many man-hours were spent on direct labor on the project?
1. 40
2. 64
3. 80
4. 88

Learning Objective: Describe and prepare official Navy letters, messages, instructions, and prepare notices for use by subordinates.

1-7. The copy of a standard naval letter prepared by Charlie or Delta Company for the CO's signature is normally a
1. smooth copy
2. rough copy
3. perfect copy

In answering items 1-8 through 1-10, refer to textbook figures 1-5 and 1-6.

1-8. Which of the following lines of the standard naval letter may NOT be required in all correspondence being prepared?
1. "To" line
2. "From" line
3. "Subject" line
4. "Identification Symbol" line

1-9. In a standard naval letter, which of the following abbreviations is NOT used?
1. Ref:
2. Encl:
3. Sub:

1-10. In a standard naval letter. which of the following formats is optional?
1. Spelling out or abbreviating the month
2. Stamping or typing the date
3. Either 1 or 2 above

1-11. Who is responsible for the finished correspondence prepared by you?
1. Drafting office
2. Department head
3. Duty officer
4. You

1-12. In correspondence requiring a classification, where is it shown?
1. Left-hand margin
2. Right-hand margin
3. Top of page only
4. Top and bottom of the page

1-13. When preparing a naval letter, you are NOT allowed to cover two or more subjects even though they are closely related.

1-14. Which paragraph, if any, of a 3-paragraph naval letter should state the purpose of the letter?
1. First
2. Second
3. Third
4. None

1-15. When answering another letter, you should refer to it in the last paragraph of your letter.

1-16. As a writer of official correspondence, which of the following guidelines must you follow?
1. Maintain continuity when passing from one unit to another
2. Arrange your units in satisfactory order
3. Complete each unit before moving to the next
4. Each of the above

1-17. Which of the following is a poor practice in preparing a naval letter?
1. Repeating yourself
2. Using introductory phrases
3. Deleting intensive words
4. Cutting down on the use of big words

1-18. When a memorandum is typed on a plain sheet of bond paper, the word "memorandum" must appear on the sheet. This word is typed in which of the following ways?
1. In capital letters at the right margin above the "from" line
2. In capital letters at the left margin above the "from" line
3. In lowercase letters, two spaces below the "subject" line
4. In lowercase letters between the "from" and "to" lines

1-19. What is the chief purpose of the format of a speedletter?
1. To help disseminate information within the Navy Directives Issuance System
2. To enable urgent correspondence to be transmitted by electrical means
3. To point out the necessity for priority handling
4. To make possible the transmission of classified documents

1-20. A speedletter may be handwritten instead of typed when
1. identifying blocks are used in it
2. enclosures are listed in it
3. time is critical
4. it is classified

1-21. Who authorizes the transmission of a message?
1. The drafter
2. The originator
3. The releasing officer
4. Each of the above

1-22. Messages that must be delivered promptly should be brief, concise, and contain a message heading and a message text.

1-23. What format correctly expresses a date-time group in a naval message?
1. 07 DEC 81 @ 1330
2. 07 DEC 81; 1:30 P.M.
3. 071330Z DEC 81
4. DEC 071330Z 81

1-24. At most, how many spaces and characters are there per line of text in a naval message?
1. 49
2. 57
3. 69
4. 98

1-25. Of the following symbols or punctuation marks, which is NOT used in a naval message?
1. *
2. ?
3. &
4. /

---

Learning Objective: Describe principles of administrating a safety program.

---

1-26. In establishing a safety organization, each unit of the NCF must develop an accident prevention program and enforce safe working practices.

1-27. When does a safety officer formulate safety doctrine and policy for the battalion?
1. After conducting on-the-job analyses
2. After consulting with project supervisors
3. Both 1 and 2 above

1-28. In addition to assigning crewmembers to equipment operation, project supervisors are also responsible for the crew's safety, health, and physical welfare.

1-29. Working your plan for controlling the hazards of a job will help you do which of the following?
1. Upgrade production
2. Prevent accidents
3. Instill respect
4. Each of the above

1-30. To help prevent accidents, you can review the previous accident experience on the job, select the right methods and right personnel for the job, and make specific work assignments.

1-31. How often should you hold a standup safety meeting at the project site?
1. Weekly
2. Biweekly
3. Monthly
4. Whenever an accident has been reported

1-32. Which of the following results should be obtained from a group discussion pertaining to an accident which happened on the job and resulted in an injury?
1. Kind of injury sustained
2. Ways of preventing the accident
3. Cause of the injury
4. All of the above

1-33. Regularly scheduled standup safety meetings must be kept interesting. You can help keep them from becoming dull by taking which of the following actions?
1. Letting your crew air their gripes at the meetings
2. Exceeding the time limits you set for the meetings
3. Having the same crewmember conduct all meetings
4. Showing good motion pictures and other visual aids on suitable subject matter

1-34. What information is included in the periodic safety report that you submit to the safety chief?
1. Time spent at safety meetings
2. Attandance figures
3. Subject matter covered
4. Each of the above

1-35. In case of an accident to one of your crewmembers, you must answer the questions listed on OPNAV Form 5102/1.

- In answering items 1-36 through 1-38, refer to figures 1-8 through 1-11 of your textbook.

1-36. What block describes job disposition after the accidental injury?
1. 11
2. 20
3. 23
4. 32

1-37. What block contains information pertaining to the circumstances and events that caused the accident?
1. 11
2. 20
3. 23
4. 32

1-38. What block describes the employment status of the injured person?
1. 11
2. 20
3. 23
4. 32

1-39. What is the most important part of the OPNAV Form 5102/1, Accident Injury/Death report?
1. Block #23, Job Disposition After Injury
2. Block #24, Number of Lost Work Days
3. Block #33, Corrective Action Taken/ Recommended

1-40. The most important reason for any accident investigation is prevention of a similar accident.

---

Learning Objective: Describe techniques of conducting PRCP interviews and using data in assigning personnel.

---

1-41. The purpose of the Personnel Readiness Capability Program is to provide accurate up-to-date personnel information that will enable the NCF to
1. schedule day-to-day work assignments for individual crewmembers
2. combine all the information relevant to the planning and scheduling of project functions into a single master plan
3. increase its capabilities to plan, make decisions, and control

Use the following alternatives in answering items 1-42 through 1-46.

1. Individual General Skills
2. Individual Rating Skills
3. Military Skills
4. Crew Experience (Skills)

1-42. Skills related to two or more ratings which are primarily nonmanipulative are classified as

1-43. Skills you acquired as a result of working with others on a particular project are normally classified as

1-44. Skills you acquired as a result of training for combat are broadly classified as

1-45. Nontechnical skills you acquire by participating in a cross-rate training program are generally classified as

1-46. Technical skills specifically related to one of the Construction ratings are classified as

1-47. What management tool should you use in collecting crewmember skill data?
1. Volume I, PRCP Skill Definitions
2. PRCP Standards and Guides
3. Matrix Numbers 1 and 2
4. Section II, Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards

1-48. If you collect any information through observation or an interview concerning an individual's skills, you must send it to FACSO, Port Hueneme on a/an
1. IBM card
2. PRCP Skill Update Record
3. 3 by 5 card
4. message form

1-49. The Individual Rating Skill Interview and Other Interviews are types of interviews conducted by the PRCP interviewer.

1-50. Before conducting an individual rating skill interview, what must you do?
1. Review the appropriate section of the Occupational Standards Manual
2. Prepare an interviewee's service record
3. Prepare an interviewee's checkoff sheet
4. Learn as much as you can about the skills and tasks explained in the interviewing guides

1-51. Refer to textbook figure 1-13. In order to qualify for skill level 1, a welder must be able to demonstrate which of the following skills?
1. Prepare an arc welder for welding
2. Arc weld mild steel plate that is 1/4 inch thick or less
3. Both 1 and 2 above

1-52. When introducing the skill material to an interviewee, you start by reading the skill definition.

1-53. A typical task with task elements and related action statements is illustrated in textbook figure 1-15. Under Task Element .01b, which of the following tasks are required?
1. F and G only
2. A, C, and E only
3. A, B, C, and E only
4. A, B, C, E, F, and G

In answering items 1-54 through 1-56, assume you are a PRCP interviewer and are interviewing personnel for particular skill levels. Each item is to be judged true or false.

1-54. You should explain the purpose of the interview to each interviewee.

1-55. You should explain that your interviewees should NOT be embarrassed if they do NOT know everything that is expected of them about a specific skill level.

1-56. You should first read the task element, then the action statement to each interviewee.

1-57. Who decides whether a person does or does NOT have a skill?
1. PRCP coordinator
2. PRCP interviewer
3. Training officer

---

Learning Objective: Describe the development of On-The-Job training program and daily work assignments.

---

1-58. The primary purpose of on-the-job training in a SEABEE organization is to
1. indoctrinate new personnel on a job
2. develop supervisors in management skills
3. help individuals acquire the necessary knowledge, skills, and habits to do a specific job
4. instill each person with interest and enthusiasm for the work to be done

1-59. Before setting up an on-the-job training program, you should
1. work up a set of lesson plans
2. select the type of training to be used
3. analyze the problem to determine the type of training required
4. rely on your experience to determine the training objectives

1-60. In determining the need for training, you should consider the specific job requirements and the individual skills of the trainee.

1-61. After an on-the-job training program has been implemented, how should follow-up on the program be maintained?
1. By keeping training records current
2. By insuring that the program does not lag
3. By insuring that newly developed skills are properly utilized
4. All of the above

1-62. When properly used, a most effective method for training workers on the job is the
1. self-study method
2. coach-pupil instruction method
3. group instruction method
4. academic-type instruction method

1-63. In on-the-job training, the term group instruction means the same as classroom or academic-type instruction.

1-64. Of the following examples, which describes piecemeal instruction?
1. Letting others know what, when, where, and perhaps, how and why
2. Explaining regulations, procedures, and orders
3. Holding special meetings
4. Each of the above

1-65. Interviews between the trainee and the trainer in a developmental on-the-job training program does NOT help to do which of the following?
1. Disclose the training needs of the trainee
2. Formulate the overall training objectives
3. Assess the progress of the trainee
4. Resolve the trainee's questions concerning safety and skill techniques

1-66. Taking which of the following steps may help you to plan and carry out a successful training program?
1. Using correct methods to insure learning
2. Measuring achievement at regular intervals
3. Recording results
4. All of the above

1-67. The essential part of a performance check is a typical work situation in which the trainee's work can be examined and evaluated.

1-68. What is the primary purpose of issuing a job order?
1. To specify work to be done
2. To specify when the job is to be completed
3. Both 1 and 2 above
4. To list job priority

In answering items 1-69 through 1-73, select the classification of a job order from column B for the purpose stated in column A.

| A. Purposes | B. Classifications |
|---|---|
| 1-69. Trash and garbage disposal | 1. Rework |
| 1-70. Patchwork of leaking roof which requires more than 16 man-hours | 2. Standing Job Order |
| 1-71. Installation of electrical wiring to correct faulty work done by the public works personnel | 3. Emergency Work |
| 1-72. Public works engineering for fiscal year 1982 | 4. Minor Work |
| 1-73. Immediate repair of a water main leak | |

1-74. Why is it good practice to rotate job assignments among your crewmembers?
1. To make the work more interesting to them
2. To prevent one crewmember from doing all work of a certain type
3. To enable them to acquire more skills
4. Each of the above

# Assignment 2

Supervision: Shop and Construction Site Organization

Textbook Assignment: Pages 2-1 through 2-4 and 3-1 through 3-12

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Learning Objective: Point out principles of leadership as they apply to supervision and identify the responsibilities of supervisors.

---

2-1. Whether or not you become a good supervisor will depend on your ability to do which of the following?
1. Organize
2. Delegate
3. Coordinate
4. Each of the above

2-2. Throughout military history, successful leaders have based their daily actions on
1. the Golden Rule
2. general principles
3. leadership principles
4. common knowledge

2-3. What is the ultimate objective of a good supervisor?
1. To accomplish a task or mission successfully
2. To be able to delegate authority
3. To perform highly technical tasks, working alone
4. To supervise and train lower rated personnel

2-4. In planning a project, what should you do before making the man-hour estimate?
1. Prepare a bill of materials
2. Determine the sequency of operations
3. Assign your crews in accordance with their capabilities
4. Encourage your personnel to work faster

2-5. Before assigning work to your crews, you should have information about which of the following?
1. Their experience
2. Leave schedules
3. Training required
4. All of the above

2-6. What is one of the common faults of a new supervisor?
1. Lack of coordination
2. Lack of organization
3. Failure to delegate authority

2-7. Delegating authority to make certain decisions works to your advantage because it enables you to concentrate on important aspects of the job.

2-8. By delegating authority, you are relieved of the responsibility for a project.

2-9. What is the primary responsibility of every supervisor?
1. To plan and organize
2. To produce
3. To make out daily man-hour reports
4. To train subordinates

2-10. Who has first or immediate responsibility for the safety, health, and welfare of a group of workers?
1. Safety officer
2. Department head
3. Job supervisor
4. Executive officer

2-11. Crews will produce more and be more willing to cooperate when
1. allowed to set their own start time
2. permitted to secure early
3. allowed to work carelessly
4. told the whats and whys of their work

2-12. Failure to keep your superiors informed may result in their lack of concern for you and your crewmembers.

2-13. Which of the following could be indicators of low morale?
1. Equipment damages or losses due to carelessness
2. Absences without leave
3. Requests for transfer
4. All of the above

2-14. High morale of your crewmembers is a direct result of their being confident and doing well on the job.

2-15. A battalion's training program is formed to provide naval personnel with skills to
1. prepare personnel for advancement
2. accomplish the current and mobilization missions of the battalion
3. accomplish the homeport projects only
4. prepare personnel for civilian life

2-16. Who must emphasize the importance of training to your crewmembers?
1. S-2 officer
2. Executive officer
3. You, the supervisor
4. Company training petty officer

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Learning Objective: Indicate the requirements for laying out a shop and setting up shop equipment.

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2-17. As the shop supervisor, you determine the layout of shop materials and equipment to achieve a smooth workflow and higher production.

2-18. When planning the layout and organization of the metal shop, what factor should you consider first?
1. The lighting arrangement
2. The type of work to be done
3. The mode of ventilation
4. The location of power outlets

2-19. When planning a shop, which of the following other factors should you consider?
1. Size of the shop space and the number of personnel expected to work in the shop
2. Type of tools available and location of power outlets
3. Type of ventilation readily available and adequacy of lighting
4. All of the above

2-20. If the only space available for your shop is NOT large enough for your operation, you should insist on a larger one.

2-21. In planning the arrangement of equipment in a shop, which of the following factors should you consider?
1. That shop entrances and exits remain clear
2. The sequence of operations
3. Sufficient working space and adequate workbenches
4. All of the above

2-22. In what type of shop would the problem of placing stationary machines usually be more difficult to resolve?
1. Sheet metal
2. Welding
3. Fabrication
4. General-purpose

2-23. What condition usually has the most positive effect on work output in a metal shop?
1. Spacing of worktables
2. Supply of materials
3. Nearness of equipment and materials to operator's work station
4. Nearness of electrical outlets for extension cord rigged equipment

2-24. Adequate worktables and workbenches are necessary and should be positioned with respect to fixed equipment.

2-25. When a storeroom is available, tools and materials should NOT be kept near machines or equipment.

2-26. What type of storage facility should be used for stowing electrodes?
1. Wall locker
2. Hot locker
3. Bench drawer
4. Vertical rotor bins

2-27. Where should the office of a sheet metal shop be located?
1. Away from the storage area
2. Away from areas of maximum noise
3. Near the layout tables
4. Near the spot welding section

2-28. Of the following, which is a poor practice in the use of a bulletin board?
1. Locating it where personnel pass it daily
2. Allowing material to remain on it for long periods of time
3. Rearranging and changing material frequently

2-29. Which of the following factors should you consider when planning the layout of a shop
1. Use of nonskid flooring in critical areas
2. Keeping the entrance and exit clear
3. Adequacy of lighting and ventilation
4. All of the above

Learning Objective: Recognize methods of laying out facilities for construction projects in the field.

2-30. Insuring that work will flow smoothly through the fabrication yard should be a major concern of the supervisor setting up the yard.

2-31. Of the following, which would NOT be found in a typical fabrication yard?
1. Material storage area
2. Tool and equipment storage and repair area
3. A working area
4. A welding shop

2-32. In the operation of a fabrication yard, which of the following is NOT a good practice?
1. Using personnel who specialize on one group or class of work
2. Allowing material to backtrack or crossover
3. Operating with a minimum of handling over the shortest haul
4. Safeguarding personnel from injuries

In answering items 2-33 through 2-36, select from column B the minimum space required to store, repair, or maintain the tools and equipment in column A.

| | A. Equipment and Tools | B. Space Requirements |
|---|---|---|
| 2-33. | Heavy equipment | 1. 1/4 sq yd per worker |
| 2-34. | Pneumatic tools | 2. 1/2 sq yd per worker, one-half of it under cover |
| 2-35. | Rigging | 3. 20 sq yd or more |
| 2-36. | Handtools and hardware | 4. 50 to 200 sq yd |

2-37. Which of the following factors allows tool and equipment requirements to vary on each project?
1. Method of fabrication
2. Length of time allowed for fabrication
3. Either 1 or 2 above

2-38. On a typical construction project, which of the following tools or equipment would a fabrication crew need?
1. Safety equipment
2. C-clamps, center punches, drills, wrenches, hoists, and slings
3. Drill presses, roller tables, push cars, and special lifting hooks
4. All of the above

2-39. What would be an ideal location for the material storage area at the construction site?
1. Near the center of operations
2. Near an access road or railway siding on either end of the fabrication yard, out of the way
3. Near the fabricated member storage area

2-40. Materials stored out of doors should be protected from damage or deterioration from exposure to weather and free from ignition by flying sparks.

2-41. How should the working areas of the fabrication yard be arranged?
1. By setting up operations so that the job will run smoothly and efficiently from start to finish
2. By designating areas for laying out cutting, drilling, and fitting up assembled members
3. Both 1 and 2 above

2-42. The best location for an assembling area is near the fabricated member storage area.

2-43. Where should the fabrication member storage area be located?
1. Adjacent to the last fabrication operation
2. Near an access road
3. Both 1 and 2 above
4. Near the material storage area

Learning Objective: Indicate procedures for handling and stowage of materials at the jobsite.

2-44. Your operation should run smoothly when the flow of materials and equipment is timely, an excessive buildup of material is avoided, and supplies are NOT exhausted before they are requested.

2-45. A shortage of material for a job is likely when the material is unusually slow in arriving at the jobsite.

2-46. If notified of a possible material shortage because of faster job progress, the OIC may take what action to insure the timely arrival of material on a scheduled job?
1. Assign an expediter
2. Send a supply memorandum requesting quicker service
3. Authorize a shorter workday

2-47. When machine-powered hoisting equipment can NOT be made available for a job, what action should you take?
1. Use a gin pole, tripod, or another hand-powered hoisting device
2. Secure the job until the equipment is available
3. Schedule the work around this equipment

2-48. Material stored at the jobsite should be as close as possible to the area where it will be used.

2-49. By what means should you identify the different types of materials used in your shop?
1. Stock numbers
2. Labels or color markings
3. Shipping tags
4. All of the above

2-50. In determining the minimum number of repair parts to be kept on hand, you should consider the length of time needed for resupply.

2-51. When NOT in use, each tool or piece of equipment should be stored in its proper place.

2-52. In selecting a place to stow tools, you should consider which of the following factors?
1. Size and shape of tool
2. Frequency of use
3. Value of the tool
4. All of the above

2-53. Which of the following tools should be protected from shock and pressure while in storage?
1. Scribers and dividers
2. Drill bits and files
3. Depth and surface gages
4. Compasses and torch tips

2-54. When issued and again when returned, handtools should be checked for which of the following conditions?
1. Dull cutting edges
2. Mushroom heads
3. Broken handles
4. All of the above

2-55. In handling bundles of sheet metal, which of the following lifting devices should NOT be used?
1. Wire rope slings
2. Straps
3. Plate clamps

2-56. To help prevent hand injuries, you should require handlers of lumber and reinforcing steel to wear gloves.

2-57. When hoisting bundles of long reinforcing bars, you can avoid bending them too much by using a spreader bar consisting of a
1. fabricated truss assembly
2. H-beam
3. piece of cast iron pipe

2-58. When lifting a heavy object by hand, you should lift with your back instead of your legs to avoid serious injury.

2-59. Piles of steel pipe that are stacked laterally should be approached from the end of the stack.

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Learning Objective: Point out fundamentals of directing crews in cutting and welding operations.

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2-60. Regardless of their size, welding shops must have equipment that can accurately shape and cut metal before it is welded.

2-61. What tool is used in preparing and finishing welded areas?
1. Power hacksaw
2. Portable grinder
3. Power cutoff saw

2-62. Welders wear protective clothing to protect them from metal sparks. Of the following conditions, which has a bearing on the type of clothing worn?
1. Size of the job
2. Nature of the job
3. Location of the job
4. All of the above

2-63. In directing crews engaged in cutting and welding operations, the first thing you should do is to
1. determine the welding process
2. select your crew leader
3. review drawings and sketches

2-64. In using a drawing or sketch from which to fabricate or assemble material, you get information from
1. the job specifications
2. the bill of materials
3. welding symbols

2-65. On a large project, a crewmember should be made responsible for delivery, unloading, checking, and stowage of material.

2-66. How should you assess the quality of a welder's work?
1. By checking welding techniques and operating conditions
2. By observing the consumption of the electrode and whether it melts down smoothly or unevenly
3. By noting the size and shape of the weld, the weld crater, and the sound of the arc
4. All of the above

● In answering questions 2-67 through 2-70, refer to textbook table 3-1.

2-67. To avoid cracked welds, which of the following steps should be taken?
1. Heat parts before welding
2. Allow joints a proper and uniform gap
3. Set the amperage as low as possible
4. All of the above

2-68. Undercutting is usually caused by faulty electrode manipulation or setting current too high.

2-69. You can cut down on spatter while welding by taking which of the following steps?
1. Adjusting current properly
2. Selecting suitable electrodes
3. Both 1 and 2 above

2-70. Which of the following is NOT a cause of poor appearance in a weld?
1. Faulty electrode
2. Improper use of electrode
3. Metal hardened by air
4. Wrong arc voltage and current

2-71. In general, the quality of an oxygas cut can be determined by the shape and length of the drag lines, the smoothness of sides, and the amount of slag adhering to the metal along with the ease of slag removal.

2-72. A good oxygas cut can be identified through drag lines that are
1. long and irregular
2. almost straight up and down
3. grooved or fluted

# Assignment 3

Shop and Construction Site Organization (continued)

Textbook Assignment: Pages 3-13 through 3-35

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Learning Objective: Point out fundamentals of directing crews engaged in layout, cutting, bending, and placing reinforcing steel.

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3-1. Because of its ability to adhere with concrete, deformed rebar is preferred over smooth rebar.

3-2. When requesting reinforcing steel, you ask for a No. Five bar. What is the actual size of this bar?
1. 1/2 inch
2. 5/8 inch
3. 3/4 inch

3-3. When needing to know the design of a structure, including the size and location of the members, you should look at which of the following?
1. Engineering drawings
2. Placement drawings
3. Both 1 and 2 above

3-4. The size, shapes, and locations of rebars in a structure can be found in the placement drawings.

3-5. What are the two basic types of schedules used in rebar work?
1. Critical path and precedence
2. Footings and foundations
3. Horizontal and vertical

3-6. On large jobs, what should be done to the rebar just after is is cut and bent?
1. Deliver it to the jobsite for installation
2. Bundle and tag it according to size, length, and shape
3. Place it on cribbing to help keep it clean

3-7. You can insure a good bond between rebar and concrete by keeping the rebar free of foreign substances.

3-8. Under which of the following conditions is it an accepted practice to have any part of the metal exposed in concrete work?
1. Where the surface will not be exposed to weather
2. Where discoloration will not be objectionable
3. Both 1 and 2 above
4. Where the support of the concrete is not critical to the structure

3-9. Rebars should be tied properly so that concrete can cure to its maximum strength.

3-10. Which of the following is an unsafe practice in working with reinforcing steel?
1. One of the two crewmembers carrying a load of steel realease his end of the load first
2. A crewmember attches a wire rope sling in order to lift bundles of reinforcing steel
3. Several two-man teams remove reinforcing bars from a truck by lowering both ends at the same time

3-11. Safety precautions can NOT be considered regulations unless they are issued by competent authority; most are common sense measures that will prevent accidents.

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Learning Objective: Point out fundamentals in driecting crews engaged in erecting rigid frame and other preengineered structures.

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3-12. Preengineered structures are shipped as complete kits, except for erection instructions which are supplied by operations.

3-13. Of the following conditions, which must be considered in planning the erection of a preengineered structure?
1. Site and probable weather conditions
2. Skill and experience of personnel
3. Time allowed to complete the project
4. All of the above

3-14. Before they can do any work on a pre-engineered structure, the Steelworkers usually have to wait for the Equipment Operators and Builders to finish the foundation.

3-15. You can avoid most problems that arise with the beginning of a tank, a tower, or antenna construction by doing which of the following?
1. Using skilled personnel only
2. Using the latest set of instructions
3. Starting with a sound foundation
4. All of the above

3-16. When serving as the signalman in charge of a rigging crew, you can expect the crane operator to act only on your signal unless another person in your crew signals for
1. stop
2. move slowly
3. hoist
4. emergency stop

---

Learning Objective: Recognize principles of designing and erecting simple hoisting devices.

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3-17. Field-erected hoisting devices basically consist of a block and tackle system arranged on some form of skeleton structure consisting of wooden poles or steel beams.

3-18. When natural holdfasts of sufficient strength are NOT available, which of the following devices can be used?
1. Log deadman only
2. Combination log picket holdfast only
3. Combustion picket holdfast only
4. Any manmade holdfast

3-19. When using trees as holdfasts, you should always attach the guys near
1. a sturdy branch to avoid slipping
2. the center of the trunk of a tree
3. ground level

3-20. After a guy line to a picket holdfast is tightened, what means should be used to secure the guy line?
1. A clove hitch
2. Two clove hitches
3. A half hitch
4. Two half hitches

3-21. The simplest type of holdfast that is suitable for an anchor guy and can bear loads up to 4,000 pounds is a 3-2-1 combination picket.

3-22. Suppose a picket holdfast will be used for several days. What should the guys be made of?
1. Small stuff
2. Galvanized wire
3. Both 1 and 2 above

3-23. Which of the following is the best description of the combination log picket?
1. A log buried in the ground with a guy connected to it at its center
2. The guy is anchored to a log or timber supported against four or six combination picket holdfasts
3. A log lashed to the trunks of two trees with a guy connected to the center of the log

3-24. Rock holdfasts are made by inserting pipes, crowbars, or steel pickets in holes drilled in solid rock.

3-25. How should the holes for a rock holdfast be drilled?
1. 1 to 2 feet deep and straight up and down
2. 1 1/2 to 3 feet deep and at a slight angle away from the direction of pull
3. 1 1/2 to 3 feet deep and at a slight angle towards the direction of pull

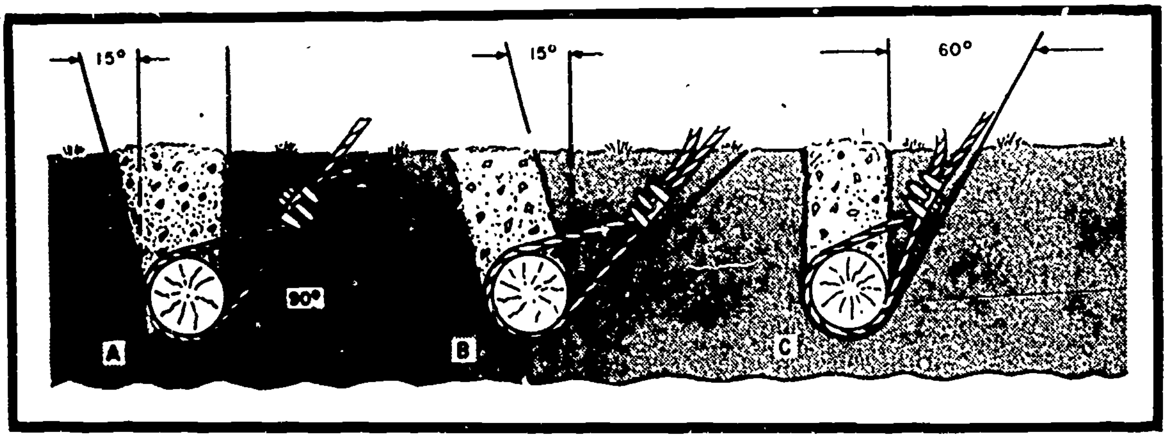



Figure 3A.

In answering items 3-26 and 3-27, refer to figure 3A.

3-26. When preparing to use a deadman as an anchor for a guy, you should begin by making an excavation similar to the one shown at
1. A
2. B
3. C

3-27. A way that a deadman should be buried and the guy wrapped around it is illustrated at
1. A only
2. B only
3. C only
4. A, B, or C

3-28. When the steel picket holdfast is being used, there is NO advantage to using two or more units in combination.

3-29. The maximum height of a timber gin pole that has an 8-inch diameter is
1. 10 feet
2. 28 feet
3. 48 feet
4. 50 feet

3-30. The minimum distance from the base of the gin pole to the anchorage of the guy lines for a 15-foot gin pole is
1. 15 feet
2. 30 feet
3. 45 feet
4. 60 feet

3-31. Which part of a gin pole assembly is most likely to be the weakest point?
1. Loadline
2. Fall line
3. Holdfast
4. After guy line

3-32. What position should the gin pole be in to have the LEAST amount of stress on the guys?
1. Almost horizontal
2. Vertical
3. 45° angle

3-33. When rigging a gin pole, you should use a square knot to
1. hang the guys on the pole
2. tie the guys to the holdfasts
3. tie the forward guys to the back guys
4. secure the ends of the lashings

3-34. When laying out the guy line on the ground prior to erection of a 12-foot pole, you should make them how long?
1. 12 feet
2. 24 feet
3. 48 feet
4. 72 feet

3-35. To keep a gin pole from skidding while being erected, what should you do?
1. Reeve tackle to the rear of the pole and attach it to a stationary object
2. Set up a picket holdfast about 3 feet forward of the pole base and tie it off at the base of the pole
3. Have part of the erection crew tie it off at the base of the pole and pull forward while the rest of the crew raises the pole from the rear

3-36. Gin poles of 50 feet or less can be easily handled by hand.

3-37. To properly erect a gin pole, you should have a crew consisting of how many members?
1. 10 or more
2. 6 to 9
3. 3 to 5

3-38. How deep should the hole for the base of the gin pole be?
1. 6 to 12 inches
2. 16 to 18 inches
3. 20 to 24 inches

3-39. When raising the gin pole, what can you do to get the block in reach?
1. Tie a line to the hook of the movable block
2. Overhaul the tackle until it is longer than the pole, and secure it to an anchorage
3. Bot 1 and 2 above

3-40. What is meant by "drifting"?
1. Moving an object left or tight
2. Moving the top of the pole 15° without moving the base
3. Hoisting or placing a load

3-41. The shear legs and the A-frame are one and the same lifting device.

3-42. Besides lifting heavy machinery or bulky objects, shear legs can be used for
1. unloading trucks and flat cars
2. supporting ends of a cableway and highline
3. hoisting over wells, mine shafts, and other excavations

3-43. As part of the shears' rigging, the after guy should be strong enough to lift how much of the load?
1. One-half
2. One-fourth
3. Three-fourths

3-44. After wrapping the tops of the poles for shear legs with small stuff, you must tighten and secure the lashing by
1. mousing
2. frapping
3. guying
4. shearing

3-45. When preparing to erect a 40-foot shear, how far apart should you dig the holes that will support the legs?
1. 10 feet
2. 16 feet
3. 20 feet
4. 24 feet

3-46. Holes about 1 foot deep will keep the shear legs from kicking out while in operation.

3-47. When a load is applied, it is a good practice to lash the butt ends of the shears with chain, line, or boards to keep them from spreading.

3-48. Which of the following is an advantage of using the tripod in a hoisting operation?
1. It is stable
2. It requires no guys or anchorage
3. It has a capacity greater than that of shears made of the same size material
4. Each of the above

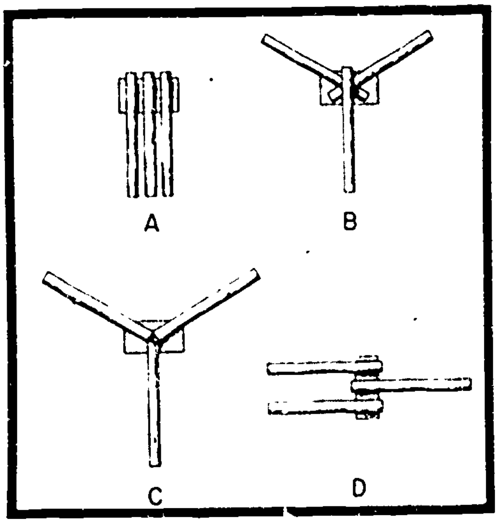



Figure 3B.

3-49. When erecting a 35-foot tripod without the aid of mechanized equipment or auxiliary hoists, which arrangement shown in figure 3B should you use for lashing the poles prior to erection?
1. A
2. B
3. C
4. D

3-50. The proper spread for the legs of a tripod is between one-half and two-thirds the length of a leg.

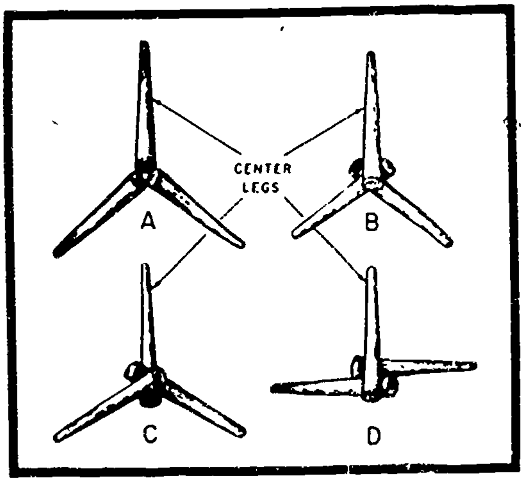



Figure 3C.

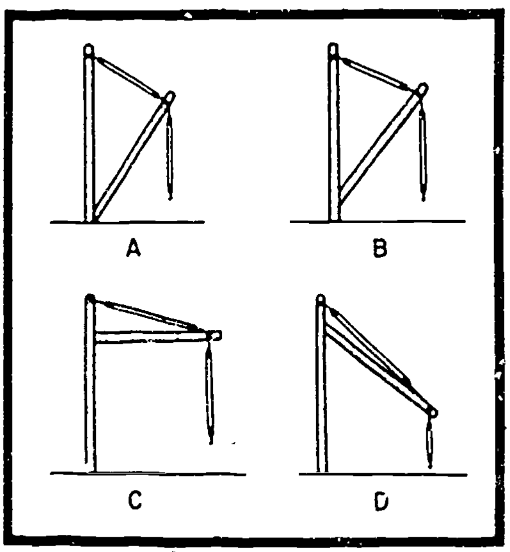
3-51. As viewed from the top, a properly erected tripod looks like which part of figure 3C?
1. A
2. B
3. C
4. D

3-52. The boom derrick consists of a mast with a boom attached that is capable of moving an object in any direction.

3-53. If a 20-foot-long boom is needed to provide the desired working radius for a boom derrick, what is the approximate length of the mast?
1. 20 feet
2. 30 feet
3. 40 feet
4. 60 feet

3-54. When erecting a boom derrick, you should keep the bottom end of the boom from slipping downward on the mast by securing it with
1. cleats
2. the topping lift
3. a sling
4. guys

3-55. What blocks are attached at the same point on a boom derrick?
1. Fairlead block and fixed tackle block
2. Fixed tackle block and fixed topping lift block
3. Running topping lift block and fairlead block
4. Fixed tackle block and running topping lift block




* Figure 3D.

3-56. The recommended heavy-load position of the boom on a boom derrick is shown in figure 3D at
1. A
2. B
3. C
4. D

3-57. The pole derrick is suitable for lifting loads of 1 to 2 tons.

3-58. The average person can pull with a force of nearly 100 pounds on a single vertical line. The same person can pull on a single horizontal line with a force of
1. 30 pounds
2. 60 pounds
3. 90 pounds
4. 120 pounds

3-59. Which of the following is an advantage in using a chain hoist over other devices?
1. Loads can remain stationary without requiring attention
2. Loads can be handled cautiously
3. Heights can be adjusted accurately
4. Each of the above

In answering items 3-60 through 3-62, select from column B the hoist best suited for the operation in column A.

| | A. Operations | | B. Hoists |
|---|---|---|---|
| 3-60. | Lifting ordinary loads frequently | A. | Differential chain hoist |
| 3-61. | Lifting light loads occasionally | B. | Ratchet-handle pull hoist (come-along) |
| 3-62. | Pulling heavy objects horizontally over short distances | C. | Spur gear hoist |

3-63. What part of a chain hoist assembly is intentionally manufactured to be the weakest part?
1. Spur gear assembly
2. Chain lock assembly
3. Upper hook
4. Lower hook

3-64. The hooks or links of a chain hoist that show signs of spreading or excessive wear should be replaced before the hoist is used again.

3-65. After erecting a pole derrick for a lifting job, where should you install a hand-operated winch?
1. At least one pole length behind the derrick
2. Near the foot of the derrick
3. On either side of the knee braces
4. To the right of the pole employing a snatch block and fairlead

3-66. Suppose a power-driven winch is set up so that the hoisting line leaves the drum at an angle upward from the ground. Which of the following actions should be taken to avoid lifting the winch clear of the ground?
1. Increase the size of the winch
2. Move the load slowly
3. Place a leading block in the system to change the direction of pull
4. All of the above

3-67. As a hoisting line is being wound on a drum, you must make sure that the fleet angle does NOT exceed how many degrees?
1. 6
2. 2
3. 8
4. 4

3-68. The lifting capacity of a crane is dependent upon the
1. diameter of the winch
2. boom length and angle
3. size of the lifting hook
4. size of the fleet angle

3-69. Box hooks are used for
1. moving small boxes over short distances
2. raising mediumweight boxes and crates to enable placement of slings or dunnage
3. moving large boxes over long distances

3-70. The hook-on man should know the hand signals used to direct operators of hoisting equipment, but may need to devise special signals to direct winch operators.

3-71. When a lift is properly loaded, precise control of the movement of a hoisted load is provided by the use of
1. slings
2. dunnage
3. tag lines
4. box hooks

3-72. Hoisting chains should be replaced when an inspection reveals which of the following defects?
1. Gouge marks or fractures
2. Stretch of more than 5% of their original length
3. Wear greater than 25% of their original thickness
4. All of the above

3-73. If a crane boom or cable touches an energized powerline, the crane operator may avoid electrocution by jumping clear of the crane.

# Assignment 4

Construction Inspections and Quality Control

Textbook Assignment: Pages 4-1 through 4-15

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Learning Objective: Recognize the inspectors responsibilities as to the quality of work performed by work crews on assigned projects.

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4-1. The validity of an inspection for quality control can best be determined by the qualifications of the inspector.

4-2. The main responsibility of the construction inspector is to make sure that
1. work performed is of the highest standard of quality
2. work is performed in accordance with the drawings and specifications for the project
3. items required for the project are on hand before the work starts
4. tact and courtesy are stressed in all relations with the crewmembers and with their superiors

4-3. The quality requirements for temporary or emergency construction may be intentionally lowered.

4-4. The tolerance for concrete work can seldom be held closer than
1. 1/8 inch
2. 1/4 inch
3. 1/2 inch
4. 5/8 inch

4-5. Of the following operations, which must the inspector insist on being done correctly?
1. Principle centerlines
2. Column lines
3. Controlling overall dimensions
4. All the above

4-6. As a project nears its completion, the inspectors should tighten up on quality of the work to be accepted.

4-7. When should the inspector make sure that every item needed to complete a construction project has been provided?
1. When the project is almost complete
2. At the beginning of construction
3. When one-half of the project is done

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Learning Objective: Point out techniques of inspecting work areas, tools, and equipment.

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4-8. When making inspections of welding shops, you should see that welding operations are done in an orderly and logical sequence and that hazards and unsafe working conditions for welders have been eliminated.

4-9. Safety inspections of the work areas in a sheet metal shop include which of the following steps?
1. Checking work areas for cleanliness and orderliness
2. Noting whether or not sheet metal crews observe all safety precautions in performing their duties
3. Insuring that materials are properly stored and walkways kept clear
4. All of the above

4-10. Slivered tool handles should be immediately wrapped with tape to prevent injury.

4-11. When inspectors are on the job checking for the quality of workmanship, they should also keep an eye open for which of the following safety infractions?
1. Personnel wearing loose fitting clothes or gloves
2. Unqualified personnel operating power machines
3. Tools or materials left lying around on benches, near machines, or on floors
4. All of the above

4-12. To ground a two-pronged plug, which of the following procedures would be correct?
1. Connecting a built-in third wire to a known ground
2. Connecting a third wire between the frame of the tool and a known ground
3. Both 1 and 2 above

4-13. The outside appearance of fiber line is usually a good indication of its internal condition.

4-14. You may determine if a fiber line is mildewed by
1. checking the line for dampness
2. looking for discoloration of the outside fibers
3. smelling the line and checking for discoloration of the inner fiber strands
4. checking the outside fibers for mold

4-15. A fiber line whose center core breaks away in small pieces upon examination was probably overstrained.

4-16. Wire ropes should be removed from service when found to have which of the following conditions?
1. Temporary seizings
2. Fishhooks and kinks
3. Worn and corroded spots
4. Both 2 and 3 above

4-17. A given wire rope is unsafe for hoisting purposes under which of the following conditions?
1. Its diameter is less than 85 percent of the original diameter
2. 4 percent of the total number of wires in the rope have breaks within the length of one lay
3. Individual wires are broken next to one another
4. Both 2 and 3 above

4-18. A 6 X 37 wire rope that is used to hoist materials may be considered safe if the number of broken wires in one strand does NOT exceed
1. 24
2. 12
3. 9
4. 8

In answering items 4-19 and 4-20, use the rules of thumb given in the textbook.

4-19. The safe working load of a fiber line in good condition that has a circumference of two inches is
1. 300 lb
2. 420 lb
3. 600 lb
4. 780 lb

4-20. The safe working load of a new 1 1/2-inch wire rope is
1. 18,000 lb
2. 22,000 lb
3. 24,000 lb
4. 25,000 lb

4-21. Chain size is determined by the
1. circumference of the link
2. circumference of the rod from which
3. major axis of the link
4. diameter, in inches, of the rod from which the link is made

4-22. In areas where abrasion or corrosion is a concern, you should use chains rather than wire rope.

4-23. A chain link should be replaced under which of the following conditions?
1. It is cracked
2. Its surface is polished or worn
3. It is distorted
4. Each of the above

4-24. The slip hook is designed to be used with which of the following?
1. Wire rope
2. Chains
3. Fiber line
4. All the above

4-25. The grab hook is used on chains where the loop formed with the hook is NOT intended to close up around the load.

4-26. Any deviation from the original inner arc of a hook indicates that the hook has been overloaded.

4-27. Hooks should be replaced when they are in which of the following conditions?
1. Badly worn
2. Severely distorted
3. Cracked
4. All of the above

4-28. The safe working load for a hook with a diameter of 1 1/2 inches is approximately
1. 1 ton
2. 2 tons
3. 1/2 ton
4. 1 1/2 ton

4-29. A properly made sling can be constructed from
1. fiber line only
2. wire rope only
3. chain only
4. fiber line, wire rope, or chain

4-30. A sling made of wire rope is more reliable than one made of fiber line or chain because of its
1. better suitability for lifting hot items in foundries
2. high wear resistance and slower loss of strength
3. greater flexibility and resistance to wear

4-31. In lifting sharp objects with a sling, you can use heavy fabric or old rubber tires as padding to avoid damaging the sling.

4-32. Of the following materials, which would be most likely used as guy lines on a temporary structure?
1. Wire rope
2. Fiber line
3. Both 1 and 2 above

4-33. The LEAST number of guys that should be used to anchor a gin pole is
1. one
2. six
3. three
4. four

4-34. The recommended minimum distance from the base of a 12-foot gin pole and its guy line anchoring point is
1. 12 feet
2. 18 feet
3. 24 feet
4. 32 feet

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Learning Objective: Identify principles of checking the quality of welds.

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4-35. The main objective of pipe welding inspection is to insure that welding meets specified requirements.

In answering items 4-36 through 4-40, select from column B the phase corresponding with the welding inspection in column A.

| | A. Welding Inspections | B. Inspection Phases |
|---|---|---|
| 4-36. | Vary operating conditions | 1. Prewelding |
| 4-37. | Check pipe alinement | 2. During welding |
| 4-38. | Check interior of pipe for globules | 3. After welding |
| 4-39. | Check size and shape of weld crater | |
| 4-40. | Check for length and location of welds | |

---

4-41. A weld defect is classified as dimensional when it refers to which of the following?
1. Incorrect joint preparation and weld size
2. Warpage
3. Incorrect weld profile
4. Each of the above

4-42. When a complete weldment exhibits warpage due to structural distortion after cooling, which of the following processes will sometimes correct the defect?
1. Applying positive and negative stresses to the weldment
2. Applying thermal expansion and contraction to the weldment
3. Peening the weldment
4. Straightening the weldment with or without heating

4-43. The size of a fillet weld is expressed in terms of
1. its depth
2. its width
3. the length of the shortest leg of its triangular cross section
4. the length of the longest leg of its triangular cross section

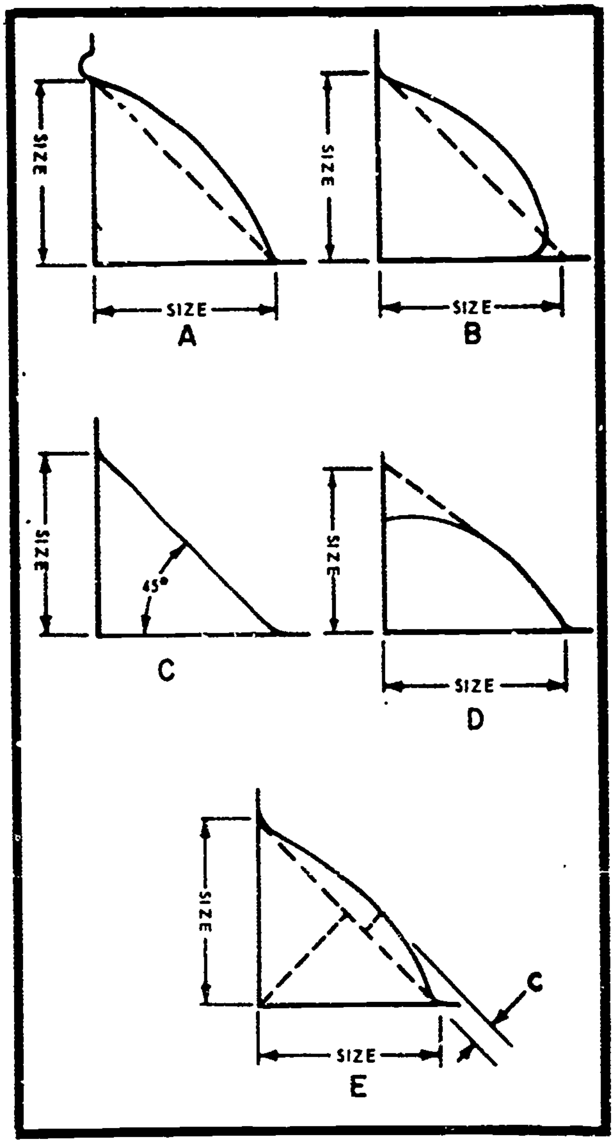


Figure 4A.-Welds profile

- In answering items 4-44 and 4-45, refer to figure 4A.

4-44. The weld profile represented in view D of the figure is defective because of
1. excess convexity
2. insufficient leg size
3. overlap
4. undercut

4-45. The amount of convexity in a weld profile is shown in which view or views?
1. A and B
2. C and D
3. A only
4. E only

4-46. Excess concavity in a fillet weld can usually be removed by reducing the welding current if the weld is in the vertical position and the welding is done from the top down.

4-47. Excess weld reinforcement may be caused by improper welding techniques and insufficient welding current.

4-48. A structural discontinuity weld defect in metal-arc welding may result from a deficiency of weld metal or fusion.

4-49. Which of the following conditions is classified as a structural discontinuity?
1. Incomplete penetration
2. Porosity
3. Imperfect fusion
4. Each of the above

4-50. When inspecting reinforcing steel operations, you must make sure that all work performed is in accordance with the latest issue of which of the following sources?
1. Instructions from the Public Works Officer
2. Placing plans
3. Instructions from the company commander
4. Each of the above

4-51. How should the inspector verify that fabricated bars are cut and bent correctly?
1. By checking with the crew leader
2. By visual check and occasional measurement
3. By means of reports submitted by the crew leader
4. By insuring that adequate cutting and bending equipment is available

4-52. During the setting of steel and before concreting, an inspector of reinforcing steel operations must make sure that every wall or slab has which of the following?
1. Proper type, size, and number of reinforcing bars
2. Proper number of bar supports
3. Welded wire fabric in place
4. All of the above

4-53. Experienced inspectors eliminate major errors by having studied the placing plans, by going over the steel in place, by measuring here and there, and by comparing one detail with another.



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4-54. In architectural concrete and exposed work, what is the usual amount of concrete cover over bars?
1. 1 inch
2. 2 inches
3. 1 1/2 inches
4. 2 1/2 inches

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Learning Objective: Point out fundamentals of inspecting rebar.

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4-55. The project supervisor is responsible for seeing that the prefabricated structure is erected in accordance with the project plans and specifications.

4-56. When templates are required on a project, who is responsible for supplying them?
1. The building manufacturer
2. The engineering department
3. The operations department

4-57. Whether a project progresses smoothly or NOT is usually determined by the condition of the
1. foundation
2. materials on arrival
3. subassemblies

4-58. To find the exact location of every part in the structure, to which of the following drawings should you refer?
1. Fabrication
2. Erection
3. Shop

4-59. Bolted work is hard to inspect and poor workmanship is easy to hide.

4-60. Structural steelwork must be erected true to line level, and plumb.

# Assignment 5

Advanced Base Planning, Embarkation, and Project Turnover: Planning, Estimating, and Scheduling

Textbook Assignment: Pages 5-1 through 5-6, and pages 6-1 through 6-28

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Learning Objective: Point out principles involving the use of the Facilities Planning Guide.

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5-1. Included among the contents of NAVFAC P-437, Volume I, are the
1. amounts of fuel required to operate components
2. sizes of crew it takes to operate facilities
3. drawings of facilities and assemblies
4. acres of land a facility occupies

5-2. Volume II of NAVFAC P-437 is a source of information for planning an advanced base component, facility, or assembly.

5-3. NAVFAC P-437 lists by National Stock Number the material requirements for which of the following units?
1. Facility
2. Assembly
3. Component
4. Each of the above

5-4. To make the P-437 compatible with other DOD planning guides, which related publication establishes category codes?
1. Table of AFGC/s (OPNAV-41P3)
2. NAVFAC P-72
3. NAVFAC P-405
4. NAVFAC P-315

5-5. To find a facility that requires enlisted personnel quarters, under which of the following category codes should you look?
1. 300 - Research, Development and Evaluation
2. 700 - Housing and Community Support
3. 900 - Real Estate

5-6. Assemblies are grouped by numbers that relate to the Occupational Field 13 skill required to install them,

5-7. How can components or facilities be tailored?
1. By specifying requirements for tropical or northern temperate zones
2. By deleting or adding facilities or assemblies
3. Both 1 and 2 above

5-8. In the ABFC system, which code identifies asssemblies required for use in northern temperate zones?
1. T
2. C
3. N
4. NT

5-9. Refer to textbook figure 5-1. Approximately how many man-hours should it take to construct a small helicopter landing pad?
1. 150
2. 244
3. 500

5-10. How do you obtain fixtures that are NOT furnished with a facility or an assembly listed in NAVFAC P-435?
1. By picking them up at a supply depot
2. By ordering them separately
3. By purchasing them on the open market

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Learning Objective: Identify procedures and techniques used by the SW in preparing material and equipment for embarkation.

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5-11. To meet the requirements for contingency support, units of the NCF must be capable of redeployment within how many days?
1. 7
2. 10
3. 15
4. 21

5-12. When an embarkation order is issued, either for a training exercise or an actual movement, which of the following tasks should be yours?
1. Securing materials on site or turning them into MLO
2. Turning clean tools into the central toolroom
3. Cleaning and securing project sites
4. Each of the above

5-13. The company or department embarkation representative is responsible to insure that mount-out box construction, color coding, and numbering are in accordance with established directives.

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Learning Objective: Point out principles of coordinating and supervising a project turnover.

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5-14. Who conducts the camp, supply, and material inventories at the site of an NMCB that is completing its deployment?
1. Personnel of the relieved NMCB only
2. Personnel of the relieving battalion
3. Personnel of both battalions concerned

5-15. The purpose of a BEEP is to provide a uniform procedure for
1. evaluating and accounting for the equipment, records, and correspondence of a deployed battalion
2. equipping a battalion before it deploys
3. conducting maintenance inspections three months after a battalion arrives on station

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Learning Objective: Indicate principles and techniques of administration or supervision in project planning and estimating.

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5-16. In planning a construction project, with which of the following estimates should you be concerned?
1. Equipment
2. Material
3. Manpower
4. Each of the above

5-17. Whether a construction project fails or succeeds may depend upon the accuracy of the calculations for each phase of development.

5-18. As petty officer in charge of construction work, you should confirm the planning for the next workday at the end of each workday.

5-19. To be an effective supervisor, which of the following factors should you consider in your day-to-day planning?
1. Keeping each crewmember fully occupied
2. Having enough equipment on hand to get the job done
3. Having enough supplies on hand to get started
4. All of the above

5-20. The department head instructed you to complete a certain job by a certain time. Being responsible for a number of other jobs, you place a junior petty officer in charge of the crew assigned to this job. Who is responsible if the work falls behind schedule?
1. The senior crew member
2. The junior petty officer
3. You

5-21. As an estimator for a given project, you may be called upon to prepare which of the following estimates?
1. Quantities of materials required for the work to be done by the EO's
2. Quantities of materials required for work to be done by SEABEES other than the EO's
3. Man-hours required to complete the job
4. Each of the above

5-22. To estimate quantities of work elements and materials for a certain project, you must consult the
1. OICC
2. project drawings only
3. project specifications only
4. project drawings and specifications

5-23. When the project specifications differ from the drawings, what is the normal procedure to follow?
1. Obtain a new set of drawings and specifications
2. Follow the specifications
3. Follow the drawings
4. Consult the OICC

5-24. Which of the following methods is one of the best for reducing the errors made in the preparation of a quantity estimate?
1. Compare the estimate with the true quantities of the various items used on a similar job completed previously
2. Compare the estimate with an independent estimate of the same project made by another person
3. Let another person who is familiar with the project carefully check all computations
4. Review each part of the estimate with the person who will do the work on that particular part of the project

5-25. How are work element estimates prepared?
1. By computing the man-hours required to complete one of the work elements of the project
2. By computing quantities of material required for one of the work elements of the project
3. Both 1 and 2 above
4. By computing all quantities of the various items of work shown or referenced on the drawings

5-26. When measuring quantities of materials for the work elements of a building project, you should usually begin by measuring the work elements on the
1. basement level
2. succeeding floor levels
3. foundation and footing plan
4. mechanical and electrical drawings

5-27. The concrete, reinforcing, architectural, structural, mechanical, and electrical drawings for a given project are drawn separately. In what order should you examine or work the drawings?
1. Concrete, reinforcing, mechanical architectural, structural, and electrical
2. Concrete, reinforcing, architectural, structural, mechanical, and electrical
3. Mechanical, concrete, reinforcing, architectural, structural, and electrical
4. Mechanical, architectural, structural, concrete, reinforcing, and electrical

5-28. When you are measuring quantities on a drawing, what procedure is recommended to avoid duplications?
1. Start at the center and work towards the sides, checkmarking (✓) the particular work as you measure and record it
2. Start at one side and work toward the opposite side, color marking the particular work as you measure and record it
3. Start at the top and work down, lining out each piece of work as you measure and record it
4. Start at the bottom and work upward, lining out each piece of work as you measure and record it

5-29. When assigned the job of preparing the work element summary sheet for a certain project, from what sources do you obtain the required information?
1. Drawings
2. Specifications
3. Worksheets
4. Job orders

5-30. When entering required details on a work element estimate summary, you should make it a practice to
1. put them in alphabetical order
2. record them so that its reviewers can understand what was taken off and how computations were made
3. list them according to their priorities
4. number them

5-31. "Materials takeoff" is another name for
1. material estimate
2. equipment summary
3. work element

5-32. In preparing a materials takeoff for a project, you should make a list of
1. the quantities of each work element required to construct the project
2. all materials placed in the project plus earth excavation and fill
3. the materials and quantities required to construct the project
4. all materials used on the project

● In answering items 5-33 through 5-36 refer to the textbook procedure for preparing a material estimate.

5-33. The first step of the procedure is to obtain which of the following from the work element estimate?
1. Work element quantity
2. Work element conversion unit
3. Quantity required
4. Waste and loss factor

5-34. Where do allowances for waste and loss appear in the procedure for preparing a material estimate?
1. On the worksheet before the work elements are converted into quantities of materials
2. On the worksheet after the work elements are converted into quantities of materials
3. On the recap sheet before the quantities are totaled
4. On the recap sheet after the quantities are totaled

5-35. After all entries are made, which of the following forms becomes the material estimate?
1. Material estimate worksheet
2. Material estimate recap worksheet
3. Work element estimate worksheet
4. Work element estimate summary sheet

5-36. As an estimator, you should determine if an increase in material waste or loss on a job is warranted.

5-37. Which of the following items of information is included on the equipment estimate for a construction project?
1. The number of days each piece of equipment will operate
2. The type of equipment required
3. The amount of equipment required
4. Each of the above

5-38. How does an estimator obtain the required amount of operating time for a particular piece of equipment used on a construction project?
1. By dividing the quantity of work which the equipment is to perform by the estimated production rate per day
2. By dividing the quantity of work which the equipment is to perform by the production rate per day obtained from Navy school charts
3. By dividing the quantity of work which the equipment is to perform by 3/4 of the design capacity of the equipment
4. By making an estimate after considering work conditions, experience, and previous performance of SW's, etc.

5-39. The number of pieces of each type of equipment required at any one time for a project is determined from the prepared equipment schedule.

5-40. When preparing equipment estimates, which of the following factors should you consider?
1. Type of material to be handled
2. Experience of operators
3. Condition of equipment, weather conditions, and completion date
4. All of the above

5-41. What should be the estimator's attitude with respect to the various sources of information about production rates usually available in SEABEE operations offices?
1. Use the rates because they are usually very accurate and readily adaptable to any project
2. Do not refer to the rates when making estimates because every project is different
3. Use the rates but make necessary adjustments after considering the basis on which they were established
4. Use only production rates contained in a government manual; disregard all other sources

5-42. How are the man-days listed on a typical manpower estimate for a construction project?
1. Total only
2. Total for each work element and of each rating only
3. Total for the project and for each rating only
4. Total for the project and for each work element, or the total of each rating for each work element

5-43. Which of the following is a basis for preparing a preliminary manpower estimate?
1. General description of a project
2. Computation of project area or other measure
3. Preselected man-days per unit
4. Each of the above

5-44. You must prepare a preliminary manpower estimate for the construction of an NCO club. The building will be 90 feet wide, 110 feet long, constructed of brick and concrete, and fully equipped. The project site is in an area where conditions are favorable for construction. How many man-days will be required to complete the club? (Refer to textbook table 6-2.)
1. 1,920
2. 2,970
3. 5,940
4. 9,900

5-45. Of the following, which is used to determine labor requirements of a given project?
1. Preliminary manpower estimates
2. Detailed manpower estimates
3. Construction schedule
4. Work elements

5-46. Refer to textbook table 6-3. How many man-days are required under average conditions to complete a 1,000-sq ft storage shed?
1. 35
2. 70
3. 350
4. 3,500

5-47. Refer to textbook table 6-4. When columns and beams, trusses, and purlins being erected total 90 tons, approximately how many man-days would be required under adverse conditions?
1. 101
2. 267
3. 368
4. 441

Learning Objective: Recognize fundamentals of construction scheduling.

5-48. Before work starts on a project, the supervisor is guided by a construction schedule that serves to
1. integrate all previous analysis and planning
2. determine the technical data for the project
3. show the sequence in which personnel, materials, and equipment are needed

5-49. During construction of a project, the construction schedule enables the supervisor to
1. verify the amounts of materials and equipment needed for the project
2. furnish data on the methods and techniques of construction operations
3. determine whether work items are on or behind schedule
4. consolidate the materials takeoff for a continuous flow of the production process

5-50. Which of the following statements regarding the uses of construction schedules is true?
1. They become useless when project plans and specifications are changed
2. They may serve as a basis for estimating material requirements
3. They may be used for preparation of progress reports
4. They are useless after completion of a project

5-51. After completion of a project, an analysis of the construction schedule should identify information that has a future use.

5-52. Which of the following is NOT included among the elements of scheduling work?
1. Quantity of work to be done
2. Number of pieces of equipment
3. Unit of measurement
4. Time required for each work item

5-53. From what schedule can you obtain the separate work elements of a project?
1. Deployment schedule only
2. Project schedule only
3. Deployment or project schedule

5-54. In addition to the principles that scheduled operations can NOT exceed a unit's capacity and that they must follow the sequence of work, what other scheduling principle should a supervisor apply in developing a good construction schedule?
1. Use the analysis of completed projects as a basis for accurate scheduling
2. Prepare checklists to effect intelligent overall supervision of the project
3. Follow the best sequence of work items required for the particular job
4. Keep a balance between starting critical items at the earliest time and maintaining a continuous effort for each task

5-55. Approximately what percentage of the total project, shown in textbook figure 6-1, will have been accomplished, if at the end of May, project 1 was 43 percent complete, project 2 was 22 percent complete, and project 3 was 67 percent complete?
1. 34
2. 42
3. 52
4. 58

5-56. Refer to textbook figure 6-8. Approximately how many cubic yards were trenched and backfilled on the POL system at the end of July?
1. 858
2. 968
3. 1342
4. 1716

5-57. The first thing you should do in scheduling a project is to determine the construction sequences.

5-58. The completion of an access road is estimated to take 500 man-days. With a work force of 40, approximately how many workdays are scheduled to complete the project?
1. 5
2. 12
3. 18
4. 22

5-59. How often should you report work completed on your assigned project?
1. Daily
2. Weekly
3. Biweekly
4. Monthly

5-60. What construction report, if any, is usually made in narrative form?
1. Daily
2. Weekly
3. Monthly
4. None

# Assignment 6

Planning, Estimating, and Scheduling (continued)

Textbook Assignment: Pages 6-28 through 6-60

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Learning Objective: Indicate principles and techniques of Critical Path Method (CPM).

6-1. By definition, the Critical Path Method is a
1. technique of program evaluation and review
2. means of preparing arrow diagrams
3. method of designing arrow diagram problems
4. system of planning, scheduling, and controlling construction projects

6-2. As a project supervisor, an arrow diagram should aid you in construction management because it
1. identifies the amount of spare time available for each of the work items, services, or tasks involved in a given project
2. enables you to visualize, at a glance, the sequence and interrelationships of the individual items of work, services, or tasks involved in a given project
3. provides a quantitative analysis, in graphic form, of the material required for a given project

In answering items 6-3 through 6-8, use the following alternatives.

1. an activity
2. an arrow
3. a circle
4. an event

6-3. The starting point of an activity is referred to as

6-4. In the preparation of an arrow diagram, an activity is indicated by the use of

6-5. An event is depicted on an arrow diagram by

6-6. A service or task that is indicated on an arrow diagram is referred to as

6-7. On an arrow diagram, the starting point of an activity is depicted by

6-8. An individual item of work is represented on an arrow diagram by

6-9. How many (a) activities, and (b) events are shown in textbook figure 6-14?
1. (a) 6 (b) 6
2. (a) 6 (b) 7
3. (a) 7 (b) 6
4. (a) 7 (b) 7

6-10. Before the work represented by activity (3) - (5) in textbook figure 6-14 can start, which of the following activities must be completed?
1. (1) - (3) and (3) - (4)
2. (3) - (4)
3. (1) - (2) and (1) - (3)
4. (1) - (3)

6-11. If an arrow diagram for a given project is inaccurate and unrealistic, network analysis will prove unsatisfactory.

6-12. In arrow diagram development, what is indicated by the question "What activity must be completed before this one can start?"
1. An event into which the activity should enter
2. An event from which to start the activity
3. The critical activities and events of the diagram
4. Only the critical activities of the diagram

6-13. You have established the starting point for a new activity on an arrow diagram. Which of the following questions should be answered in order to establish its termination point?
1. Is this a critical activity?
2. What is the estimated duration of this activity?
3. What activities must be accomplished before this one can proceed?
4. What activities cannot proceed if this one is not completed?

6-14. Which of the following statements describes the relationship between activities E and F of textbook figure 6-20?
1. Both activities start at the same point
2. Each is an independent activity
3. Of the two activities, E requires more time than F for completion
4. Each of the above

6-15. In the preparation of an arrow diagram that involves work items done by several ratings, you should consult with responsible representatives to insure that these items are accurately and realistically described.

6-16. At most, how many activities may carry the same event number at both the tail and head of the arrow?
1. One
2. Two
3. Three

6-17. What type of activity should you insert in an arrow diagram that does NOT represent work performance?
1. Extension
2. Connector
3. Network
4. Service

6-18. In textbook figure 6-21, the work item SURVEY & STAKEOUT can also be called activity
1. (1) - (2)
2. (2) - (3)
3. (3) - (2)
4. (1) - (3)

6-19. When shown on an arrow diagram, a dummy activity serves to indicate
1. duration
2. cost
3. sequence or a dependency connector
4. work

6-20. An arrow diagram can sometimes describe a time relationship.

6-21. Refer to problem 1 in the textbook. At what event does obtaining draintile start?
1. First
2. Second
3. Third
4. Fourth

6-22. In problem 2 of the textbook, obtaining the trencher is known as a
1. dependent activity
2. dummy activity
3. delivery activity
4. duration activity

6-23. The arrow diagram for problem 2 in the textbook describes the
1. dependency relationship only
2. time relationship only
3. dependency and time relationships
4. delivery activity

6-24. In arrow diagraming, you can help remember the assumptions made about an activity by putting them in writing.

6-25. Refer to problem 3 in the textbook. Which view of textbook figure 6-24 indicates the event for fine grade to be completed?
1. A
2. B
3. C
4. D

In answering items 6-26 and 6-27, use the following alternatives.

1. establish dependency between nondependent activities
2. maintain the uniqueness of the I - J identification system
3. transfer dependency from dependent activities to nondependent activities
4. describe dependencies in such a way that nondependent activities are not shown as dependent

6-26. The dummy activity illustrated in textbook figure 6-25 is used to

6-27. In textbook figure 6-26, the dummy activity is used to

6-28. View B of textbook figure 6-26 is in error because it shows
1. fine grade depending on the completion of prefab forms
2. availability of a backhoe depending on the completion of prefab forms
3. fine grade and availability of backhoe depending on the layout and excavation

6-29. Refer to the dummy problem in the textbook. Which view of textbook figure 6-27 removes the assumption that placing gravel second half does NOT start until draintile is installed?
1. A
2. B
3. C
4. D

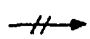
6-30. An estimate of the time it should take to complete each event of an arrow diagram is known as
1. spare time
2. duration time
3. delayed time
4. critical time

6-31. The critical path of an arrow diagram is the
1. shortest path through the diagram
2. path through the diagram that requires the longest time to complete all the critical jobs
3. path through the diagram that includes all the longest individual work elements
4. path through the diagram consisting of the longest arrows

6-32. To determine easily the amount of time it should take to finish each individual activity in an arrow diagram, you assume that the usual number of crewmembers or pieces of equipment are available.

6-33. The critical path is usually identified by what symbol in an arrow diagram?

1. 

2. 

3. 

4. 

6-34. What usually happens in an arrow diagram when a critical path is shortened?
1. At least one other path becomes the critical path
2. Exactly two other paths become critical paths
3. The shortened path remains the critical path
4. No other path becomes the critical path

6-35. A special symbol is used on arrow diagrams to enable project managers to pick out a/an
1. earliest event
2. latest event time
3. shortest path
4. milestone

6-36. In using an arrow diagram, you can find the earliest time that an event can occur by adding the durations of the activities on the
1. paths parallel to the critical path
2. longest path leading up to the event
3. shortest path leading from the event

6-37. Refer to textbook figure 6-31. Of the symbols shown, which designates the latest event time?

1. 

2. 

3. 

4. 

6-38. The earliest and latest event times for an activity will differ in the case where it is NOT on the critical path of an arrow diagram.

6-39. Refer to textbook figure 6-32. What event in the arrow diagram shows that waterproofing the arch and installing the ventilator are completed?
1. 10
2. 12
3. 16
4. 17

6-40. How should you calculate the latest start time for an activity shown in textbook figure 6-32?
1. Work from right to left, subtracting job duration from the preceding latest event time
2. Work from left to right, adding job duration to the preceding earliest event time
3. Work from left to right, adding job duration to the preceding latest event times
4. Either 2 or 3 above

6-41. What name is given to the spare time made available to perform a task shown on an arrow diagram?
1. Flex
2. Slack
3. Critical
4. Droop

6-42. By subtracting both the duration and earliest event time at the tail of the arrow from the latest event time at the head of the arrow of any activity, you can calculate the
1. start time
2. finish time
3. slack
4. duration

6-43. What, if anything, might happen should you change the slack of the earliest and latest event times of a fully developed arrow diagram?
1. Insufficient use is made of crew and equipment
2. Another critical path might develop
3. The job becomes inflexible
4. Nothing

6-44. Refer to textbook figure 6-32. Because of the slack in it, which activity can be scheduled to end the day before critical activity (17) - (18) begins?
1. ( 1) - ( 6)
2. (11) - (15)
3. (11) - (18)
4. (16) - (18)

6-45. How was time saved for critical path activity (3) - (5) of textbook figure 6-32?
. By taking advantage of slack
2. By preparing a timetable
3. By counting weekends as project days
4. Each of the above

6-46. Which of the following events may lead to the addition of new activities to an arrow diagram?
1. Delayed material delivery
2. Manpower shortage
3. Design modifiction
4. Each of the above

6-47. Two or more activities that start on the same date are placed on the project schedule according to the amount of slack in them.

6-48. After you prepare a preliminary schedule of activities like the one in textbook figure 6-32, your next step is to transfer the given values to a
1. work report
2. bar chart
3. 3 x 5 card

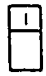
6-49. When splitting work elements to make maximum use of manpower, you should check the arrow diagram for which of the following purposes?
1. To calculate amount of time saved
2. To determine the effect that splitting has on subsequent activities
3. To determine that effect of splitting on preceding activities
4. To calculate slack

Learning Objective: Indicate principles and techniques of precedence diagraming.

6-50. Which, if any, of the following representations is NOT in precedence diagraming?

1. $\boxed{\text{FINISH}}$

2. - - - - ->

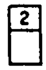
3. 


4. None

6-51. How are activities and events shown in a precedence diagram?

1. 

2. $\boxed{\text{START}}$

3. 


4. Both 2 and 3 above

6-52. Where would a delay between the start of one activity and the start of another activity be indicated on a precedence diagram?
1. Within the activity
2. At the start of each event
3. On the connector
4. Each of the above

6-53. How is a partial finish indicated in a precedence diagram?
1. By drawing the connector from the start of the preceding activity
2. By drawing the connector from the end of the following activity
3. By drawing arrow networks on the work elements
4. By lettering, starting with A in the basic time units

6-54. By what means would you represent activities that are remote from each other, but need to be connected on a precedence diagram?
1. By sequencing connectors
2. By a circle containing the following activity number
3. By a circle containing the preceding activity number
4. Both 2 and 3 above

6-55. Direct linking of a particular large complex on a precedence diagram is accomplished by introducing a focal activity of zero duration.

6-56. Which form of representation of dependencies should NOT be used in precedence diagraming?
1. Indirect
2. Direct
3. Splitting
4. Parallel

6-57. Information for a precedence activity is usually contained within which of the following?
1. Event
2. Network
3. Bill of materials
4. Activity box

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Learning Objective: Recognize fundamentals of equipment maintenance.

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6-58. Which of the following advantages are obtained through proper equipment maintenance?
1. Safe working conditions and habits
2. Fewer breakdowns
3. Extended equipment life
4. All of the above

6-59. How often may maintenance of equipment be required?
1. Daily
2. Weekly
3. Monthly
4. Each of the above

6-60. By setting up a maintenance program, you can insure proper care and upkeep of the equipment.

6-61. Equipment history files should contain information about which of the following?
1. Repair methods
2. Troubles encountered
3. PM dates and materials used
4. All of the above

# Assignment 7

Metals Identification and Testing; Company Chief

Textbook Assignment: Pages 7-1 through 7-18 and pages 8-1 through 8-7

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Learning Objective: Recognize principles and techniques of testing hardness in metals.

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7-1. Of the many tests used to determine the degree of hardness in metal, which of the following is the simplest to use?
1. Rockwell
2. File
3. Brinell

7-2. Which of the following is a definition of hardness?
1. Resistance of penetration
2. Resistance to abrasion
3. Resistance to machine cutting
4. Each of the above

7-3. Hardness of a metal is measured by its resistance to penetration or indentation by an indenter of fixed size and shape, while a specific load is applied.

7-4. Which of the following instruments are ordinarily used for measuring hardness of metal?
1. Rockwell and Brinell
2. Vickers and Scleroscope
3. Eberback and Monotron
4. Tukon and Hobart

7-5. Which of the following is the basic principle of the Rockwell test?
1. Any metal can be tested for hardness
2. A hard metal will penetrate a softer one
3. The softer the metal being tested, the deeper the penetration will be

7-6. The average depth of penetration on samples of very soft steel, using the Rockwell hardness tester, is approximately
1. .002 inch
2. .004 inch
3. .006 inch
4. .008 inch

7-7. To avoid bulging or marking the test specimen when you are using the indenter-type hardness test, the specimen thickness should be at least how many times the depth of penetration?
1. 4
2. 6
3. 8
4. 10

7-8. What is the first thing that you should do after you have placed the metal on the anvil of the Rockwell tester at the start of the test?
1. Apply the minor load
2. Apply the major load
3. Turn the zero adjuster
4. Bring the test piece into contact with the testing cone or ball

7-9. After the minor load has been applied to the specimen on the Rockwell hardness tester, the next step is to
1. turn the elevating wheel until the small pointer is nearly vertical
2. set the dial zero behind the pointer
3. turn the elevating wheel until the long pointer is nearly vertical
4. tap the depressor bar

7-10. What are the positions of the major and minor loads when you read the hardness number on the Rockwell tester dial?
1. The minor load rests on the specimen and the major load is raised
2. The major load rests on the specimen and the minor load is raised
3. Both loads rest on the specimen
4. Both loads are raised

7-11. How large a load would be applied to a test specimen of ferrous metal in the Brinell hardness tester?
1. 500 kg
2. 720 kg
3. 1,500 kg
4. 3,000 kg

7-12. The Brinell hardness tester is excellent for testing soft and medium-hard metals.

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Learning Objective: Recognize principles and techniques of testing the tensile strength of metals.

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7-13. Which of the following is a definition of tensile strength?
1. Resistance of a metal to longitudinal stress or pull
2. Resistance of a soft metal to penetration by a hard metal
3. Resistance of a metal to abrasion

7-14. The tension test is classified as a nondestructive metal test.

7-15. The diameter and gage length of a test piece that is used in a tension test must be accurate because they help to determine
1. tensile strength and fracturing load
2. fracturing load and percentage of elongation
3. strain measuring points and amount of elongation
4. tensile strength and percentage of elongation

7-16. In a tension test, a smooth, steady pull is applied on a test specimen and its resistance is measured until it breaks.

7-17. Of the following properties, which can NOT be determined from the results of the tension test?
1. Yield point
2. Modulus of elasticity
3. Elastic limit
4. Hardness

7-18. Which of the following procedures should you follow when making a tensile strength test, assuming a steel specimen has been properly set up with an extensometer attached?
1. Apply a steadily increasing load
2. At frequent intervals, release the load
3. Increase the load in small amounts, until permanent deformation occurs
4. All of the above

7-19. When automatic equipment is NOT being used, the extensometer is removed from a specimen in tension testing when the specimen begins to
1. stretch elastically
2. stretch permanently
3. neck in
4. fracture

7-20. In tension testing which of the following occurs just before the specimen breaks?
1. Metal fatigue
2. Necking in
3. Breaking point

7-21. A 2-inch length of metal has a gage length of 2 1/2 inches after tension testing. What is its percentage of elongation?
1. 20 percent
2. 25 percent
3. 100 percent

7-22. On the stress-strain curve, the line representing brittle metal will show up as a steep sloping, nearly straight line.

7-23. If a stress-strain curve is plotted from the data of a tension test, the part of the curve that is a straight line is used to determine
1. ductility
2. brittleness
3. modulus of elasticity
4. modulus of plasticity

7-24. Refer to view A of textbook figure 7-6. How much pressure did it take to break the test specimen?
1. 45,000 psi
2. 60,000 psi
3. 90,000 psi
4. 105,000 psi

7-25. Refer to view ., textbook figure 7-6. With test machines equipped with autographic recorders, the curve between d and e looks the same as those taken with test machines not equipped with autographic recorders.

7-26. Which of the following properties of metal are most difficult to determine?
1. Toughness and hardness
2. Ductility and brittleness
3. Elastic limit and yield point

7-27. If a high degree of accuracy is not required, the elastic limit of ordinary steels can be determined by the scribe method.

7-28. When using the scribe method, what should be suspect if two distinct lines result?
1. The elastic limit was not reached
2. The elastic limit was reached
3. The elastic limit was exceeded

---

Learning Objectives: Point out the fundamentals of magnetic particle inspection.

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7-29. During the magnetic particle inspection, if the magnetic field is disturbed by a crack or some other defect in the metal, the pattern is interrupted and the particles cluster around the defect.

7-30. In the magnetic particle inspection, the test piece may be magnetized by which method?
1. Passing an electric current through it
2. Passing an electric current though a coil or wire that surrounds it
3. Both 1 and 2 above

7-31. The magnetic particle inspection is satisfactory for detecting surface cracks and subsurface cracks that are one-half of an inch below the surface.

7-32. In the magnetic particle inspection, each area of the test piece must be inspected twice to obtain the best results.

7-33. When you are using the prod kit supplied with the unit, the space between prod contact points is
1. 1 to 12 inches
2. 2 to 8 inches
3. 4 to 6 inches

7-34. Hairline cracks are difficult to detect by the magnetic particle process.

7-35. In the magnetic particle inspection, a crack is indicated by a fuzzy and poorly defined particle pattern.

7-36. When a small compass is held near the work piece, the deviation of the compass needle from its normal position indicates the presence of a magnetic field.

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Learning Objective: Identify principles and techniques of liquid penetrant inspections.

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7-37. Which of the following defects can be detected by the use of a liquid penetrant?
1. Surface cracks
2. Subsurface cracks
3. Voids beneath the surface

7-38. Which of the following groups of liquid penetrants are fluorescent?
1. 1 and 3
2. 2 and 4
3. 3 and 4

7-39. All dirt, grease, scale, lint, salt, and other materials must be removed from the test piece before the liquid penetrant test is made.

7-40. The liquid penetrant and the test piece must be maintained at a temperature in which range?
1. 50° to 75°
2. 50° to 100°
3. 70° to 100°

7-41. The surface of the test piece must be kept wet with the penetrant for a minimum of how many minutes?
1. 5 or 10
2. 15 or 30
3. 40 or 60

7-42. When performing the liquid penetrant inspection, you should allow the developer to remain on the test piece for approximately how many minutes?
1. 7
2. 15
3. 30

---

Learning Objective: Identify techniques of testing sample welds and methods of identifying metals.

---

7-43. In the free-bend test for checking a weld, what is the maximum length allowable for cracks?
1. 1/32 inch
2. 1/16 inch
3. 1/8 inch

7-44. The guided-bend test is used to
1. measure the ductility of metal and percentage of elongation
2. determine the quality of the weld metal at the face and root of a welded joint
3. determine the internal quality of the weld metal

7-45. To fulfill the requirements of the guided-bend test the specimen must bend 180° and NO cracks should appear greater than
1. 1/16 inch
2. 1/8 inch
3. 1/4 inch

7-46. The neck-break test is designed to show which of the following defects?
1. Slag inclusions
2. Gas pockets
3. Lack of fusion
4. All the above

7-47. A number of tests are available to help identify metal. Which are the most common?
1. Bend and chemical tests
2. Surface appearance, spark, and chip tests
3. Tensile and hardness tests

7-48. Of the following metals, which will ignite and burn violently when heated with a torch?
1. Aluminum or aluminum alloy
2. Copper-nickle alloy
3. Brass or bronze
4. Magnesium or magnesium alloy

---

Learning Objective: Identify the Company Chief's responsibilities regarding company projects, military duties, PRCP, training, and administration.

---

7-49. The Company Chief must insure that areas of responsibility and levels of authority are clearly defined for each enlisted person in the company.

7-50. When inspecting company projects, the Company Chief must insure which of the following practices?
1. Proper use of manpower
2. Proper use of material and equipment
3. Safe working practices
4. All of the above

7-51. The Company Chief assists in assigning personnel to weapons and positions in the company military organization.

7-52. The information obtained from the PRCP is useful in determining the state of readiness and the capabilities of a SEABEE unit.

---

In answering items 7-53 through 7-57, select from column B the category of the duty performed by the Company Chief in column A.

---

| | A. Duties | B. Categories |
|---|---|---|
| 7-53. | Assisting in the assignment of personnel to training designed to develop construction combat skills | 1. Military |
| 7-54. | Anticipating morale problems and initiating corrective action before working relations or production are affected | 2. Battalion training |
| 7-55. | Assisting in ceremonies, briefings and conferences | 3. Project management |
| 7-56. | Establishing a training program to insure the unit's capabilities, utilizing PRCP data | |
| 7-57. | Insuring the unit's readiness with respect to manpower, material, and equipment | |

---

7-58. What is the main objective of all NMCB administered training?
1. Personnel development
2. Skill development
3. Overall battalion readiness
4. Combat readiness

7-59. The type and organization of a company training program depends on which of the following factors?
1. Availability if training facilities
2. Operational commitments of the battalion
3. Experience of company petty officers
4. All of the above

---

In answering items 7-60 through 7-62, select from column B the individual who performs the function in column A.

| A. Functions | B. Individuals |
|---|---|
| 7-60. Gives instructor training and safety training | 1. Company Commander |
| | 2. Company Clerk |
| 7-61. Prepares training schedules | 3. Company Chief |
| | 4. Platoon Leader |
| 7-62. Collects training information and prepares company records and reports | |

---

7-63. When selecting instructors from among the competent petty officers, whom should the Company Chief first seek out?
1. Those who are experienced or familiar with the instructional methods and techniques
2. Those who are able to motivate others
3. Experts in the technical aspects of their rating
4. All of the above

7-64. Training petty officers to become effective instructors is a primary concern of the company training program.

7-65. In conducting supervised training, the most effective method for developing skills of the building trades is on-the-job training. This type of training should apply to whom?
1. New personnel in an organization
2. Persons who are assigned new jobs
3. Both 1 and 2 above

7-66. The training requirements for an OJT program are determined by which of the following combinations of attributes?
1. Required skills and knowledge plus possessed skills and knowledge
2. Possessed skills and required knowledge plus possessed knowledge an required skills
3. Required skills and knowledge minus possessed skills and knowledge

7-67. New instructors can obtain already prepared lesson plans and instructors' guides from the local NCTC.

7-68. When selecting the instructional methods to be used in an on-the-job training program, which of the following factors should you consider?
1. Time available
2. Student population
3. Capability of each student
4. Each of the above

7-69. Before starting a project, which of the following steps should an instructor take?
1. Have the materials and equipment ready
2. Have the jobsite and work place properly arranged
3. Give directions on how to accomplish the job safely, easily, and economically
4. Each of the above

7-70. Although the subject matter might dictate the method or combination of methods of OJT to be used in certain situations, the most effective method is
1. group instruction
2. coach-pupil instruction
3. piecemeal instruction
4. self-study

7-71. Group instruction for OJT is generally the same as classroom instruction.

7-72. With respect to personnel administration, which of the following is a duty of the Company Chief?
1. Supervising the clerical and administrative details of the company
2. Counseling enlisted company personnel on professional and personal matters effecting their efficiency
3. Insuring fair duty rotation and satisfactory schedules of company personnel going on leave and R & R
4. Each of the above

7-73. An important part of the Company Chief's responsibilities is supervising and coordinating the preparation of enlisted evaluations to insure that they are fair and accurate.

7-74. With respect to organizational policies, what information should be in written directives?
1. Safety requirements
2. Shop rules
3. Local policies
4. All of the above

7-75. Listening to what another person has to say to you is an important part of communication.

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| 15 ☐ | ☐ | ☐ | ☐ | 40 ☐ | ☐ | ☐ | ☐ | 65 ☐ | ☐ | ☐ | ☐ | | |
| 16 ☐ | ☐ | ☐ | ☐ | 41 ☐ | ☐ | ☐ | ☐ | 66 ☐ | ☐ | ☐ | ☐ | | |
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| 21 ☐ | ☐ | ☐ | ☐ | 46 ☐ | ☐ | ☐ | ☐ | 71 ☐ | ☐ | ☐ | ☐ | | |
| 22 ☐ | ☐ | ☐ | ☐ | 47 ☐ | ☐ | ☐ | ☐ | 72 ☐ | ☐ | ☐ | ☐ | | |
| 23 ☐ | ☐ | ☐ | ☐ | 48 ☐ | ☐ | ☐ | ☐ | 73 ☐ | ☐ | ☐ | ☐ | | |
| 24 ☐ | ☐ | ☐ | ☐ | 49 ☐ | ☐ | ☐ | ☐ | 74 ☐ | ☐ | ☐ | ☐ | | |
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| 4 | ☐ | ☐ | ☐ | ☐ | _____ |
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| 6 | ☐ | ☐ | ☐ | ☐ | _____ |
| 7 | ☐ | ☐ | ☐ | ☐ | _____ |
| 8 | ☐ | ☐ | ☐ | ☐ | _____ |
| 9 | ☐ | ☐ | ☐ | ☐ | _____ |
| 10 | ☐ | ☐ | ☐ | ☐ | _____ |
| 11 | ☐ | ☐ | ☐ | ☐ | _____ |
| 12 | ☐ | ☐ | ☐ | ☐ | _____ |
| 13 | ☐ | ☐ | ☐ | ☐ | _____ |
| 14 | ☐ | ☐ | ☐ | ☐ | _____ |
| 15 | ☐ | ☐ | ☐ | ☐ | _____ |
| 16 | ☐ | ☐ | ☐ | ☐ | _____ |
| 17 | ☐ | ☐ | ☐ | ☐ | _____ |
| 18 | ☐ | ☐ | ☐ | ☐ | _____ |
| 19 | ☐ | ☐ | ☐ | ☐ | _____ |
| 20 | ☐ | ☐ | ☐ | ☐ | _____ |
| 21 | ☐ | ☐ | ☐ | ☐ | _____ |
| 22 | ☐ | ☐ | ☐ | ☐ | _____ |
| 23 | ☐ | ☐ | ☐ | ☐ | _____ |
| 24 | ☐ | ☐ | ☐ | ☐ | _____ |
| 25 | ☐ | ☐ | ☐ | ☐ | _____ |
| 26 | ☐ | ☐ | ☐ | ☐ | _____ |
| 27 | ☐ | ☐ | ☐ | ☐ | _____ |
| 28 | ☐ | ☐ | ☐ | ☐ | _____ |
| 29 | ☐ | ☐ | ☐ | ☐ | _____ |
| 30 | ☐ | ☐ | ☐ | ☐ | _____ |
| 31 | ☐ | ☐ | ☐ | ☐ | _____ |
| 32 | ☐ | ☐ | ☐ | ☐ | _____ |
| 33 | ☐ | ☐ | ☐ | ☐ | _____ |
| 34 | ☐ | ☐ | ☐ | ☐ | _____ |
| 35 | ☐ | ☐ | ☐ | ☐ | _____ |
| 36 | ☐ | ☐ | ☐ | ☐ | _____ |
| 37 | ☐ | ☐ | ☐ | ☐ | _____ |
| 38 | ☐ | ☐ | ☐ | ☐ | _____ |
| 39 | ☐ | ☐ | ☐ | ☐ | _____ |
| 40 | ☐ | ☐ | ☐ | ☐ | _____ |
| 41 | ☐ | ☐ | ☐ | ☐ | _____ |
| 42 | ☐ | ☐ | ☐ | ☐ | _____ |
| 43 | ☐ | ☐ | ☐ | ☐ | _____ |
| 44 | ☐ | ☐ | ☐ | ☐ | _____ |
| 45 | ☐ | ☐ | ☐ | ☐ | _____ |
| 46 | ☐ | ☐ | ☐ | ☐ | _____ |
| 47 | ☐ | ☐ | ☐ | ☐ | _____ |
| 48 | ☐ | ☐ | ☐ | ☐ | _____ |
| 49 | ☐ | ☐ | ☐ | ☐ | _____ |
| 50 | ☐ | ☐ | ☐ | ☐ | _____ |
| 51 | ☐ | ☐ | ☐ | ☐ | _____ |
| 52 | ☐ | ☐ | ☐ | ☐ | _____ |
| 53 | ☐ | ☐ | ☐ | ☐ | _____ |
| 54 | ☐ | ☐ | ☐ | ☐ | _____ |
| 55 | ☐ | ☐ | ☐ | ☐ | _____ |
| 56 | ☐ | ☐ | ☐ | ☐ | _____ |
| 57 | ☐ | ☐ | ☐ | ☐ | _____ |
| 58 | ☐ | ☐ | ☐ | ☐ | _____ |
| 59 | ☐ | ☐ | ☐ | ☐ | _____ |
| 60 | ☐ | ☐ | ☐ | ☐ | _____ |
| 61 | ☐ | ☐ | ☐ | ☐ | _____ |
| 62 | ☐ | ☐ | ☐ | ☐ | _____ |
| 63 | ☐ | ☐ | ☐ | ☐ | _____ |
| 64 | ☐ | ☐ | ☐ | ☐ | _____ |
| 65 | ☐ | ☐ | ☐ | ☐ | _____ |
| 66 | ☐ | ☐ | ☐ | ☐ | _____ |
| 67 | ☐ | ☐ | ☐ | ☐ | _____ |
| 68 | ☐ | ☐ | ☐ | ☐ | _____ |
| 69 | ☐ | ☐ | ☐ | ☐ | _____ |
| 70 | ☐ | ☐ | ☐ | ☐ | _____ |
| 71 | ☐ | ☐ | ☐ | ☐ | _____ |
| 72 | ☐ | ☐ | ☐ | ☐ | _____ |
| 73 | ☐ | ☐ | ☐ | ☐ | _____ |
| 74 | ☐ | ☐ | ☐ | ☐ | _____ |
| 75 | ☐ | ☐ | ☐ | ☐ | _____ |

**PRINT OR TYPE**

NAME ______________________ ADDRESS ______________________
Last First Middle Street/Ship/Unit/Division, etc.

City or FPO State Zip

RANK/RATE ________ SOC. SEC. NO. ______________ DESIGNATOR ________ ASSIGNMENT NO. ________

☐ USN ☐ USNR ☐ ACTIVE ☐ INACTIVE OTHER (Specify) ______________ DATE MAILED ________

SCORE

| | 1 T | 2 F | 3 | 4 | | | 1 T | 2 F | 3 | 4 | | | 1 T | 2 F | 3 | 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ☐ | ☐ | ☐ | ☐ | _____ | 26 | ☐ | ☐ | ☐ | ☐ | _____ | 51 | ☐ | ☐ | ☐ | ☐ | _____ |
| 2 | ☐ | ☐ | ☐ | ☐ | _____ | 27 | ☐ | ☐ | ☐ | ☐ | _____ | 52 | ☐ | ☐ | ☐ | ☐ | _____ |
| 3 | ☐ | ☐ | ☐ | ☐ | _____ | 28 | ☐ | ☐ | ☐ | ☐ | _____ | 53 | ☐ | ☐ | ☐ | ☐ | _____ |
| 4 | ☐ | ☐ | ☐ | ☐ | _____ | 29 | ☐ | ☐ | ☐ | ☐ | _____ | 54 | ☐ | ☐ | ☐ | ☐ | _____ |
| 5 | ☐ | ☐ | ☐ | ☐ | _____ | 30 | ☐ | ☐ | ☐ | ☐ | _____ | 55 | ☐ | ☐ | ☐ | ☐ | _____ |
| 6 | ☐ | ☐ | ☐ | ☐ | _____ | 31 | ☐ | ☐ | ☐ | ☐ | _____ | 56 | ☐ | ☐ | ☐ | ☐ | _____ |
| 7 | ☐ | ☐ | ☐ | ☐ | _____ | 32 | ☐ | ☐ | ☐ | ☐ | _____ | 57 | ☐ | ☐ | ☐ | ☐ | _____ |
| 8 | ☐ | ☐ | ☐ | ☐ | _____ | 33 | ☐ | ☐ | ☐ | ☐ | _____ | 58 | ☐ | ☐ | ☐ | ☐ | _____ |
| 9 | ☐ | ☐ | ☐ | ☐ | _____ | 34 | ☐ | ☐ | ☐ | ☐ | _____ | 59 | ☐ | ☐ | ☐ | ☐ | _____ |
| 10 | ☐ | ☐ | ☐ | ☐ | _____ | 35 | ☐ | ☐ | ☐ | ☐ | _____ | 60 | ☐ | ☐ | ☐ | ☐ | _____ |
| 11 | ☐ | ☐ | ☐ | ☐ | _____ | 36 | ☐ | ☐ | ☐ | ☐ | _____ | 61 | ☐ | ☐ | ☐ | ☐ | _____ |
| 12 | ☐ | ☐ | ☐ | ☐ | _____ | 37 | ☐ | ☐ | ☐ | ☐ | _____ | 62 | ☐ | ☐ | ☐ | ☐ | _____ |
| 13 | ☐ | ☐ | ☐ | ☐ | _____ | 38 | ☐ | ☐ | ☐ | ☐ | _____ | 63 | ☐ | ☐ | ☐ | ☐ | _____ |
| 14 | ☐ | ☐ | ☐ | ☐ | _____ | 39 | ☐ | ☐ | ☐ | ☐ | _____ | 64 | ☐ | ☐ | ☐ | ☐ | _____ |
| 15 | ☐ | ☐ | ☐ | ☐ | _____ | 40 | ☐ | ☐ | ☐ | ☐ | _____ | 65 | ☐ | ☐ | ☐ | ☐ | _____ |
| 16 | ☐ | ☐ | ☐ | ☐ | _____ | 41 | ☐ | ☐ | ☐ | ☐ | _____ | 66 | ☐ | ☐ | ☐ | ☐ | _____ |
| 17 | ☐ | ☐ | ☐ | ☐ | _____ | 42 | ☐ | ☐ | ☐ | ☐ | _____ | 67 | ☐ | ☐ | ☐ | ☐ | _____ |
| 18 | ☐ | ☐ | ☐ | ☐ | _____ | 43 | ☐ | ☐ | ☐ | ☐ | _____ | 68 | ☐ | ☐ | ☐ | ☐ | _____ |
| 19 | ☐ | ☐ | ☐ | ☐ | _____ | 44 | ☐ | ☐ | ☐ | ☐ | _____ | 69 | ☐ | ☐ | ☐ | ☐ | _____ |
| 20 | ☐ | ☐ | ☐ | ☐ | _____ | 45 | ☐ | ☐ | ☐ | ☐ | _____ | 70 | ☐ | ☐ | ☐ | ☐ | _____ |
| 21 | ☐ | ☐ | ☐ | ☐ | _____ | 46 | ☐ | ☐ | ☐ | ☐ | _____ | 71 | ☐ | ☐ | ☐ | ☐ | _____ |
| 22 | ☐ | ☐ | ☐ | ☐ | _____ | 47 | ☐ | ☐ | ☐ | ☐ | _____ | 72 | ☐ | ☐ | ☐ | ☐ | _____ |
| 23 | ☐ | ☐ | ☐ | ☐ | _____ | 48 | ☐ | ☐ | ☐ | ☐ | _____ | 73 | ☐ | ☐ | ☐ | ☐ | _____ |
| 24 | ☐ | ☐ | ☐ | ☐ | _____ | 49 | ☐ | ☐ | ☐ | ☐ | _____ | 74 | ☐ | ☐ | ☐ | ☐ | _____ |
| 25 | ☐ | ☐ | ☐ | ☐ | _____ | 50 | ☐ | ☐ | ☐ | ☐ | _____ | 75 | ☐ | ☐ | ☐ | ☐ | _____ |

STEELWORKER 1&C
NAVEDTRA 10654-E

**PRINT OR TYPE**

NAME ______________________________ ADDRESS ______________________________
Last First Middle — Street/Ship/Unit/Division, etc.

City or FPO State Zip

RANK/RATE ________ SOC. SEC. NO. ______________________ DESIGNATOR ________ ASSIGNMENT NO ________

☐ USN ☐ USNR ☐ ACTIVE ☐ INACTIVE OTHER (Specify) ______________ DATE MAILED ________

SCORE

| | 1 T | 2 F | 3 | 4 | | | 1 T | 2 F | 3 | 4 | | | 1 T | 2 F | 3 | 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 26 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 51 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 2 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 27 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 52 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 3 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 28 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 53 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 4 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 29 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 54 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 5 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 30 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 55 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 6 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 31 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 56 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 7 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 32 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 57 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 8 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 33 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 58 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 9 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 34 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 59 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 10 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 35 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 60 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 11 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 36 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 61 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 12 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 37 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 62 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 13 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 38 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 63 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 14 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 39 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 64 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 15 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 40 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 65 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 16 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 41 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 66 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 17 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 42 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 67 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 18 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 43 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 68 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 19 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 44 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 69 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 20 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 45 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 70 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 21 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 46 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 71 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 22 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 47 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 72 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 23 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 48 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 73 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 24 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 49 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 74 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |
| 25 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 50 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ | 75 | ☐ | ☐ | ☐ | ☐ | _ _ _ _ _ |

**PRINT OR TYPE**

NAME ______________________________ ADDRESS ______________________________
Last First Middle Street/Ship/Unit/Division, etc.

______________________________
City or FPO State Zip

RANK/RATE ________ SOC. SEC. NO. ______________ DESIGNATOR ________ ASSIGNMENT NO. ________

☐ USN ☐ USNR ☐ ACTIVE ☐ INACTIVE OTHER (Specify) ______________ DATE MAILED ________

| SCORE |
|---|
| |

| No. | 1 T | 2 F | 3 | 4 | | No. | 1 T | 2 F | 3 | 4 | | No. | 1 T | 2 F | 3 | 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ☐ | ☐ | ☐ | ☐ | _____ | 26 | ☐ | ☐ | ☐ | ☐ | _____ | 51 | ☐ | ☐ | ☐ | ☐ | _____ |
| 2 | ☐ | ☐ | ☐ | ☐ | _____ | 27 | ☐ | ☐ | ☐ | ☐ | _____ | 52 | ☐ | ☐ | ☐ | ☐ | _____ |
| 3 | ☐ | ☐ | ☐ | ☐ | _____ | 28 | ☐ | ☐ | ☐ | ☐ | _____ | 53 | ☐ | ☐ | ☐ | ☐ | _____ |
| 4 | ☐ | ☐ | ☐ | ☐ | _____ | 29 | ☐ | ☐ | ☐ | ☐ | _____ | 54 | ☐ | ☐ | ☐ | ☐ | _____ |
| 5 | ☐ | ☐ | ☐ | ☐ | _____ | 30 | ☐ | ☐ | ☐ | ☐ | _____ | 55 | ☐ | ☐ | ☐ | ☐ | _____ |
| 6 | ☐ | ☐ | ☐ | ☐ | _____ | 31 | ☐ | ☐ | ☐ | ☐ | _____ | 56 | ☐ | ☐ | ☐ | ☐ | _____ |
| 7 | ☐ | ☐ | ☐ | ☐ | _____ | 32 | ☐ | ☐ | ☐ | ☐ | _____ | 57 | ☐ | ☐ | ☐ | ☐ | _____ |
| 8 | ☐ | ☐ | ☐ | ☐ | _____ | 33 | ☐ | ☐ | ☐ | ☐ | _____ | 58 | ☐ | ☐ | ☐ | ☐ | _____ |
| 9 | ☐ | ☐ | ☐ | ☐ | _____ | 34 | ☐ | ☐ | ☐ | ☐ | _____ | 59 | ☐ | ☐ | ☐ | ☐ | _____ |
| 10 | ☐ | ☐ | ☐ | ☐ | _____ | 35 | ☐ | ☐ | ☐ | ☐ | _____ | 60 | ☐ | ☐ | ☐ | ☐ | _____ |
| 11 | ☐ | ☐ | ☐ | ☐ | _____ | 36 | ☐ | ☐ | ☐ | ☐ | _____ | 61 | ☐ | ☐ | ☐ | ☐ | _____ |
| 12 | ☐ | ☐ | ☐ | ☐ | _____ | 37 | ☐ | ☐ | ☐ | ☐ | _____ | 62 | ☐ | ☐ | ☐ | ☐ | _____ |
| 13 | ☐ | ☐ | ☐ | ☐ | _____ | 38 | ☐ | ☐ | ☐ | ☐ | _____ | 63 | ☐ | ☐ | ☐ | ☐ | _____ |
| 14 | ☐ | ☐ | ☐ | ☐ | _____ | 39 | ☐ | ☐ | ☐ | ☐ | _____ | 64 | ☐ | ☐ | ☐ | ☐ | _____ |
| 15 | ☐ | ☐ | ☐ | ☐ | _____ | 40 | ☐ | ☐ | ☐ | ☐ | _____ | 65 | ☐ | ☐ | ☐ | ☐ | _____ |
| 16 | ☐ | ☐ | ☐ | ☐ | _____ | 41 | ☐ | ☐ | ☐ | ☐ | _____ | 66 | ☐ | ☐ | ☐ | ☐ | _____ |
| 17 | ☐ | ☐ | ☐ | ☐ | _____ | 42 | ☐ | ☐ | ☐ | ☐ | _____ | 67 | ☐ | ☐ | ☐ | ☐ | _____ |
| 18 | ☐ | ☐ | ☐ | ☐ | _____ | 43 | ☐ | ☐ | ☐ | ☐ | _____ | 68 | ☐ | ☐ | ☐ | ☐ | _____ |
| 19 | ☐ | ☐ | ☐ | ☐ | _____ | 44 | ☐ | ☐ | ☐ | ☐ | _____ | 69 | ☐ | ☐ | ☐ | ☐ | _____ |
| 20 | ☐ | ☐ | ☐ | ☐ | _____ | 45 | ☐ | ☐ | ☐ | ☐ | _____ | 70 | ☐ | ☐ | ☐ | ☐ | _____ |
| 21 | ☐ | ☐ | ☐ | ☐ | _____ | 46 | ☐ | ☐ | ☐ | ☐ | _____ | 71 | ☐ | ☐ | ☐ | ☐ | _____ |
| 22 | ☐ | ☐ | ☐ | ☐ | _____ | 47 | ☐ | ☐ | ☐ | ☐ | _____ | 72 | ☐ | ☐ | ☐ | ☐ | _____ |
| 23 | ☐ | ☐ | ☐ | ☐ | _____ | 48 | ☐ | ☐ | ☐ | ☐ | _____ | 73 | ☐ | ☐ | ☐ | ☐ | _____ |
| 24 | ☐ | ☐ | ☐ | ☐ | _____ | 49 | ☐ | ☐ | ☐ | ☐ | _____ | 74 | ☐ | ☐ | ☐ | ☐ | _____ |
| 25 | ☐ | ☐ | ☐ | ☐ | _____ | 50 | ☐ | ☐ | ☐ | ☐ | _____ | 75 | ☐ | ☐ | ☐ | ☐ | _____ |

STEELWORKER 1&C
NAVEDTRA 10654-E

**PRINT OR TYPE**

NAME ______________________________ ADDRESS ______________________________
Last First Middle Street/Ship/Unit/Division, etc.

______________________________
City or FPO State Zip

RANK/RATE ________ SOC. SEC. NO. ____________________ DESIGNATOR ________ ASSIGNMENT NO. ________

☐ USN ☐ USNR ☐ ACTIVE ☐ INACTIVE OTHER (Specify) ____________________ DATE MAILED ________

SCORE

| | 1 T | 2 F | 3 | 4 | | | 1 T | 2 F | 3 | 4 | | | 1 T | 2 F | 3 | 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ☐ | ☐ | ☐ | ☐ | _____ | 26 | ☐ | ☐ | ☐ | ☐ | _____ | 51 | ☐ | ☐ | ☐ | ☐ | _____ |
| 2 | ☐ | ☐ | ☐ | ☐ | _____ | 27 | ☐ | ☐ | ☐ | ☐ | _____ | 52 | ☐ | ☐ | ☐ | ☐ | _____ |
| 3 | ☐ | ☐ | ☐ | ☐ | _____ | 28 | ☐ | ☐ | ☐ | ☐ | _____ | 53 | ☐ | ☐ | ☐ | ☐ | _____ |
| 4 | ☐ | ☐ | ☐ | ☐ | _____ | 29 | ☐ | ☐ | ☐ | ☐ | _____ | 54 | ☐ | ☐ | ☐ | ☐ | _____ |
| 5 | ☐ | ☐ | ☐ | ☐ | _____ | 30 | ☐ | ☐ | ☐ | ☐ | _____ | 55 | ☐ | ☐ | ☐ | ☐ | _____ |
| 6 | ☐ | ☐ | ☐ | ☐ | _____ | 31 | ☐ | ☐ | ☐ | ☐ | _____ | 56 | ☐ | ☐ | ☐ | ☐ | _____ |
| 7 | ☐ | ☐ | ☐ | ☐ | _____ | 32 | ☐ | ☐ | ☐ | ☐ | _____ | 57 | ☐ | ☐ | ☐ | ☐ | _____ |
| 8 | ☐ | ☐ | ☐ | ☐ | _____ | 33 | ☐ | ☐ | ☐ | ☐ | _____ | 58 | ☐ | ☐ | ☐ | ☐ | _____ |
| 9 | ☐ | ☐ | ☐ | ☐ | _____ | 34 | ☐ | ☐ | ☐ | ☐ | _____ | 39 | ☐ | ☐ | ☐ | ☐ | _____ |
| 10 | ☐ | ☐ | ☐ | ☐ | _____ | 35 | ☐ | ☐ | ☐ | ☐ | _____ | 60 | ☐ | ☐ | ☐ | ☐ | _____ |
| 11 | ☐ | ☐ | ☐ | ☐ | _____ | 36 | ☐ | ☐ | ☐ | ☐ | _____ | 61 | ☐ | ☐ | ☐ | ☐ | _____ |
| 12 | ☐ | ☐ | ☐ | ☐ | _____ | 37 | ☐ | ☐ | ☐ | ☐ | _____ | 62 | ☐ | ☐ | ☐ | ☐ | _____ |
| 13 | ☐ | ☐ | ☐ | ☐ | _____ | 38 | ☐ | ☐ | ☐ | ☐ | _____ | 63 | ☐ | ☐ | ☐ | ☐ | _____ |
| 14 | ☐ | ☐ | ☐ | ☐ | _____ | 39 | ☐ | ☐ | ☐ | ☐ | _____ | 64 | ☐ | ☐ | ☐ | ☐ | _____ |
| 15 | ☐ | ☐ | ☐ | ☐ | _____ | 40 | ☐ | ☐ | ☐ | ☐ | _____ | 65 | ☐ | ☐ | ☐ | ☐ | _____ |
| 16 | ☐ | ☐ | ☐ | ☐ | _____ | 41 | ☐ | ☐ | ☐ | ☐ | _____ | 66 | ☐ | ☐ | ☐ | ☐ | _____ |
| 17 | ☐ | ☐ | ☐ | ☐ | _____ | 42 | ☐ | ☐ | ☐ | ☐ | _____ | 67 | ☐ | ☐ | ☐ | ☐ | _____ |
| 18 | ☐ | ☐ | ☐ | ☐ | _____ | 43 | ☐ | ☐ | ☐ | ☐ | _____ | 68 | ☐ | ☐ | ☐ | ☐ | _____ |
| 19 | ☐ | ☐ | ☐ | ☐ | _____ | 44 | ☐ | ☐ | ☐ | ☐ | _____ | 69 | ☐ | ☐ | ☐ | ☐ | _____ |
| 20 | ☐ | ☐ | ☐ | ☐ | _____ | 45 | ☐ | ☐ | ☐ | ☐ | _____ | 70 | ☐ | ☐ | ☐ | ☐ | _____ |
| 21 | ☐ | ☐ | ☐ | ☐ | _____ | 46 | ☐ | ☐ | ☐ | ☐ | _____ | 71 | ☐ | ☐ | ☐ | ☐ | _____ |
| 22 | ☐ | ☐ | ☐ | ☐ | _____ | 47 | ☐ | ☐ | ☐ | ☐ | _____ | 72 | ☐ | ☐ | ☐ | ☐ | _____ |
| 23 | ☐ | ☐ | ☐ | ☐ | _____ | 48 | ☐ | ☐ | ☐ | ☐ | _____ | 73 | ☐ | ☐ | ☐ | ☐ | _____ |
| 24 | ☐ | ☐ | ☐ | ☐ | _____ | 49 | ☐ | ☐ | ☐ | ☐ | _____ | 74 | ☐ | ☐ | ☐ | ☐ | _____ |
| 25 | ☐ | ☐ | ☐ | ☐ | _____ | 50 | ☐ | ☐ | ☐ | ☐ | _____ | 75 | ☐ | ☐ | ☐ | ☐ | _____ |

**PRINT OR TYPE**

STEELWORKER 1&C
NAVEDTRA 10654-E

NAME ______________________________ Last First Middle

ADDRESS ______________________________ Street/Ship/Unit/Division, etc.

______________________________ City or FPO State Zip

RANK/RATE ________ SOC. SEC. NO. ______________________ DESIGNATOR ________ ASSIGNMENT NO ________

☐ USN ☐ USNR ☐ ACTIVE ☐ INACTIVE OTHER (Specify) ______________ DATE MAILED __________

SCORE

| | 1 T | 2 F | 3 | 4 | | | 1 T | 2 F | 3 | 4 | | | 1 T | 2 F | 3 | 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ☐ | ☐ | ☐ | ☐ | _____ | 26 | ☐ | ☐ | ☐ | ☐ | _____ | 51 | ☐ | ☐ | ☐ | ☐ | _____ |
| 2 | ☐ | ☐ | ☐ | ☐ | _____ | 27 | ☐ | ☐ | ☐ | ☐ | _____ | 52 | ☐ | ☐ | ☐ | ☐ | _____ |
| 3 | ☐ | ☐ | ☐ | ☐ | _____ | 28 | ☐ | ☐ | ☐ | ☐ | _____ | 53 | ☐ | ☐ | ☐ | ☐ | _____ |
| 4 | ☐ | ☐ | ☐ | ☐ | _____ | 29 | ☐ | ☐ | ☐ | ☐ | _____ | 54 | ☐ | ☐ | ☐ | ☐ | _____ |
| 5 | ☐ | ☐ | ☐ | ☐ | _____ | 30 | ☐ | ☐ | ☐ | ☐ | _____ | 55 | ☐ | ☐ | ☐ | ☐ | _____ |
| 6 | ☐ | ☐ | ☐ | ☐ | _____ | 31 | ☐ | ☐ | ☐ | ☐ | _____ | 56 | ☐ | ☐ | ☐ | ☐ | _____ |
| 7 | ☐ | ☐ | ☐ | ☐ | _____ | 32 | ☐ | ☐ | ☐ | ☐ | _____ | 57 | ☐ | ☐ | ☐ | ☐ | _____ |
| 8 | ☐ | ☐ | ☐ | ☐ | _____ | 33 | ☐ | ☐ | ☐ | ☐ | _____ | 58 | ☐ | ☐ | ☐ | ☐ | _____ |
| 9 | ☐ | ☐ | ☐ | ☐ | _____ | 34 | ☐ | ☐ | ☐ | ☐ | _____ | 59 | ☐ | ☐ | ☐ | ☐ | _____ |
| 10 | ☐ | ☐ | ☐ | ☐ | _____ | 35 | ☐ | ☐ | ☐ | ☐ | _____ | 60 | ☐ | ☐ | ☐ | ☐ | _____ |
| 11 | ☐ | ☐ | ☐ | ☐ | _____ | 36 | ☐ | ☐ | ☐ | ☐ | _____ | 61 | ☐ | ☐ | ☐ | ☐ | _____ |
| 12 | ☐ | ☐ | ☐ | ☐ | _____ | 37 | ☐ | ☐ | ☐ | ☐ | _____ | 62 | ☐ | ☐ | ☐ | ☐ | _____ |
| 13 | ☐ | ☐ | ☐ | ☐ | _____ | 38 | ☐ | ☐ | ☐ | ☐ | _____ | 63 | ☐ | ☐ | ☐ | ☐ | _____ |
| 14 | ☐ | ☐ | ☐ | ☐ | _____ | 39 | ☐ | ☐ | ☐ | ☐ | _____ | 64 | ☐ | ☐ | ☐ | ☐ | _____ |
| 15 | ☐ | ☐ | ☐ | ☐ | _____ | 40 | ☐ | ☐ | ☐ | ☐ | _____ | 65 | ☐ | ☐ | ☐ | ☐ | _____ |
| 16 | ☐ | ☐ | ☐ | ☐ | _____ | 41 | ☐ | ☐ | ☐ | ☐ | _____ | 66 | ☐ | ☐ | ☐ | ☐ | _____ |
| 17 | ☐ | ☐ | ☐ | ☐ | _____ | 42 | ☐ | ☐ | ☐ | ☐ | _____ | 67 | ☐ | ☐ | ☐ | ☐ | _____ |
| 18 | ☐ | ☐ | ☐ | ☐ | _____ | 43 | ☐ | ☐ | ☐ | ☐ | _____ | 68 | ☐ | ☐ | ☐ | ☐ | _____ |
| 19 | ☐ | ☐ | ☐ | ☐ | _____ | 44 | ☐ | ☐ | ☐ | ☐ | _____ | 69 | ☐ | ☐ | ☐ | ☐ | _____ |
| 20 | ☐ | ☐ | ☐ | ☐ | _____ | 45 | ☐ | ☐ | ☐ | ☐ | _____ | 70 | ☐ | ☐ | ☐ | ☐ | _____ |
| 21 | ☐ | ☐ | ☐ | ☐ | _____ | 46 | ☐ | ☐ | ☐ | ☐ | _____ | 71 | ☐ | ☐ | ☐ | ☐ | _____ |
| 22 | ☐ | ☐ | ☐ | ☐ | _____ | 47 | ☐ | ☐ | ☐ | ☐ | _____ | 72 | ☐ | ☐ | ☐ | ☐ | _____ |
| 23 | ☐ | ☐ | ☐ | ☐ | _____ | 48 | ☐ | ☐ | ☐ | ☐ | _____ | 73 | ☐ | ☐ | ☐ | ☐ | _____ |
| 24 | ☐ | ☐ | ☐ | ☐ | _____ | 49 | ☐ | ☐ | ☐ | ☐ | _____ | 74 | ☐ | ☐ | ☐ | ☐ | _____ |
| 25 | ☐ | ☐ | ☐ | ☐ | _____ | 50 | ☐ | ☐ | ☐ | ☐ | _____ | 75 | ☐ | ☐ | ☐ | ☐ | _____ |