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A SUGGESTED GUIDE TO THE PREPARATION OF HANDBOOKS OF JOB INSTRUCTIONS

By

Robert B. Miller

May 1956

MAINTENANCE LABORATORY
Air Force Personnel and Training Research Center
Air Research and Development Command
Lowry Air Force Base, Colorado

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FOREWORD

This Memorandum contains suggested procedures for preparing handbooks of job instructions, and is titled "A Suggested Guide" in order to emphasize that it does not necessarily reflect the official views of the Air Force Personnel and Training Research Center or any other Air Force agency.

Because the preparation of job instructions is marked by continuing refinements of procedures, it is considered in connection with this report that further research, development and testing are needed for many of the suggestions whose soundness may not be self-evident.

The contractor who prepared this document has conducted a number of studies concerned with the forecasting and description of job and training requirements for Air Force personnel. His experience in this work, therefore, is reflected in the suggested procedures.

It is believed that this report, though tentative in many of its practical implications, contains suggestions which, if adopted, would represent an improvement over certain of the existing practices in the development of job instructions for Air Force personnel. Further development and evaluation of principles for effective presentation of job instructions for maintenance personnel has been undertaken in conjunction with Project 7709, Maintenance and Servicing Training, and can be expected to result in added specificity and refinements for certain of the procedures described in the present report.

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CHAPTER I

THE PURPOSES OF JOB INSTRUCTIONS

Job instructions can be the most important single tool in making a job simple or difficult. As such they are critical to training and to operational efficiency and deserve all the care and competence that can be brought to bear in their preparation. The finished product will probably result only from considerable labor and planning, and at least some trial and error.

An estimate of the value of well prepared instructions can be made by thinking of the thousands of times each page, and perhaps each paragraph, will be consulted during training operations. If a sentence, or a page, causes confusion, that confusion will be multiplied many times. If an incompletely worked-out reference results in a five-minute delay in locating an item of information, that five minutes must be multiplied by every occasion in which that information will be sought through that reference. If the instruction contains some error or ambiguity, that error in operations may be a liability multiplied by every user and occasion on which he uses it.

Precisely because job instructions are such an important tool on the job, learning how to use them is a training requirement. If they are *unnecessarily* difficult to use, they become a training liability. As such they may tend to eliminate--screen out--trainees on a basis irrelevant to the job to be performed. The ability to unravel complicated sentences and sets of symbols, or to infer what has to be done from "scientific-style" writing and content, ordinarily are not job requirements unless the handbook of instructions makes them so.

It cannot be too strongly emphasized that the job of using or maintaining equipment does not demand the same information as is required for *designing* that equipment. There are circumstances, as will be pointed out, where the "why" is nearly as important to get across as the "how to" kind of information. But these are very special circumstances, and even here the content must be examined for precisely that minimum information that will tend to guarantee successful job performance.

A successful set of job instructions is prepared from the viewpoint of the needs and capabilities of the user, not those of the handbook writer and his engineering associates. In many cases, especially in maintenance and support positions, the user will be of about average intelligence. Among some groups of trainees there will be sizeable numbers of users who may be substantially *below* average intelligence. Not infrequently the users will have had little or no high school instruction, and may have passed high school English courses only with great difficulty. The realities of manpower availability dictate, however, that many of these persons *must* be put on technical jobs. By way of contrast, the writer of instructions generally will be considerably above the average intelligence level of the user. This means he must deliberately change his normal vocabulary, style of writing, and the amount of information he is tempted to put into a sentence, paragraph, or the book itself.

What Is a Job Instruction?

A job instruction is a set of symbols which cue the operator or mechanic to make correct and efficient responses in the job situation. A good job instruction statement contains three principal parts. One part tells what action signal or condition should be perceived, noted, or otherwise taken into account. It describes the essential stimulus for the action to be taken. The second part of the instruction describes what should be done, the action to be taken; in other words, it describes the response, or the essential feature of the response. The third part of the instruction tells how the user will know if the action he has taken is adequate or inadequate.

An example or two will make this clear. Consider the statement, "When pointer X reads zero, press switch A all the way down." The first part of this statement describes the stimulus for action, the second part describes the action. In this case a physical action is taken. Ordinarily a job instruction is never complete unless it specifies some physical action, although it may include a number of steps, such as a mental calculation, that should occur between the stimulus and the physical action. Thus we might say, "When pointer X reads zero, note whether the pointer tends to oscillate." This instruction is incomplete until it produces a physical action statement such as, "If it oscillates, turn power switch OFF; if it does not oscillate, press switch A."

In most actions it is proper to look for an indication of response adequacy; in other words, did the response produce the required result? This is the third part of an instruction. Thus the instruction becomes: "When pointer X reads zero, press switch A all the way down: X should read 10." We have described here (a) a display condition, (b) a control action, and (c) indication of response adequacy. The form of this description parallels the form of the activity. This is the ideal form of the job instruction if the user of the instruction can readily find and identify pointer X, a zero reading, switch A, and an X reading of 10.

General Rules for Good Job Instructions

Later sections of this Guide will discuss in detail the testing of job instructions to insure their effectiveness. For the present let us establish some general criteria and guiding factors for good job instructions.

1. Job instructions are specific to the users of the instructions.

The most important test of job instructions begins when they are put into the hands of the intended user in an on-the-job situation. Although it is important that he understand the words and symbols as such, it is of key importance that he be able to translate the words into the required actions. The efficiency with which he can do this is a direct measure of the usefulness of the instructions.

This means that before preparing job instructions we must have some estimate of the capabilities of the intended user. An experienced electronics engineer can be given a circuit schematic and told to align the set. He may be able to perform the right actions without further details. A less broadly experienced man might require fifty more detailed statements; and a novice might require several thousand still more detailed statements. This means that a set of job instructions may be excellent for an experienced electronics engineer, but quite useless for the novice.

2. Job instructions are specific to a given task and position.

Instructions should be directed to a person charged with specific job responsibilities on a given piece of equipment. It is not safe to consider general instructions about a class of equipments as adequate for working with a particular equipment. Thus the principles of tuning a radio apply to any radio, and an expert or engineer could adapt them to tuning a radio he had never before seen. But it is unrealistic to count on having this kind of expert using the handbook on the job.

Different echelons of maintenance will perform different tasks on the same equipment, although there will also be cases in which there is task overlap. These differences and similarities should be reflected in the contents of the handbooks prepared for the respective positions. In summary, job instructions should provide information specific to a given position as reflected in its performance on a given equipment.

3. Job instructions tell what to do, when to do, and how to do it.

The primary requirement of job instructions is to provide directions to the man on the job rather than an explanation of why he should do as instructed. This does not mean that training should be devoid of "principles of operation" or other explanations. It does mean that such information generally should be presented elsewhere than in the "how to do it" manual that the man props open in front of him while operating or repairing the equipment.

It is true that the conditions under which some job operations are performed may be so complex that it is simpler (even from the operator or mechanic's standpoint) to present a set of principles rather than list all the alternative conditions and responses. Trouble shooting complex equipment is an example.[1] But even in these cases it is important to find and present only the information essential to the man in deciding what to do.

A warning repeated in this Guide is that it is important not only to tell a man what to do, but when to do it. This means helping him to recognize the conditions that indicate that the task or operation is to be performed, or must not be performed, as the case may be.

Job instructions need to be complete. There obviously is no open-and-shut criterion for completeness. A few words may be ample for a skilled operator, whereas five pages of instruction might be incomplete for a novice. Ideally, the instructions would be so complete that one who had never performed the job, or a job like it, could perform the operations from them after one demonstration. We would have to assume that he knew the nomenclature and locations of the displays, controls, and other things named in the instructions. In a later chapter (pages 42-46) we will discuss the yardstick of completeness, and how to obtain and test it.

4. Job instructions should require a minimum of interpretation.

If the trainee (or operator) must scratch his head and ask, "What does this statement mean that I am supposed to do?" we have failed to communicate instructions to him. We may have used the wrong words, or too few or too many of them, or organized them improperly. We should try to reduce to a practical minimum his having to figure things out; on the other hand we aim at brevity. These two objectives often demand compromises because they seem incompatible.

5. Job instructions should optimize ease of learning.

It is desirable for instructions not only to be easy to follow, but easy to memorize. These two objectives are not always equivalent. It may be easy to follow instructions because they are detailed, but difficult to memorize them because they are so long. We should find ways of laying out instructions that make them easy to follow, but also, because of organization and some guideposts, relatively easy to memorize.

Although many jobs do not require complete memorization of job instructions, some degree of memorization is generally necessary for efficient job performance. Frequently it is desirable, if not absolutely necessary, that the operator or mechanic memorize instructions implicit between items in a check list. A check

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[1] It is for this reason that some of the instructions in this Guide are in the form of principles about what to do rather than specific prescriptions.

list is frequently a summary of high spots in a set of more detailed job instructions. This suggests that we try to integrate the preparation of check lists and job instructions.

6. Information should be easy to find.

Information should be easy to find under the conditions that are likely to arise in job performance. This means that topics should be organized and indexed according to expected groupings of job activity, and the kinds of questions that may arise in job performance. In other words, the classification and organization of topics and information should be guided by the sequences expected in job operations, and the contingencies that may arise in trying to perform them.

Effective use of key words, symbols, indexes, and topical diagrams that anticipate user demand will help make information easy to find. This may sometimes require elimination, as well as the putting in, of reference symbols, or deviation from conventional textbook indexes.

7. There should be a minimum of irrelevance or "noise."

Engineers speak of a noisy signal as one that contains irrelevance that interferes with the response to the message. Any markings on the white page of the job instruction that do not contribute to a message will tend to interfere with it. This statement applies to drawings, schematics, sentences, words, symbols, indentations, type face, borders, and pictures.

Before interpreting this statement too literally, it should be remembered that a message consists not only of information content, but of organization and context. Organization may establish emphasis; it may also simplify the grasp of ideas by setting them off from each other in units for easy remembering. Any means of providing such emphasis and simplification is a proper part of the message itself. If the means used seems to call attention to itself in its own right and out of the instructional context (such as many cartoons, for example), it becomes an irrelevance.

8. The job instruction book should be easy to handle.

The over-all size, binding, and proportions should provide optimal convenience when the handbook is carried, held, and examined on the job. The size of foldout pages should be compatible with limits of work space in which the foldout may have to be used. The construction of the book should be sturdy enough to withstand considerable use in job situations, including exposure to grease and oil, tearing action, and so on. Repair of the book should be as simple as possible; provision should be made for restoration or substitution of pages, diagrams, and covers.

Summary and Conclusions

Job instructions are clearly an important, if not the most important, single factor in the simplification of training and in operational performance of procedural tasks. It may be said that what job instructions do not do by themselves, training must accomplish by other means.

Satisfying the eight criteria will necessarily require compromise, for many of the factors entering into an "ideal" (as opposed to a "practical") set of job instructions tend to conflict with each other. Compromise means judgment must be used in weighing one factor against another. The basis for this judgment consists mainly in having a clear picture of the specific capabilities of the users of the job instructions, knowing precisely what they are to be instructed to do, anticipating their contingencies, and giving them instructive information as briefly as possible.

CHAPTER II

INITIAL STEPS IN PREPARING JOB INSTRUCTIONS

The data for job instructions consist of the information about what the user of the instructions is going to have to do. This information may not be couched in the language intended for the instructions. But the operations to be performed must be known before they can be described in any form or style of language.

The source of this information presumably will be the engineers who designed, developed, or tested the equipment. The information may be in oral or written form, or consist of an actual series of operations that the engineer is able to perform on equipment, but has not described.

Step 1 Design and Test the Procedures to Be Described by Job Instructions

The design of a work procedure may in itself help to simplify the preparation of the instructions for doing it. The simpler the operations, the more likely it will be simple to describe them clearly. The following considerations, although not exhaustive, will have bearing:

a. Environmental conditions. Design the procedure in the realistic work context. Maintenance performed in an aircraft in zero weather is different from maintenance of the same items of equipment in the manufacturer's laboratory. Take into account the limitations and contingencies to be found in the realistic environment.

b. Operational requirements. It is also essential that the procedure actually result in what is to be claimed for it in the job instructions. If a predicted or promised outcome occurs only in some proportion of times, what should be done when the procedure fails? Furthermore, careful study of the operational requirements of the procedure may result in a reduction of steps. An example would be arranging a check procedure in an order that maximizes the useful information obtained in each step; or that provides internal checks of correct operator performance.

c. Human requirements. The design of the procedure may also attempt deliberately to take account of human capabilities and limitations. This may be done through work simplification, reduction of hazard, and counteracting tendencies to error. Suggestions about design for operational and human requirements may be obtained from maintenance and operational personnel who have actually had first-hand experience with the type of procedure and equipment under study. Engineering psychologists also may have assisted in providing for human requirements in procedure design.

Testing the procedures should be done under as realistic a simulation of field conditions as possible. These should include conditions expected to be as bad for performing the procedure as is likely to be demanded by operations. Especially in maintenance, it would be desirable to have the procedures tried out by persons other than the engineers who were closely identified with development and engineering test of the equipment. Ideally, examples of personnel expected to be used on the job would serve as subjects in the test study. Planning, time, and expense at this time may save many later revisions of Technical Orders and handbooks of instructions.

At this point, we will presume that procedures are available and tested for a given job. The way in which they are described here, however, will not necessarily be that of the instruction handbook.

Step 2 <u>Determine What Activities, Tasks and Duties Will Be Performed by the Person for Whom a Handbook of Job Instructions Is Being Prepared</u>

Since instruction handbooks will be organized around position duties rather than equipments, it is necessary to know what tasks will be performed by a man in Position A versus what will be done by men in Position B. (The term "position" has the Air Force meaning of all the activities, tasks and duties performed by a man with a specific job title. We will use the words "job" and "position" interchangeably.) Simply list by name the tasks and procedures to be performed on equipment X by Position A, so that they can be unambiguously identified. Then do the same for what Position B is intended to do on equipment X. This will tell us in general terms what will be the contents of Handbook A and Handbook B for equipment X.

This step may be eliminated automatically if it is presumed that only a single set of position requirements will include all the procedures and activities under study.

Step 3 <u>Thoroughly Describe the Procedures to Be Performed</u>[2]

This will be a preliminary description aimed at thoroughness. This description should include the following material:

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[2] A detailed method is given in Miller, R. B. <u>A Suggested Guide to Position-Task Description</u>. Lowry Air Force Base, Colo.: Armament Systems Personnel Research Laboratory, Air Force Personnel and Training Research Center, April 1956. <u>Technical Memorandum</u>. (ASPRL-TM-56-6.)

a. The operational purpose for performing the procedure.

b. How the operator, i.e., position incumbent, will know when the procedure is to be performed, and under what circumstances; and in what conditions to avoid performing the procedure. This statement may include the time sequence relating this to other procedures to be performed by the same operator.

c. Activity elements or steps to be performed. Each element should have its temporal relation to other elements indicated, such as one being done after another, or at the same time as another, or as being contingent on the outcome of some other step.

Each activity element should include the following information:

1) Its temporal relation to other activity elements, such as preceding, following, being concurrent, or contingent.

2) The control and/or tool to be manipulated in that particular element or step.

3) The specific activity to be performed.

4) The indication that the activity has or has not been successful; in other words, the indication of response adequacy.

5) Remarks, such as qualifying conditions, precautions, hazards.

6) Tricks of the trade. These may be suggestions, and less formal than the statement of a position element. Examples would be how to weave a particular set of wires together to facilitate soldering; or how to make an especially difficult access in starting a nut on a bolt. In general, an attempt should be made to incorporate these tricks of the trade as formal elements, but this may be done later in actually preparing the instructions. A trick of the trade that has general applicability to a variety of elements in a number of tasks in a position might better be put in a special section of the handbook devoted to such items, but referenced where applicable.

It should again be noted that the above descriptions are the raw information from which the final instructions will be prepared. They should include engineering diagrams, photographs and other pictorial material. They should also include a complete nomenclature of the indicators, controls, tools, test equipment, signals, functions and other terminology developed by the engineers in design, and for anticipating maintenance and operation of the equipment.

Step 4 Describe Information Required by the User for Meeting Decision-Making Requirements

A decision-making requirement occurs when the operator or mechanic has to respond to complex conditions for which it is impracticable to write out a specific response for each contingency. This means the operator has to use judgment or make some inferences in arriving at the proper action. Trouble shooting of complex electronic equipment is an example; identifying and coping with complex emergency conditions is another; the pattern of fuel consumption from various tanks under different distributions of cargo load in a transport aircraft is still another.

In outline, the procedure is as follows:

a. Determine the general job circumstances where interpretations and inferences must be made, problems solved, plans or strategies formulated, or when search must be conducted. These are circumstances where Standing Operating Procedures do not cover the specific individual control movements to be made to each individual signal or individual pattern of signals.

b. For each such type of situation, list the variables in the conditions that should be taken into account by the operator in deciding what response to make.

c. As a corollary to b., list the various controls and control manipulations (or maneuvers) that the operator should make, singly or in combination, to representative patterns of conditions.

d. Determine the minimum information the operator must have in order to make the proper inference from any combination of variables in a situation, and from this inference, choose the proper response to make.

A Note on Tracking Tasks

A tracking task is one in which a more or less continuously varying signal is matched with more or less continuous control action. Verbal instructions alone are insufficient to produce good tracking performance: skill is the result of actual practice. For this reason handbooks of instruction are of limited importance in these tasks, and little attention will be given to this topic.

Tracking tasks are, however, usually carried out in combination with plans, strategies, and the choice of maneuvers. These present training problems requiring handbooks of training instructions. But since we are not directly concerned here with training as such, we will ignore these matters, too, even while recognizing the need for supplying data to training.

Summary

The essential raw data in preparing job instructions are the careful descriptions of the duties, tasks and elements of the position for which the instructions are to be prepared. These data will consist of work procedures, operationally tested in so far as is possible and will include the step-by-step elements that make up these procedures. We should also have the information essential for the operator (or mechanic) to solve problems and otherwise cope with job situations too complex to be reduced to step-by-step SOP. It will be especially helpful to anticipate the kinds of errors likely to be made. These data must be supplied by the manufacturer of the equipment and from agencies having previous experience with similar equipment. In some cases, the raw data may have to be modified by work methods specialists into sufficient work procedures.

We should also have estimates of the limitations in vocabulary, and of ability to translate words into action on the part of selectees for training and operations.

CHAPTER III

PROCEDURES AND FORMATS FOR JOB INSTRUCTIONS

The major factors which render job instructions ineffective and difficult to use are specific and readily identified. One of the most obvious is the use of a specialized and complex language. Other common liabilities are the inclusion of irrelevant information, the failure to specify what to do in contingencies, crowding too much information into an action unit, and finally, the use of a complex referencing system. This chapter is directed toward positive recommendations which will reduce these liabilities.

Describing Standard Routine Procedures

Content of Job Instructions

The following topics enumerate the kinds of information necessary for performing a routine task. Means are suggested for presenting that information in a set of job instructions.

Conditions indicating that the task is to be performed. Conditions should be described in a way readily identifiable by the operator[3] in his work environment. If the task is to be performed as one in a regular series of other tasks, some of the following items are not applicable.

1. Describe the work or operational context. What other activities by the operator precede, follow, or are concurrent with the task?

2. Describe the special indications or signals which indicate need for performing the task. Include where pertinent, indications that mean the task should not be performed.

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[3] Unless otherwise specified, "operator" means a person who is either operating or maintaining equipment, or performing supporting operations. He is whoever will be using the job instructions either in operations or training.

Personnel required. Specify by title and number of individuals the persons (if any) required to assist in performing the task. Also specify the station at which the others are to be located, and their mode of communication if they must coordinate effort. If they must work cooperatively in performing a procedure, code each man (such as G1 and G2) by selecting symbols not likely to be confused with other symbols. Then precede each descriptive step with the proper symbol, thus:

Step 10. (G1) Set PURSUIT-STRAIGHT LINE switch to PURSUIT
11. (G1) Reverse RUN-RUN switch
12. (G2) Set CAL-NORM switch to NORM

Equipment required. Specify any equipment necessary for performing the task. Include tools and test equipment, and designate these unequivocally. If any one of several kinds of tools or instruments may serve equally well, specify the alternatives. It is especially important to be complete in describing supporting equipment for a task such as flight-line maintenance that must be performed away from a source of supply. It takes as long to return to a shop for a clip lead as for a milliammeter.

Warnings preliminary to starting the task. Specify the features for which the operator should be alert or prepared, or should actively check before starting the task so as to avoid hazard to personnel or equipment.

Nomenclature and locations of items used in instructions. In order that the operator be able to follow instructions he must be able to identify what the terms and symbols represent in the work environment. In most cases it is presumed he has learned during training what the symbols mean. But recall is often faulty. A glossary of terms, indexed for easy locating, may therefore be desirable somewhere in the handbook. Diagrams and retouched photographs are especially helpful, but space consuming. If space permits, the closer the diagram to the relevant item in the text the better, even at the sacrifice of conventional symmetry in page layout.

Setup at start of task. Specify all display or indicator conditions, and control positions that should be present before the operator starts performing the task. These are items he should inspect before he does anything else in performing the task.

Work to be done in each job element. A job element is often referred to as a step. It is the unit of "what to do" in a set of instructions. The essential items of information in describing a job element are: a description of the action performed on or with the control object; and a description of the indication which tells the individual whether his action is appropriate (correct or incorrect) and which therefore signals the next action to be taken. Additional remarks may include warnings, precautions, error tendencies, reference information, contingencies, and so forth. An example of a job element is:

"Adjust R403 until a 1:1 Lissajous figure is observed on the USM-24." Here, "R403" is the control; "adjust" is the action; and "until a 1:1 Lissajous figure is observed on the USM-24" is the indication of response adequacy.

The following discussion takes up in turn recommendations that deal with statements about controls, actions, indications of response adequacy, and remarks.

1. Control. The term should permit absolute identification by the operator of the object referred to. If it is likely to be confused with some other control, or the name for another control, a supplementary statement, diagram, or qualification should be provided either in the statement about the control, or as a Remark. On the other hand, if the element permits any one of several controls (tools or instruments) to be equivalent alternatives, this should be explicitly mentioned.

2. Activity. Human activities can be broadly grouped into perceiving, recalling, interpreting and inferring, and performing manual operations. Within these broad categories more specific activities can be identified so as to reduce ambiguity in description.

a. Perceiving. The two terms most widely used are "note" and "check." "Note" tells the operator to "look at and take notice of" some indicator or signal. The term "check" implies "look at it to see if it is all right." Both terms are useful, but an attempt should be made to find precise qualifiers. Thus "check wiring" might be qualified as "check wiring for insulation breaks and loose terminals," or "check wiring for friction with moving parts," or "check wiring for slack of more than six inches." One could make many additional kinds of checks of wiring. Minimum specifics for which the operator is responsible in "noting" or "checking" should be given, unless the context of instructions clearly implies these specifics.

If the terms "check" or "note" are used, the instructions should make clear what the operator should do, and with what priority if the check reveals that something is faulty.

If the operator must make a judgment on the basis of something he perceives, that judgment is the result of the comparison, actual or implicit, between something observed and some standard. Thus, how badly must a given wire be frayed before it is to be substituted or mended? A job element may read: "Note that resolver dials follow smoothly." But in order for the operator to make a decision as to what is "smoothly enough," he must refer either to some remembered, or described, or presented standard. Of course the instruction writer has the problem of compromising space limitation with completeness. If he chooses to be brief at the cost of being explicit, he may still provide safeguards. In some separate statement he can stipulate the precise list of judgments and standards that the user of the instructions must already have in order to interpret the words and put them into action.

b. Recalling. In some cases the proper performance of a job element requires that the operator recall information he obtained from previous steps. He may have to recall the setting of switches, or some temporary arrangement of electrical connections for making a test. Or he may have to recall the differences between one model number and another in performing the step.

Recall is sometimes unreliable. Therefore, an attempt should be made to design the procedure and prepare instructions in such a way as to demand a minimum of recall, or at least to provide the operator with reminders. The operator is especially likely to forget qualifying conditions if he becomes preoccupied with a difficult or absorbing problem of the moment. If he has to make a series of perceptions and responses in rapid succession, particularly if they demand precise timing and coordination, he may become forgetful. If he has to make computations, or otherwise carry a good deal of new information in his head at the time, he will be prone to forget factors or items of information not immediately in his field of attention.

In many cases, job instructions attempt to anticipate recall failures by inserting a "Warning," a "Note--," or a "Remark." These may be especially important where one or several elements are likely to preoccupy the operator, and to narrow his range of attention and recall.

In some situations, such as in diagnosis of a malfunction, the operator may be reminded of a relevant principle of operation. The instructions can do this by means of a coded reference to some book on principles or "theory" of operation.

c. Interpreting and inferring. This topic is given special treatment in the next section (page 22) dealing with instructions about nonroutine tasks.

d. Performing manual operations. A large number of action verbs can be listed, ranging from such vague words as "operate," or "move," to such specific terms as "twist clockwise," "pull," "push up," "press," "connect," "insert." The advantages of maximum specificity are:

1) Specificity of action description provides informational redundancy to the operator. By saying, "Twist BOMB-NAV switch CC to 'BOMB'," rather than "Move BOMB-NAV switch to 'BOMB'," we reduce his likelihood of attempting to manipulate a press-pull switch. It is true that the BOMB-NAV switch probably is labelled, and the only way to move it to "BOMB" position is by twisting it CC. But repeating the "environmental information" in the instruction will tend to reduce error probability at least by some small amount.

2) Specificity tends to "pre-set" the proper response, thus reducing the operator's requirement to think it out. The operator's thinking it out takes time, effort, and is subject to error, besides distracting him from perhaps more important matters. If he is thinking out an interpretation of job instructions, he cannot very successfully be thinking about or remembering operational data.

Terms that describe activities should be used consistently. The same kind of activity should be symbolized by the same verb; and the same verb should always denote the same kind of activity. This may mean repetitiveness, and some loss in stylistic elegance. But the operator's ease in translating the symbols into action is of overriding importance. Where ambiguity is at all probable, despite care in the choice of a verb, qualify the term. A somewhat less desirable alternative is to provide in the handbook a special glossary of terms, including activity verbs. Examples provided should apply to the specific equipment and handbook. Minimum use of a glossary should be demanded because of the loss of time resulting from having to look up things.[4]

An example of word difficulty comes from the failure to find a single verb that precisely describes the response to make in operating a toggle switch. It may be "pressed," "depressed," or "pushed," but none of these words is exactly accurate. "Throw" is a possibility, but perhaps could better be used for describing action with a knife switch. The word "snap" might be selected as the best compromise; it could be specially defined, and used to refer only to operation of toggle switches.

3. Indication of response adequacy. When a control is selected and activity performed on it or with it, the operator should look for some signal indicating a successful outcome of his response. When a light switch is turned to "ON," the indication of response adequacy is the lamp lighting up. This result indicates adequacy of response of both the operator and the equipment in getting the lamp lit. In some cases, however, only an "immediate" signal of the operator's correctness of response may be available. This would be the case in "Tighten end nuts with hand wrench until face plate is seated in frame."

The preceding examples are qualitative indications of response adequacy. An attempt should always be made to include quantitative values and tolerance limits of acceptable adequacy. For example, "Turn GAIN CONTROL knob until voltmeter reads 40 ± 2 volts." In cases where alignment must be made with least discriminable error, it is appropriate to state "exact coincidence." Where the operator should scan more than one indicator and indication for response adequacy, mention all of them.

4. Remarks. This may become a catch-all category, hence should be used sparingly. "Remarks" should not include information properly put in the text in the form of Controls, Activity, and Indication of Response Adequacy, unless it is grossly impractical to put it there.

It is essential, however, to specify what the operator should do if contingencies develop. The omission of such statements is perhaps the single worst liability in a set of instructions. It permits the operator to come to a dead end in trying to perform a procedure. The description of what to do, or a reference to instructions located elsewhere in the handbook may be made. In any event, the handbook should spell out what to do if an indication falls outside tolerance limits, after the operator has followed instructions. This spelling-out (or reference to such a spelling-out) should be an integral part of the instructions.

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[4] An alternative to a glossary may be printing definitions of common terms on training flysheets that can be removed by the operator after training in the use of the handbook.

Remarks may also include precautionary actions, warnings and, where appropriate, the reason either for performing the job element or for observing the precaution. A reason or rationale usually serves to motivate the operator to do as he is told by the instruction, although sometimes it may alert him to matters too complex to specify in the instructions. Where it is expected that the operator is especially prone to error, or to disregard instructions, a reason for performing the job element may be given. But because reasons in themselves are not instructive, they should be used sparingly and be restricted to a few words. In some instances it may be appropriate to provide a reference to sources of more complete information.

It is important to focus attention on warnings and cautions through change in typography, spacing, border, or location. But if the difference from the body of the text is too great, the material may be skipped over because it is not perceived as a part of the text.

Format for Job Elements

A standardized way of organizing and presenting job elements is desirable. This will reduce difficulty in interpretation, simplify recall and make it easier for the user to find and keep his place. It is best to begin each job element on a new line. Each element should be numbered or otherwise coded.

In some excellent examples of job instructions the action verb starts the sentence, thus:

6. Turn the selector switch to "OFF"
7. Disconnect charger cables
8. Turn selector switch to "OPERATION."

Another useful but less widely followed recommendation is that based on the normal sequence in performing action, rather than on normal syntax in writing about action. In performing action, the operator normally (a) locates and identifies the control, (b) activates the control, (c) notes indication of response adequacy. The sample format in Figure 1 shows this order.

(See Figure 1 on the following page)

TASK	PROCEDURE			REMARKS
	CONTROL	ACTIVITY	INDICATION	
1.1 Adjust radar receiver →			Adjust every 25 hours of operation	
	1.1.1 POWER ON Button	Press	Inverter starts and makes audible hum; pilot light comes on; range indicator lights come on; tiltmeter comes on scale.	Avoid starting system with covers removed from high voltage units because of shock hazard.
	1.1.2 AC Voltage Adjustment (Screwdriver)	Turn	AC Voltmeter reads 117±4.	
	1.1.3 POS Regulated Voltage Adjustment (Screwdriver)	Turn	PCS Regulated voltage meter reads +300±5.	
	1.1.4 BRIGHT Control Knob	Turn clockwise	Sweep trace becomes visible on CRT face.	
	1.1.5 FOCUS Control Knob	Turn as required	Sweep trace becomes sharper (focused).	
4.3 Start helicopter engine →			To initiate flight	First perform preflight inspection check.
	4.3.1 MIXTURE Control	Pull to IDLE CUT-OFF	Check settings before proceeding to 4.3.4.	Engine hatch doors must be in place, or airframe may crumple.
	4.3.2 FUEL BOOSTER PUMP Switch	Push to HIGH		
	4.3.3 Throttle	Turn to CLOSED		
	4.3.4 STARTER Button	Press and hold	Sound of engine being cranked smoothly for two revolutions.	If engine does not crank smoothly, there is hydraulic lock, i.e., fluid in cylinders. Clear by repeating 4.3.4 intermittently for 5-second periods, 2 minutes between attempts.
	4.3.5 IGNITION Switch	Turn to BOTH	Engine sputters and smooths into a "purr."	
	4.3.6 STARTER Button	Release	Cranking sound stops. Engine fires smoothly.	
	4.3.5 MIXTURE Control	Push to RICH	Engine continues to run smoothly. RPM increases.	

Figure 1. Sample Format for Procedures in a Standard Routine Task

Whereas this format may take an hour or two of initial "getting used to" by the user who first comes in contact with it, this way of presenting instructions has been found workable by complete novices to a new piece of equipment.[5] Few errors were made even on the first practice trial. It reportedly was easy to find one's place in the instructions. The principal disadvantage is the amount of space that is required on the page. Compromises may be made by the elimination of vertical columns.

It should always be emphasized, however, that no one format will be ideal for all purposes and for every kind of job element. A format should be a guide rather than a tyrant to the writer of instructions. Where simplicity demands violation of a format, the modification should be made evident to the reader so that he is not misled into looking for something that is not there. Occasionally some column headings may be inappropriate, or may call for runovers in space. In such cases, the format may be interrupted by suitable breaks and spacings.

Amount of information to be put in a job element. A job element is an action unit. As described above, it consists of locating and identifying a control object, activating the control, and noting the outcome of that activation in terms of qualitative and quantitative standards. Running more than one job element together in compound sentences is usually undesirable. It demands that the operator carry too much information in his head between reading the instruction and putting it into action. This means risking confusion during reading, during recall, and in execution of the instruction. Job elements should be treated as action units, and set off from each other in the form of sentences or spacing. Smoothness of style is far less important than gaining immediate comprehension and easy recall.

Emphasizing special information. A warning or precaution specific to a job element or a group of job elements should be integrated in the format, although it may be desirable to print it in a distinctive color or type face. But putting a border line around it may risk the user treating it as a parenthetical statement, and skipping it in order to maintain his continuity in the text. If a border box is placed around a warning, the word WARNING should be printed in bold type. Substitute words may be PRECAUTION or DANGER, depending on the meaning.

Illustrations for job elements. The user of instructions often has difficulty in identifying and locating the objects mentioned in the job element. This is especially true for comparative beginners on a job, or for those who perform the job infrequently. It may also be a source of error to a person who performs similar operations on items of equipment on which the controls

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[5] For details on the format and the test see Bamford, H. E., & Brinda, John. Preliminary tryout of a format for maintenance job instructions. Lowry Air Force Base, Colo.: Armament Systems Personnel Research Laboratory, Air Force Personnel and Training Research Center, March 1955. (This is an unpublished draft in the form of a laboratory Note.)

and indicators are in different locations. Space may be provided in the text for diagrams that will provide the essential cue for locating the controls and/ or indicators mentioned in the job element. By providing a picture as well as words about what to do, the reader can more readily remember the job instruction from the moment of reading it to the moment he puts it into action.

The following recommendations should be considered in using illustrative material for nomenclature and locations.

1. Present only critical cues. It is unnecessary and undesirable to represent the entire cockpit to show the location of an indicator in a readily discriminated subpanel. Show the critical sector and the critical items within the sector. If it is thought necessary, a small scale diagram of the entire area may be shown with an inset of the critical sector to indicate its relative location.

2. Line drawings sometimes may be better than photographs but each has advantages and they may be used effectively in combination.

3. Where possible, avoid breaking into the continuity of the instructions with illustrative material that is only supplementary. This is not always practicable, especially in the light of the next recommendation.

4. Put the illustration close to the statement it illustrates. Having to turn pages introduces not only delay, and having to refind one's place, but also poses short-term memory problems to the user.

5. Limit the number of items of reference information per diagram. A single illustration showing the appearance and location of items should generally have no more than four or five singled out for attention.

Experimental attempts are currently being made to develop ways of combining diagram and text material in job instructions. In one such experiment a line diagram supplements each statement of what the control setting should be and what the consequence should look like on a given indicator. For each step there is also a reference on what to do if the indication is not what it should be. This treatment consumes a large amount of space, but it provides instruction that is undeniably easy to understand and to remember at least for brief periods of time. Tryout results are not available to show the superiority of sample presentations of this kind, but research is underway to obtain such data. These developments emphasize the need to keep an inquiring attitude towards improvements in the art of communication.

Method and Principles

Decision making is required when a person lacks a rule that tells him specifically what to do in a given set of circumstances. Usually the circumstances consist of a number of different variables or conditions to which a unified response must be made by the operator. In other cases, the operator may have to make a number of tentative responses in order to get additional information for choosing the correct response alternative. Diagnosis and response in emergency conditions and trouble shooting are examples; the selection of a tool or of the proper course in an air-to-air interception are others.

It is, of course, theoretically possible to prepare a rule for every potential contingency. This might easily become an encyclopedic, highly impractical assemblage of rules, and therefore in many cases principles and strategies governing a variety of related situations may be formulated. This is frequently true of electronic trouble shooting, and sometimes in coping with emergencies. The question then arises as to what information to provide, or rather, what information it is essential to provide.

The general intent should be to reduce even the most complex problem-solving situations to a standard procedure in so far as practicable. This end can usually be best attained by taking the role of the operator in being confronted with the problem. This means developing statements leading from effects of causal factors to the proper responses for the operator to make. An example of this reduction of a multivariable situation to a set of standard procedures would be as follows: A B-47 pilot is confronted by a pair of fuel boost pump lights indicating either a possible fuel line leak or a double boost pump failure. His response to this malfunction must be determined from the collation of information presented under many possible flight conditions, and on a variety of indicators, some of which are fuel selector settings, affected engine indications at the time of detection, and system reactions to diagnostic control activations. Standing Operating Procedures for the above situation are listed in part in Figure 2. (For additional examples see pages 27, 29, and 30.)

In many cases this kind of job instruction will be used more for training purposes than in on-the-job activity. But the training conditions may occur in a job context: they may require frequent refresher study, as of aircraft emergency procedures by experienced pilots. Furthermore, the operator may actually have to turn to a handbook of instructions for guidance during a crisis. In such a case, it is essential that only critical information be provided, and in a form readily usable.

The user of the following job instructions should be completely familiar with equipment nomenclature and location, as well as the standardized abbreviations such as TME, ME and TE for fuel selector settings.

Initial Indication--Double boost pump lights "ON"

Indications	Responses
1. All fuel selectors TME	1.1 No immediate response necessary .2 When flight conditions permit: a. ME affected engine b. TE all but one other engine c. Check lights on TME engine
a. TME engine lights "OFF" (Boost pump failure)	a.1 TME opposite engine to one affected .2 TE all other good engines
b. TME engine lights "ON" (Line leak)	b.1 TE affected engine .2 Retard throttle to cutoff .3 Pull affected engine fire shutoff switch .4 Reset fire shutoff switch within 15 minutes
2. Affected engine fuel selector on TE, engine RPM above 60%	2.1 ME affected engine .2 TME opposite engine .3 TE original TME engine
3. Affected engine fuel selector on TE, engine RPM below 60%	3.1 Retard affected engine throttle to cutoff
Etc.	Etc.

Figure 2. Decision-Making Format, Sample A: B-47 Fuel Emergency

Note: For use in actual operation this example would be expanded so as also to specify the various indications and responses used by the pilot to check circuit breaker conditions for boost pump power, fuel quantities for pump restarts and air start procedures for shut down engines. In using this list the pilot finds the conditions displayed by his indicators in the Indications column, and performs in the order given the responses opposite each indication. When a response leads to further alternative indications the pilot again refers to the Indications column. He then performs, in order, the additional responses for the appropriate alternative indication.

Those familiar with IBM analysis of data by selective sorting will recognize its similarity to the scheme for decision making proposed here. The following paragraphs discuss the steps in detail.

Steps in Preparing Job Instructions for Decision-Making Situations

Step 1 Identify the Objective in Solving the Problem

This usually consists of naming the problem situation for identification purposes. For example: "Trouble shooting the computer in equipment X," "Handling fuel leak emergencies in aircraft X," "Removing a fused coil from heater unit X," and so forth.

Step 2 Specify the Indications of Trouble

This information is usually some symptom or condition observable to the operator that should indicate to him the presence or anticipation of a problem situation. It may be one or more specific or relatively vague reports of malfunction to a mechanic, or a too rapid rate of change in an indicator, or a weather condition.

It is essential that the problem indicator be one observable by the operator in the course of his performing a normal duty. The condition should not be described in terms of the cause of the symptom.

Step 3 Specify Critical Variables in the Decision

The solution of many problems requires the operator to respond to patterns of cues. What are the variables that are present in these patterns? Thus, the maneuvers for an emergency landing with defective landing gear will depend on several factors in the landing gear, the amount and kind of load in the aircraft, and the length and condition of the runway. Similarly, there will be principal factors governing the proper response to take in loss of cabin pressurization: (altitude, nature of mission, auxiliary equipment, rate of depressurization, and others). The parking of a fire truck at the site of a fire requires accounting for such variables as direction, velocity and steadiness of wind, expected combustibility of materials, length of hose, nozzle pressure, and so on.

Step 4 Specify the Alternative Responses

Each factor in a problem situation is important if it has bearing on the final response that is the outcome of a decision. The bearing of these various factors to the outcome of the response therefore needs to be stated explicitly. Thus, at least one primary condition in the choice of an emergency landing field is whether there is sufficient fuel to go to an alternative field. If lack of fuel eliminates an alternative, then the pilot is committed to land. The next variable is visibility, and after that, length of runway, and so forth. A short runway will require certain preparatory maneuvers, and so will low visibility. The two together may call for somewhat different tactics in approach and stopping.

It is not likely, of course, that under such conditions the pilot would actually consult a handbook, although he might scan a well laid out check list. The example does demonstrate the mechanics of decision making which it would be desirable to parallel in the handbook presentation.

Presumably the operations engineers will supply information on critical variables entering into problem-solving treatments in job instructions. List these in order of importance, if such an order exists, and state for each the implication for operator response. If they are interdependent in their response implications, group them accordingly.

Step 5 Provide Explanations That Simplify

The purpose of an explanation should be directed specifically to helping the operator remember what to do in given circumstances. This means the explanatory information should be limited to what the operator can use either in identifying a complex set of conditions in some simple way, or in being able to anticipate the consequences of his potential responses. If the information does not directly imply some kind of action to be performed by the operator as one of his duties, the information should not be included.

An example of a simplifying explanation is the statement that "Carbon monoxide is heavier than air, hence it tends to sink to the floor and flow downwards if possible." This item of information readily permits a mental picture to be formed, and from it the operator may take many precautions and corrective actions in emergencies.

Another example of a simplifying statement is: "Indicators 1 and 2 are powered by Box A, and Indicator 3 is powered by Box B." This information permits the operator readily to deduce that if Indicators 1 and 2 are both out, the trouble is probably in Box A; whereas if Indicators 1 and 3 are both out, but 2 is not, the trouble is likely to be neither in Box A or Box B. This is an oversimplified example of most equipment linkages, of course, but the principle is sound. It can be stated as follows: Give such information as permits the operator to picture the relationships of events and of what he is doing, in so far as this helps him quickly to make a correct decision or take the proper action.

Step 6 Specify Strategies for Getting More Information

The solution of many problems consists of a series of steps, each one of which provides additional information leading to a decision. The problem may be that of localizing a malfunction in a piece of equipment. Indicator A signals that something is wrong, but not where the trouble lies. The operator may, by looking at Indicators Y, Z, and X in that order, be able to localize the malfunction precisely enough to decide what corrective action is necessary.

In another type of example, the operator may have to move certain controls tentatively and note if the symptom picture is changed, and how. This information is added to that already observed by the pilot in narrowing down the field to the source of the problem.

Here again detail should be carefully restricted to what the operator has to do or to work with. Let us assume that in the case of a fuel leak in an engine the only thing the pilot can do is to shut off the engine; it makes no difference whether he localizes the leak to a duct or valve within the engine. Therefore, his search strategy should take him only to the gross isolation of the leak to the engine. On the other hand, if localizing the leak within the engine (rather than merely to the engine) might make the difference between his deciding or not deciding to shut off an adjacent engine, or to turn on fire extinguishers, then the search strategy should take him to such localization. It is also useless to describe to him localization that depends on information not accessible to him during the performance of his duty requirements.

Diagrams may sometimes supplement, and even substitute for, discussion of procedures the operator should take when faced by various contingencies.

Examples of Instructions on Decision-Making Activities

Two brief examples are provided in addition to Figure 2 on page 23. The first outlines one of several means whereby trouble-shooting procedure and information content can be presented to an electronics flight-line maintenance mechanic. The second example suggests how to describe the information critical to diagnosis and corrective response in a helicopter emergency situation of a given type.

Location of malfunction in the GCA radar system. In trouble shooting, the maintenance mechanic finds a symptom reported to him by the operator. He proceeds to locate the source by following the steps as given in Figure 3, page 27.

Helicopter operation: dealing with an emergency. Two alternative formats are shown for laying out the decision-making procedure in dealing with a sudden indicated drop in fuel pressure during flight. The first layout is recognized as conventional in approach, but illustrating the attempt at brevity and clarity

MAINTENANCE OF GROUND CONTROL APPROACH RADAR:

Trouble-Shooting Steps for "No Range Marks"

	Symptom	Information needed	Activity	Indication	Interpretation	Remarks
1.	No range marks on scope face	Can manipulation of operator's controls restore range marks?	Turn all switches to normal operating position	Still no range marks, but range scale lights and target pips are present	Defect lies in parts which generate and/or carry range mark signal to scope	If other video signals are normal, difficulty is located outside of scope circuit
2.	Range marks only are missing	Is the generator being triggered to produce the signal?	Apply AC voltmeter to input terminals of generator	Trigger is present	Trouble lies in generator; or there is a break in the circuit from generator to scope	This is tested first because it is so likely to be the trouble
3.	Range mark generator is being triggered but range mark signal does not reach scope	Does the generator produce signal current to provide the range mark?	Apply DC voltmeter to output terminals of generator	DC voltage present	Circuit between generator and scope is broken	Mechanic will proceed to narrow the limits within which the break exists
4.	Signal leaves generator but does not reach scope	Is the break between the coupler and the scope or between generator and the coupler?	Apply voltmeter to output of coupler	Voltage is present	Break is in circuit line or in socket carrying current to scope	If voltage is not indicated here, then break is in coupler

Figure 3. Decision-Making Format, Sample B: Trouble Shooting

(Format and example were provided by Dr. Richard W. Highland, Armament Systems Personnel Research Laboratory, Air Force Personnel and Training Research Center.)

which the foregoing considerations demand. The second presentation of the same example is more experimental, and may illustrate the usefulness of a semidiagrammatic method for presenting relationships.

1. Narrative form

Figure 4 illustrates the layout without diagrams, in which the sequence of of paragraphs presents the information in the sequence required by the operator. At each step, two alternative outcomes are possible. They are mentioned successively. The operator must recall the contents of several lines preceding the line he is reading. But, on the other hand, the conventional paragraphical form will be easily followed by the operator who lacks experience in using the diagrammatic form.

Where reference is made to content on a remote page, consider the length of the material so cited. If it is brief enough (one sentence), include it as a step, so that the pilot under time stress or emotional stress is not unduly taxed in an emergency. It is best to make reference only to material which the pilot has either so well memorized that even in an emergency he need not reread it, or which he can look for without time pressure. It is important not to interrupt the continuity of the instructions on the page he is reading.

2. Diagram form

This is illustrated in Figure 5. Here the successive steps in the procedure follow each other down the page, with the two outcomes of each step laid out on the same line.

In this illustration, interpretations are inserted between "IF YOU SEE" and "YOU MUST." These serve to focus the response, by providing the operator with an image of what to look for. They are included only if they are short enough not to interfere with continuity. If they are longer than those given here, they should be relegated to the Remarks column.

In all four examples of decision-making layout shown it would be possible to substitute pictures for words describing the indicators and indications, the controls, and in some cases the proper control action to accompany given indications. Pictures or diagrams might be used to supplement rather than substitute for words. The latter might be more practicable, and less subject to error than the former layout. Although these possibilities hold promise, it would be desirable to test with some actual users such experimental methods of presenting information. Thus, it might turn out that the diagrams would be extremely valuable for training purposes, or for activities that were performed only very rarely in job operations; but for the more proficient user of instructions the diagrams might be an impediment, if for no other reason than because of the space required for them.

Instructions for Dealing With an Emergency
During Helicopter Operation

1. Emergency procedure for loss of fuel pressure with full fuel tanks

1-1. Primary Symptom: Needle of FUEL PRESSURE GAGE reads below minimum operating level (i.e., below red index mark on dial: see page X, fig. x) but FUEL QUANTITY GAGE indicates ample supply.

Push FUEL BOOSTER PUMP switch to HIGH

1-2. Begin landing procedure (see page XX).

1-3. During descent, attempt to locate trouble as being electrical or mechanical.

Sniff, to detect odor of fuel.

1-4. If odor IS detected, even though booster pump maintains pressure,

Land at once.

1-5. If there is NO detectable odor of fuel,

Observe engine noise and exhaust trail for indications of choking of engine.

1-6. If backfire noise and smoke occur, (indicating choking of engine), assume a leak which by-passes carburetor and may cause engine to stall, and

Land at once.

1-7. If there is NO smoke or backfire,

Read ENGINE OIL PRESSURE GAGE.

1-8. If oil pressure reads zero, then assume 26-volt instrument system has failed.

Continue flight under emergency precautionary conditions (see page XXX).

1-9. If ENGINE OIL PRESSURE GAGE reads Normal,

Check fuse of FUEL PRESSURE GAGE.

1-10. If fuse appears OK (filament not broken; glass not cloudy), trouble has not been located.

Land at once.

1-11. If FUEL PRESSURE GAGE fuse has blown,

Replace fuse.

1-12. If indicated pressure returns to Normal and remains Normal, then trouble has been corrected.

Proceed in normal flight.

1-13. If fuse blows again and gage fails,

Complete mission with caution.

Figure 4. Decision-Making Format,
Sample C: Narrative Form

INSTRUCTIONS FOR DEALING WITH AN EMERGENCY
DURING HELICOPTER OPERATION

1. Emergency Procedure for Loss of Fuel Pressure With Full Fuel Tanks.

Begin landing procedure (Refer to Page ______).

Push FUEL BOOSTER PUMP switch to HIGH.

Sniff to detect odor of fuel in cockpit.

- IF odor is detected
  - There is a leak in the fuel supply system
  - LAND AT ONCE
- IF odor is NOT detected
  - There is either:
    - a. a leak by-passing carburetor with no loss of fuel, OR
    - b. an electrical failure of gage, OR
    - c. a failure of engine-driven fuel pump.
  - Listen to engine. Watch exhaust trail.
    - IF there is backfire noise and smoke in the exhaust trail
      - Fuel is leaking past gage into induction system but without carburetion
      - LAND AT ONCE
    - IF engine sounds normal; no smoke in exhaust.
      - Pressure may have dropped and is compensated by booster
      - Read ENGINE OIL PRESSURE GAGE.

REMARKS

When pressure gage needle falls below indicated safe operating area, but FUEL QUANTITY GAGE indicates sufficient reserves, proceed as shown.

Choking the engine with too rich a fuel mixture causes backfiring.

Landing is indicated even if booster pump restores pressure, because of fire hazard from escaped fuel.

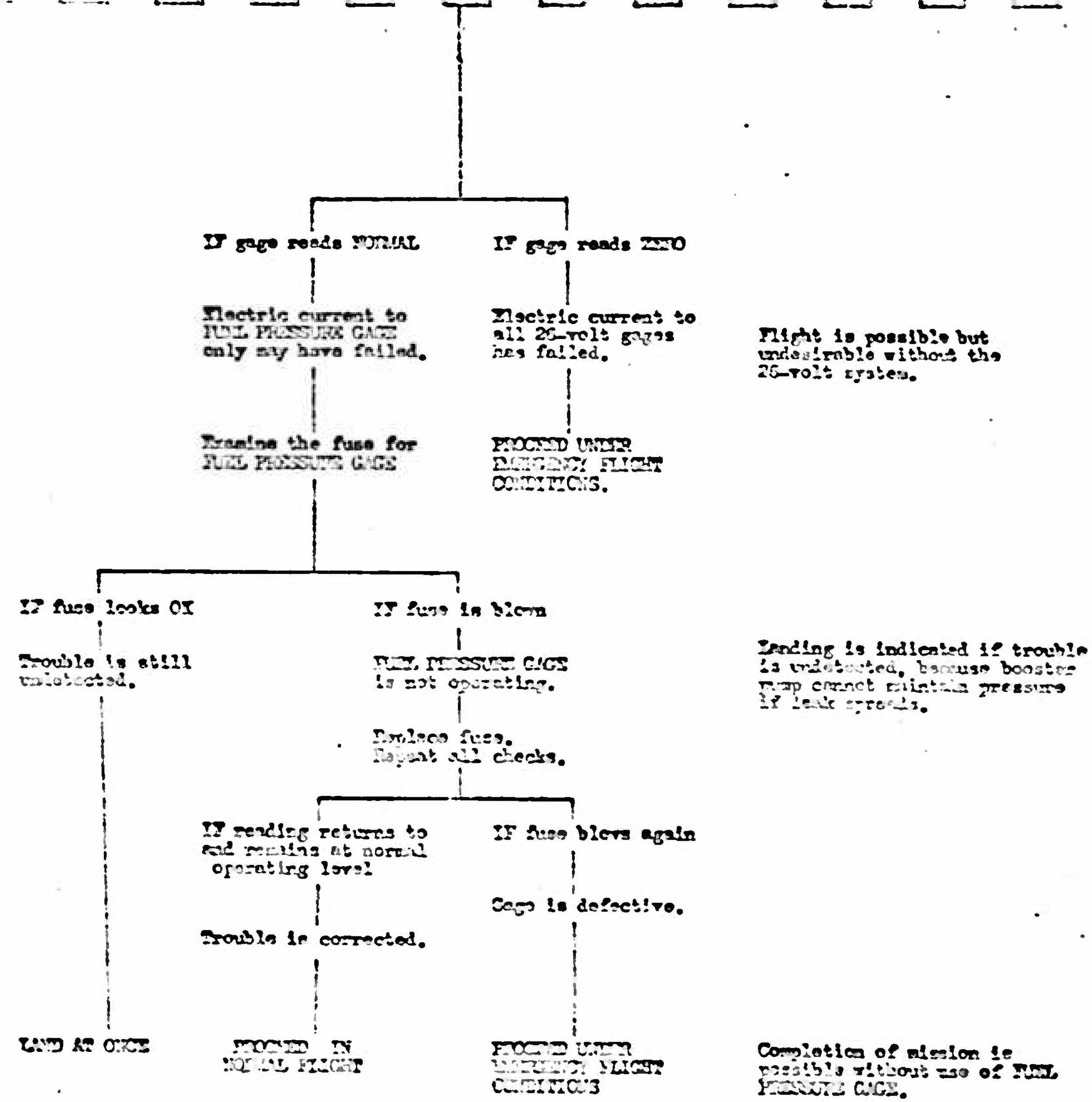

Figure 5. Decision-Making Format, Sample D: Semi-diagrammatic form.

The Index to the Handbook

The index of a set of job instructions should be an effective time-saver. If it is merely a catalogue of where names are mentioned in the text, however, it may not only waste time and exasperate the reader, but it may cause him to forget what he was looking for, and why he was looking for it.

The index should therefore be prepared with the needs of the user in mind. The user of a handbook of instructions will generally want to know how to perform some operation, and either the table of contents or the index must tell him where to look. Key words should generally have subtitles indicating the job context of the page reference cited. The intent is to save the user from needlessly having to consult the referenced page in order to determine whether he has chosen the correct reference.

There is an exception to the general rule of including only "how to do it" references. The user may want to find out what symptoms are associated with some given condition or equipment malfunction. Thus he may be faced with the appearance of some symptom, develop a hunch as to the cause, and want to check his hunch by finding out what additional symptoms accompany the causal influence he has in mind. In this case, the index may help him by naming the cause (such as "Rectifier X, failure symptoms: p. Y ; figure y) and telling him where in the text he can find a list of the associated symptoms. It is possible that the handbook will contain a special section listing common equipment failures and the symptoms associated with the failure.

The shorter the index, the easier it is to find an item in the index. Reference should be not only by page, but by paragraph. References should include not only verbal content, but pertinent diagrammatic material. The index should include items appearing in the table of contents.

CHAPTER IV

SPECIAL TREATMENT OF MAINTENANCE JOB INSTRUCTIONS

In general, all of the comments in the previous chapters are as applicable to maintenance as to operator requirements for instructors. Several specific items will be amplified because of their special importance to maintenance.

Determining the Objects with Which a Position Deals

In order to maintain relevance, the handbook should describe only those operations performed on or with an equipment, by a man in a given position. In general this means mentioning only those objects in, or on, the equipment with which he deals. Careful reference should be made to the position description data in order to maintain this relevance.

Diagrams: Block, Circuit, Schematic

The purposes of an electronic design engineer in preparing the design of circuits differ radically from the purposes of the maintenance mechanic in the use of block, circuit, and schematic diagrams. The information provided on diagrams included in instruction handbooks should be geared to the specific needs of the mechanic.

The following considerations apply to diagrams prepared for the mechanic.

1. Standardize symbols. Use the same symbol in the same way throughout the handbook. If possible, use the symbols already known to the expected mechanics, and use them as he has used them. It is better to develop a new symbol, however, than to use an old one in a way different from the way the mechanic has used it before.

2. Use as few symbols as necessary for the given position. Symbols may refer to objects, functions performed by objects, or combinations of these two factors. Many differentiations of functions and objects important to the equipment designer may be irrelevant to the mechanic in a given position. Eliminate differentiations among symbols that are not reflected in distinctions the mechanic needs to make in performing his specific duties.

3. Show in diagrams only those objects, functions, and relationships essential to aid in job performance. The following activities are not exhaustive of all those in which a mechanic may consult a diagram, nor may all of them belong to any specific position. They do, however, provide a practical basis for deciding what diagrams are needed.

a. Tracing signal flow. It is usually simpler to trace lines on a page than wires, cables, and often hidden connections.

b. Location of check points; the relation of these to other check points; points that yield much information about the system per check; best places for breaking an information loop.

c. Check values and tolerances at given check points.

d. Adjustment points (specific to position duties).

e. Schematizing the various functions performed in a given box or component as they affect changes in output signals.

f. Some may show physical locations of parts.

g. Symbols for matching job instructions with part referred to.

Block diagrams, which are comparatively simple, should be used in preference to wiring diagrams if the former will serve the purpose intended.

4. Organize diagrammed information according to job need. The organization of a diagram should, if possible, show parallels with the steps taken in the procedure with which the diagram is to be used. If, however, the same diagram is to be used as a supplement to a number of different job procedures, the coding system may become unduly complex.

Other aids in the organizing of diagrammatic materials are as follows:

a. Consistent series of diagrams from simple block to schematics. If it is necessary to show various levels of detail in a series of diagrams, attempt topological consistency. If the transmitter is diagrammed as being above the receiver in Diagram A, it should be above the receiver in Diagram B. It may also be helpful to have locator guides, where practicable, to show which segment of a simple, over-all diagram is represented in greater detail by an expanded wiring or schematic diagram. Another possibility is to use a marginal grid system, with codings that permit subdivision, that is consistent throughout a series of diagrams.

b. Color used consistently in a given family of diagrams.

c. Functional connections clearly identifiable from crossover lines in the diagram.

The extent to which a functional diagram can also suggest the relative physical location of the items diagrammed will reduce the mental translating required of the mechanic. Simplicity in functional layout may often be incompatible with showing physical locations, however, so that the best working compromise may consist of more than one diagram.

Providing Support for Trouble Shooting

Since trouble shooting is usually the most difficult part of the job, both in electrical and mechanical maintenance, every effort should be made to assist the mechanic. The previous chapter (pages 22 through 28) suggested some methods of presenting information and procedures for trouble shooting. If likely causes are cited for given symptoms, the mechanic should be told what to do if none of the likely causes turns out to be the true cause.

Difficulty often arises in trouble shooting from the large amount of information specific to the malfunction which the mechanic has to remember in reaching a diagnosis and choosing a corrective action. An example is (a) the number of data channels that might influence a given signal; (b) the specific values obtained at check points; (c) the locations of objects diagrammed; and (d) instructions about what he should or might do. Such amounts of information are retained with relative ease by the electronics expert with thousands of hours experience, but become confusing to the less experienced.

One practical aid consists of glassine envelopes and overlays with which the mechanic may cover particular pages and diagrams in the handbook. He may write check values, or pencil critical parts of a diagram on the glassine as a memory aid, or X out verbal and diagrammatic material he has already used without solving the problem.

CHAPTER V

ILLUSTRATIVE MATERIAL, LAYOUT AND CONSTRUCTION

Illustrations

Comments have already been made (Chapter IV) about the preparation of wiring and other diagrams used in electrical and electronic maintenance. The following comments are somewhat parallel, but make reference to other forms of visual aid material such as photographs, drawings, and diagrams.

The following steps suggest both a procedure and critique for the preparation of illustrative material.

Step 1 Decide What Job Information the Illustration Is to Provide

This is equivalent to identifying the specific purpose the illustration will aid the operator to accomplish. The following list is fairly exhaustive of the functions of illustrative material in an instruction handbook:

a. Locations and nomenclature.

b. Functional interrelationships of kinds specific to job action such as trouble shooting, and complex operating procedures involving potential misuse or hazard. Diagrams may also show, in a form easier to grasp than through words, how several variables interact to produce a given effect.

c. Sequence of operations, and contingent operations in the form of a graphic summary of verbal material.

d. As an aid to the reader's picturing the accompanying instructions for better interpretation and recall. Pictures are often better recalled than verbal statements about visual material.

Step 2 Include Only Those Elements of Information Critical to Job Use

This means a selection of only those lines, details, and renderings sufficient to convey the essential message intended. Thus, photographs are often poorer than diagrammatic representations because photographs often contain much visual irrelevance, which may obscure the essential message. The tendency to "pretty up" a diagram with shading and decorations, however, must be firmly suppressed. Skillful variation in the thickness of a line is usually effective in suggesting contour and three-dimensionality in a drawing, without reducing its vividness as is often the case with shading and hatching.

Unless the illustration is intended to aid in identifying parts and their locations, realism and consistency in scale is less important than clearly revealing the essential information.

Step 3 **Select Labels for Items Within the Illustration**

Label only the critical information in the diagram, and only those items that are not explanatory without a label. An attempt to introduce lengthy text in diagrammatic treatment is often an unsuccessful compromise.

Labels in illustrations should be unambiguously relatable to accompanying text. Where a series of diagrams is used on the same page or pages in sequence, and items in diagrams are numbered rather than named, the numbers must not be confused with numbers in the text in these several pages, or with numbered items on other nearby diagrams. Where items in the text are number-coded for reference to numbered items on an illustration, the reader must have no doubt about which diagram is being referred to.

Arrows may be used to symbolize sequence, flow or relationship. Arrows used for these purposes must not be confused with arrows that are used to direct attention, or that lead from a label to the object labelled. Important as arrows often are in conveying a message, they should not be more visually compelling than the illustrative context--in other words, they should not be a design element in themselves. The head of the arrow should be readily identified from the shaft. Arrows representing ribbons as seen in perspective or three-dimensions, have been effectively used to represent flow or motion in three-dimensional continuity.

Step 4 **Select a Label or Title for the Illustration**

Each illustration should be number-labelled for unambiguous reference in the text and index. The title should be short, preferably under seven words. A long, explanatory title is better broken into a brief identifying label of a few words, followed by a subtitle explanatory statement.

If the main purpose of the illustration is to show some principle of action, this principle may be briefly stated as a subtitle unless it is stated within the frame of the illustration. It is generally good to reinforce the main point of what is illustrated by a verbal statement, if that statement can be limited to a single sentence of a few words.

If the diagram is not immediately adjacent to the text it supplements, the relevant page and paragraph should be cited in the caption.

Page Layout

Aesthetic considerations such as symmetry and layout consistency should be secondary to clarity and continuity of subject matter. Narrower margins may be permitted than is usually the case for textbooks.

Foldout pages. These should be kept to a minimum, although scattering content, rightfully belonging on one large page, over a number of pages may be worse than a foldout page. Foldout pages are especially a nuisance if they have both vertical and horizontal folds. In any foldout page no more than one horizontal fold should be made (that is, a fold made at right angles to the binding of the book) although several vertical folds may be made to be pulled out sideways. The opened-out page should not be longer than an arm's length, about 35 inches. When folded into the book, the edges of the folds should be staggered towards the outer margin to facilitate folding the opened page back into the book. This is called a "pyramid gate fold." If possible, section edges of the diagram should fall on crease lines. In any event, small but critical information should not fall on crease lines where it will be worn away. These recommendations are based on ease of use, and the likelihood that job instructions may often have to be used without a desk or table top space on which to rest folded out pages. They may also have to be used out of doors in wind.

Page identification. Each page should be identified by the following information:

1. Technical Order number, or other military serial designation; preferably centered in the top margin.

2. Section number.

3. Topic and paragraph numbers, inclusive of content on the page; best at upper, outer margin.

4. Page number; lower outer margin.

5. Foldout pages should have page number and figure coding completely visible when all pages are folded into the book. It is also helpful to have a short form of the title or key word in the title visible here.

Physical Construction of the Handbook

Size. For ideal working purposes, the maximum size of a handbook of instructions may be larger if the operator does all his work in the same room than if he must move from one place to another and carry the instructions around. For non-mobile personnel, the standard Technical Order size 8 1/2 by 11 inches is satisfactory. If the book is to be carried around, as in flight-line maintenance, it is desirable to fit it into a fatigue uniform pocket. The maximum such a pocket will admit is about 5 by 8 inches, with a thickness of about 1 1/2 inches. Even this size will strain a pocket.

Paper. The pages should be tough, high rag content paper that is water resistant. Foldout pages should be of paper that does not break at the folds; this is especially true of any "master" trouble-shooting diagrams. The paper should not be glossy.

Covers. The covers should be of a soft, semi-rigid leatherette or plastic material that is durable and will resist cracking at the edges or along binding seams. They will need to withstand water, oil and grease, perspiration.

Binding. This should be of the spiral, gyral or plastic type that permits the opened book to lie flat. The mechanic and operator frequently must use both hands in operations; they usually will not have a hand to spare for holding the book open. The frequency with which the handbook is used demands a tough, durable binding.

It is recognized that revisions of sections of job handbooks frequently are made. A permanent binding prohibits substitution of pages. The plastic binding does permit substitutions to be made, but a special tool is required. Ring binders take up extra space, and pages are easily torn out and get lost. It is clear that no universally satisfactory solution now available is both economical in terms of page substitution, and practical for on-the-job operations. A thorough cost analysis may show that replacement of the complete handbook is cheaper in the long run than providing [illegible] inserts and substitute pages.

CHAPTER VI

GEARING JOB INSTRUCTIONS TO OPERATIONAL CHECK LISTS

A check list usually is an abbreviated set of job instructions. Its use assumes familiarity with the procedure being performed.

It is obviously inefficient to learn a procedure from job instructions in one way, and perform it differently from a check list. Even though the difference may be no more than the rearrangement of the same steps into a different order, confusion, time delay, and error are invited. It is true that exigencies at certain sites may demand a rearrangement of a procedure, and the Air Force characteristically permits each base, and sometimes organizations within a base, to establish its own check lists. But differences among check lists for the same procedure also arise because different items of information are abstracted as check list items, without rearrangement of steps or substitution of human actions.

The manufacturer may reduce some of the incompatibilities found between check lists and job instructions by carefully working out check lists himself. If so, the following considerations will serve to guide him.

1. A check list item directs attention to what it is operationally essential to do in a procedure. Thus a check list item may state an end effect which could not be achieved except by performing a number of suboperations or job elements. A check mark appearing beside the item therefore implies that these actions must have been performed.

2. A check list item is a memory aid to the operator or mechanic. Its wording, and the information in it, should be such that it will help him recall the more complete instructions in the handbook. Parallels in wording will help. Parallels in marginal spacing may also help in the recall of the handbook context.

3. Check list items should be directed toward evidence of response adequacy. This rule will have many important and necessary exceptions where an incorrectly made human response may result in delay, hazard, or damage to equipment. But check lists should also direct the user's attention to how the equipment is performing as a consequence of his performing successive steps in a procedure. Standard values and tolerances should be provided of critical indicators of equipment performance.

4. Check list items should include critical specific actions to be performed. If the incorrect selection or manipulation of a given switch at a given time may jeopardize a large amount of effort or materiel, the operator should have such actions specified in the check list.

5. Check list items should point out what specific action to take in error-likely situations. These include situations in which the operator may overlook some important action, even with the handbook open before him, or expose himself or the equipment to needless hazard. This consideration is not independent from item 4 above.

6. Check list items should have a coded reference to the inclusive material in the job instruction handbook dealing with each item. This permits the operator quickly to look up and fill in from the handbook the information he needs that is not provided by the check list item.

7. The specificity of the check list items should be compatible with the ability of the operator. That is, if the check list is supposed to be used with little or no reference to the job instructions, it will have to be much more detailed for a newcomer on the job than for the person who has performed the task many times. If an operator must shift work among a variety of somewhat similar equipments requiring subtle differences in procedure, the check list he works from should be more detailed than if his work is repetitive on the same equipment.

8. Check lists likely to be used when the operator is under emotional stress should be more detailed than those used under tranquil conditions. Under stress there is proneness to forget even familiar patterns of activity. Thus, the detailed check list may compensate for tendency to memory failure. It is possible that a detailed check list may also be called for if the operator is acting under time stress with the likelihood of skipping essential activities. Under such circumstances, of course, the operator may skip using the check list, too, because it takes still more time to consult. Compromises need to be based on a study of what happens when a given check list is actually used in operations by the personnel for whom it is intended.

The layout of the job instruction text should provide parallel structure to the check list derived from it, and emphasize check list items in the instructional context. Thus the words used in a check list may be set out in distinctive type readily picked out by scanning the page. Topical material in some cases may be blocked out with check list item titles.

This relating of check list to job instruction text will speed up the rate at which the student or operator can become practically independent of the instructions, and perform the task competently from the check list itself. On the same basis, error will be reduced in the mental transposing of job instructions into the context of check list items.

CHAPTER VII

TESTING THE JOB INSTRUCTIONS

Any set of job instructions should be thought of as provisional until it has been successfully tried out. The tryouts should be directed to two major purposes: one is to determine the technical correctness and adequacy of the information, instructions, and illustrations; the other is to determine their practical usability. The tryout should simulate the limitations and difficulties of combat conditions.

Engineering Tryout for Technical Correctness of Information

In this test, engineers who are expert in the task and the equipment meticulously follow the instructions as they are printed, and attempt to do what is specified. Where a procedure, a numerical value, or a contingency is described inaccurately, or where undesirable options may be implied, the experts make suitable corrections. They may also recommend changes for improving the efficiency with which the task is performed according to the instructions. The following considerations apply:

1. Require the expert actually to do what is described in each step of the instructions. This should include the use of diagrams and illustrative material that support the text.

2. The expert should carefully examine the description of when and under what conditions each task is to be performed, and judge its accuracy and completeness.

3. A separate monitor (who is not himself an expert) should observe the expert, comparing each step performed with what is described in the instructions for that step. The monitor should note inconsistencies.

4. Operational conditions under which the task will be performed should be simulated as closely as possible. This includes the hazards, contingencies, and limitations that may realistically be expected; the instructions should be expected to stand up under as adverse conditions as those in which performance by the job incumbents will be expected. Other factors will be limited work space, weather, illumination, location of tools and accessory equipment. If the task includes trouble shooting or diagnosis, the expert should not know in advance what the "trouble" consists of.

5. The expert should understand precisely what duties and tasks are expected of the position being simulated. This is an extremely important consideration, because the expert may frequently attribute broader

capabilities to a position than were stipulated by the position requirements. Reference should be made to the document specifying the position requirements (described on page 8).

6. If possible more than one expert should perform the tryout. Each should do so independently in order to determine the reliability of the criticisms and judgments.

7. The expert should check the handbook for the following factors:

a. Correctness of locations and nomenclature used in text and illustrations.

b. Correctness of all standard values and tolerances. Unrealistic tolerances should be increased, if possible, or statements should be given as to what kinds of compromises in tolerances may be acceptable under severe conditions of immediate demand for the equipment. These are operational policy matters, but they have extremely practical importance to the mechanic who is trying to meet time deadlines, and to officers who are attempting to meet mission quotas. The problems frequently come to a focus in decisions of what "fudge factors" are permitted in putting an urgently needed piece of equipment into use. On the other hand, if <u>no</u> "fudge factors" should be permitted on certain tolerances under any circumstances, it may be advisable to make some explanatory statements to that effect. It is possible that the manufacturer will not want to commit such data to a handbook of instructions, but prefer to issue it separately to maintenance officers to be used at their discretion.

c. Correctness of tools and equipment specified.

d. Correctness of diagrams, schematics, and other trouble-shooting aids.

e. Statements of contingencies and what to do about them. It is unlikely that the tryout can sample very widely from operational contingencies. Presumably the expert will be aware of possibilities, and with these in mind he should examine the job instructions for realistic coverage. He should study carefully the recommendations as to what to do in meeting various contingencies, and, if at all practicable, try to put the recommendations into practice. He should not use tools, instruments or other facilities not available to the operator or mechanic under work conditions.

WARNING: Be sure that the engineering expert understands what duties and tasks the particular position does and does not entail.

Tryout with Novices for Interpretability of Instructions

This phase of the tryout should determine how successfully the users of the handbook will be able to translate words and illustrations into the correct action. The following considerations should guide revision and acceptance of the handbook.

1. Select subjects for the tryout. The operators or mechanics chosen for the tryout should be representative of the actual persons who will use them. It is more important to get the reactions of the poorer quality personnel than of superior individuals. In training and operations the poorer ones will tend to be more dependent on the instructions, and for a longer period of time; they will also have the greatest problems in interpreting them. Testing with subjects selected from among the more limited in ability (who still will be responsible for performing the job) is like torture testing of equipment: the weak spots show up most rapidly. This is the intent of the tryout.

Arrangements often can be made through the Air Force for providing the subjects. Those who are planning the test should try to specify the educational and training background of the subjects, their individual aptitude test scores, and, where relevant, their relative performance in previous basic training courses if they are expected to transition to the subject equipment. These data should be kept and matched with the performance of the subjects during the tryout.

2. Fulfill the training presuppositions for use of the handbook. This will generally mean supervised familiarization of the subjects with nomenclature and locations of indicators, controls, signals, work objects, tools, test instruments, and other items referred to in the job instructions. In order to shorten this period, nomenclature and locations can be taught only for one segment of the instructions at a time, and then have the subjects tested on that segment. This method is likely to be less practical if the handbook also contains procedures for diagnosing troubles, or for coping with emergency situations. These areas can be tested last, however, after the subjects have acquired more familiarization with the equipment through performance of the standardized routine procedures.

Presumably the subjects will also get a demonstration of the procedures by a competent instructor. The demonstrator should pace his performance to allow time for subjects to follow it with handbook presentation. The demonstrator should not add verbal material that is not in the handbook. It might be desirable for someone (not a subject) to read the instructions aloud. Questions asked by the subjects during the instructions should be recorded.

Probably immediately after the demonstration, each subject should be required to go through one or more guided or coached performances of the procedure using the handbook for instructions. The coach should let the subject take the initiative, and give help only when the subject obviously is doing the wrong thing, or preparing to do the wrong thing. Aid should be provided for locating items difficult to find, although if labelled illustrations are provided by the text, an attempt should be made to determine how efficient they are.

Neither in the familiarization trials nor the test trials should there be a systematic attempt to force the subjects to perform tasks within time limits, especially time limits within which experts could perform the task. On the other hand, it will always be desirable to urge the subjects to complete tasks as rapidly as consistent with avoidance of errors.

3. Test the indoctrinated subjects with the handbook. It will be desirable to allow about half a day to elapse between the familiarization described in item 2 above, and the first of the tests. This time lapse forces the subject to be more dependent on the handbook than on what he observed in the demonstration.

One observer, completely conversant with the procedures being tested, should be assigned to watch one subject during the test(s).

For each step (element) of the procedure being performed the observer should note the following:

a. Errors made by the subject

b. Kind of error

c. Excessive time delays

d. Total time between completion of each step

e. Gross inefficiency in carrying out the step

f. Dead ends: when the subject comes to a point from which he does not know how to go on.

When it is clearly established that a subject has reached a dead end, the observer should try to find out the reason by discussing the problem with the subject. The observer may then help the subject over the hurdle, if possible, by pointing out to the subject something in the instructions that he failed to notice.

4. Note the reduction in time and errors between successive repetitions by the same subject of the same procedure. It may be desirable to have the subject repeat the procedure until he can perform it without error and within the operational time limits permitted. These data will be valuable in providing estimates of training time, assuming that the instructions will not be substantially modified.

The limitation in the above arrangement is that forgetting will take place between the subject's mastery of one procedure and his learning of another procedure. If time permits, the subject should be retrained until he has achieved mastery of all procedures covered by the handbook of instructions.

At least five different subjects should be put through the same test in order to determine reliability of the test of the handbook version. Thus, if only one of the five subjects has difficulty with a given step, it may not be worth while to try to change it.

If subjects seem generally to have difficulty with a step or an entire procedure, an effort should be made to correct possible deficiencies in instructions. If, however, this does not seem practicable, recommendations can be made that the training agency concentrate special training time and effort on those steps or procedures. The latter recommendation is an explicit acceptance of the limitations of the instructions.

An attempt should be made not only to add material that seems necessary, or to make changes as indicated by the tryout, but also to eliminate material that is unnecessary to the subject in performing the procedures.

5. Test the revisions of the handbook of instructions. It is always possible that changes in the instructions may have a reverse effect than that intended. Consequently, the revised versions should be tested in the same way as the preliminary version. Comparisons should be made between time and error data obtained from the present tryout and the preceding tryout.

When the Instructions Can Be Tested

Instructions can be tested with reasonable validity on the first slow production models of the simulators. These early simulators are usually to be developed concurrent with the first slow production copies of the operational equipment. Further results can be obtained, of course, by conducting the tryouts during Operational Suitability Tests (OST). Since this is late in the developmental picture for handbooks of instructions to be prepared (vital as they are for training purposes), advance arrangements should be made for going into full gear in reproduction of the final version.

GLOSSARY

This Glossary consists of important and commonly used terms drawn from all four of the Proposed Guides in this series. In nearly every case the term is also defined in one or more places in the text, often with examples and qualifications. The list here is not exhaustive of technical terms used in the Guides, but is mainly a selection of those having significance to the QPRI program. Terms concerning stages of weapon system development have been omitted because they are subject to change; however, many of these terms are provided in Chapter II in A Suggested Guide to Position-Task Description.

Activity Analysis (Activity Data) - Made by getting data from human performance of position activities from incident logs, interviews, direct observations, reports of accidents, human errors, and so forth. Distinguish from EQUIPMENT ANALYSIS.

Automatic or Automatized Response - Human responses that are performed without verbal or conceptual mediation; responding without "thinking" about it. Response automaticity is acquired through repetitive practice.

Behavior - A general term covering any form of human action; it usually implies some signal or stimulus condition plus an implicit or overt response made to the signal.

"Black Box" - A group of electrical or electronic parts that can be plugged in or unplugged from an equipment as a single physical and functional unit. Commonly synonymous with COMPONENT and LINE REPLACEABLE UNIT in describing a type of maintenance such as "black-box maintenance."

Block Diagram (Functional Block Diagram) - Used in electrical and electronic maintenance; shows functional relationships among components, assemblies, in the equipment. Especially important in line maintenance. Distinguish from CIRCUIT DIAGRAM.

Circuit Diagram - Used in electrical and electronic maintenance; shows specific wire connections, individual parts such as resistors, potentiometers, and so forth. Distinguish from BLOCK DIAGRAM.

Compensatory Tracking - Form of tracking in which the error signal to be corrected by the operator is a compound of the target and cursor deviation from some absolute reference; display shows momentary target deviations from the way the aircraft or gun is "pointing." Usually is more difficult task than PURSUIT TRACKING.

Component - A combination of parts, assemblies, accessories, and attachments, which together form an equipment to accomplish a specific complete function.

Continuous Task - See TRACKING.

Control - An object to be manipulated so as to modify the action of equipment. In description of activities, it may include tool used.

Criterion Output - Acceptable qualitative and quantitative values and standards of performance. Should be thought of in statistical terms, such as "In 90% of all cases under combat conditions the electronic components in the aircraft will be ready for take-off within four hours after returning from a mission, unless they have suffered battle damage." The term may be applied to human performance and to system performance.

Criterion Output Variable - Some form of work the system does, related to achieving an intended objective, to which quantitative tolerances or qualitative standards can be applied independent of other variables. Thus, accuracy in range with respect to height of fall is one criterion output variable in a bomb system.

Cross Training - Training a man for another position, or for tasks in another position, while he is assigned to a given position.

Cycle - Some representative series of events that is repeated in operations. See MISSION CYCLE, POSITION CYCLE.

Decision Making - The use of available information immediately presented and recalled in determining some state of affairs, and selecting a response alternative where no specific prescription for the contingency is known or recalled by the operator or mechanic. Conceptual activity is implied by the term when used in these Guides.

Display - The source of information, or the information presented, for the use of the human component. It may be an indicator, indication, or information directly presented in the man-machine environment.

Duty - A set of position activities comprising a major requirement within a specific position. A duty indicates in general terms what a man is supposed to do with (or to) a machine, rather than how he is to do it, or the specific parts of the machine with which he is to do it. Duties are of two types, POSITION FUNCTIONS and POSITION SEGMENTS, depending on the method of analyzing the position.

Duty Cycle - The total sum of events, or kinds of events, relevant to a position that typically occur in performing some specified duty.

Element - A unitary human operation in a position, identified by a specific stimulus or signal on a specific indicator or display, a specific control activation, and a feedback signal of response adequacy. Generally equivalent to a "step" in a procedure.

Equipment Analysis - A procedure for describing position-task requirements from the demands placed upon the operator or maintenance mechanic by the (a) performance requirements of the equipment, (b) the controls whereby such performance may be modified, and (c) the information provided the man through displays. Equipment analysis can be made without observing a man performing in the system; it can be provided from blueprint data on display-control configurations plus the information to be supplied by the system for the man operating or maintaining it. Distinguish from ACTIVITY ANALYSIS.

Flight-Line Maintenance (Line Maintenance) - Maintenance performed on equipment while installed in its normal operating position. In electronics maintenance, usually implies "black-box" or "down-to-plug-in-components" maintenance. Somewhat parallel but not always identical to ORGANIZATIONAL MAINTENANCE. Distinguish from SHOP MAINTENANCE.

Functional Characteristics - What something is supposed to do or accomplish rather than the mechanism by which it does it. Characteristics are functional with respect to some objective, such as training, operating efficiency, and so forth. Functional characteristics are statable in various degrees of analytic detail.

Indication of Response Adequacy - A signal from a display, from observation of a control setting, or from the environment that a given response action has had the required effect. This signal is often the indication for initiating the next element (step) in a procedure.

Inferring - See INTERPRETING.

Interpreting - Implicit symbolic activity that includes making computations, drawing inferences, making judgments, assigning causes to symptoms, translating symbols into decisions and actions.

Job - Used here as equivalent to the term POSITION; never meaning "task" or "assignment."

Manning Table - An official document stating the estimated number and types of positions required to operate, maintain and directly support a given system.

Manually Operating - Any work-directed physical action performed on a control, tool, or other work object.

Mediation - See VERBAL MEDIATION.

Mission Cycle - The total series of events representative of what occurs from the beginning of an operational sequence until that sequence starts over again. It may include the combined activities of several operators, maintenance mechanics, and others. For airborne operator activities, a mission cycle characteristically begins with briefing and terminates with debriefing.

On-the-Job Training - Training that is usually given by a supervisor in the actual context of work operations.

Part - The smallest object in an equipment which is encountered outside the factory. It is never repaired; only tested and replaced if defective.

Part-Task, or Part Task - See PART-TASK TRAINING.

Part-Task Training - A scheme of training for a position in which the component skills are practiced separately to some level of performance before being practiced together.

Perceiving - Detecting presence or absence of given cues; discriminating in-tolerance from out-of-tolerance conditions; identifying cues, signals, patterns by means of human senses.

Phase of Instruction - A group of related topics or TRAINING UNITS, dealing with some common training objective, that are taught together over a period of several days or weeks. Often deals with the training of a number of tasks treated as a DUTY.

Phase of Training - May be one of several successive stages in acquiring mastery of a skill or procedure, or may be some aspect of an ability such as knowledge of nomenclature or locations of parts in learning a procedure.

Plug-In Unit - Same as COMPONENT.

Position - The total set of activities and responsibilities assigned to one man in an expected operational or maintenance situation.

Position Cycle - The total series of events in a representative MISSION CYCLE as they affect performance requirements of a single given position. Usually only certain portions or aspects of a mission cycle affect a given position. May be thought of as the work cycle for a given position.

Position Definition - A word-picture summary of what the operator or maintenance mechanic will have to do and the general conditions under which he will have to do it, plus brief descriptions of duties and tasks.

Position Element - Same as ELEMENT.

Position Function - A form of DUTY; position activity which tends to persist or recur throughout a position cycle, and together with other position functions tends to be exhaustive of what needs to be done. Example: Checking equipment for in-tolerance and out-of-tolerance conditions.

Position Organization Table - List of position titles and respective duties and tasks that, taken together, is expected to fulfill the qualitative personnel requirements of an organizational unit acting as an operational entity. In QPRI, this listing is limited to positions required for operation, maintenance and direct support of the weapon system.

Position Segment - A form of DUTY: all the tasks and task-related events that occur during some time segment of a position cycle. Examples: taxiing an aircraft to the runway (which includes maintaining communications and other activities time-shared with maneuvering the aircraft); take-off; flying a traffic pattern; making a bomb run, and so forth.

Position Structure - The basis for methodical assignment of all tasks within an organizational unit to some position rather than to some other position on the grounds of (a) requirements of the organizational unit to accomplish its mission and (b) the psychological factors going into individual training and performance. Position structuring results in Position Organization Tables which permit establishment of Manning Tables and Tables of Organization.

Procedural Task (Discontinuous Task) - A task readily divisible into discrete steps or elements as contrasted to a TRACKING TASK in which a more or less continuously changing response is made to a continuously changing signal. Examples of procedural tasks: preflight checks, engine starting procedures, trouble shooting.

Program (Program Variable) - Equipment or situational conditions that affect the performance of an activity, whether as part of a mission, segment, duty, task or position element. Example is "weather" in flying, of which a <u>program variable</u> would be "wind direction" or "wind velocity." Program information is essential in position-task description in order to determine sample situations for training, training devices, proficiency examinations, that will be representative of the range and severity of conditions under which performance will be required.

Pursuit Tracking - Form of tracking in which target track and cursor track are both shown relative to some third reference in the display such as north, or the earth horizon. Permits the operator to extrapolate independently both for target and for cursor motions. Example is PPI form of radar display. Usually an easier task than COMPENSATORY TRACKING.

Qualitative Personnel Requirements Information (QPRI) - Essential data about operational and position requirements from which Qualitative Personnel Requirements (QPR) can be formulated. QPR consist of the specifications for human capabilities in a system, and the characteristics whereby such capabilities can be obtained by means of position structure, selection, training, training devices, proficiency test, operating procedures, handbooks of instructions, and so forth.

Recalling - The activity of remembering information.

1. Short-term recall - Retention of given information peculiar to a given mission or work assignment during that mission.

2. Long-term recall - Retention of given information throughout an indefinite number of missions, such as SOP's often include.

Remarks - A category in position description formats for otherwise unclassified information such as "precautions," "contingencies," "qualifications to an instruction."

Segment - Events and activities occurring in some period of time. See POSITION SEGMENT.

Shop Maintenance - Maintenance performed in a shop, usually within "black-boxes" or plug-in assemblies at the operational base or site on equipment that is removed from installation. Also called FIELD MAINTENANCE. Distinguish from FLIGHT-LINE MAINTENANCE.

Table of Organization - An official document listing the positions and numbers of individuals for each position to be officially established for organizational strength. Also includes duties assigned to each position, and rank(s) to be assigned to given positions.

Task - A group of human operations which usually occur at about the same time or in close sequence to each other, have some common purpose, and are usually directed towards some specific machine output(s) which they have in common. A task may be considered a "duty applied to some specific component of the equipment."

Task Diagrams (Task Block Diagrams, Time Charts) - Diagrammatic means of showing how the tasks in one or more positions are temporally related to each other during operations, either by being concurrent or in sequence. Time charts are more detailed presentations of this information than task block diagrams.

Time-Sharing - Activities that are concurrent or overlapping in time.

Tracking, or Tracking Task - More or less continuous control action to a more or less continuously varying signal. (Opposed to PROCEDURAL TASK.)

Training Characteristics - Specified conditions to be supplied for acquiring a given skill or knowledge. These conditions include samples of situations for practice content, form of practice, method of delivering knowledge of results, monitoring of training, organization of content, units of practice, proficiency criteria.

Training Segment - A group of related tasks and activities regarded trainable as a homogeneous cluster over a continuous period of time. May often be equivalent to all the tasks included in a duty. Training segments are divided into PHASES OF INSTRUCTION which in turn are divided into TRAINING UNITS.

Training Unit - Subject matter covered by some part of a job procedure, or of a generalized skill, which can readily be learned as a whole; content that requires from one to ten hours to learn.

Transfer of Training - The carry-over of a skill learned in one context to learning or performance of skill in another context. Usually the transfer facilitates performance in the new situation, but sometimes it may interfere at least temporarily.

Transition Training - Training a person for a new position that is similar to a position for which he has already been trained and in which he may have had experience.

Trouble Shooting - The locating of a malfunction on the basis of symptoms, and/or through making a series of checks.

Verbal Mediation - "Thinking" or the implicit use of words, ideas, concepts in arriving at an overt response to some perceived signal or condition.

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13. ABSTRACT

This memorandum contains suggested procedures for preparing handbooks of job instructions. The preparation of job instructions is marked by continuing refinements of procedures. The results of this study indicate that further research, development, and testing are needed for many of the suggestions in which the soundness may not be self-evident. The information in this report, though tentative in many of its practical implications, suggest if adopted, improvements over certain of the existing practices in the development of job instructions for Air Force personnel. Further development and evaluation of principles for effective presentation of job instructions for maintenance personnel has been undertaken, and can be expected to result in added specificity and refinements for certain procedures described in the present report. (U)

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