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# BASIC ELECTRONICS SKILLS AND KNOWLEDGE

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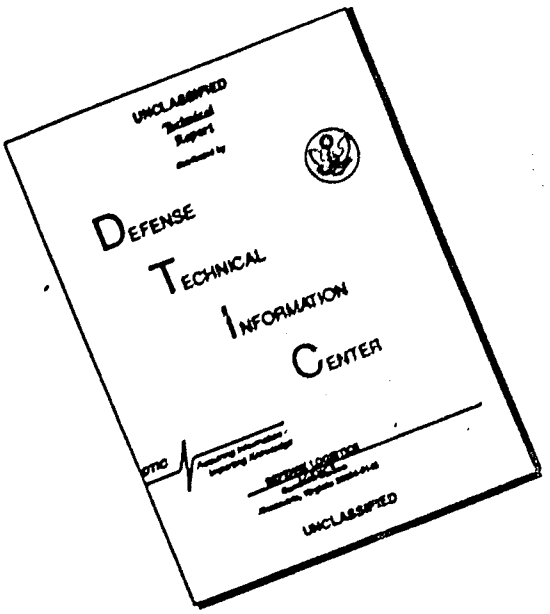
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An analytical process for deriving skills and knowledges for an electronic maintenance MOS was developed. The process model that was developed assumes that the MOS is well documented. The process first identified all tasks performed on specifically designated equipment groups (end items) using a Task Identification Matrix (TIM). One fourth of the tasks performed on each item were selected, using various criteria, for detailed task element analysis. The task elements are validated prior to the detailed analysis. The purpose → next page

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of the analysis is to identify behaviors and knowledges not possessed by the general population. The product of the analysis is an extensive list of behavior/information statements that are used to construct a maintenance fundamentals job description questionnaire. This is then administered to a representative sample of job incumbents as a way of validating the list of job fundamentals. This information is then provided to course developers for their use in building training programs.

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## SECTION I

## INTRODUCTION

Over the past twenty years the US Army Air Defense School (USAADS) has expressed a concern and interest in the questions of what kind and how much training the average soldier must have to perform successfully as an electronic technician. Generally the answer has been that at least two kinds of training are needed: First he must have a working knowledge of electricity/electronics; and second he must have a working knowledge of the maintenance tasks required for the system for which he is responsible. These two categories of training have been called Basic Electronics (BE) and systems training respectively.

The question of how much training is needed has tended to look at the depth of understanding that is necessary to perform the job successfully. A continual problem with this question has been that the term "perform successfully" has been defined differently by field management personnel than by school personnel. The unit commander has been driven by his pressures to keep his systems operational as much as possible, regardless of the situations. Over the years, his definition of a good technician was one who could keep the system up. It matters not that the technician must perform unauthorized tasks to accomplish this or that he must fabricate a temporary fix to substitute for a non-available component.

The technician who could perform beyond the normal and authorized level of effort was not rare. Early in the history of Air Defense systems, reference publications were, more often than not, incomplete, inaccurate, or not accessible. It became necessary to acquire not only functional knowledge and skills, but also theoretical knowledge and skills. The successful technician not only knew how a piece of equipment worked, he also found out why. He often had the performance capabilities of a design engineer.

These conditions have created a historically derived perceptual set that technicians can always use a more theoretical understanding of why an electronic system operates. This set has led to considerable research over the past two decades. Much of the work has been focused on how best to teach BE. The Functional Context approach to training was designed as a way of increasing the meaningfulness of BE. The Hawkeye approach developed by HumRRo in the 1960's (Hawkeye, 1969), integrated basic troubleshooting concepts into a job aid. The multi-level training system (Foster, 1972) was another attempt to integrate theory, training, and experience in the development of technical expertise. However, front-end-loading of electronic training with BE has tended to prevail in some form. The traditional instructor-taught class and laboratory approach has been the one most often used. The development of a common BE preparation course, COBET given prior to a more specific BE concept course was attempted, but was discontinued.

Numerous studies have been done over the past three decades by all services in an effort to reduce the complexity and the cost of electronic maintenance training while producing more competent technicians. These studies have demonstrated repeatedly that enormous savings are possible when the resultant training is based on a detailed analysis of the job. Elliott (1966, 1967) and Elliott and Joyce (1968, 1971), demonstrated that "electronically naive" high school students with as little as 13 hours of self-paced instruction could solve between and within-stage electronics troubleshooting and repair problems in far less time and with fewer diagnostic errors than conventionally training journeyman Air Force electronic technicians.

Pieper (1968 and 1969) demonstrated that well designed courses of shorter length (15 versus 24 weeks) could produce higher proficiency graduates in a modified F-111A weapon control system technician course. Significant additional course cost reductions were also achieved through substitution of simulators for expensive and scarce tactically configured equipment. Requirements for instructors were also significantly reduced through self-pacing.

Part of the savings which these and other studies have demonstrated resulted from, 1) changes in instructional approach, 2) changes in mode of presentation, 3) the use of simulators which provided more and more valid task practice, and 4) novel types of performance aids which simplified the tasks making them both easier to perform and easier to learn. Yet, a common thread runs through them all. They are all based on a careful examination of what the job incumbent does on the job and restriction of course content to only material functionally related to job content. In almost every case, it has been possible through systematic task identification and analysis to define a list of skills and knowledge necessary and sufficient for job task performance, limit training content to that list, and demonstrate large savings in course costs and increased end-of-course proficiency. The most prominent training content casualty associated with the approach has been "Electronic Theory" or "Basic Electronics"; the body of knowledge which explains at the electron flow level of abstraction how the equipment does what it does, including the mathematics which describes quantitatively both the static and dynamic transfer functions. Only reluctantly have the schools allowed the BE content to be considered for modifications. The belief is widespread that "a thorough grounding in the fundamentals" leads 1) directly to rapidly accelerating skill acquisition on the job, 2) ultimately to higher levels of proficiency, 3) to maximized transfer of training and thus to greater versatility of the job, 4) to more successful career progression, 5) to better personnel retention, 6) greater maturation through professional pride, and on and on. Has there been any truth in this? The history of the research has provided some support for both sides of the issue.

Nevertheless, the latter views regarding BE have been widely held by senior NCOs and by Commanding Officers in the field who have responsibility for maintenance, by school instructors both military and civilian and by school course developers. On the other hand, the savings demon-

strated by those studies which altered BE content and mode of instruction are real and repeatable.

Most of the successful repetitions have occurred when researchers (like ARI and its contractors) have done the analyses and developed the course materials. When the schools have done it, the typical pattern has been to make changes, try them out and then to return to the old way. Courses have been shortened with, presumably, some cost savings; but the hoped-for improvement in proficiency did not materialize. In all services, the typical result has been an eventual return to theory based courses due in part to pressure from the field for more training in basic electronics. This pressure was readily acceeded to by the school staff who were predominately of the opinion that more basic electronics is better in the long run and who, perhaps more importantly, believed that their opinion has been validated by the data.

Some studies conducted by various agencies have used questionnaires as a means of obtaining feedback from the field concerning the assessment of training needs that could be met in the USAADS. This feedback has more often than not been opinion based, and biased by the previously described perceptual set of senior NCOs and commanders. There appeared to be different definitions of the term "theory" by the various responders.

This report describes a research effort that has addressed both the "what kind" and "how much" training questions for three MOS's, 24E Improved HAWK Fire Control Mechanic, 24H Improved HAWK Fire Control Repairman, 24J Improved HAWK Pulse Radar Repairman. The specific issue concerned was the development of an analytical process for deriving basic electronic skills and knowledge that underlie the technical job performance for these electronic maintenance MOS's. Earlier efforts by the USAF (O'Connor, 1975) attempted to achieve the same end but from a school content origination of job descriptions. The USAF assemption apparently was that all skills and knowledge that could possibly be required on the job were already included in existing course POIs. The purpose of the USAF

effort was seemingly to be able to eliminate unwanted and irrelevant content from the school courses.

The position taken in the project reported here was that for the USAADS to realize the maximum benefits of job-oriented electronics maintenance training, a method for determining what to train, especially with reference to basic electronic content, should be derived from an analyses of the actual jobs to be performed. What the student needs to be able to do on the job is purely an empirical question. However, the empirical approach to obtaining this information is time consuming, costly and requires extensive use and coordination of personnel and equipment resources. The purpose of this project, therefore, was to develop task analytical procedures, derived from an empirical approach, for determining fundamental skills and knowledge required in the performance of electronic maintenance jobs. Accordingly, the following objectives were established for achieving this purpose:

1. Identification of the task content of jobs at various maintenance levels.
2. Identification of requisite skills and knowledge for electronic maintenance tasks.
3. Development and validation of measures of electronic maintenance skills and knowledge.
4. Development of guidelines for course developers.

## Overview and Rationale for Research Approach

The assumption underlying this project was that an analytical process for deriving skills and knowledge for electronic maintenance jobs could be developed that had empirical validity. If this could be shown to be true, considerable amounts of resources and time could be saved in designing maintenance training which focused on only job relevant skills and knowledge in training. In order to ensure the validity of the analytical products, the process began with a job description and finished with an evaluation of incumbent job performance. A sequential

process was developed that first studied an entire job for an MOS. The job had previously been broken into tasks, using the Instructional Systems Design (ISD) (TRADOC PAM 350-30) definition of a task - an activity that has an identifiable beginning and end serving some meaningful purpose. Tasks were then broken into elements following the ISD process. A task element was defined as an activity (procedural step) that is performed only as part of the effort to accomplish the task objective. The isolated performance of a task element serves no meaningful purpose in and of itself. Since the ISD process essentially ends the task analysis at this point, a set of analytical procedures were developed for further analyzing task elements. Most job description reports do not present information of exactly how each task element is carried out. This was true of the MOS Data Bank (MOD-B) report for the MOS's studied in this project. The CODAP program used to analyze the MOS data was not designed to answer training design questions. Therefore, the use of the MOD-B reports for training design required several assumptions about exactly how the job was performed at the task element level of description from which skills and knowledge statements are derived. In this project each task element was examined following a sequence of analytical questions. After all tasks were analyzed to the skills and knowledge level, the results were assimilated to determine the most commonly occurring skills and knowledge. This kind of information is the desired input to training program design. When the course developer has a description of exactly which skills and knowledge are actually applied at the task element level he can design a more relevant training course.

A skill was defined here as an activity that cannot be readily performed by the general population. It is an activity that would not be found in the behavior repertoire of most people. A skill would be an activity that required practice before it could be successfully performed. It could not be carried out by simply following instructions. Knowledge was defined as information that must be recalled or recognized before a subsequent activity could be carried out. It may be

information about how to do something, where something is located or a specification/standard against which other information must be compared.

The products of the task element analysis - lists of skills and knowledge were used as the basis for a job description questionnaire. The assumption was made that if the analytical process for identifying basic skills and knowledge was valid such a questionnaire should produce a majority of positive responses to questions about their application. The development and administration of this Basic Electronic Skills and Knowledge (BESK) questionnaire was the first of a two step validation process.

The second step involved the construction and administration of a job performance test. The performance test was used as an additional means of confirming the results of the analytical process for determining basic skills and knowledge. The assumption was that if the analytical process produced valid results the most successful and more experienced job incumbents would perform better on the test than the least successful and less experienced. The test was therefore administered to samples of electronic maintenance technicians with varying amounts of experience and different ranks.

The final step of the project was to outline the analytical process as guidelines for course developers at the USAADS. The responsibility for the application of the task analytical process has not been established, but the results of the analysis will definitely serve as input to the design of maintenance training courses, at least at the level of course content decision making.

The task analytical process was not designed to include all tasks in the analysis. One of the fist steps was to select representative tasks of the MOS. This was accomplished by estimating task complexity and determing the amount of duplication of tasks in the job. Task uniqueness in terms of the kinds of components was also considered. The task selection procedures were instituted because of the time

restrictions on this project, but a modification of these procedures was included in the final guidelines.

The last point to cover in this section deals with the original requirement to determine electronic maintenance task content across skill levels within an MOS. The training and operations reality is that there are two skill levels in electronic maintenance - qualified to perform maintenance and not qualified. The USAADS trains to one skill level - qualified. The field maintenance supervisors and unit commanders do not differentiate between EPMS skill levels 2 and 3 in terms of maintenance job activities. The only differences are found in non-maintenance activities, those more related to the supervisor role. However this study of the maintenance level concept did deal with two kinds of electronic maintenance MOS's within the Improved HAWK System that imply different kinds of skills or at least different kinds of maintenance orientation. These are the mechanic and repairman technicians. But these are not part of one career progression ladder. Within these two MOS's many maintenance tasks overlap and many do not. The mechanic is system operation oriented. The repairman is chassis function oriented. The mechanic repairs and troubleshoots down to but not within the chassis. The repairman usually begins where the mechanic left off. The repairman repairs and troubleshoots down to the component level. Both, generally, must have the same kinds of fundamental electronic skills and knowledge to perform their jobs. The mechanic does have to have more knowledge of how the complete system operates.

In addition to including the two maintenance orientations as independent variables, it was decided that electronic maintenance experience would be looked at to determine whether proficiency, and thus skill level might be related to years of experience.

## SECTION II

## RESEARCH APPROACH

The report has been organized around the discussion of each of the tasks. Each discussion presents first a description of what the task was and how it was carried out. Second, there is a discussion of the results that were obtained, and last a summary of conclusions that were reached. Task 1, 2, and 3 each produced results that served as inputs to each subsequent task. Task 4 produced an outline of how to use the task analytical process model in deriving fundamental skills and knowledge that are subordinate to electronic maintenance task performance in the 24E, 24H, and 24J MOS's. The body of the report presents a description of the research project and the analytical and empirical results. Actual research instruments and products are presented in the Appendices.

### Overview of the Development of Task Analytical Process Model

The research objective of developing a Task Analytical Process Model (TAPM) for deriving fundamental skills and knowledge for electronic maintenance jobs was first analyzed for project planning. Because of the sheer magnitude of a complete analysis of all job tasks, it was deemed desirable that the process model be able to reduce the size and complexity of such an effort as much as possible and still produce complete and valid results. There are several thousand tasks that qualified technicians must be able to carry out in the maintenance of the equipment for which they are responsible. Many tasks are redundant to a great degree. For example, relay assemblies are used throughout the HAWK system in different equipment end items and chassis. The primary difference in the tasks of repairing different chassis by replacing a relay assembly deals with the specific function and location of each assembly. Since the underlying skills and knowledge that are relevant to working with an identical component are the same, the decision was made to analyze only once these tasks involving the replacement of identical components even though the components occurred at many different locations.

This preliminary thinking led to the conclusion that the model should include procedures for selecting representative tasks for detailed analysis. Task 1 was concerned with the process of identifying, evaluating and selecting representative tasks. The procedures for performing each selected tasks were validated before the detailed analysis could be conducted. Tasks were selected for analysis using a definition of criticality that included density of performance, impact on readiness status and frequency of malfunction occurrence.

With an input of validated task procedures, Task 2 was concerned with the application of the analytical model process procedures. A list of job activities was compiled and coded as each task element was examined. Only activities that could be classified as skills or the recall and recognition of information (use of knowledge) were listed. Task 2 was completed by summarizing the number of times each skill or use of knowledge occurred in the performance of the selected tasks. The development and application of the TAPM was documented so as to prepare a set of guidelines for use of the TAPM by course developers.

Task 3 was a study to validate the use of the TAPM. A performance oriented test involving the use of electronic maintenance fundamentals was developed and administered to samples of technicians in each of the MOS's. The test content was based upon the products of the TAPM analysis. Each test participant was rated by his supervisor on a set of external performance criteria. His performance test results were then compared with these ratings.

Task 4 consisted of the preparation of a set of guidelines on how to use the Task Analytical Process Model. It described how to construct a Task Identification Matrix (TIM).

## Electronic Maintenance Task Analysis

The purpose of this first task was to develop a method for selecting representative maintenance tasks. Since the MOS's selected as vehicles for this study were well documented, it was decided that a cost

effective approach would be to use the already published materials as a starting point. Table 1 presents a list of the documents that were assembled for review.

Table 1

Documents Reviewed for TIM Preparation

| MOS | Document Number and Title |
|---|---|
| ALL | AR-220-1 Missile System Availability Indicator |
| ALL | AR-611-201 Career Management |
| ALL | TM-9-1425-525 ESC Equipment Serviceability Criteria Improved HAWK |
| ALL | TM-9-1425-525-12-4 General Maintenance |
| ALL | TM-9-1425-525-34 General Maintenance |
| 24E, 24H | TM-9-1430-526-12-1 Improved Battery Control Central AN/TSW-8 |
| 24H | TM-9-1430-526-34-1 Units of Improved Battery Control Central AN/TSW-8 Tested at High Frequency Console |
| 24H | TM-9-1430-526-34-2 Improved Battery Control Central AN/TSW-8 |
| 24E, 24H | TM-9-1430-526-24P Improved Battery Control Central AN/TSW-8 |
| 24E, 24J | TM-9-1430-534-12-1 Improved Radar Set AN/MPQ-50 |
| 24J | TM-9-1430-534-34-1 Units of Improved Radar Set AN/MPQ-50, Tested at High Frequency Console |
| 24J | TM-9-1430-534-34-2 Improved Radar Set AN/MPQ-50 |
| 24E, 24J | TM-9-1430-534-24P Improved Radar Set AN/MPQ-50 |
| 24H | TM-9-1430-527-12-1 Information and Coordination Central AN/MSQ-95 |
| 24H | TM-9-1430-527-12-3 Fault Isolation Information and Coordination Central |
| 24H | TM-9-1430-527-24P Information and Coordination Central AN-MSQ-95 |
| 24E, 24J | TM-9-1430-529-12-1 Improved Radar Set AN/MPQ-51 |
| 24E, 24J | TM-9-1430-529-34-1 Units of Improved Radar Set AN/MPQ-51 Tested at High Frequency Console |
| 24J | TM-9-1430-529-34-2 Improved Radar Set AN/MPQ-51 |
| 24E, 24J | TM-9-1430-529-24P Improved Radar Set AN/MPQ-51 |

## Development of the Task Identification Matrix (TIM)

The first decision that was made in Task 1 was to limit the study to major equipment end items that were common across the mechanic and repairman jobs. Because of limited contract time it was not possible to include all equipment and items in this study. However, a full blown use of the TIM would include all system equipment for analysis. The two major equipment end items included in this project were:

Improved Battery Control Central (IBCC)

Improved Pulse Acquisition Radar (IPAR)

The 24E mechanic has responsibilities for both the IBCC and IPAR. The 24H repairman is responsible for the IBCC and the 24J for the IPAR.

When the description of the hardware items for the Air Defense System are thorough and complete the TIM should begin with a listing of equipment items down to the lowest level of authorized repair. In each end item there is a point in the breakdown of the equipment into subunits (chassis, components, or parts) where only replacement of the unit is authorized. Repair of that unit would not be authorized at the designated echelon where a job incumbent is assigned. The information about the authorization for maintenance is found in two places:

1. the Maintenance Allocation Chart in the TMs; and
2. the Parts Manuals.

In this project the information was obtained from:

TM-9-1430-526-24-P Improved Battery Control Central AN/TSW-8, Section II-Column 2-pages 2-1 through 2-207.

TM-9-1430-526-12-1 Improved Battery Control Central AN/TSW-8 Appendix B pages B-1 through B-5.

TM-9-1430-534-24P Improved Radar Set AN/MPQ-50, Section II Column 2, pages 2-1 through 2-168.

TM-9-1430-534-12-1 Improved Radar Set AN/MPQ-50, Appendix C pages C-1 through C-19.

The listing of equipment should next be grouped in some logical manner. Either a hardware grouping or a functional subsystem grouping

could be used. It was decided that the hardware grouping would work more efficiently with the IBCC and IPAR. As the subunits are placed in their appropriate group a check is made to see if the same kind of subunit had already been listed. The idea is to eliminate duplicate listing of the same kind of equipment. Since the tasks to be performed on these would be very similar, no purpose would be served by listing all individual subunits. Appendix A presents the equipment item listing in the form of a Task Identification Matrix for the IBCC and IPAR. It should also be noted that the number of duplications of each subunit is indicated in the first column following the item name.

The second step was to determine the kinds of task activities that mechanics and repairmen perform on the equipment for which they are responsible. Again the published documentation was reviewed to identify the maintenance activities that are to be performed. It was determined that there are four general categories of maintenance activites.

1. Periodic Checks
2. Preventive Maintenance
3. Malfunction Diagnosis (Troubleshooting)
4. Corrective Maintenance

Each of the categories requires various kinds of tasks be performed. Some tasks are required to be performed in more than one category. Table 2 presents a list of twelve different tasks. Two of these are seldom performed by the 24E, 24H, and 24J technicians - overhaul and rebuild. Of the remaining tasks there is some difficulty in meaningfully separating the activities. For example a larger unit may be repaired by replacing, aligning, and adjusting a smaller unit. The first administration of the complete TIM (the equipment items within groups listed vertically with tasks across the top horizontally) led to a revision where only the categories were used across the top. It was pointed out that if a technician performs one of preventive maintenance tasks, he almost always performs the others. This modification was made as a concession to data

Table 2

Definition of Maintenance Task Verbs

| | |
|---|---|
| Inspect: | To determine the serviceability of an item by examining its physical, mechanical and/or electrical characteristics and comparing the state of these characteristics with established standards. (Also to examine and to perform preventive maintenance.) |
| Test: | To verify serviceability of an item by measuring its mechanical and/or electrical characteristics and comparing these measurements with established standards. (Also to detect functional failure, to evaluate and to check.) |
| Diagnose: | To isolate a malfunctioning item (component, module, subassembly or assembly) that is the source of operational failure. (Also to troubleshoot.) |
| Service: | To perform operations, such as cleaning, charging, and adding fuel, lubricants, cooling agents and air, on a periodic schedule to keep a system in proper operating condition. (Also to perform preventive maintenance.) |
| Adjust: | To bring an operating characteristic of an item into prescribed limits by setting variable controls to the specific, proper or exact positions. |
| Align: | To adjust specified variable elements of an item to bring about optimum or desired functional performance. |
| Calibrate: | To detect and adjust any discrepancy in the accuracy of an instrument (measurement or diagnostic equipment) when compared to an instrument which is a certified standard of known accuracy. |
| Install: | To seat or fix into position an item (component, module, subassembly or assembly) in a manner to allow the proper functioning of equipment or a system. (Also to emplace.) |
| Replace: | To remove a non-functioning item and to substitute a serviceable like-type part, subassembly, module (component or assembly) in a manner to allow the proper functioning of an equipment/system. (Also to assemble and disassemble.) |
| Repair: | To restore an item to serviceable condition. Consists of maintenance services (inspect, test, service, adjust, align, calibrate, replace) or other maintenance actions |

(welding, grinding, riveting, straightening, facing, re-machining, or resurfacing) to correct specific damage, fault, malfunction, or failure in a part, subassembly, module/component/assembly, end item or system.

Overhaul: To restore an item to a completely serviceable/operational condition as prescribed by maintenance standards. This is normally the highest degree of maintenance performed by the Army. Overhaul does not normally return an item to like new condition.

Rebuild: To restore unserviceable equipment to a like-new condition in appearance, performance, and life expectancy. This is accomplished through complete disassembly of the item, inspection of all parts or components, repair or replacement of worn or unserviceable elements (items) according to original manufacturing tolerances and specifications, and subsequent reassembly of the item. Rebuild is the highest degree of material maintenance applied to Army equipment.

collection validity. The original TIM for the IBCC had over 1200 cells each of which represented a task. When job incumbents were asked to check each cell and indicate whether they performed the task and if so how often, they felt overwhelmed. Some respondents required several hours to fill out the form. Others just got it over with as quick as possible. Job incumbents felt the modified form was less cumbersome.

## Administration of the TIM

The TIM was constructed as an instrument to be used for identifying the tasks actually performed in an MOS and to gather information for input to the decision as to which tasks should be considered for detailed analysis. The TIM was first tried out administratively. Other than being cumbersome, it was found that the original list of interview questions used with the TIM had to be changed. Each of the following questions was asked during the administrative tryouts:

1. Which of the tasks in the TIM have you performed?
2. Do you use any other names (verbs) when referring to these tasks?
3. How often do you perform each of these tasks?
4. When you are performing these tasks, approximately how much time (hours) is required to complete each task?
5. If each task was not performed, what impact would there be on the operational readiness (green, amber, or red) of the system?
6. How long after your first assignment to a maintenance duty position were you required to perform each task?
7. How long did it take you to learn to perform each task?

It was found that questions 4, 5, 6, and 7 could not be answered meaningfully. The time it takes to perform a task varies with the situation and conditions. Only a few of the most experienced technicians could respond to the readiness impact question. Since the operational readiness of a system is established formally, it was decided to refer this question to the official classification scheme. Number 6 became irrelevant since the answer was confounded with the specific kind of experiences a technician had. The learning time question was also meaningless because learning

of a single task could not be separated from learning several others of a similar kind. Thus, as a result of the administrative tryout, questions 4-7 were deleted.

The TIM was next given to 20 technicians, ten mechanics and ten repairmen. The sample represented a diverse population in terms of rank, experience, length of service, age and education.

The results indicated many similarities in the kinds of maintenance activities actually performed on the job between the mechanics and repairmen. Some of this overlap was found to be due to the performance of unauthorized maintenance tasks on site. It was indicated that in many situations mechanics had to perform unauthorized repairman tasks under command pressure to keep the system operational. Other similarities are due to the fact that the repairman is authorized to perform almost all tasks that the mechanic performs.

Definite differences were also noted between the mechanic and repairman MOS's. In the interviews the mechanics indicated they use more mechanical than electronic skills, whereas the repairmen reported using more electrical than mechanical skills. The mechanic more often only removes or replaces entire units, whereas the repairman will repair the same unit.

Specifically, the results of the TIM interviews were that ten IPAR tasks had been performed at least ten times by 100% of the 24Es. All but one of the 24Js had also performed all ten of these maintenance tasks on the IPAR chassis listed below:

| Functional Group Number | Chassis Name |
|---|---|
| 1060 | Dickie Fix Amplifier |
| 1070 | Dickie Fix-Fix Amplifier |
| 1090 | Interference Blanker |
| 2405 | MTI Video Amplifier and Multivibrator |
| 2415 | Carrier Generator |

| | |
|---|---|
| 2425 | Delay Amplifier |
| 2435 | COHO Oscillator Assembly |
| 2455 | MTI Amplifier |
| 2605 | Voltage Regulator |
| 2620 | Reference Voltage Regulator |

Eighty percent of the 24E and 24H participants reported having performed various kinds of maintenance tasks ten times or more on the IBCC chassis listed below:

| Functional Group Number | Chassis Name |
|---|---|
| 1400 | Tactical Control Console |
| 1470 | 14KV Power Supply |
| 1600 | Video Amplifier |
| 2710 | 10KV Power Supply |
| 2760 | Video Amplifier |
| 2985 | Scan Servo Assembly |
| 3500 | Reference Voltage Regulator |
| 4260 | Automatic Test Set |
| 5010 | TCC/TC Video Mixer |
| 5150 | TCC/FC Clamp Gate Generator |
| 5190 | Symbol Generator |
| 6195 | Range/Speed Indicator |
| 6610 | Range Electronic Control Amplifier |
| 6710 | Elevation Electronic Control Amplifier |
| 6780 | Azimuth Electronic Control Amplifier |
| 6930 | ROR Video Amplifier |
| 7010 | ROR Sweep Generator |
| 7110 | ROR Electronic Control Amplifier |
| 7290 | Scan Servo Amplifier |
| 8600 | TCO/TCA Communications Unit |

Respondents completing the TIM were asked for additional job related information. A copy of this questionnaire is provided in Appendix A.

The responses to the questions indicated that personnel in the 24E MOS spent fifty percent of their time performing supervisory or administrative duties and fifty percent of their time performing "Hands on Maintenance". Personnel in the 24H and 24J MOS spent forty percent of their time performing administrative or supervisory duties and sixty percent of their time performing "Hands on Maintenance".

The majority of the respondees in all MOS's indicated they learned to operate and use the test equipment on the job. Many respondents claimed they were not taught in school to use the particular test equipment that they subsequently used on the job.

## Selection of Tasks for Detailed Analysis

Task 2 was conducted for the purpose of selected high density, critical and representative tasks for the detailed analysis. The TIM provided the density data in terms of the most often performed tasks by a majority of the technicians.

Criticality data was obtained from two sources, equipment readiness status and high failure rates. First, the operational readiness criteria from AR-220-1, Missile System Availability Indicator, and TM-9-1425-525 ESC, Equipment Serviceability Criteria Improved HAWK, was applied to each equipment item rather than to each task. The rationale was that if preventive maintenance and periodic checks are not performed, a debilitating problem might occur or go undetected that could lead to red-lining the system. Also, if a problem does occur to cause a system to be down, troubleshooting and corrective maintenance must be performed to get the system back on the air. Therefore, if a technician cannot perform any maintenance task when it must be performed, the operational readiness criteria for classifying the equipment status comes into play. The operational readiness criteria were applied to all items and the results are shown in Appendix A in the last column of the TIM. These results were not as helpful in narrowing the list of critical tasks as much as was the failure rate data.

Second, the US Army Missile Material Readiness Command at Redstone Arsenal has been collecting malfunction and time-to-repair data for Improved HAWK battalions in Europe over the last year or so. Table 3 presents the data from a 1977 report of the most frequently failing items in the IBCC Fire Control Console and Tactical Control Console and the IPAR. These data were being collected on a continual basis at the time of the preparation of this report.

In addition to the criticality data, one other kind of information was used for the task selection decisions. A review of the higher density tasks was conducted by a project staff member with over twenty years of electronic maintenance experience. His review had the purpose of designating those several tasks that required the same kinds of maintenance procedures. This review was made keeping in mind the lists of tasks indicated by the malfunction and time-to-repair data. The final list of tasks selected for analysis is presented in Table 4. A total of 21 tasks was selected. The second column in Table 4 indicates the number of other tasks similar to the listed task. For example, the first task is similar to 24 other tasks performed by the 24E and 24J technicians. The 21 tasks that were analyzed represented a total of 270 tasks.

Table 3

Most Frequently Malfunctioning Equipment

(Extract From US Army Missile Materiel Readiness Command Data Bank Report)

| Major Item: IPAR | | Organizational Maintenance | | | Direct Support Unit | | |
|---|---|---|---|---|---|---|---|
| Functional Group Number | Nomenclature | No. Failed | % Failed | MTTR[1/] | No. Failed | % Failed | MTTR |
| 4600 | Pressurization Unit | 31 | 13.3% | .86 | 43 | 12.7% | 3.69 |
| 1250 | Cooler Liquid | 23 | 9.9 | 1.42 | 24 | 7.1 | 2.25 |
| 2425 | Delay Amplifier | 16 | 6.9 | 1.71 | 34 | 10.1 | 2.9 |
| 2415 | Carrier Generator | 15 | 6.4 | 1.33 | 32 | 9.5 | 3.6 |
| 3550 | High Voltage Power Supply | 14 | 6.0 | 2.66 | 23 | 6.8 | 2.2 |
| 2465 | Video Integrator | 9 | 3.8 | 1.51 | 13 | 3.9 | .53 |
| 4920 | Modulator Sub. Assy. | 8 | 3.4 | 1.64 | 10 | 3.0 | 1.95 |
| 2455 | MTI Amp. | 7 | 30 | 170 | 12 | 3.6 | 4.08 |
| | [2/] | 123 | 53% | | [3/] 191 | 56.5% | |

[1/] MTTR = Mean Time to Repair (Hours)

[2/] A total of 232 equipment failures were recorded April 1 to September 30, 1977 (182 days)

[3/] A total of 338 equipment failures were recorded March 1 to September 30, 1977 (213 days)

Table 3 (cont.)

| Major Item: IBCC (TCC) | | Organizational Maintenance | | | Direct Support Unit | | |
|---|---|---|---|---|---|---|---|
| Functional Group Number | Nomenclature | No. Failed | % Failed | MTTR | No. Failed | % Failed | MTTR |
| 2985 | Scan Servo Assembly | 31 | 16.8% | 2.84 | 55 | 16.5% | 3.94 |
| 3468 | Voltage Regulator | 17 | 9.3 | 158 | 19- | 5.7 | 2.91 |
| 5310 | Symbol Multivibrator | 10 | 5.4 | 1.63 | 37 | 11.1 | 2.99 |
| 5190 | Symbol Generator | 9 | 4.9 | .62 | 20 | 6.0 | 4.18 |
| 1600 | Video Amplifier | 7 | 3.8 | 1.01 | 11 | 3.3 | 3.11 |
| 7290 | Scan Servo Amplifier | 7 | 3.8 | .75 | 9 | 2.7 | 2.27 |
| 1470 | 14KV Power Supply | 5 | 2.7 | .78 | 10 | 3.0 | 5.40 |
| 5410 | PS1 Video Gate | 5 | 2.7 | .53 | 24 | 7.2 | 3.58 |
| | | 81 | 49.71% | | 185 | 55.4% | |

Table 3 (cont.)

| Major Item: IBCC (FCC) | | Organizational Maintenance | | | Direct Support Unit | | |
|---|---|---|---|---|---|---|---|
| Functional Group Number | Nomenclature | No. Failed | % Failed | MTTR | No. Failed | % Failed | MTTR |
| 4730 | Marker Generator | 14 | 15.5% | .52 | 16 | 11.4% | 3.27 |
| 6610 | Range ECA | 11 | 12.2 | .52 | 17 | 12.1 | 4.04 |
| 7250 | Display Generator | 10 | 11.1 | 1.10 | 14 | 10.0 | 3.05 |
| 6710 | Elevation ECA | 6 | 6.6 | .83 | 10 | 7.1 | 3.61 |
| 7210 | Firing Interlock Assy. | 4 | 4.4 | .53 | 12 | 8.6 | 2.43 |
| 6780 | Azimuth ECA | 4 | 4.4 | .77 | 6 | 4.3 | 2.83 |
| 5710 | Relay Assy. (FC) | 4 | 4.4 | .88 | 6 | 4.3 | 2.42 |
| | | 53 | 58.8% | | 81 | 57.8% | |

Table 4

Tasks Selected for Detailed Analysis

| Task Number | Number Similar Tasks | Performed by MOS | |
|---|---|---|---|
| 1 | 24 | 24E<br>24J | Electrically aline the stabilizing system, STALO, and preselector in the Improved Pulse Acquisition Radar. (IPAR) |
| 2 | 4 | 24E | Aline the STALO Automatic Frequency Control (AFC) in the IPAR. |
| 3 | 24 | 24E | Aline the Scan Servo Assembly in the Improved Battery Control Central (IBCC). |
| 4 | 6 | 24E<br>(24H) | Replace and check out the Cathode Ray Tubes (CRT) in the IBCC. |
| 5 | 4 | 24E | Check Firing Console in the IBCC using weekly check procedures. |
| 6 | 12 | 24J<br>24H | Test the High Frequency Console using the self test procedures. |
| 7 | 6 | 24H | Test the Display Generator at the High Frequency Console. |
| 8 | 4 | 24H | Test the Range Speed Indicator at the High Frequency Console. |
| 9 | 30 | 24H | Test the Scan Servo Assembly at the High Frequency Console. |
| 10 | 35 | 24J | Test the AFC Amplifier at the High Frequency Console. |
| 11 | 40 | 24J | Test the IF pre-amplifier at the High Frequency Console. |
| 12 | 0 | 24J<br>24E | Replace the heat exchanger. |
| 13 | 1 | 24J | Repair the heat exchanger. |
| 14 | 2 | 24E | Replace the pressurization unit. |
| 15 | 0 | 24J | Repair the pressurization unit. |
| 16 | 36 | 24H | Test the 14KV High Voltage Power Supply at the High Frequency Console. |

Table 4 (cont.)

Tasks Selected for Detailed Analysis

| Task Number | Number Similar Tasks | Performed by MOS | |
|---|---|---|---|
| 17 | 12 | 24H | Test the Symbol Multivibrator at the High Frequency Console. |
| 18 | 4 | 24H | Test the Symbol Generator at the High Frequency Console. |
| 19 | 2 | 24H | Fault isolate the Information Coordination Central. |
| 20 | 0 | 24E<br>24J | Fault isolate the Antenna Control Circuits of the Improved Range Only Radar. |
| 21 | 3 | 24E<br>24J | Fault isolate the Improved Pulse Acquisition Radar. |

## SECTION III

## DEVELOPMENT OF THE TASK ANALYTICAL PROCESS MODEL

Most traditional approaches to task analysis have resulted in descriptions of tasks that required many assumptions of exactly how the task procedures were carried out. Training courses generated from such analytical results have been prone to errors of omission and inclusion. Some essential job skills have been omitted, while other non-relevant behaviors have been included as training subject matter.

The purpose of Task 2 was to develop an analytical process that would reduce assumptions about requisite job behaviors. The model was intended to provide a systematic and logical process for identifying basic skills and knowledge underlying successful job performance. The focus of this task was on the development and subsequent use of the process model. The Task Analytical Process Model that was developed provided a systematic approach to performing a detailed task element analysis. The assumptions that were made in using the process were:

1. Task element descriptions are valid.
2. Task element descriptions are complete.
3. The user must have sufficient job knowledge to (ask) answer the process questions.
4. The user does not have to be knowledgable in the instructional development process.
5. The user must be able to make decisions about the behavior repertoire of the general public.

The model was developed by analyzing task elements in detail from a naive point of view. The model consisted of a set of detailed questions about exactly how the task element was performed. The questions were sequential and iterative. The cyclic sequence of questioning continued until each task element was examined and a decision was made about the skill nature of the required action.

The analytical process was developed from the following general model of work activities: Input-Processing-Output. The process began with an analysis of the initiation of a task and was carried through to the completion of the task. The Input element of the general model consisted of initiating cues and situation conditions for the task. It also included the evaluation procedures that would determine when the task would be considered completed. The work flow, worker relationships and work procedures were also considered necessary parts of the Processing phase.

The Output element was defined as consisting of a finished product, which could have been a repaired, checked, serviced or replaced equipment item. A comparison of the output against the input standards would have led to a decision as to whether the activity was complete.

The sequence of steps included in the Task Analytical Process Model was structured as a flow chart presented in Figure 1.

This sequence of questions was applied to the IBCC and IPAR. It was found that there were tasks that varied in complexity from a low level to a high level as a function of the amount of implied activities. The implied activities were categorized into the following general groups:

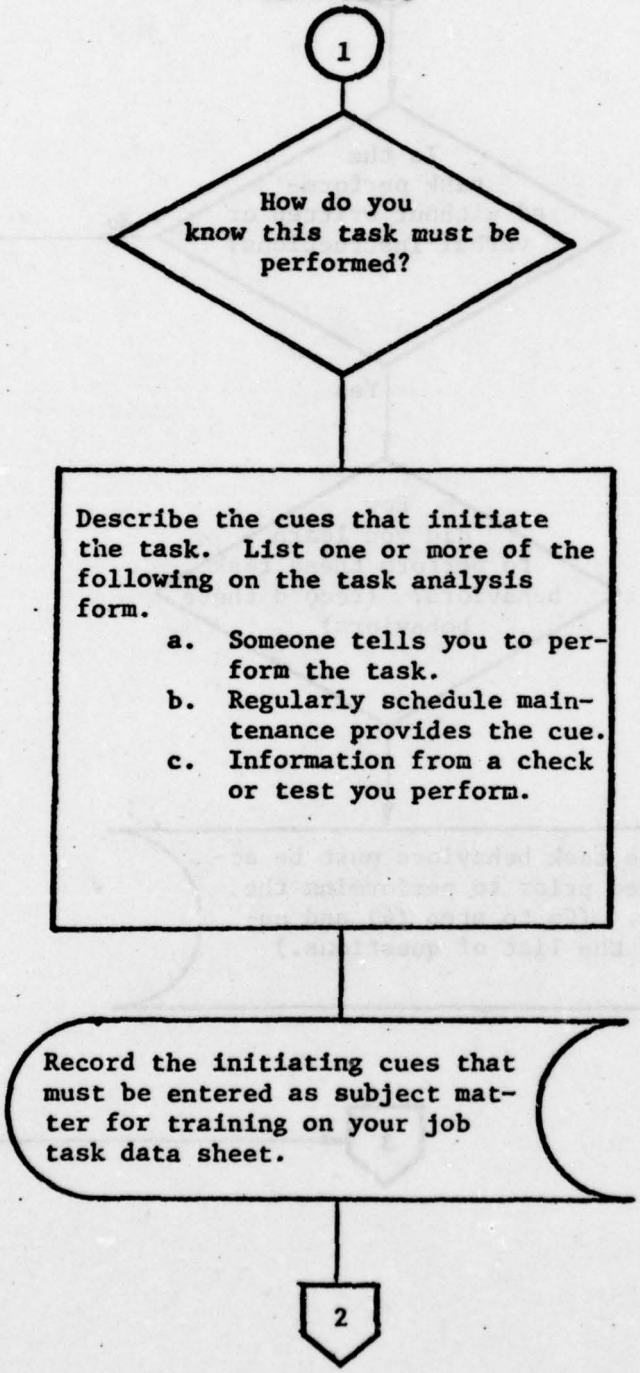
1. Skills
2. Knowledge recall and use of special information
3. System specific activities
4. Safe operating procedures
5. General work habits
6. Use of job performance aids
7. Recognition of normal and non-normal operation/cues

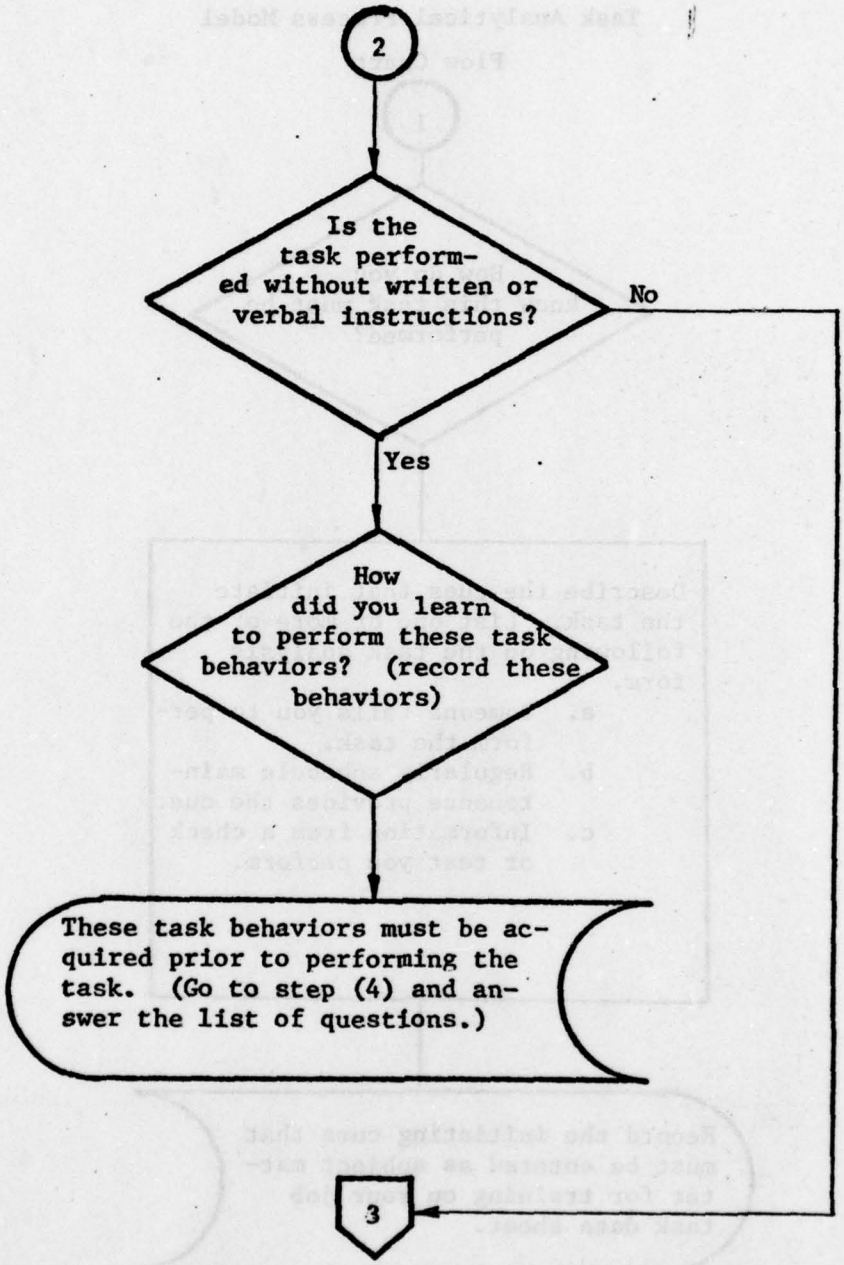
Since the focus of this study was on the determination of basic electronic skills and knowledge, the system equipment activities category was not dealt with in detail in the analyses. It should be noted, however that a qualified technician must be very familiar with the operation of his equipment, be able to diagnose system problems, and locate chassis and components within the system.

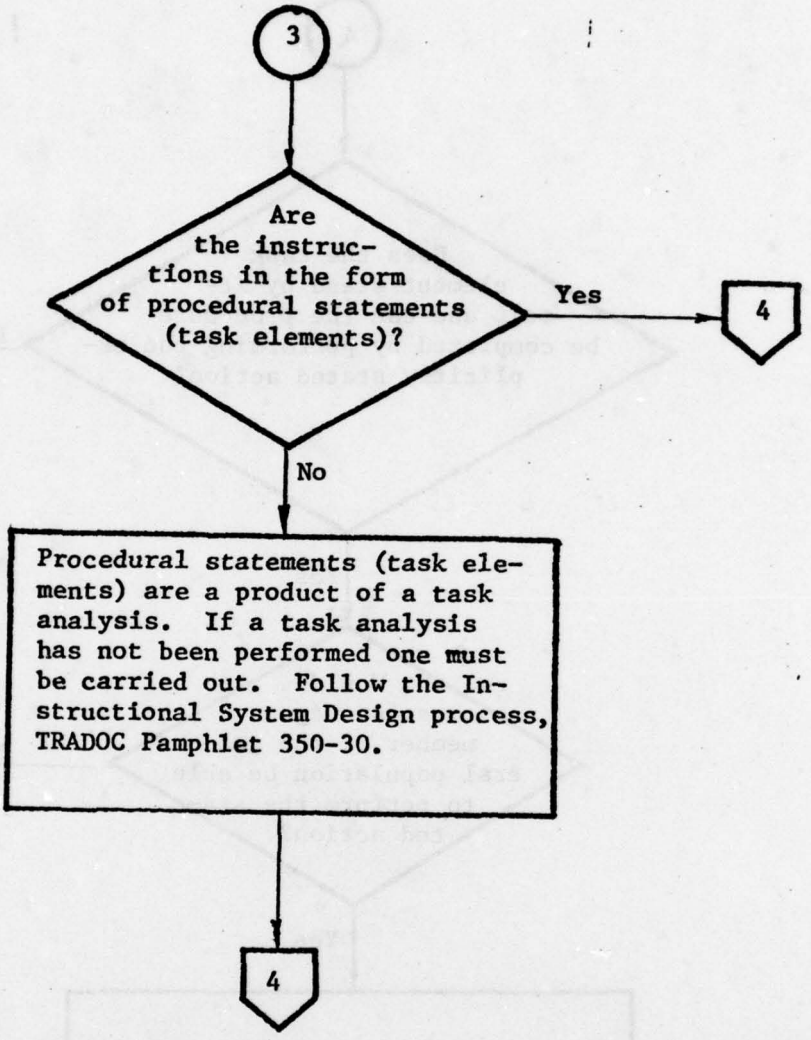
Table 7

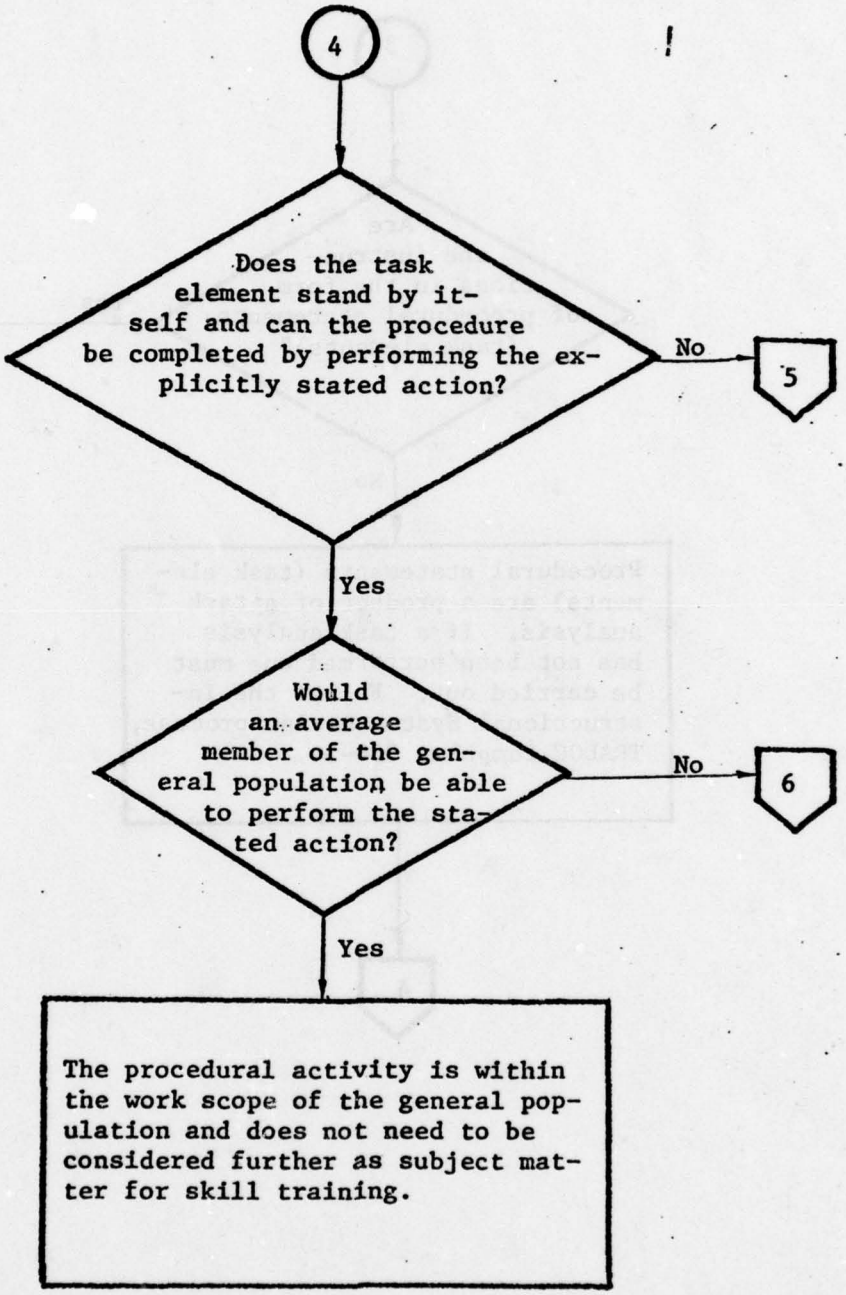
Task Analytical Process Model

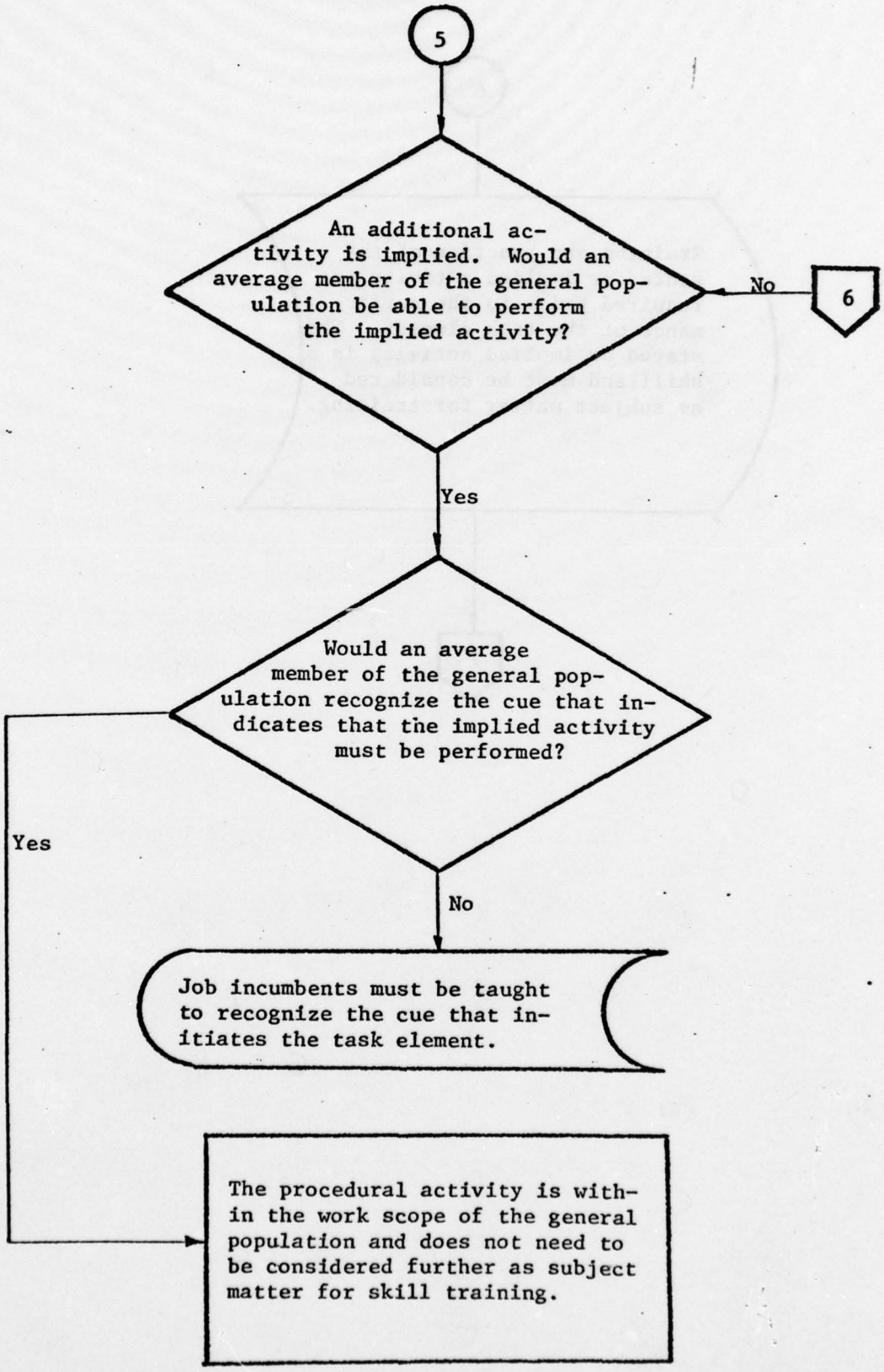
Flow Chart

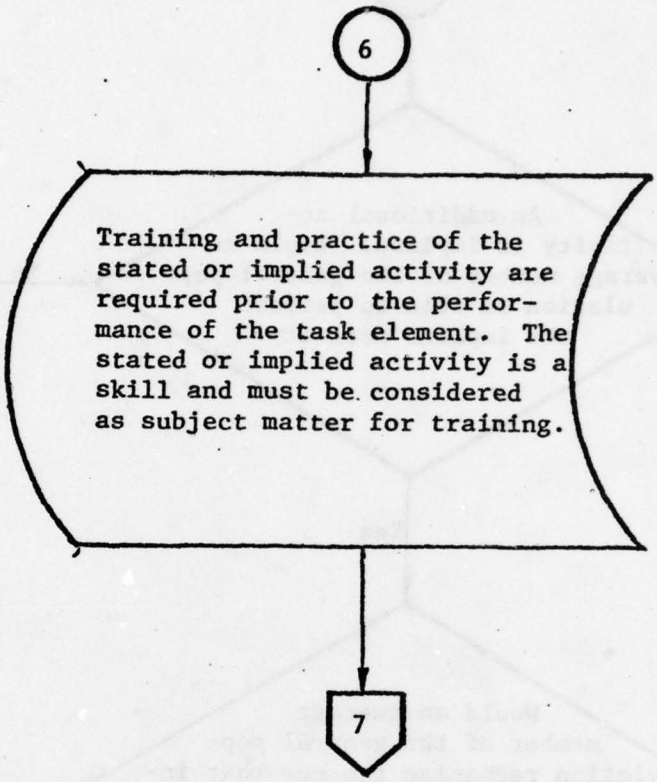


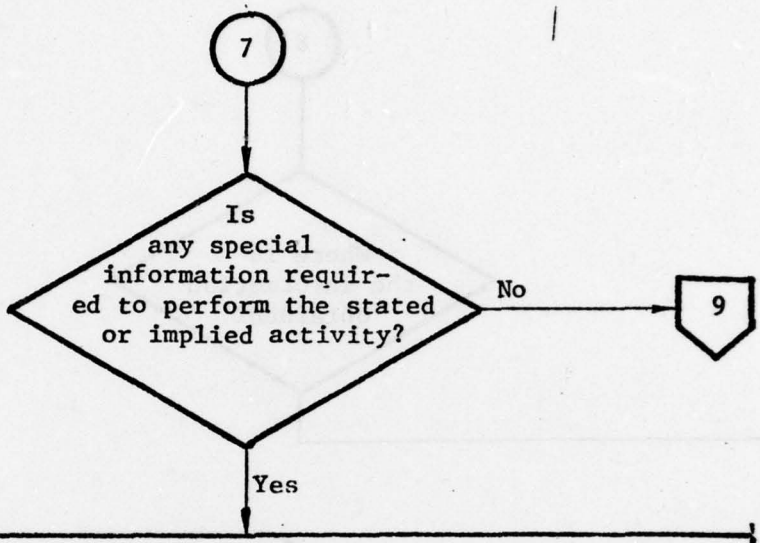

2
Is the task performed without written or verbal instructions?
No
Yes
How did you learn to perform these task behaviors? (record these behaviors)
These task behaviors must be acquired prior to performing the task. (Go to step (4) and answer the list of questions.)
3


3
Are the instruc-tions in the form of procedural statements (task elements)?
Yes
4
No
Procedural statements (task elements) are a product of a task analysis. If a task analysis has not been performed one must be carried out. Follow the Instructional System Design process, TRADOC Pamphlet 350-30.
4


4
Does the task element stand by itself and can the procedure be completed by performing the explicitly stated action?
No
5
Yes
Would an average member of the general population be able to perform the stated action?
No
6
Yes
The procedural activity is within the work scope of the general population and does not need to be considered further as subject matter for skill training.


5
An additional activity is implied. Would an average member of the general population be able to perform the implied activity?
No
6
Yes
Would an average member of the general population recognize the cue that indicates that the implied activity must be performed?
Yes
No
Job incumbents must be taught to recognize the cue that initiates the task element.
The procedural activity is within the work scope of the general population and does not need to be considered further as subject matter for skill training.


6
Training and practice of the stated or implied activity are required prior to the performance of the task element. The stated or implied activity is a skill and must be considered as subject matter for training.
7




Record the special information. The special information includes any indication or data that is used for deciding:

1. What procedural step must be performed next.

2. When an activity is completed, e.g., when the physical, mechanical or electrical characteristics of equipment are changed, how do you know when the changes have been completed? When the position of a switch has been changed the status or characteristics of the equipment item should be altered. The knowledge of what the expected changes should be is used to evaluate the result of turning the switch.

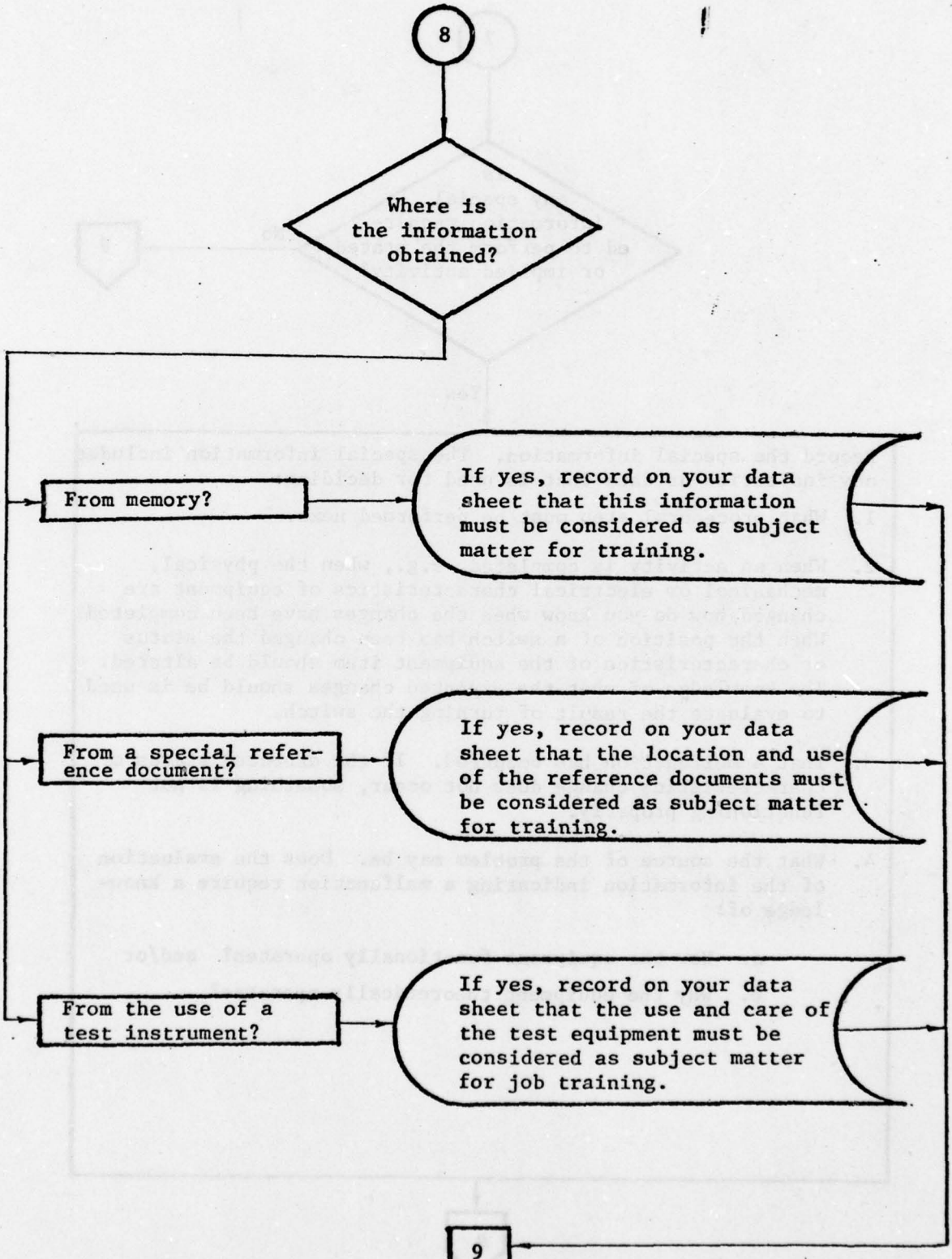
3. That a malfunction has occurred. If the expected status or characteristics change does not occur, something is not functioning properly.

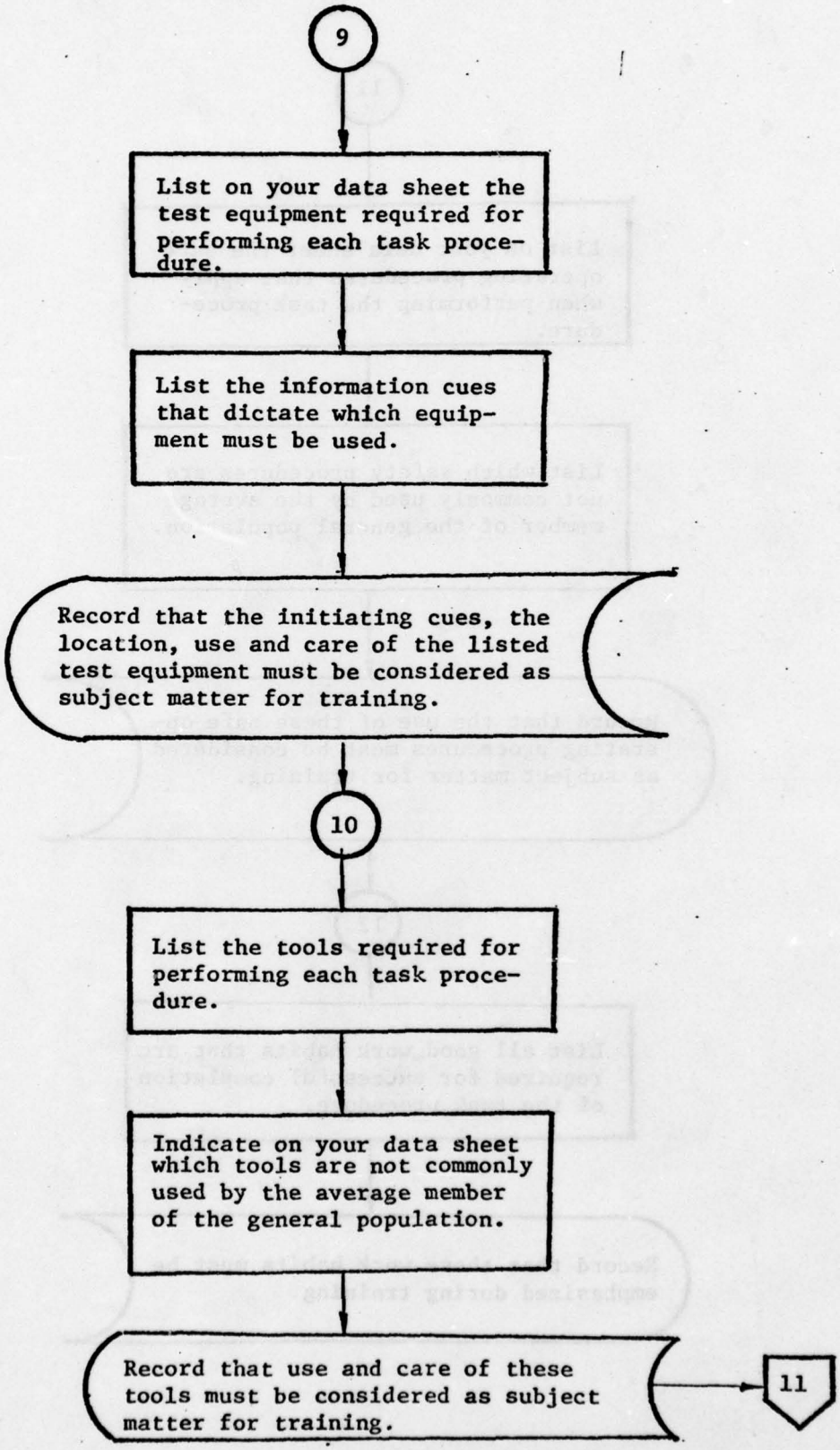
4. What the source of the problem may be. Does the evaluation of the information indicating a malfunction require a knowledge of:

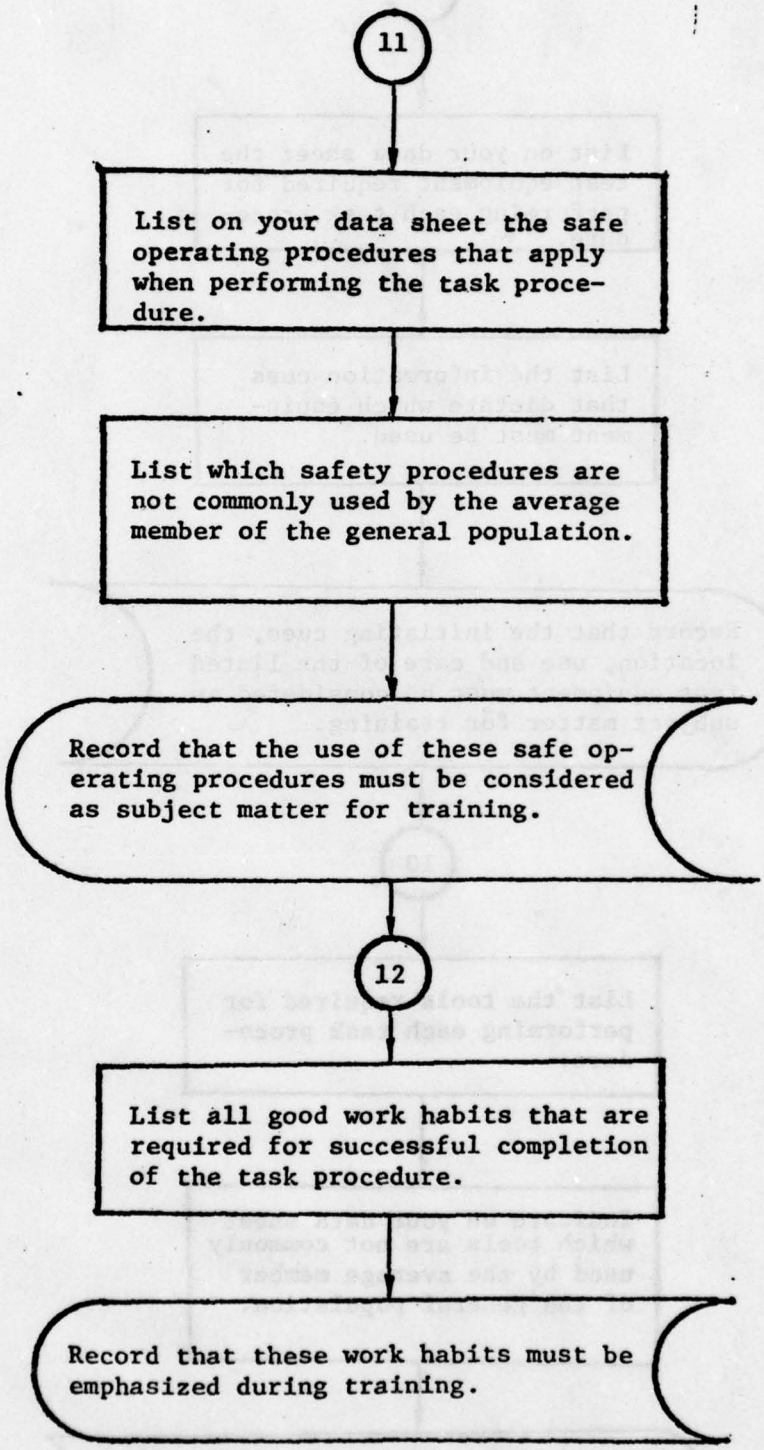
    a. How the equipment functionally operates? and/or

    b. Why the equipment theoretically operates?




8
Where is the information obtained?
From memory?
If yes, record on your data sheet that this information must be considered as subject matter for training.
From a special reference document?
If yes, record on your data sheet that the location and use of the reference documents must be considered as subject matter for training.
From the use of a test instrument?
If yes, record on your data sheet that the use and care of the test equipment must be considered as subject matter for job training.
9


9
List on your data sheet the test equipment required for performing each task procedure.
List the information cues that dictate which equipment must be used.
Record that the initiating cues, the location, use and care of the listed test equipment must be considered as subject matter for training.
10
List the tools required for performing each task procedure.
Indicate on your data sheet which tools are not commonly used by the average member of the general population.
Record that use and care of these tools must be considered as subject matter for training.
11


11
List on your data sheet the safe operating procedures that apply when performing the task procedure.
List which safety procedures are not commonly used by the average member of the general population.
Record that the use of these safe operating procedures must be considered as subject matter for training.
12
List all good work habits that are required for successful completion of the task procedure.
Record that these work habits must be emphasized during training.

Category 4, Safe Operating Procedures, and Category 5, General Work Habits were defined in terms of specific behavoir statements (See Appendix B). Safe operating procedures and good work habits were defined as behaviors that were required to be performed whenever appropriate. The application of these behaviors were considered to reflect a general positive and responsible attitude toward the maintenance job. These were not individual behaviors that could be meaningfully counted in an analysis of maintenance task procedures. Rather, they were noted as being necessary to the overall success of the job.

Category 7, Recognition of Cues, actually referred to a basic assumtion that there were normal and non-normal operating conditions. This concept was considered to underlie preventative maintenance, periodic checks and troubleshooting in the sense that the sooner non-normal functioning could be predicted or detected the better. Being alert to signals of operational functioning and malfunctioning was considered a general work habit, but it was singled out as a behavior that should be taught rather than just an attitude.

Job Performance Aids, Category 6, referred to any kind of formal job assistance that would be available to the technician on the job. Included were reference manuals, charts, troubleshooting guides, coded schematic diagrams, etc.

One special skill that included the use of subordinate skills was malfunction diagnosis. Several approaches to troubleshooting had been proposed over the years including the use of job performance aids. The analysis here resulted in this skill being described as a problem solving exercise. An outline is presented in Appendix B to represent a general approach to describing the diagnostic process.

As the use of the analysis process model proceded, it became difficult to differentiate between a skill and a knowledge, so the distinction was essentially dropped. As the TAPM questions were asked, specific behavioral statements were prepared as responses and given a code desig-

nation. Nine categories of statements resulted from the use of the model:

B-1 Electronic Concepts
B-2 Tools
B-3 Hardware
B-4 Test Equipment
B-5 Mechanical Skills
B-6 Mathematical Concepts
B-7 Electronic Components
B-8 Electronic Circuits
B-9 General Electrical and Mechanical Equipment

These category titles were choosen to indicate the content focus of a set of skill and knowledge statements. The specific statements for each category are presented as Appendix B.

The task analytical process model was applied quantitatively to 18 of the 21 IBCC and IPAR tasks. Across these eighteen tasks, the analysis resulted in the identification of 11,507 applications of a skilled behavior or the recall and use of special information. The summary of this analysis is presented in Table 5. The nine skill and knowledge categories are listed in the left column. The total application of skills and knowledge from each category is listed in the right hand column. Table 5 presents the number of times during the analysis of each task that skills and knowledge in each of the nine categories were counted as being applied in the performance of the task procedures. Skills and knowledge dealing with electronic components were found to be applied 4,876 times, more than any other category. The use of electronic concepts was found to occur 3,074 times.

The most complex, in terms of the use of skills and knowledge was task 7, which required twice as many applications as any other task. A detailed breakout of this summary is presented in Appendix C.

Table 5

Summary of the Detailed Skills and Knowledge Results from the Use of the Task Analytical Process Model

| Skill Knowledges Categories | Tasks | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Total each task | 858 | 190 | 172 | 237 | 1060 | 1118 | 2820 | 370 | 420 |
| B-1 Electronic Concepts | 87 | 26 | 29 | 37 | 221 | 284 | 960 | 63 | 79 |
| B-2 Tools | 112 | 8 | 17 | 27 | 32 | 21 | 17 | 31 | 31 |
| B-3 Hardware | 3 | 12 | 14 | 32 | - | - | - | - | 8 |
| B-4 Test Equipment | 93 | 30 | 1 | - | 4 | 182 | 556 | 30 | 63 |
| B-5 Mechanical Skills | 48 | 4 | 17 | - | 31 | 33 | 22 | 20 | 73 |
| B-6 Mathematical Concepts | 3 | - | - | - | - | 82 | 291 | 19 | 38 |
| B-7 Electronic Components | 497 | 107 | 77 | 138 | 770 | 514 | 961 | 201 | 108 |
| B-8 Electronic Circuits | 3 | 3 | 3 | 3 | 2 | 2 | 13 | 6 | 3 |
| B-9 Electronic Circuits | 12 | - | 14 | - | - | - | - | - | 17 |

Table 5 (cont.)

| | Tasks | | | | | | | | | Total Across Tasks |
|---|---|---|---|---|---|---|---|---|---|---|
| | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | |
| | 503 | 684 | 55 | 116 | 97 | 104 | 336 | 1046 | 1318 | 11,507 |
| B-1 | 96 | 209 | 6 | 27 | 20 | 27 | 123 | 372 | 408 | 3,074 |
| B-2 | 28 | 8 | 6 | 14 | 13 | 14 | 38 | 12 | 33 | 462 |
| B-3 | - | 6 | 14 | 20 | 28 | 16 | 13 | 11 | 25 | 202 |
| B-4 | 101 | 88 | - | 4 | - | 4 | 28 | 170 | 201 | 1,555 |
| B-5 | 9 | 12 | 9 | 17 | 20 | 17 | 5 | 16 | 17 | 370 |
| B-6 | 74 | 40 | 3 | 2 | 2 | 2 | 2 | 64 | 142 | 764 |
| B-7 | 189 | 292 | 10 | 27 | 10 | 18 | 107 | 381 | 469 | 4,876 |
| B-8 | 6 | 29 | - | - | - | - | 20 | 20 | 20 | 133 |
| B-9 | - | - | 7 | 5 | 4 | 6 | - | 3 | 3 | 71 |

Three additional tasks were selected and analyzed because of their unique skills and knowledge requirements. Task 19, Troubleshoot the Information Co-ordination Central, was selected because it dealt with special digital technology skills and knowledge that were required in the 24H MOS. The rationale for selecting this special task was that fundamental digital technology skills and knowledge are proper subject matter for basic electronics training and therefore the task should be analyzed to identify skills and knowledge that could differentiate between MOS's.

The other tasks, Task 20, Perform Troubleshooting of the Antenna Control Circuits of the Improved Range Only Radar, and Task 21, Perform Troubleshooting of the Improved Pulse Acquisition Radar, were selected for unique requirements of knowledge and skills with antenna control circuits (Task 20) and Radar Transmitter and receiver operation (Task 21).

These three tasks served as examples where special basic skills may be needed in one MOS but not in related MOS's.

## Electronic Maintenance Job Fundamentals Questionnaire

The results of the task element analysis led to the preparation of statements describing fundamental skills and knowledge that were determined to logically underlie electronic maintenance job performance. As a check of the validity of the results of the logical analysis, these statements were organized into the form of a questionnaire, which was then administered to technicians from the 24E, 24H, and 24J MOS's.

The Electronic Maintenance Job Description Survey consisted of a total of 556 items dealing with work behaviors. The complete questionnaire is presented in Appendix D. Thirty eight of the items described general work habits and safety procedures. The remaining 518 items were skill and knowledge statements. The skill and knowledge items were clustered in 36 topic groups (see Table 6). It was decided to use the same form of the questionnaire for all three MOS's. This added a validity check to the data. Some items were MOS specific and the rationale

for their use was that only technicians with the MOS's should respond to these items. This provided a validity check for the questionnaire results in that technicians with another MOS should not respond to other MOS specific items.

The questionnaire was divided into three sections. The first was a background information section. Only part of this information was actually used in the analysis because of the small number of responses to some items. The second section asked for ratings of the importance of each item to overall job success. The third section asked the technician to indicate whether or not he had performed the activity described.

The questionnaire was first given an administrative tryout with only a few subsequent modifications being made. The validation tryout was administered as follows:

| | Ft. Bliss | Redstone | Total |
|---|---|---|---|
| 24E | 20 | | 20 |
| 24H | 8 | 7 | 15 |
| 24J | | 15 | 15 |
| | | | 50 |

A high degree of agreement was found between the results of the task element analysis and the responses to the Job Description Survey. Table 6 presents the summary of the survey responses. There were a total of 518 skills and knowledge items in the survey. Samples of technicians in each MOS indicated whether they performed the behavior in each statement. A total of 454 of the items were reported as being performed by more than 50% of the 24E mechanics. This was 88% of all items. Totals of 422 (81%) and 474 (92%) items were performed by over 50% of the 24H and 24J, respectively. Because the same survey questionnaire was used across these three MOS's, some items were not applicable to all MOS's. Therefore, 100% affirmative responses was not expected within any MOS.

Looking at the results for individual item clusters in Table 6 revealed more differences between the 24H MOS and the other two, which again was expected. The 24E and 24J technicians are responsible for a larger number of the same pieces of equipment. Almost all items derived from the logical task element analysis within each MOS were reported as being performed by 90% or more of the technicians (for the items relevant to their MOS). The results in terms of percent performing each item is presented in Appendix E.

The question of whether a technician should have understanding of the "why an electronic component or circuit works at the electron level" question has had its proponents and opponents over the years. The task element analysis indicated that a technician needs to know how a circuit, component or chassis operates, but does not need to know why they function at the electron level. However, individual technicians have cited special problem situations where the best available solution essentially required design theory knowledge. It also became apparent in this project that the more experience and the more education a technician had, the more he felt that the electron theory knowledge was needed for successful maintenance performance.

Accordingly, the questionnaire included statements concerning the use of both "how it operates" and "why it functions" kinds of knowledge. Items TH19-1 through TH19-26 presented these kinds of questions. Generally, a higher percent of technicians answer that they refer to or apply information about how something works than they do why something works. (See Appendix E).

The information presented in Appendix E can be used to establish priorities for selecting content for maintenance training courses. For example some material would be given lower priority with reference to actual application on the job. Table 7 presents an example of skills and knowledge that were reported as being seldomly applied by the 24E technicians.

Table 6

Electronic Maintenance

Job Description Survey

Skills and Knowledge Clusters

| Cluster Code | Cluster Topic | Total # of items | # of items over 50% | | |
|---|---|---|---|---|---|
| | | | 24E | 24H | 24J |
| B1 | Electronic terms | 22 | 21 | 19 | 22 |
| B2 | Measurement units | 7 | 6 | 7 | 7 |
| B3 | Electrical circuits | 2 | 2 | 2 | 2 |
| B4 | Vacuum tube circuits | 12 | 12 | 12 | 12 |
| B5 | Solid state circuits | 11 | 10 | 11 | 7 |
| B6 | Microwave circuits | 8 | 8 | 4 | 8 |
| B7 | Electrical items | 20 | 20 | 16 | 20 |
| B8 | Test equipment | 15 | 12 | 9 | 15 |
| B9 | High frequency console | 12 | 1 | 12 | 12 |
| T10 | Tools | 22 | 18 | 19 | 20 |
| M11 | Mechanical items | 22 | 22 | 15 | 22 |
| MC12 | Mathematical and measurement concepts | 43 | 28 | 36 | 32 |
| SC13 | Electronic symbols and designations | 11 | 11 | 11 | 11 |
| SC14 | Schematic symbols | 140 | 121 | 106 | 120 |
| SC15 | Schematic reference designations | 46 | 46 | 45 | 46 |
| B16 | General Electronic maintenance procedures | 13 | 12 | 13 | 13 |
| I17 | Information use | 9 | 9 | 9 | 9 |
| Th18 | Theory Use | 26 | 26 | 17 | 26 |
| EE19 | Transmitters | 7 | 7 | 0 | 7 |
| EE20 | Receivers | 7 | 7 | 0 | 7 |
| EE21 | Electric motors | 7 | 5 | 7 | 5 |
| EC22 | Cathode ray tubes | 4 | 4 | 3 | 4 |
| EC23 | Vacuum tubes | 3 | 3 | 3 | 3 |
| EC24 | Resistors | 4 | 4 | 4 | 4 |

| Cluster Code | Cluster Topic | Total # of items | # of items over 50% 24E | 24H | 24J |
|---|---|---|---|---|---|
| EC25 | Capacitors | 4 | 3 | 4 | 4 |
| EC26 | Diodes | 3 | 3 | 3 | 3 |
| EC27 | Transformers | 3 | 3 | 3 | 3 |
| EC28 | Relays | 3 | 3 | 3 | 3 |
| EC29 | Circuit cards | 4 | 3 | 3 | 3 |
| EC30 | Switches | 3 | 3 | 3 | 3 |
| EC31 | Fuses | 3 | 3 | 3 | 3 |
| EC32 | Lamps | 3 | 3 | 3 | 3 |
| EC33 | Connectors | 4 | 4 | 4 | 4 |
| EC34 | Power cables | 5 | 3 | 5 | 3 |
| EC35 | Data cables | 5 | 3 | 3 | 3 |
| EC36 | Coaxial cables | 5 | 5 | 5 | 5 |
| | Total | 518 | 454 (88%) | 422 (81%) | 474 (92%) |

Table 7

Skills and Knowledge Reported Used by Less Than 50%
of The 24E Technicians

Using or referring to the following:

| | | | |
|---|---|---|---|
| Bandpass | 40% | Rectangle | 35% |
| Henries | 40 | Right triangle | 35 |
| N nano | 50 | Nano-seconds | 30 |
| Square root | 25 | Binary numbers | 45 |
| Square of a number | 30 | Octal numbers | 25 |
| Algebra equations | 15 | Hexidecimal | 25 |
| Radius of a circle | 50 | Boolean algebra | 30 |
| Minutes in a degree | 30 | Logic diagrams | 50 |
| Perimeter of a circle | 40 | Truth tables | 35 |
| Intersect | 50 | Parallax theory | 55 |
| Rank order | 40 | | |

Performing the following:

| | | | |
|---|---|---|---|
| Adjust electric motors | 45% | Repair circuit cards | 20% |
| Select capacitors by color code | 45 | Fabricate power cables | 20 |
| | | Repair data cables | 35 |
| Remove/replace electric motors | 40 | Fabricate data cables | 15 |
| Repairing adder circuits | 40 | | |

Using the following:

| | | | |
|---|---|---|---|
| Stop watch | 50% | Thickness gauge | 40% |
| High frequency console | 10 | Dial indicators | 50 |
| Rulers | 50 | Card extractors | 40 |

## SECTION IV
## NON-FUNCTIONALLY RELATED EVALUATION CRITERIA

In the introduction of this report it was mentioned that field commanders and supervisors possibly had a different set from which they evaluate maintenance competency. This perceptual set was laced with beliefs about how a "good" technician should behave on the job. On the negative side, the set also included beliefs about the undesirable behaviors of the inadequate technician. One such positive belief was that the good technician will do what he has to do to keep the system on the air. Also, he will take the initiative and make the decision to perform unauthorized maintenance tasks. He will work long hours, staying on the job until the system is up again. The good technician also looks good; is neat, keeps his work area neat and clean, is careful in his work, etc.

One phase of this research project was to identify non-functionally related job performance evaluation criteria and determine the extent of the relationship between ratings with these criteria and actual task element performance. The non-functionally related evaluation criteria were identified in a series of interviews with officer, warrant officer, non-commissioned officer and enlisted personnel. The interview questions are presented in Appendix F (pages F1 & F2). These questions were used to guide the interview only. The purpose of asking questions was to stimulate the thinking of those interviewed. The desired result was an extensive list of evaluation or comparative statements reflecting perceived differences between "good" and "poor" electronic maintenance technicians.

Interviews were conducted at Ft. Bliss and at Redstone Arsenal. The grades of the interviewees varied from E-4 to E-5. All supervisors and commanders interviewed had had field experience, some with several years on-site.

Three kinds of information were obtained. First, evaluative and comparative information was obtained for the purpose of constructing

evaluation criteria statements. Second, descriptions of field units with good as well as poor maintenance programs were recorded. And third, information reflecting technician and supervisors beliefs about the school training programs was volunteered.

The interviews were successful in that the desired information was obtained. There was a high degree of consistency in the responses from over 30 interviewees. The most agreement was found with the statement that new school graduates are almost always not qualified to perform maintenance. The consensus was that it generally takes from one to five months to qualify the new school graduates so they can be given responsibility for maintenance within a unit. Some individuals never become qualified, always working in an assistant role.

The interview results were used to construct a questionnaire with 51 items (Appendix F, pages F3 to F7). Many of the statements reflect the use of good work habits and safe operating procedures. Other items are statements of attitudes toward work and especially toward maintenance. The remaining items can be classified as behaviors that represent personality characteristics.

The questionnaire was then administered to a total of 56 supervisors and commanders at Ft. Bliss and Redstone Arsenal. For this administration the questionnaire called for an indication of how important, on a scale of 0 to 10, each item was for use as an evaluation criterion. The purpose of the administration was to obtain data, to be used for selecting the most important evaluation criteria. Twenty items rated as the most important by the 56 supervisors and commanders were used to construct a shorter evaluation form. The short form with the assessment scale is included in Appendix F (F-8-F-10).

A summary of the results of the administration of the 51 item questionnaire to the 56 supervisors and commanders is presented in Table 8.

Table 8

Mean Importance Ratings on Evaluation Criteria Statements

| Statement Number */ | Fort Bliss | | | Redstone Arsenal | | |
|---|---|---|---|---|---|---|
| | NCO | Warrant Officer's | Company Grade Officer's | NCO | Warrant Officer's | Company Grade Officer's |
| 1. | 9.6 | 9.8 | 9.1 | 7.8 | 7.8 | 8.0 |
| 2. | 9.6 | 7.8 | 7.0 | 8.1 | 7.8 | 7.6 |
| 3. | 9.0 | 8.2 | 9.0 | 8.1 | 7.6 | 8.2 |
| 4. | 8.1 | 6.6 | 5.7 | 7.7 | 6.5 | 8.2 |
| 5. | 9.0 | 7.7 | 7.0 | 8.1 | 6.8 | 6.6 |
| 6. | 8.9 | 8.0 | 7.8 | 8.7 | 7.6 | 8.8 |
| 7. | 8.6 | 8.5 | 7.5 | 8.2 | 7.1 | 7.2 |
| 8. | 8.7 | 8.2 | 6.7 | 8.1 | 7.3 | 8.2 |
| 9. | 8.9 | 8.6 | 6.7 | 8.2 | 7.8 | 7.0 |
| 10. | 9.7 | 8.2 | 8.2 | 8.7 | 7.1 | 8.0 |
| 11. | 7.5 | 8.5 | 7.0 | 8.7 | 8.0 | 8.2 |
| 12. | 9.5 | 8.8 | 7.8 | 8.9 | 8.3 | 8.2 |
| 13. | 7.5 | 7.8 | 6.7 | 7.8 | 8.0 | 6.0 |
| 14. | 9.5 | 9.6 | 7.7 | 9.0 | 8.6 | 7.8 |
| 15. | 7.5 | 7.5 | 6.7 | 7.4 | 6.6 | 4.6 |
| 16. | 9.2 | 9.2 | 8.8 | 8.7 | 7.8 | 7.0 |
| 17. | 8.5 | 7.6 | 6.7 | 8.6 | 7.5 | 7.8 |

*/ See Appendix F (pages F-3-F-7) for statements

Table 8 (cont.)

| Statement Number | Fort Bliss | | | Redstone Arsenal | | |
|---|---|---|---|---|---|---|
| | NCO | Warrant Officer's | Company Grade Officer's | NCO | Warrant Officer's | Company Grade Officer's |
| 18. | 8.3 | 7.7 | 6.0 | 8.1 | 6.8 | 7.6 |
| 19. | 9.1 | 8.0 | 7.0 | 7.6 | 6.7 | 8.2 |
| 20. | 9.8 | 8.5 | 8.3 | 8.5 | 7.8 | 7.8 |
| 21. | 9.5 | 8.1 | 7.4 | 8.6 | 8.0 | 6.4 |
| 22. | 9.9 | 9.4 | 8.3 | 9.2 | 8.5 | 8.8 |
| 23. | 9.0 | 8.1 | 7.9 | 8.5 | 8.8 | 8.4 |
| 24. | 7.9 | 7.9 | 4.9 | 6.8 | 5.8 | 2.4 |
| 25. | 8.1 | 7.2 | 5.7 | 8.2 | 7.3 | 7.4 |
| 26. | 9.3 | 9.6 | 8.4 | 9.2 | 8.8 | 8.4 |
| 27. | 8.7 | 9.9 | 9.1 | 8.6 | 8.5 | 7.8 |
| 28. | 9.1 | 9.5 | 8.3 | 8.8 | 8.5 | 7.0 |
| 29. | 8.8 | 9.4 | 8.7 | 8.5 | 8.7 | 8.2 |
| 30. | 8.5 | 7.7 | 5.1 | 7.5 | 7.7 | 6.0 |
| 31. | 6.6 | 5.2 | 7.0 | 7.5 | 7.7 | 3.6 |
| 32. | 9.4 | 8.4 | 8.9 | 9.1 | 7.5 | 7.6 |
| 33. | 9.7 | 8.9 | 8.6 | 9.1 | 8.3 | 9.2 |
| 34. | 8.9 | 8.2 | 7.6 | 8.5 | 7.7 | 5.8 |

Table 8 (cont.)

| Statement Number | Fort Bliss | | | Redstone Arsenal | | |
|---|---|---|---|---|---|---|
| | NCO | Warrant Officer's | Company Grade Officer's | NCO | Warrant Officer's | Company Grade Officer's |
| 35. | 8.6 | 8.4 | 8.3 | 8.2 | 8.2 | 7.6 |
| 36. | 8.6 | 8.9 | 7.6 | 8.8 | 7.7 | 8.6 |
| 37. | 9.1 | 9.1 | 7.6 | 8.8 | 8.2 | 8.8 |
| 38. | 9.0 | 9.2 | 8.4 | 8.9 | 9.2 | 8.2 |
| 39. | 8.0 | 7.7 | 7.6 | 8.5 | 7.5 | 6.6 |
| 40. | 8.3 | 7.7 | 5.7 | 8.1 | 7.2 | 6.2 |
| 41. | 8.9 | 8.9 | 6.3 | 8.2 | 7.3 | 5.4 |
| 42. | 9.0 | 8.2 | 7.4 | 8.8 | 7.5 | 8.0 |
| 43. | 9.4 | 9.5 | 7.1 | 8.5 | 8.0 | 7.8 |
| 44. | 9.0 | 8.5 | 7.7 | 8.4 | 7.3 | 5.8 |
| 45. | 7.2 | 4.4 | 2.7 | 6.4 | 4.3 | 1.2 |
| 46. | 8.7 | 8.0 | 6.6 | 7.3 | 6.8 | 4.2 |
| 47. | 8.7 | 7.0 | 7.0 | 9.0 | 6.8 | 8.8 |
| 48. | 9.2 | 8.4 | 8.4 | 8.6 | 8.5 | 8.0 |
| 49. | 9.2 | 8.4 | 7.9 | 8.6 | 6.5 | 7.0 |
| 50. | 9.1 | 8.5 | 8.1 | 8.4 | 7.3 | 8.4 |
| 51. | 9.4 | 8.6 | 7.7 | 8.5 | 8.8 | 7.8 |

The results were broken out by administration location and by rank groups. The location data may be interpreted as the relevance of the statements for evaluating mechanics (Ft. Bliss data) and repairmen (Redstone data). The difference in results for rank groups can be interpreted as indicating different points of view. The NCO's and warrants, being technicians themselves, would be expected to be more concerned with those statements that would promote quality work as well as job responsibility. The company grade officers would be expected to rate items higher than would be relevant to management problems and issues.

The interpretation of the results tended to confirm the above hypotheses. Although there was no significant overall differences between Ft. Bliss and Redstone Arsenal responses, a few items reflecting MOS specific responsibilities were rated differently. For example, item 1, "Quickly and correctly identifies malfunction causes," was rated at 9.7 by Ft. Bliss NCO's and WO's, but only 7.8 by Redstone NCO's and WO's. The 24E is responsible for system troubleshooting which has command pressure to be done as quickly as possible, whereas the 24H's and 24J's working in a support unit do not generally have the same pressures. Other differences between Fort Bliss and Redstone responses were:

| Item # | | F.B. | R.A. |
|---|---|---|---|
| 19 | Emotionally mature | 8.6 | 7.1 |
| 43 | Preventive maintenance | 9.5 | 8.3 |
| 46 | Recognizes unusual conditions | 8.4 | 7.0 |
| 49 | Keeps work clean | 8.8 | 7.6 |

The company grade officers tended to rate the following kinds of items higher than other items:

| Item # | |
|---|---|
| 1 | Quickly identifies malfunction |
| 2 | Clear understanding of job objectives |
| 3 | Performs mechanical tasks correctly |
| 7 | Meets time schedules |

| Item # | |
|---|---|
| 10 | Performs all work needed to be done |
| 16 | Does not make wild guesses |
| 20 | Has high level of persistence |
| 22 | Is reliable |
| 27 | Logical in troubleshooting |
| 32 | Is honest |
| 33 | Keeps supervisor informed |

NCO's and WO's tended to rate maintenance related items higher than did officers.

| Item # | |
|---|---|
| 11 | Replaces all hardware |
| 34 | Plans the job |
| 36 | Uses correct references |
| 40 | Helps others with maintenance problems |
| 41 | High level of work endurance |
| 43 | Performs all preventive maintenance |
| 46 | Recognizes unusual conditions |

Only a few of the items were given relatively low rating. Some of the items with lower ratings were:

| Item # | | |
|---|---|---|
| 15 | Interacts with little or no conflict | 6.8 |
| 24 | He is well educated | 6.0 |
| 31 | Does not take short cuts | 6.1 |
| 45 | Has a wide range of interests | 3.4 |

In summary, it appeared that there are non-functionally related criteria that supervisors and managers would use for rating technicians.

## SECTION V

## SKILLS AND KNOWLEDGE VALIDATION

The task analytical process model was validated using a performance oriented test constructed from the 551 item job description survey questionnaire. The test consisted of 66 items divided into 9 sections, each section calling for the performance of different fundamental electronic activities. Some items were knowledge oriented and others skill oriented. A copy of the test form is included in Appendix G. The test instructions and test layout is also included in Appendix G. An outline of the test by section is presented in Table 9.

Table 9

Performance Test Outline

| Test Section Number | Evaluation Categories | # of items |
|---|---|---|
| 1 | Component Location on Schematic Diagram | 20 |
| 2 | Definition of Electronic Terms | 20 |
| 3 | Read Color Code of Resistors | 2 |
| 4 | Conversion of Measurement Units | 5 |
| 5 | Continuity Check - PSM-6 | 8 |
| 6 | Component Check - DVM | 8 |
| 7 | Circuit Check - TS-505 | 1 |
| 8 | Circuit Check - Oscilloscope | 1 |
| 9 | Troubleshoot Chassis | 1 |

The performance test was given an administrative tryout using 20 24E, 5 24H, and 5 24J technicians at Ft. Bliss. A few administrative changes were made before the conduct of the validation testing. The final form of the test is included in Appendix G. Testing was conducted at three locations: 3rd Battalion, 68th Air Defense Artillery, Homestead Air

Force Base, FL; 1st Battalion, 65th Air Defense Artillery, Boca Chica Naval Air Station, Key West, FL; and Redstone Arsenal, Huntsville, AL. A total of 29 24E's, 16 24H's, and 15 24J's were tested. Each technician was rated by two or three supervisors. For those who had taken an MOS test, the scores of their last test was obtained. The total experience in electronic maintenance was also recorded for each man tested. The average experience for the technicians is presented in Table 10 and the rank data in Table 11.

Table 10

Experience Data for Technicians

Who Took Job Performance Test

| MOS | Mean | Range |
|---|---|---|
| 24E | 31 months | 4-145 months |
| 24H | 32 | 2-100 |
| 24J | 40 | 10-100 |

Table 11

Rank Break-out for Technicians

Who Took Job Performance Test

| | Rank | | | | | |
|---|---|---|---|---|---|---|
| MOS | E-3 | E-4 | E-5 | E-6 | E-7 | TOTAL |
| 24E | 11 | 4 | 7 | 5 | 1 | 28* |
| 24H | 2 | 5 | 5 | 4 | | 16 |
| 24J | | 5 | 7 | 3 | | 15 |

*One additional technician had been reduced in grade to E-1.

Because the test was made up of various numbers of items within each section, the test performance of each technician was normalized by using

the percent correct score within each section. The percent correct scores within the section were also weighted using empirically derived weights. A sample of thirty-five experienced technicians were asked to rate the importance of each type of maintenance skill or knowledge represented in each section. They were asked to use a rating scale of 1 to 10. The ratings were averaged across the thirty-five raters. The section on identifying resistance value by reading color codes was given the lowest rating. This rating value was divided into the other values to obtain a relative weight for each item. The derived weights were:

| Section Number | Evaluation Categories | Item Weight |
|---|---|---|
| 1 | Component Location on Schematic Diagram | 1.84 |
| 2 | Definition of Electronic Terms | 1.36 |
| 3 | Read Color Code of Resistors | 1.00 |
| 4 | Conversion of Measurement Units | 1.12 |
| 5 | Continuity Checks - PSM-6 | 1.50 |
| 6 | Component Check - DVM | 1.58 |
| 7 | Circuit Check - TS-505 | 1.42 |
| 8 | Circuit Check - Oscilloscope | 1.68 |
| 9 | Troubleshoot Chassis | 1.82 |

For analysis purposes the Evaluation Categories on schematic reading were combined, as were the tests on continuity and component checks, which involved the use of the digital voltmeter. The summary of the test results are present in Tables 12, 13, and 14.

Table 12

Test Performance Results for

24E Improved HAWK Mechanic

| Sample Size | Grade | Average Experience (months) | Average Performance Per Test Section (Percent Correct) 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Average Rating | Average Weighted Test Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 3 | 6 | 86 | 71 | 13 | 40 | 89 | 49 | 50 | 58 | 17 | 58 | 7.23 |
| 4 | 4 | 14 | 83 | 70 | 0 | 45 | 94 | 75 | 25 | 100 | 0 | 66 | 7.61 |
| 7 | 5 | 37 | 86 | 69 | 15 | 34 | 98 | 48 | 57 | 43 | 43 | 71 | 7.50 |
| 6 | 6-7 | 91 | 88 | 83 | 25 | 60 | 94 | 69 | 67 | 67 | 17 | 69 | 8.56 |
| | TOTAL | | 86 | 73 | 14 | 44 | 93 | 56 | 52 | 62 | 21 | | 7.63 |

Table 13

Test Performance for 24H

Improved HAWK Fire Control Repairman

| Sample Size | Grade | Average Experience (months) | Average Performance Per Test Section (Percent Correct) 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Average Rating | Average Weighted Test Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 3 | 5 | 83 | 73 | 25 | 70 | 100 | 56 | 100 | 100 | 50 | 58 | 9.94 |
| 5 | 4 | 11 | 93 | 89 | 40 | 80 | 100 | 75 | 50 | 80 | 20 | 63 | 9.32 |
| 5 | 5 | 28 | 89 | 82 | 40 | 80 | 98 | 78 | 40 | 100 | 40 | 54 | 9.74 |
| 4 | 6 | 54 | 85 | 84 | 38 | 65 | 88 | 72 | 75 | 50 | 50 | 71 | 9.09 |
| | TOTAL | | 88 | 83 | 38 | 75 | 96 | 73 | 63 | 81 | 38 | | 9.50 |

Table 14

Test Performance for 24J

Improved HAWK Pulse Radar Repairman

| Sample Size | Grade | Average Experience (months) | Average Performance Per Test Section (Percent Correct) 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Average Rating | Average Weighted Test Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 4 | 18 | 91 | 82 | 50 | 64 | 78 | 75 | 60 | 40 | 9 | 55 | 7.90 |
| 7 | 5 | 40 | 96 | 83 | 93 | 63 | 100 | 77 | 86 | 57 | 43 | 57 | 10.20 |
| 3 | 6 | 77 | 94 | 90 | 67 | 67 | 92 | 75 | 67 | 33 | 67 | 70 | 10.50 |
| | TOTAL | | 94 | 84 | 73 | 64 | 91 | 76 | 73 | 47 | 33 | | 9.32 |

Individual technician performance data is presented in Appendix H.

The results of the validation testing confirmed that the task analytical process model produced a valid set of fundamental skills and knowledge for the electronic maintenance MOS's studied. The derived set of skills and knowledge covered two kinds of maintenance jobs - the mechanic and the repairman. The mechanic job required system rather than electronic chassis troubleshooting. The repairman was primarily concern-

ed with chassis troubleshooting. This job requirement difference was reflected in the test scores. For example, 37 percent of the repairmen successfully completed the troubleshooting task, whereas only 21 percent of the mechanics were successful.

The 24E mechanic very seldom reported working with resistors. The 24J repairman reported working with them almost on a daily basis. Test scores sharply reflected this difference in job experience. The 24E's scored 14%, 24H's scored 38%, and 24J's scored 73%. Other job differences reflected on the test were converting measurement readings from one kind of scale to another. Repairmen do this much more often than mechanics and the test scores reflect this: 24E 44%; 24H 75%; and 24J 64%. The repairmen also use a digital voltmeter in the High Frequency Console, whereas the mechanic very seldom use a DVM. Again test score differences reflect this: 24E 56%; 24H 73%; 24J 76%.

These job requirement differences account for most of the differences in total test scores between the mechanic and technician MOS's. This was demonstrated by comparing the two sets of scores:

| | 24E | 24H | 24J | Perfect Score |
|---|---|---|---|---|
| Total Test | 7.63 (57%) | 9.50 (71%) | 9.32 (70%) | 13.32 |
| Common Job Elements | 5.75 (61%) | 6.44 (69%) | 6.06 (65%) | 9.38 |

A perfect performance total test score for each set of scores is indicated in the last column. The percent the scores are of the total possible are indicated in parentheses.

Early in the project rank and experience were considered as a means for differentiating skill level of technicians. Coefficients of correlation were run for rank and experience with test scores and ratings. For the 24E mechanics, correlations significant at P = .10 were found between test scores with rank (r = .31) and experience (r = .33). Similar coefficients were found with the 24J data, but the degrees of

freedom were lower so the rank figure was not significant (with rank $r = 31$; experience $r = .42$, $p = .10$). The coefficients for the 24H were not significant.

Correlations of test scores with the external evaluation criteria of supervisory ratings and MOS test scores were also run. None of these coefficients were significant. Two explanations of this lack of correlation between test performance and supervisory ratings can be offered. The first deals with the content of the test vs. the content of job performance. The test included only electronic fundamentals and did not deal with system specific behaviors and knowledge. To the degree that performance on system specific activities influences a supervisor's ratings, the influence of performance on electronic fundamentals may be reduced. That is, a technician who performs other aspects of the job much better than he performs on fundamental tasks may be rated higher than in the reverse situation.

A second explanation would be that ratings may be based on general behavior (personality) characteristics to a greater extent than on actual job performance. If this were the case, ratings would not correlate with experience or rank either. This in fact was the case. There were no significant correlations of ratings with experience for all MOS's and none with rank for the 24H and 24J. The correlation of rating with rank was significant at $p = .10$ for the 24Es.

SECTION VI

DEVELOPMENT OF GUIDELINES FOR COURSE DEVELOPERS

## Introduction

Task analysis at the skills and knowledge level of abstraction is still somewhat of an art-form. Decisions must be made that currently can best be made by someone with a combination of training and experiences in educational technology and the job content. This project was the first step in the attempt to move the analytical process from being an art form towards being a scientific process. This first step was empirically derived and appears to have successfully moved the process towards the science end of the continum in that fewer assumptions have to be made about the job performance activities than is now the case in course development. A copy of the Guidelines is attached as Appendix I.

As the model was evolved, two assumptions had to be met. First, the MOS to be analyzed at the skill and knowledge level had to be well documented. This meant that the FM's, TM's, and AR's relevant to the maintenance job had to be available, complete, accurate, and valid. This was necessary since the first set of procedures of the process identified all maintenance tasks that were required to be performed. Being complete and valid meant that the list of task elements were sufficient for describing all activities necessary for successful task completion. If the task elements had not been validated by observing a technician in that MOS carry out the task, or by doing the task yourself, the model was designed to provide for this necessary step.

The second assumption was that the analytical process had to be carried out by someone with some minimum level of job proficiency and field experience (yet to be established). In analyzing the task elements, certain decisions had to be made that were best made at this time by a job content expert. A layman or even an instructional development expert could not make these decisions.

The Task Analytical Process Model procedures were evolved as three sets of activities. First the process of task identification and selection was dealt with. Next the task element analytical procedures were developed. And finally the process for validating the skills and knowledge was designed. One staff member had over twenty years of electronic maintenance experience in addition to educational background and experience in instructional design technology. He served as the primary analytical tool for driving the TAPM procedures. Once general approaches to each aspect of the Model were agreed upon this staff SME began working through the details. A continuing interrogative interchange was set up between the SME and project director. The project director essentially acted as a naive observer who asked the questions "What did you do?", "Why did you do that?", and "How did you know to do that?".

## Task Identification Matrix

The development of the TIM evolved from the requirement to develop a process for identifying all tasks required for performing the job of a given electronic maintenance MOS. From this pool of all tasks, representative, critical tasks were selected for detailed analysis to derive common underlying skills and knowledge.

It was determined that all maintenance tasks involve some system equipment. The first effort was then to develop a process of identifying and classifying equipment. The Maintenance Allocation Charts and Parts Manuals were used for this purpose. By cross referencing these documents, a list of equipment was prepared that could be used to categorize all maintenance activities. It was next determined that a finite number of maintenance tasks are authorized to be performed in the MOS. These twelve tasks were subsequently grouped under four categories: Periodic Checks; Preventive Maintenance; Malfunction Diagnosis; and Corrective Maintenance. Feedback from technicians and their supervisors indicated that it was at this level that technicians become certified as qualified to perform the maintenance duty.

The criteria for selecting tasks for analysis were embodied in a definition of task criticality. A task was decided to be critical if (1) it was performed by a majority of the technicians, (2) was performed often on a piece of equipment that, (3) failed at a high rate, (4) resulted in the IHAWK System being classified in a non-ready status, and (5) if it was similar to other tasks.

The percent performing and frequency of performance data was obtained by administering the TIM to a sample of job incumbents for each MOS. This process was used rather than using the MOD-B report because of the in-consistency in the level and focus of the MOD-B questions. The frequency of failure data came from actual failure reports prepared at Redstone Arsenal. The readiness status data was obtained from the Equipment Serviceability Criteria (ESC) in TM-9-1425-525.

Those tasks that were classified as critical according to the above definition were reviewed by the staff SME for similarity of skill and knowledge requirements. The 18 most representative tasks were then selected for detailed analysis. This selection process was based on the SME's expert knowledge of the job requirements.

The next essential step was to determine whether the description of each of the selected tasks was complete and valid. This was accomplished by arranging for the SME to observe each task as it was performed in an actual job setting. The procedures for each task as presented in the TM were used as an observation check list. As a procedural step (task element) was performed, it was checked off by the SME. If the technicians carried out an activity not included in the list, a note was made and he was asked why he did it. Also where steps were omitted reasons were also obtained. A combination of this information and the staff SME's knowledge produced complete and valid sets of task elements.

## Process Model Procedures

The general approach that was agreed upon for analyzing the task elements was to describe how and why each element was performed. The TAPM flow chart items were prepared from the answer to the questions the pro-

ject director asked of the staff SME.

First a list of individual behavioral statements were prepared. Where it made logical sense, the items were grouped into categories of behavioral content. Each category was given an alpha-numeric code and each statement with a category was numbered sequentially as it appeared in the analysis. The same behavioral activity was found to be performed as part of several task elements. Such an activity was given only one code number, but its numerous replications were noted to reflect the skill or knowledge density of application in the job.

After each of the 18 representative tasks were analyzed, the remaining tasks as indicated by the TIM administration were reviewed. This was for the purpose of determining whether any fundamental skills had been omitted for any MOS. It was determined that the 24H performed some tasks that required digital technology skills and knowledge. As a result three additional tasks were analyzed to identify the specific skills and knowledge in this area.

## Validation of Skills and Knowledge

For this research effort two levels of validation were used. First it was assumed that if the logical task element analysis was valid, a majority of job incumbents should report that they apply the special skills and knowledge derived for the MOS. To test this assumption a job description questionnaire was prepared from the lists of skills and knowledge. This questionnaire was then administered to a sample of technicians with the subject MOS.

The second level of validation was based upon the assumption that if a technician reports he applies certain skills and knowledge on the job, he should be able to demonstrate this on a performance test. Therefore a performance test was constructed based on the responses to the questionnaire. This test was administered to a different sample of technicians with the MOS.

In both cases, the results indicated that the previous step produced valid products. It was subsequently decided that if a validation step is necessary, the use of a job description questionnaire would be sufficient.

The list of behavioral statements produced from the task element analysis represent a pool of special skills and knowledge that must be acquired by an individual before he can perform successfully as an electronic technician. Where and how they are acquired are decisions that must be made subsequent to the application of the Task Analytical Process Model.

## SECTION VII
## SUMMARY AND CONCLUSIONS

The question of what fundamental skills and knowledge should be the subject matter of basic electronic training courses has been dealt with over more than two decades. The Basic Electronic Skills and Knowledge project addressed the problem of developing a process for generating information that can be used to make this decision. It was determined that the approach should be focused on actual job activities rather than on current training content.

The Task Analytical Process Model that was developed was an evolutionary process. The documented analytical procedures emerged as the project was carried out. First a set of procedures was developed to identify tasks performed in an electronic maintenance MOS. This produced a form called the Task Identification Matrix (TIM). This consisted of a list of equipment and list of maintenance tasks. A TIM was developed for two major pieces of Improved HAWK equipment - The Battery Control Central (IBCC) and the Pulse Acquisition Radar (IPAR). Each TIM was administered with a set of questions to technicians responsible for these equipment items. The purpose was to focus in on critical tasks that were to be used for developing the detailed task analysis process. Two other criteria were also identified and used in classifying the criticality of task. Three MOS's were responsible for this equipment - 24E; 24H; 24J.

A total of 18 tasks were initially selected for developing the analytical process. These 18 tasks were selected because they were representative of 267 tasks for the two pieces of equipment and three MOS's. The staff SME proceeded to analyze these 18 tasks. The process used was documented and described in terms of procedural steps. The analysis produced a total of 518 skill and knowledge content items. These items reflected the application of related skills and knowledge a total of 11507 times across the 18 tasks. The most often applied skills and knowledge

were classified as electronic component content. Second was the application of electronic concept skills and knowledge. The most infrequently applied skills and knowledge categories was that for electronic circuits and electronic equipment (such as motors).

The results of the analytical process were used to construct a questionnaire about the application of special skills and knowledge that were of a fundamental (basic) nature. This was administered to a total of fifty technicians (20 24E's, 15 each 24H and 24J) for the purpose of determining the validity of the analytical process. The results were that about 90 percent of the items were reported being performed by a majority of the technicians. It was concluded that the analytical process produced a valid set of basic skills and knowledge items.

As a further validity check, a performance test was constructed which reflected the responses to the questionnaire. This test was administered to 59 technicians (29 24E's, 15 each 24H and 24J). Technicians were able to demonstrate proficiency on those items common to their MOS. Again it was concluded that the analytical process produced valid skill and knowledge content items.

During the conduct of the several phases of this project information was provided by technicians that was of interest for training and management personnel. For example: Repairmen, trained at the Ordinance school, Redstone Arsenal, reported that many times in the field they had been called to assist in or to conduct system troubleshooting. They reported frustration because they could not perform well, not having had training on the entire system operation. Many expressed a desire to have been given this training while still in school. Both repairmen and mechanics reported some problem with having to learn how to operate test equipment once they got to their job assignment. They report not having seen the actual job test equipment while in school.

Another reported practice was that sometimes technicians must perform maintenance tasks that are not authorized for their MOS. This was reported being due to management pressure to return equipment to the operational status as soon as possible. Along this line it was also often reported that the difference between a unit with good maintenance as opposed to poor maintenance was the strength of the maintenance managers. In the good units, managers insist that all required maintenance tasks be performed and carried out completely. Managers in these units also promote the attitutdes of responsibility and professionalism as far as maintenance technology is concerned.

A second part of this research project addressed the issue of personnel evaluation. It had been hypothesized that maintenance supervisors and commanders used non-functionally related criteria in rating a technician as competent (qualified). During a series of open-ended interviews with supervisors and commanders a list of descriptive criteria were generated that were used to differentiate good and poor technicians.

This list was used to construct a questionnaire that was administered to another sample of maintenance supervisors and commanders. A total of 51 evaluation statements were rated as to their level of importance for judging maintenance technicians. There were no overall differences in the results for the repairman and mechanic supervisors. There was a difference in the ratings between supervisors and commanders. Supervisors were more concerned with the quality and detail of the maintenance activities per se, while the commanders were more concerned with the management of the maintenance function. This was not an unexpected, but it does confirm the different orientations taken in the evaluation of job proficiency.

The conclusions reached in this project were that a logical analytical process could be used to derive basic skills and knowledge and that, supervisory and management personnel are influenced by functionally related criteria for differentiating between qualified and non-qualified maintenance technicians.

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# Appendix A

## Task Identification Matrix

## Selected Forms and Data

DATE_____

NAME (LAST, FIRST MIDDLE INITIAL) _____ GRADE _____ AGE _____

DUTY MOS _____ ORGANIZATION _____

TIME IN PRESENT JOB _____ TOTAL TIME IN SERVICE _____

TOTAL TIME IN ELECTRONICS FIELD

HIGHEST SCHOOL GRADE OR COLLEGE YEAR COMPLETED

HOW MUCH TIME DO YOU SPEND PERFORMING SUPERVISORY OR ADMINISTRATIVE FUNCTIONS?

_____NONE OF MY TIME.
_____1-25% OF MY TIME.
_____26-50% OF MY TIME.
_____51-75% OF MY TIME.
_____76-100% OF MY TIME.

HOW MUCH TIME DO YOU SPEND PERFORMING "HANDS ON" MAINTENANCE OF EQUIPMENT?

_____NONE OF MY TIME.
_____1-25% OF MY TIME.
_____26-50% OF MY TIME.
_____51-75% OF MY TIME.
_____76-100% OF MY TIME.

LIST THE TYPE OF TEST EQUIPMENT YOU USE ON THE JOB (PLEASE LIST FROM MOST FREQUENTLY USED DOWN TO LEAST FREQUENTLY USED).

WHERE DID YOU LEARN TO USE THE TEST EQUIPMENT (MOS SCHOOL, OTHER SCHOOL, OR OJT)?

WHAT MAINTENANCE ACTIVITIES DO YOU PERFORM THAT WERE NOT TAUGHT IN SCHOOL OR SHOULD HAVE BEEN GIVEN MORE EMPHASIS?

## Task Identification Matrix

The first column indicates the Functional Group number of the System Hardware item as referenced in the appropriate Technical Manual.

The second column indicates the total like items contained within the major item. No entry in this column indicates quantity of one.

The third column contains the short name of the Hardware item.

The fourth through seventh columns contain types of maintenance activities.

The last column is divided into two parts indicating the effect the Hardware item will have on the End item and the missile system if defective.

The column is divided into two parts for each item. The upper portion indicates the condition of the end item with the lower portion indicating the condition of the system when the particular hardware item is not functioning correctly or is missing.

R = Red indicating the end item or system is not operational if this hardware item is not functioning.

A = Amber indicating the end item or system is capable of limited operation if this hardware item is not functioning.

G = Green indicating the end item or system operation is not significantly degraded if this item is not functioning.

| Functional Group Number | | Total in Major Item | System Hardware Item | Preventive Maintenance | Periodic Checks | Corrective Maintenance | Diagnosis Troubleshooting | |
|---|---|---|---|---|---|---|---|---|
| 0100 | | | Battery Control Central | | | | | R - R |
| 1200 | | | Power Distribution Control | | | | | R - R |
| 1300 | | | Synchro Buss Assembly | | | | | R - R |
| 1400 | | | Tactical Control Console | | | | | R - R |
| | 1410 | | Relay Chassis | | | | | A - A |
| | 1430 | 8 | Deflection Amplifier X and Y | | | | | R - R |
| | 1470 | 3 | 14 KV Power Supply | | | | | R - R |
| | 1500 | 4 | Fan and Dimmer Assembly | | | | | R - R |
| | 1540 | | Relay Assembly | | | | | R - R |
| | 1600 | 3 | Video Amplifier | | | | | R - R |
| | 1680 | | Defogging Relay Assembly | | | | | G - G |
| | 1700 | | Indicator Control | | | | | R - R |
| | 1750 | | Coordinate Data Control | | | | | R - R |

| Functional Group Number | | Total in Major Item | System Hardware Item | Preventive Maintenance | Periodic Checks | Corrective Maintenance | Diagnosis Troubleshooting | |
|---|---|---|---|---|---|---|---|---|
| | 1810 | | Target Assigning Control | | | | | R - R |
| | 1910 | | Interrogator Control | | | | | R R R |
| | 1960 | | Video Control Panel | | | | | R R R |
| 2100 | | | Plotting Board | | | | | G G |
| 2200 | | | Plotting Board Control | | | | | G - G |
| 2300 | | | IFAR Frequency Control | | | | | A - A |
| 2400 | | | Display Panel | | | | | R R |
| | 2440 | | Audio Frequency Amplifier | | | | | A - A |
| 2600 | | | CW Target Detection Console | | | | | A - A |
| | 2710 | | 10KV Power Supply | | | | | A A |
| | 2760 | | Video Amplifier | | | | | A A |
| | 2810 | | Test Relay Assembly | | | | | R R |
| | 2870 | | Control Shelf | | | | | R R |
| | 2930 | | Cover Assembly | | | | | R R |

| Functional Group Number | | Total in Major Item | System Hardware Item | Preventive Maintenance | Periodic Checks | Corrective Maintenance | Diagnosis Troubleshooting | |
|---|---|---|---|---|---|---|---|---|
| | 2985 | | Scan Servo Assembly | | | | | R - R |
| 3200 | | | CWTDC Commo Unit | | | | | A - A |
| 3300 | | | Doppler Voice Terminal | | | | | R - R |
| 3400 | | | Voltage Regulator Assembly | | | | | R - R |
| | 3465 | 16 | Voltage Regulator | | | | | R - R |
| 3500 | | | Reference Voltage Regulator | | | | | R - R |
| 3600 | | | Power Supply Control | | | | | R - R |
| 3700 | | | 20VDC Power Supply | | | | | R - R |
| 3800 | | | Power Distribution Panel | | | | | R - R |
| 3900 | | | AADCP Local/Remote Switch | | | | | A - A |
| 4200 | | | Indicator Control Group | | | | | R - R |
| | 4210 | | General Test Set | | | | | A - G |
| | 4260 | | Automatic Test Set | | | | | A - G |

| Functional Group Number | Total in Major Item | System Hardware Item | Preventive Maintenance | Periodic Checks | Corrective Maintenance | Diagnosis Troubleshooting | |
|---|---|---|---|---|---|---|---|
| 4310 | | FC Cursor Generator | | | | | R - R |
| 4380 | | IPAR Set Control | | | | | A - A |
| 4410 | | TCC Cursor Generator | | | | | R - R |
| 4510 | 4 | TCC/FC X,Y, Electronic Clamp Assembly | | | | | R - R |
| 4610 | 2 | Predicted Intercept Mark Generator A&B | | | | | A - A |
| 4730 | 2 | FC A&B Marker Generator | | | | | A - A |
| 4830 | | Symbol Intensity Electronic Gate Assembly | | | | | R - R |
| 4930 | | Scale of 18 Multi-vibrator | | | | | R - R |
| 4970 | | Test Set Control | | | | | R - R |
| 5010 | | TCC/FC Video Mixer | | | | | R - R |
| 5050 | | FC Short Sweep Generator | | | | | R - R |
| 5150 | 2 | TCC/FC Clamp Gate Generator | | | | | R - R |

| Functional Group Number | | Total in Major Item | System Hardware Item | Preventive Maintenance | Periodic Checks | Corrective Maintenance | Diagnosis Troubleshooting | |
|---|---|---|---|---|---|---|---|---|
| | 5190 | | Symbol Generator | | | | | R - R |
| | 5310 | | Symbol Multivibrator | | | | | R - R |
| | 5410 | | PSI Video Gate | | | | | A - A |
| | 5540 | | TCC Long Sweep Generator | | | | | R - R |
| 5700 | | 2 | Firing Console (FC "A" & "B") | | | | | A - A |
| | 5710 | 2 | Relay Assembly | | | | | A - A |
| | 5830 | 2 | Relay Chassis | | | | | A - A |
| | 6010 | 2 | Indicator Control | | | | | A - A |
| | 6055 | 2 | Cover Assembly | | | | | A - A |
| | 6075 | 2 | Range Control Assembly | | | | | A - A |
| | 6195 | 2 | Range/Speed Indicator | | | | | A - A |
| | 6275 | 2 | IHIPIR Azimuth Gear Train | | | | | A - A |
| | 6415 | 2 | Console Shelf Assembly | | | | | A - A |

| Function Group Number | | Total in Major Item | System Hardware Item | Preventive Maintenance | Periodic Checks | Corrective Maintenance | Diagnosis Troubleshooting | |
|---|---|---|---|---|---|---|---|---|
| | 6445 | 2 | TX Control, Manual Elevation | | | | | A - A |
| 6600 | | | Fire Control Group | | | | | R - R |
| | 6610 | 2 | Range Electronic Control Amplifier "A" & "B" | | | | | A - A |
| | 6710 | 2 | Elevation Electronic Control Amplifier "A" & "B" | | | | | A - A |
| | 6780 | 2 | Azimuth Electronic Control Amplifier "A" & "B" | | | | | A - A |
| | 6840 | | Height Signal Comparator | | | | | R - R |
| | 6930 | | ROR Video Amplifier | | | | | A - A |
| | 7010 | | ROR Sweep Generator | | | | | A - A |
| | 7110 | | ROR Electronic Control Amplifier | | | | | A - A |
| | 7170 | 2 | Intercept Computer "A" & "B" | | | | | A - A |
| | 7210 | 2 | Firing Interlock Assembly "A" & "B" | | | | | A - A |

| Function Group Number | | Total in Major Item | System Hardware Item | Preventive Maintenance | Periodic Checks | Corrective Maintenance | Diagnosis Troubleshooting | |
|---|---|---|---|---|---|---|---|---|
| | 7250 | 2 | Display Generator "A" & "B" | | | | | A - A |
| | 7290 | | Scan Servo Amplifier | | | | | R - R |
| | 7360 | | CWTDCS Sweep Generator | | | | | A - A |
| | 7450 | 2 | Firing Circuits Test Set "A" & "B" | | | | | A - A |
| 7700 | | | AC Lighting Power Supply | | | | | R - R |
| 7800 | | | AC Filament Power Supply | | | | | R - R |
| 7900 | | | 28VDC Power Supply | | | | | R - R |
| 8100 | | | DC Lighting Power Supply | | | | | R - R |
| 8200 | | | DC Power Supply | | | | | R - R |
| 8300 | | | Synchro Relay Assembly | | | | | R - R |
| 8400 | | | Telephone Set and Relay Assembly | | | | | R - R |
| 8600 | | | TCO/TCA Commo Unit | | | | | R - R |

| Function Group Number | Total in Major Item | System Hardware Item | Preventive Maintenance | Periodic Checks | Corrective Maintenance | Diagnosis Troubleshooting | |
|---|---|---|---|---|---|---|---|
| 9500 | | Electrical Equipment Shelter Air Conditioner | | | | | R<br>-<br>R |

| Functional Group Number | Total in Major Item | System Hardware Item | Preventive Maintenance | Periodic Checks | Corrective Maintenance | Diagnosis Troubleshooting | |
|---|---|---|---|---|---|---|---|
| 0100 | | Radar Set | | | | | R - R |
| 0500 | | Antenna Group | | | | | R A |
| 0550 | | Pedestal Antenna | | | | | R A |
| 0555 | | Brake Assembly | | | | | A G |
| 0560 | | Synchro Assembly | | | | | R A |
| 1000 | | Amplifier Cooler Group | | | | | R - A |
| 1050 | | Amplifier Assembly | | | | | R A |
| 1060 | | Dickie Fix Amplifier | | | | | A A |
| 1070 | | Dickie Fix-Fix Amplifier | | | | | A - A |
| 1080 | | Reciever Switch | | | | | R A |
| 1090 | | Interference Blanker | | | | | R A |
| 1105 | 2 | Amplifier Log IF | | | | | A A |
| 1120 | | Back Bias Amplifier | | | | | A A |
| 1160 | | Wiring Harness | | | | | R A |
| 1200 | 2 | Signal Datal Converter | | | | | A A |

| Functional Group Number | Total in Major Item | System Hardware Item | Preventive Maintenance | Periodic Checks | Corrective Maintenance | Diagnosis Troubleshooting | |
|---|---|---|---|---|---|---|---|
| 1230 | 2 | Preselector Assembly | | | | | A<br>A |
| 1245 | 2 | IF Amplifier | | | | | A<br>A |
| 1250 | | Coole Unit | | | | | R<br>A |
| 1275 | 2 | Gear Assembly | | | | | A<br>A |
| 1300 | 2 | Magnetic Amplifier | | | | | A<br>A |
| 1800 | | Cabinet Electrical Equipment | | | | | R<br>A |
| 2000 | | Radar Set Group | | | | | R<br>A |
| 2100 | | Commo Station | | | | | A<br>G |
| 2200 | | Indicator Azimuth Range | | | | | R<br>A |
| 2215 | | Control Monitor | | | | | R<br>A |
| 2230 | | Sweep and Video Chassis Assembly | | | | | R<br>A |
| 2245 | | Range Mark Generator | | | | | R<br>A |
| 2260 | | Control Power Supply | | | | | R<br>A |
| 2275 | | Wiring Harness | | | | | R<br>A |

| Functional Group Number | Total in Major Item | System Hardware Item | Preventive Maintenance | Periodic Checks | Corrective Maintenance | Diagnosis Troubleshooting | |
|---|---|---|---|---|---|---|---|
| 2320 | | Indicator Assembly Azimuth Range | | | | | R - A |
| 2328 | | Deflection Coil Drive | | | | | R - A |
| 2400 | | Signal Comparator | | | | | R A |
| 2405 | | Amplifier Multi-vibrator | | | | | A - A |
| 2415 | | Generator Video Pulse | | | | | R - A |
| 2425 | 2 | Delay Amplifier | | | | | A A |
| 2435 | | COHO Oscillator Assembly | | | | | A - A |
| 2445 | | Test Generator | | | | | A A |
| 2455 | | MTI Amplifier | | | | | A A |
| 2465 | | Mixer Video Signal | | | | | R A |
| 2520 | | Wiring Harness | | | | | R A |
| 2600 | | Low Voltage Power Supply | | | | | R - A |
| 2605 | 6 | Voltage Regulator | | | | | R A |

| Functional Group Number | | Total in Major Item | System Hardware Item | Preventive Maintenance | Periodic Checks | Corrective Maintenance | Diagnosis Troubleshooting | |
|---|---|---|---|---|---|---|---|---|
| | 2615 | | Balance Selector | | | | | R/A |
| | 2620 | | Reference Voltage Regulator | | | | | R - A |
| | 2630 | | Semiconductor Device | | | | | R/A |
| | 2645 | | Resistor Assembly | | | | | R/A |
| | 2650 | | Resistor Assembly | | | | | R/A |
| | 2655 | | Resistor Assembly | | | | | R/A |
| | 2660 | 3 | Resistor Assembly | | | | | R/A |
| | 2665 | | Panel Electrical System | | | | | R - A |
| 2700 | | | Mount Assembly Telescope | | | | | R - A |
| 2800 | | | Cabinet, Electrical System | | | | | R - A |
| | 2880 | | Panel, Power Distribution | | | | | R - A |
| 3000 | | | High Voltage Power Supply | | | | | R - A |
| | 3300 | 3 | Fan Ventilating | | | | | R/A |

| Functional Group Number | | Total in Major Item | System Hardware Item | Preventive Maintenance | Periodic Checks | Corrective Maintenance | Diagnosis Troubleshooting | |
|---|---|---|---|---|---|---|---|---|
| | 3550 | | Power Supply | | | | | R/A |
| | 3600 | | Fan Centrifugal | | | | | R/A |
| | 3900 | | Chassis Electrical Equipment | | | | | R/A |
| | 3960 | | Resistor, Variable, Motor-driven | | | | | R/A |
| 4000 | | | Reciever-Transmitter Group | | | | | R/A |
| | 4150 | | STALO Power Supply | | | | | R/A |
| | 4155 | | AFC Amplifier | | | | | R/A |
| | 4160 | | STALO Servo Amplifier | | | | | R/A |
| | 4200 | | Pulse Generator | | | | | R/A |
| | 4250 | | Trigger Pulse Amplifier | | | | | R/A |
| | 4350 | | Control Oscillator (STALO) | | | | | R/A |
| | 4360 | | Oscillator, Radio Frequency | | | | | R/A |
| | 4372 | | Control Oscillator | | | | | R/A |

| Functional Group Number | | Total in Major Item | System Hardware Item | Preventive Maintenance | Periodic Checks | Corrective Maintenance | Diagnosis Troubleshooting | |
|---|---|---|---|---|---|---|---|---|
| | 4376 | | Cavity, Tuned | | | | | R A |
| | 4380 | | Drive Assembly, Mechanical | | | | | R - A |
| | 4390 | | Cabinet Electrical Equipment | | | | | R - A |
| | 4475 | | Mixer, AFC | | | | | R A |
| | 4600 | | Pressurization Unit | | | | | R A |
| | 4850 | | Cabinet, Modulator | | | | | R A |
| | 4870 | | Stabilitrow Drive Assembly | | | | | R - A |
| | 4890 | | Stabilizer | | | | | R A |
| | 4920 | | Modulator Sub-Assembly | | | | | R - A |
| | 4940 | | Modulator Sub-Assembly | | | | | R - A |
| | 4945 | | Panel Power Distribution | | | | | R - A |

# Appendix B

## Products of Task Analytical Process Model

B-1 Electronic Concepts

B-1-1 Voltage

B-1-2 Performs electrical alinement

B-1-3 Attenuates signals

B-1-4 Electrically grounds equipment etc. (Recalls what happens or doesn't happen when something is grounded or not grounded).

B-1-5 Recognizes in-phase and out-of-phase signals.

B-1-6 Interprets information as input to decision for subsequent action.

B-1-7 Discriminates between signals and noise on oscilloscope presentation.

B-1-8 Relates amplitude level to amount of voltage.

B-1-9 Recognizes indication of non-normal Bi-Polar Video signals.

B-1-10 Recognizes indications of optimum Bi-Polar Video amplitudes.

B-1-11 Refers to radar transmitter and receiver theory of operation.

B-1-12 Recalls insulative properties of common materials.

B-1-13 Recalls conductive properties of common materials.

B-1-14 Recalls positive/negative electrical potential.

B-1-15 Applies the theory of Direct Current (DC) in diagnosing and correcting electronic malfunctions.

B-1-16 Adjusts equipment until desired indication is obtained (light "just" goes out - "just" stops oscillating).

B-1-17 Adjust equipment for a null indication (null is not to be confused with zero).

B-1-18 Inspect electronic equipment for physical damage and the presence of moisture and other contaminants.

B-1-19 Recalls and uses electronic symbology notations and values.

B-1-20 Identifies diodes.

B-1-21 Recalls alternating current (AC) theory.

B-1-22 Uses resonant circuit theory (Frequency, Bandwidth, Center Frequency and Bandpass).

B-1-23 Discriminates and interprets complex electronic signals, comparing leading and trailing edges to determine time relationships.

B-1-24 Recalls that time is displayed and measured along the horizontal plane on the oscilloscope.

B-1-25 Uses theory of magnetism in selection of tools.

B-1-26 Uses Ohms Law, (theory of resistance) in troubleshooting circuitry.

B-1-27 Uses and checks coaxial cables based on knowledge of construction and function of coaxial cable.

B-1-28 Uses Radio frequency probes (RF probes) that are impedance matched and calibrated with a particular meter.

B-1-29 Select proper test equipment to measure RF signals.

B-1-30 When working with vacuum tubes refers to vacuum tube theory when interpreting signal information.

B-1-31 When working with resistors refers to resistor theory when interpreting signal information.

B-1-32 When working with capacitors refers to capacitor theory when interpreting signal information.

B-1-33 Isolates causes of malfunction in electronic equipment.

B-1-34 When working with circuit cards, refers to theory of transistor operation to determine signal inputs and outputs.

B-1-35 When working with circuit cards, refers to theory of diode operation to determine signal inputs and outputs.

B-1-36 When working with transformer refers to transformer theory when interpreting signal information.

B-1-37 When working with relays refers to relay theory when interpreting signal information.

B-1-38 When working with antennas and waveguides refers to RF microwave theory to interpret signal information.

B-1-39 When working with electric motors (AC or DC) refers to motor theory to interpret signal information.

B-1-40 When working with pressurization units refers to compressor theory to interpret signal information.

B-1-41 When working with pumps (liquid) refers to pump theory to interpret signal information.

B-1-42 When working with antenna positioning systems refers to parallax theory and antenna control system theory to interpret signal information.

B-2 Tools

B-2-1 Uses attenuator probes.

B-2-2 Uses jumper leads.

B-2-3 Uses hand tools.

B-2-3-1 Screwdrivers - flat tip

2 Screwdrivers - cross tip (Phillips)

3 Hexagon headed - L shaped (Allen wrenches)

4 Open end wrenches

5 Rulers

6 Pliers

7 Torque wrenches

B-2-4 Uses soldering sets

B-2-4-1 Soldering Irons

2 Soldering Aids

3 Heat Syncs

4 Solder

5 Flux

B-2-5 Uses - Thickness Guage

B-2-6 Uses - Dial Indicators

B-2-7 Uses - Non magnetic tools and tuning wands

B-2-8 Uses - RF Probes

B-2-9 Uses - Card Extractors

B-3 Hardware

B-3-1 Uses gaskets

B-3-2 Uses nuts and bolts

B-3-3 Identifies threaded - unthreaded holes

B-3-4 Uses Index pins (locking pins for gear assembly)

B-3-5 Uses retaining clamps and screws

B-3-6 Uses turnlock fasteners

B-3-7 Uses set screws

B-3-8 Uses coaxial cables

B-3-9 Uses TEE connectors

B-3-10 Uses BSM connectors

B-3-11 Uses fuses

B-3-12 Uses clamps (light bulbs)

B-3-13 Uses wire

B-3-14 Uses waveguide

B-3-15 Uses dessicant

B-3-16 Uses filters - air and liquid

B-3-17 Uses coolant fluid and lubricants

B-3-18 Uses coaxial connectors

B-3-19 Uses plugs, connectors, and jacks.

B-4 Test Equipment

B-4-1 Uses - Multimeter

B-4-2 Uses - Oscilloscope

B-4-3 Uses - Electronic Voltmeter

B-4-4 Uses TS-505 A/U multimeter

B-4-5 " " " B/U multimeter

B-4-6 " " " C/U multimeter

B-4-7 " " " D/U multimeter

B-4-8 Insulates multimeter from metal portion of radar.

B-4-9 Recalls that case of the TS-505 A/U - B/U - C/U multimeters have a high positive potential.

B-4-10 Does not touch the case of the TS-505 A/U, B/U or C/U multimeter after leads are connected to test jack.

B-4-11 Grounds the TS-505 D/U multimeter when it is to be used and does not need to insulate it.

B-4-12 Obtains minimum meter indications.

B-4-13 Determines oscillation as a movement at a steady rate between two limits.

B-4-14 Uses a stop watch.

B-4-15 Interprets meter reading as input decision for subsequent action.

B-4-16 Uses high frequency console.

B-4-16-1 Multimeter A & B

2 Dual Pulse Generator

3 Oscilloscope

4 Multifunction Generator

5 Modulator Oscillator

6 600 Ohm Attenuators

7 CW Oscillator

8 Amplifier Indicator

9 Thermal noise generator

10 Signal Generator

11 50 Mhz Counter

B-4-17 Interprets simple and complex wareforms presented as signal on oscilliscope.

B-4-18 Uses tube adapter

B-4-19 Uses tube tester (TV-7)

B-4-20 Uses digital volt meter

B-4-21 Uses a wavemeter

## B-5 Mechanical Skills

B-5-1 Uses degrees in a circle to determine or locate a position.

B-5-2 Turns controls in a clockwise or counterclockwise direction.

B-5-3 Mechanically aligns synchros to zero.

B-5-4 Discriminates between specific gears using references, drawings or diagrams.

B-5-5 Mechanically centers potentionmeters.

B-5-6 Removes and installs index pins correctly.

B-5-7 Applies pressure to remove mechanical error from gear assemblies.

B-5-8 Removes and installs diodes.

B-5-9 Removes and installs gears and other mechanical components.

B-5-10 Checks gear assembly backlash.

B-5-11 Adusts gear backlash.

B-5-12 Adjusts mechanical components to a specified tolerance.

B-5-13 Greases and oils gears and gear train components.

B-5-14 Installs and uses tube adapters.

B-5-15 Installs and removes vacuum tubes.

B-5-16 Installs and removes circuit cards.

B-5-17 Installs and removes relays.

B-5-18 Installs and removes transformers.

B-5-19 Installs and removes resistors.

B-5-20 Installs and removes capacitors.

B-5-21 Installs and removes chassis.

B-5-22 Installs and removes switches.

B-5-23 Installs and removes fuses and lamps.

B-5-24 Installs waveguide.

B-5-25 Installs antennas.

B-5-26 Installs and removes electric motors.

B-5-27 Installs and removes pressurization units.

B-5-28 Installs and removes dessicant.

B-5-29 Installs and removes pumps.

B-5-30 Installs and removes air filters.

B-5-31 Installs and removes fluid filters.

B-5-32 Installs coaxial connectors.

B-5-33 Installs plugs, connectors and jacks.

B-5-34 Fabricates gaskets.

B-5-35 Fabricates cables.

B-6 Mathematic Concepts

B-6-1 Uses "ratio".

B-6-2 Uses symbol to represent mathematical values.

B-6-3 Uses addition, subtraction and division, performs comparisions.

B-6-4 Uses basic geometry - (radius, degrees in a circle etc.)

B-6-5 Uses inch and or foot pounds in determining and measuring torque values.

B-6-6 Uses concepts of maximum and minimum.

B-6-7 Plots information on a scale or a graph.

B-6-8 Interprets and uses information contained on a graph or scale.

B-6-9 Recalls and uses geometric terms.

B-6-9-1 Intersect

2 Rectangle

3 Vertical

4 Horizontal

B-6-10 Uses positive and negative values.

B-6-11 Uses time measurements.

B-6-12 Uses Binary numbering system.

B-6-13 Uses Octal numbering system.

B-6-14 Uses Hexa decimal numbering system.

B-6-15 Uses Boolean Algebra.

B-6-16 Uses Logic Diagrams.

B-6-17 Uses Truth Tables.

B-6-18 Converts Binary values to and from.

B-6-18-1 Decimal values

2 Octal values

3 Hexadecimal values

B-6-19 Reads and interprets Fluid and Air pressure gauges (PSI).

B-6-20 Recalls and uses Parallax System theory.

B-7 Electronic Components

B-7-1 Uses (removes, replaces, selects) switches.

B-7-2 Uses variable resistors.

B-7-3 Locates physical position of components and chassis.

B-7-4 Electrically aligns synchros.

B-7-5 Uses data and power cables.

B-7-6 Locates test points on equipment.

B-7-7 Locates ground points on equipment.

B-7-8 Adjusts controls to obtain proper indication.

B-7-9 Recognizes indications of improper equipment conditions.

B-7-10 Takes corrective action when indications of improper conditions occur.

B-7-11 Uses, replaces Cathode Ray Tubes (CRT).

B-7-12 Makes corrections and disconnections of various types of multi connector power, data and coaxial cables.

B-7-13 Uses capacitors.

B-7-14 Uses vacuum tubes.

B-7-15 Uses resistors.

B-7-16 Uses circuit cards.

B-7-17 Uses transformers.

B-7-18 Uses relays.

B-7-19 Uses electric motors.

B-7-20 Uses fluid pumps.

B-7-21 Uses pressurization units (Compressors - Air).

B-8 Electronic Circuits

B-8-1 Applies vacuum tube theory in working with the following circuits.

B-8-1-1 Amplifiers - (Single and multistage).

2 Cathode followers

3 Multivibrators

4 Power supplies

5 Voltage regulators

6 Oscillators

7 Sweep generators

8 Timing - (Pulse)

9 Display (CRT)

10 High voltage power supplies and regulators

11 Clamping - Limiters

12 Noise generators

B-8-2 Uses schematics.

B-8-3 Uses technical maintenance manuals.

B-8-4 Uses supply (repair part) manuals.

B-8-5 Uses flow charts.

B-8-6 Applies solid state theory in working with the following circuits.

B-8-6-1 AND - Gates

2 OR - Gates

3 NOR - Gates

4 NAND - Gates

5 Flip Flops

B-8-6-6 Drivers

7 Amplifiers - single and multistage

8 Adders

9 Counters

10 Power Supplies

11 Input Circuits

12 Output Circuits

13 Oscillators

14 Couplers

B-8-7 Applies microwave theory (RF theory) in working with the following circuits.

B-8-7-1 Transmitter lines and antennas

2 Oscillators

3 Amplifiers

4 Amplitude Modulation

5 Frequency Modulation

6 Pulse Modulation

7 Detectors

8 Frequency Convertors

B-8-8 Antenna positioning circuits

B-8-9 Parallax circuits

B-9 General Electrical and Mechanical Equipment

B-9-1 Tightens synchros maintaining a specific meter reading.

B-9-2 Recalls electro - mechanical servo systems functional operation.

B-9-3 Energizes and de-energizes equipment.

B-9-4 Uses gear trains.

B-9-5 Uses resolvers.

B-9-6 Uses computers.

B-9-7 Uses motors.

B-9-8 Uses pumps.

B-9-9 Uses pressurization units (Compressors).

## Appendix B

## Safe Working Procedures

Using safe working procedures include the following:

1. De-energizes (turns OFF) equipment when removing and replacing chassis and components, and connecting test equipment leads.

2. Discharges capacitors in high voltage power supplies, regulators and transmitters before working with or around them.

3. Properly grounds equipment prior to applying power.

4. Keep hands or other parts of the body out of energized equipment, especially in areas where vision is obstructed.

5. Removes hand jewelry and dangling necklaces, chains, etc. before working on energized equipment (or tape them so they won't get caught).

6. Practices the "one hand" rule when working with conductive materials.

7. Does not sit or lean on energized equipment.

8. Keeps equipment dry when working under incliment weather conditions.

9. Does not use water to put out electrical fixes.

10. Never works alone around energized equipment.

11. Uses appropriate safety devices and equipment, such as hooks, ropes, poles, rubber gloves, goggles and first aid equipment, when called for.

12. Immediately turns off power if energized equipment gets wet.

13. Stays alert and does not engage in horseplay around energized equipment.

14. Does not allow test equipment leads, tools, wires, etc. short circuit components.

15. Inspects switches and connector wires for servicability

Cont.

(looks for bare wires, sparks, excessive heat).

16. Does not cheat safety interlocks except when referenced procedures specifically call for it.

17. Wears safety goggles and gloves when handling radioactive materials or glass tubes.

18. Disposes of radioactive materials and glass tubes in the prescribed manner.

19. Does not work on energized equipment when sleepy or under the influence of medication, drugs or alcohol.

20. Does not work under suspended loads.

## Appendix B

### Use of Good Work Habits

Good work behaviors include the following:

1. Plans the job - determining what activities must be carried, assembling the necessary tools, test equipment, schematics, Technical Manuals (TM's) and other references prior to starting the work.

2. Recognizes working difficulties as they develop during work performance, analyzes the problem, makes a decision as to what action to take and takes the corrective action.

3. Uses proper tools, test equipment materials and references.

4. Removes and replaces parts/components correctly by performing all necessary steps and using all required hardware (screws, nuts, washers, bolts, etc.).

5. Inspects all tools, equipment, materials, hardware and components as they are used.

6. Replaces all damaged parts/components with serviceable ones.

7. Assumes responsibility for all of his work activities.

8. Performs each task thoroughly but efficiently.

9. Does not jump to conclusions.

10. Double checks switch positions cable connections, etc., prior to completing repair and diagnosis activities.

11. Performs work conscientiously, completely, and accurately.

12. Initiates any maintenance activities that must be performed, but not necessarily specifically assigned.

# Diagnosis of Electronic Malfunctions

Steps:

1. Identify the Problem.

   All symptoms must be analyzed to determine the problem.

2. Recall relative information.

   Items of information that are known, have been previously catalouged and have a relation to the problem must be considered.

3. Unknowns must be identified.

   There must be a recognition of those items of information that are necessary but are at present unknown. This unknown information must be acquired.

4. Propose a solution.

   A possible solution must be framed and evaluated to determine if the proposed solution conforms to the known information.

5. Testing the solution.

   a. After the proposed solution is framed and evaluated, the proposed solution must be implemented, (tested), on the physical equipment.

6. b. Evaluate and revise the proposed solution. Where the facts, (results) are in conflict with the proposed solution. (Did not isolate or identify the cause of malfunction).

7. Decision:

   When the proposed solution has been evaluated and the cause of malfunction isolated, a decision is now made to correct (repair) the cause of malfunction.

# Appendix C

## Task Analytical Process Model

## Detailed Summary of Skills and Knowledge

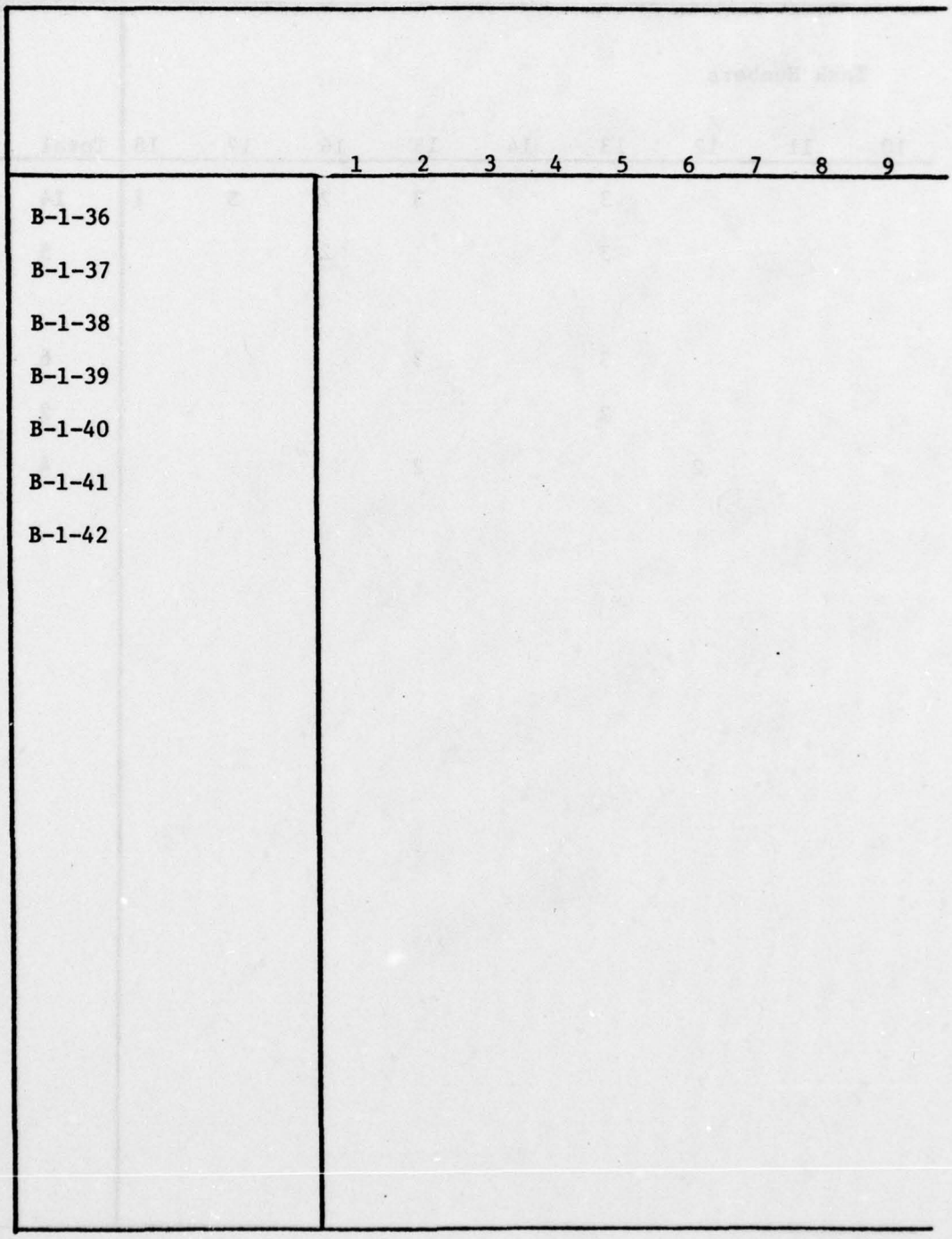
B-1 - Electronic Concepts

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Totals | 87 | 26 | 29 | 37 | 221 | 284 | 960 | 63 | 79 |
| Skill Numbers | | | | | | | | | |
| B-1-1 | | | | 6 | 3 | | | | |
| B-1-2 | 6 | | 5 | | | | | | |
| B-1-3 | 3 | | | | | 17 | | | |
| B-1-4 | 11 | 5 | | | | | 3 | 3 | 1 |
| B-1-5 | 3 | | | | | | | | |
| B-1-6 | 15 | | 12 | 5 | 120 | 91 | 284 | 22 | 23 |
| B-1-7 | 9 | | | | | 21 | 37 | | |
| B-1-8 | 5 | | | | | 11 | 37 | | 16 |
| B-1-9 | 2 | | | | | | | | |
| B-1-10 | 2 | | | | | | | | |
| B-1-11 | 2 | 2 | | | | | | | |
| B-1-12 | 3 | 1 | | 1 | 1 | 1 | 2 | 1 | 1 |
| B-1-13 | 3 | 1 | | | | | | | |
| B-1-14 | 3 | 1 | | | | | 268 | 1 | |
| B-1-15 | 6 | 5 | | | | | 11 | | |
| B-1-16 | 6 | 11 | 12 | 25 | 97 | 35 | 24 | 11 | 24 |

| Task Numbers | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | Totals |
| 96 | 209 | 6 | 27 | 20 | 27 | 123 | 372 | 408 | 3074 |
| | 9 | | 2 | | 2 | 7 | 5 | 2 | 36 |
| | | | | | | | | | 11 |
| 8 | 3 | | | | | 22 | | | 53 |
| 2 | 5 | | 2 | 1 | 2 | | 1 | | 36 |
| 1 | | | | | | | | | 4 |
| 17 | 40 | 2 | 4 | 6 | 6 | 17 | 57 | 85 | 806 |
| 12 | 9 | | | | | | 44 | 53 | 185 |
| 8 | 6 | | | | | 8 | 55 | 64 | 210 |
| | | | | | | | 1 | | 3 |
| | | | | | | 1 | | | 3 |
| | | | | | | | | | 4 |
| 1 | 5 | | | | | 6 | 39 | | 62 |
| | 5 | | | | | 6 | 7 | | 22 |
| | | | | | | 4 | 5 | 67 | 349 |
| | 12 | | | | | 6 | 5 | 5 | 50 |
| | | | | | | 2 | | 13 | 260 |

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| B-1-17 | 8 | | | | | | | | |
| B-1-18 | | | | | | 1 | 1 | | 1 |
| B-1-19 | | | | | | 101 | 278 | 17 | 10 |
| B-1-20 | | | | | | | | 1 | |
| B-1-21 | | | | | | | 10 | 1 | |
| B-1-22 | | | | | | | | | |
| B-1-23 | | | | | | | | | |
| B-1-24 | | | | | | | | | |
| B-1-25 | | | | | | | | | |
| B-1-26 | | | | | | 6 | 5 | 6 | 3 |
| B-1-27 | | | | | | | | | |
| B-1-28 | | | | | | | | | |
| B-1-29 | | | | | | | | | |
| B-1-30 | | | | | | | | | |
| B-1-31 | | | | | | | | | |
| B-1-32 | | | | | | | | | |
| B-1-33 | | | | | | | | | |
| B-1-34 | | | | | | | | | |
| B-1-35 | | | | | | | | | |

| Task Numbers | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | Total |
| | | | | | | | | | 8 |
| | 7 | 2 | | 3 | | 2 | 1 | | 18 |
| 28 | 20 | | | | | 7 | 73 | 64 | 598 |
| | | | | | | | | 2 | 3 |
| | 6 | | 5 | | 6 | 3 | 3 | 5 | 39 |
| 3 | | | | | | | | | 3 |
| 2 | | | | | | | | | 2 |
| 7 | | | | | | | 7 | 32 | 46 |
| 1 | | | | | | 4 | 42 | 5 | 52 |
| 6 | 17 | | 3 | | 3 | | 5 | | 54 |
| | 2 | | | | | | | | 2 |
| | 3 | | | | | | | | 3 |
| | 4 | | | | | 5 | | | 9 |
| | 13 | | | | | 7 | 5 | | 25 |
| | 12 | | | 5 | | 7 | 5 | 4 | 33 |
| | 12 | | | 5 | | 2 | 2 | 2 | 23 |
| | 17 | | | | | 1 | 5 | 2 | 25 |
| | 2 | | | | | | | | 2 |
| | | | | | | 2 | | 2 | 4 |


1 2 3 4 5 6 7 8 9
B-1-36
B-1-37
B-1-38
B-1-39
B-1-40
B-1-41
B-1-42

| Task Numbers | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | Total |
| | | | 3 | | 3 | 2 | 5 | 1 | 14 |
| | | | 3 | | | 2 | | | 5 |
| | | | 3 | | 3 | | | | 6 |
| | | | 2 | | | | | | 2 |
| | | 2 | | | 2 | | | | 4 |

| B-2 - Tools | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Totals | 112 | 8 | 17 | 27 | 32 | 21 | 17 | 31 | 31 |
| Skill Numbers | | | | | | | | | |
| B-2-1 | 2 | | | | | 21 | 12 | 5 | |
| B-2-2 | 4 | | | | | | | | |
| B-2-3-1 | 106 | 8 | 12 | 21 | 32 | | 5 | 5 | 1 |
| B-2-3-2 | | | | | | | | 6 | |
| B-2-3-3 | | | 5 | | | | | | 22 |
| B-2-3-4 | | | | 5 | | | | | |
| B-2-3-5 | | | | 1 | | | | 4 | |
| B-2-3-6 | | | | | | | | 3 | |
| B-2-3-7 | | | | | | | | | 1 |
| B-2-4-1 | | | | | | | | 2 | |
| B-2-4-2 | | | | | | | | 2 | |
| B-2-4-3 | | | | | | | | 2 | |
| B-2-4-4 | | | | | | | | 1 | |
| B-2-4-5 | | | | | | | | 1 | |
| B-2-5 | | | | | | | | | 2 |
| B-2-6 | | | | | | | | | 5 |
| B-2-7 | | | | | | | | | |
| B-2-8 | | | | | | | | | |
| B-2-9 | | | | | | | | | |

| Task Numbers | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | Total |
| 28 | 8 | 6 | 14 | 13 | 14 | 38 | 12 | 33 | 462 |
| | | | | | | | | | |
| 17 | | | | | | 5 | | 10 | 72 |
| | | | 1 | | 1 | 6 | | | 12 |
| | | 2 | | | | | | 1 | 193 |
| | | 2 | 2 | 3 | 2 | 5 | | 10 | 30 |
| | | | 2 | 3 | 2 | | | | 34 |
| | | 2 | 3 | 2 | 3 | | | | 15 |
| | | | | 3 | | | | | 8 |
| | | | 1 | 2 | 1 | 2 | 2 | 2 | 13 |
| | | | | | | | | | 1 |
| | | | 1 | | 1 | 4 | 2 | 2 | 12 |
| | | | 1 | | 1 | 4 | 2 | 2 | 12 |
| | | | 1 | | 1 | 4 | 2 | 2 | 12 |
| | | | 1 | | 1 | 4 | 2 | 2 | 11 |
| | | | 1 | | 1 | 4 | 2 | 2 | 11 |
| | | | | | | | | | 2 |
| | | | | | | | | | 5 |
| 3 | | | | | | | | | 3 |
| 8 | 8 | | | | | | | | 16 |
| | | | | | | | | | -- |

B-3 - Hardware

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| | 3 | 12 | 14 | 32 | - | - | - | - | 8 |
| B-3-1 | | | | | | | | | |
| B-3-2 | 2 | | | 20 | | | | | |
| B-3-3 | 1 | | | | | | | | |
| B-3-4 | | 5 | 4 | | | | | | 4 |
| B-3-5 | | 7 | 10 | | | | | | |
| B-3-6 | | | | 5 | | | | | |
| B-3-7 | | | | 7 | | | | | 2 |
| B-3-8 | | | | | | | | | |
| B-3-9 | | | | | | | | | 2 |
| B-3-10 | | | | | | | | | |
| B-3-11 | | | | | | | | | |
| B-3-12 | | | | | | | | | |
| B-3-13 | | | | | | | | | |
| B-3-14 | | | | | | | | | |
| B-3-15 | | | | | | | | | |
| B-3-16 | | | | | | | | | |
| B-3-17 | | | | | | | | | |
| B-3-18 | | | | | | | | | |
| B-3-19 | | | | | | | | | |

| Task Numbers | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | Total |
| -- | 6 | 14 | 20 | 28 | 16 | 13 | 11 | 25 | 202 |
| | | 2 | 6 | 4 | 2 | | | | 14 |
| | | 2 | 5 | 6 | 2 | 4 | 2 | 2 | 45 |
| | | | | | | | | | 1 |
| | | | 2 | | 2 | | | | 17 |
| | | | 3 | | 2 | | | | 22 |
| | | 2 | | 2 | | | | | 9 |
| | | | | | | | | | 9 |
| | 2 | | | | | 2 | 2 | 6 | 12 |
| | 2 | | | | | 2 | 2 | 6 | 14 |
| | 2 | | | | | 2 | 2 | 5 | 11 |
| | | | | | | 2 | 2 | 5 | 9 |
| | | | | | | | | | |
| | | | | | | 1 | 1 | 1 | 3 |
| | | | | 2 | | | | | 2 |
| | | | 2 | 4 | | | | | 6 |
| | | 2 | | 3 | 3 | | | | 8 |
| | | 2 | | | 3 | | | | 5 |
| | | 2 | | 3 | | | | | 5 |
| | | 2 | 2 | 4 | 2 | | | | 10 |

| B-4 - Test Equipment | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Totals | 93 | 30 | 1 | - | 4 | 182 | 556 | 30 | 63 |
| Skill Numbers | | | | | | | | | |
| B-4-1 | 14 | 10 | | | | | | | |
| B-4-2 | 12 | | | | | | | | |
| B-4-3 | 10 | | | | | | | | |
| B-4-4 | 3 | 1 | | | | | | | |
| B-4-5 | 3 | 1 | | | | | | | |
| B-4-6 | 3 | 1 | | | | | | | |
| B-4-7 | 3 | 1 | | | | | | | |
| B-4-8 | 3 | 1 | | | | | | | |
| B-4-9 | 3 | 1 | | | | | | | |
| B-4-10 | 3 | 1 | | | | | | | |
| B-4-11 | 3 | 1 | | | | | | | |
| B-4-12 | 1 | 1 | | | | | | | 2 |
| B-4-13 | 3 | 1 | 1 | | | | | | |
| B-4-14 | 3 | | | | 4 | | | 1 | |
| B-4-15 | 14 | 10 | | | | 25 | 239 | | 33 |
| B-4-16 | | | | | | 1 | 1 | 1 | 1 |
| B-4-16-1 | | | | | | 33 | 231 | 13 | 27 |
| B-4-16-2 | | | | | | 16 | 9 | 1 | |

| Task Numbers | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | Total |
| 101 | 88 | -- | 4 | -- | 4 | 28 | 170 | 201 | 1,555 |
| | | | 2 | | 2 | | | | 28 |
| | | | | | | | | | 12 |
| | | | | | | | | | 10 |
| | | | | | | | | | 4 |
| | | | | | | | | | 4 |
| | | | | | | | | | 4 |
| | | | | | | | | | 4 |
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| | | | | | | | | | 4 |
| | | | | | | | | | 4 |
| | | | | | | | | | 5 |
| | | | | | | | | | 8 |
| 23 | 24 | | 2 | | 2 | 14 | 27 | 15 | 428 |
| 1 | 11 | | | | | 2 | 1 | | 19 |
| 11 | 25 | | | | | 12 | 20 | 32 | 404 |
| 3 | | | | | | | 5 | 1 | 35 |

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| B-4-16-3 | | | | | | 27 | 37 | 7 | |
| B-4-16-4 | | | | | | 6 | 1 | | |
| B-4-16-5 | | | | | | 2 | | | |
| B-4-16-6 | | | | | | 2 | | | |
| B-4-16-7 | | | | | | 2 | | | |
| B-4-16-8 | | | | | | 2 | | | |
| B-4-16-9 | | | | | | 2 | | | |
| B-4-16-10 | | | | | | 6 | | | |
| B-4-16-11 | | | | | | 31 | 1 | 5 | |
| B-4-17 | 12 | | | | | 27 | 37 | 2 | |
| B-4-18 | | | | | | | | | |
| B-4-19 | | | | | | | | | |
| B-4-20 | | | | | | | | | |
| B-4-21 | | | | | | | | | |

| Task Numbers | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | Total |
| 19 | 7 | | | | | | 60 | 79 | 236 |
| 2 | | | | | | | | | 9 |
| | | | | | | | | | 2 |
| 3 | | | | | | | | | 5 |
| | | | | | | | | | 2 |
| | | | | | | | | | 2 |
| | | | | | | | | | 2 |
| 8 | 8 | | | | | | 1 | 1 | 24 |
| 9 | 7 | | | | | | 1 | 7 | 61 |
| 21 | 6 | | | | | | 55 | 66 | 226 |
| 1 | | | | | | | | | 1 |

B-5 - Mechanical Skills

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Totals | 48 | 4 | 17 | - | 31 | 33 | 22 | 20 | 73 |
| Skill Numbers | | | | | | | | | |
| B-5-1 | 12 | | | | 5 | | | | |
| B-5-2 | 24 | 4 | 10 | | 26 | 25 | 22 | 14 | 17 |
| B-5-3 | 4 | | 1 | | | | | | |
| B-5-4 | 3 | | 1 | | | | | | 21 |
| B-5-5 | 5 | | 2 | | | 8 | | 4 | |
| B-5-6 | | | 2 | | | | | | 5 |
| B-5-7 | | | 1 | | | | | | 8 |
| B-5-8 | | | | | | | | 2 | |
| B-5-9 | | | | | | | | | 2 |
| B-5-10 | | | | | | | | | 5 |
| B-5-11 | | | | | | | | | 7 |
| B-5-12 | | | | | | | | | 7 |
| B-5-13 | | | | | | | | | 1 |
| B-5-14 | | | | | | | | | |
| B-5-15 | | | | | | | | | |
| B-5-16 | | | | | | | | | |
| B-5-17 | | | | | | | | | |
| B-5-18 | | | | | | | | | |

| Task Numbers | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | Total |
| 9 | 12 | 9 | 17 | 20 | 17 | 5 | 16 | 17 | 370 |
| | | | | | | | | | |
| | | | | | | | | | 17 |
| 4 | | | 2 | 4 | 3 | 2 | 7 | 6 | 170 |
| | | | | | | | | | 5 |
| | | | | | | | | | 25 |
| | | | | | | | 6 | 5 | 30 |
| | | | | | 2 | | | | 9 |
| | | | | | | | | | 9 |
| | | | | | | | | | 2 |
| | | | | | | | | | 2 |
| | | | | | | | | | 5 |
| | | | | | | | | | 7 |
| | | | 2 | 2 | 2 | | | | 13 |
| | | | 1 | 2 | 1 | | | | 5 |
| 1 | | | | | | | | | 1 |
| 4 | 12 | | | | | | | | 16 |
| | | | | | | | | | -- |
| | | | 1 | | | 1 | | | 2 |
| | | | 1 | | 1 | | | 1 | 3 |

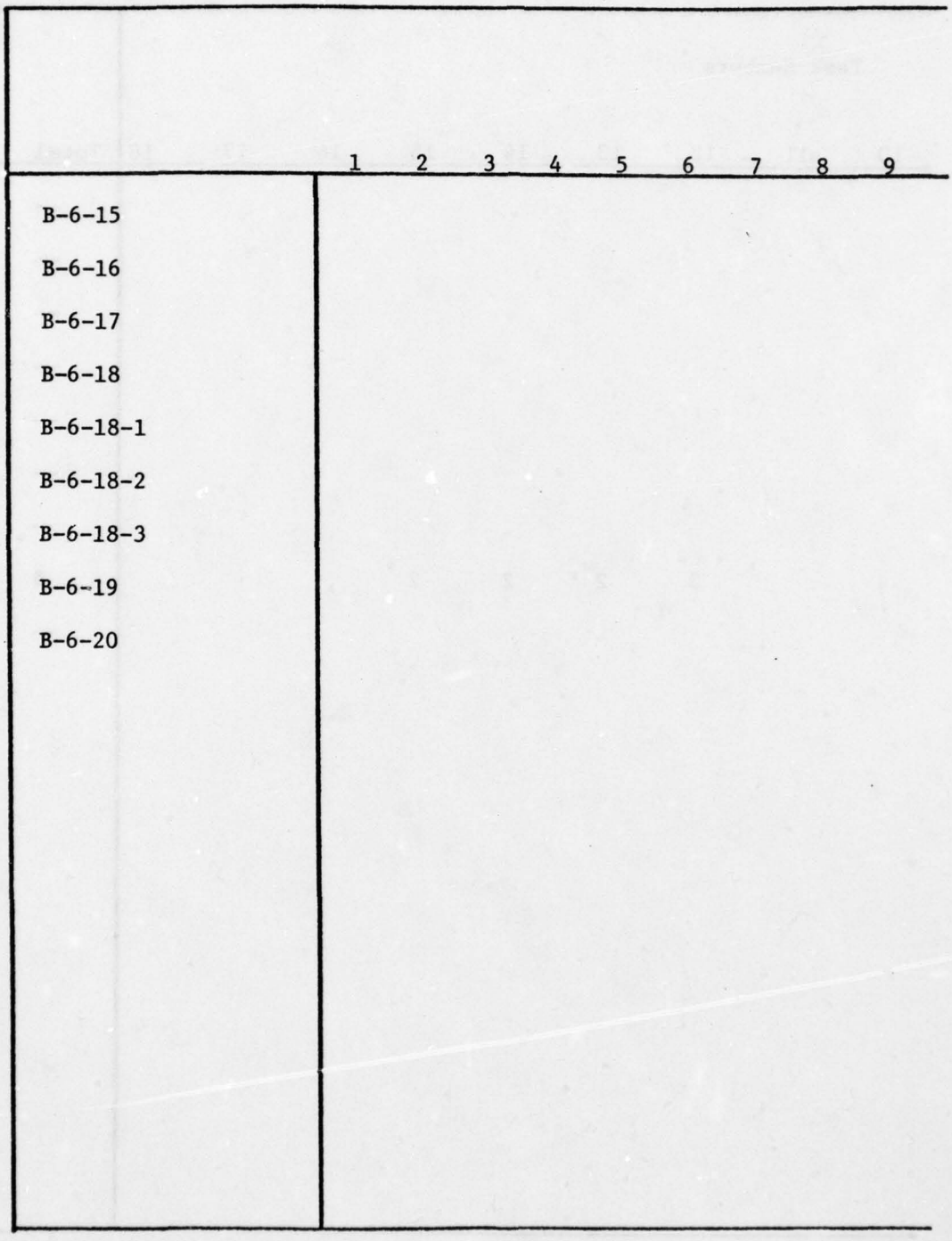
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| B-5-19 | | | | | | | | | |
| B-5-20 | | | | | | | | | |
| B-5-21 | | | | | | | | | |
| B-5-22 | | | | | | | | | |
| B-5-23 | | | | | | | | | |
| B-5-24 | | | | | | | | | |
| B-5-25 | | | | | | | | | |
| B-5-26 | | | | | | | | | |
| B-5-27 | | | | | | | | | |
| B-5-28 | | | | | | | | | |
| B-5-29 | | | | | | | | | |
| B-5-30 | | | | | | | | | |
| B-5-31 | | | | | | | | | |
| B-5-32 | | | | | | | | | |
| B-5-33 | | | | | | | | | |
| B-5-34 | | | | | | | | | |
| B-5-35 | | | | | | | | | |

| Task Numbers | | | | | | | | | |
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| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | Total |
| | | | | | | 1 | | 1 | 2 |
| | | | | | | | 1 | 1 | 2 |
| | | | | 2 | | | | 1 | 3 |
| | | | | | | | | | - |
| | | | | 2 | | 1 | 2 | 2 | 7 |
| | | | | | | | | | - |
| | | | | | | | | | - |
| | | | 1 | | 1 | | | | 2 |
| | | | 1 | 2 | | | | | 3 |
| | | | 1 | 4 | | | | | 5 |
| | | 2 | | | | | | | 2 |
| | | 1 | | | 1 | | | | 2 |
| | | 4 | | | 2 | | | | 6 |
| | | | | | | | | | - |
| | | 2 | 2 | 2 | 2 | | | | 8 |
| | | | 3 | | | | | | 3 |
| | | | 2 | | 2 | | | | 4 |

B-6 - Mathematic Skills

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Totals | 3 | - | - | - | - | 82 | 291 | 19 | 38 |
| Skill Numbers | | | | | | | | | |
| B-6-1 | 3 | | | | | | 1 | | |
| B-6-2 | | | | | | 72 | 282 | 13 | 28 |
| B-6-3 | | | | | | 10 | 8 | 6 | |
| B-6-4 | | | | | | | | | 5 |
| B-6-5 | | | | | | | | | 5 |
| B-6-6 | | | | | | | | | |
| B-6-7 | | | | | | | | | |
| B-6-8 | | | | | | | | | |
| B-6-9 | | | | | | | | | |
| B-6-9-1 | | | | | | | | | |
| B-6-9-2 | | | | | | | | | |
| B-6-9-3 | | | | | | | | | |
| B-6-9-4 | | | | | | | | | |
| B-6-10 | | | | | | | | | |
| B-6-11 | | | | | | | | | |
| B-6-12 | | | | | | | | | |
| B-6-13 | | | | | | | | | |
| B-6-14 | | | | | | | | | |

| Task Numbers | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | Totals |
| 74 | 40 | 3 | 2 | 2 | 2 | 2 | 64 | 142 | 764 |
| | | | | | | | | | |
| 3 | | | | | | | | 3 | 10 |
| 24 | 21 | | | | | 2 | 64 | 79 | 585 |
| 15 | 11 | | | | | | | 48 | 98 |
| | | | | | | | | | 5 |
| | | | | | | | | | 5 |
| 5 | 6 | | | | | | | | 11 |
| 4 | | | | | | | | | 4 |
| 3 | | | | | | | | | 3 |
| | | | | | | | | | - |
| 1 | | | | | | | | | 1 |
| 1 | | | | | | | | | 1 |
| 4 | | | | | | | | | 4 |
| 3 | 1 | | | | | | | | 4 |
| 4 | 1 | | | | | | | 5 | 10 |
| 7 | | | | | | | | 7 | 14 |
| | | | | | | | | | -- |
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| | | | | | | | | | -- |

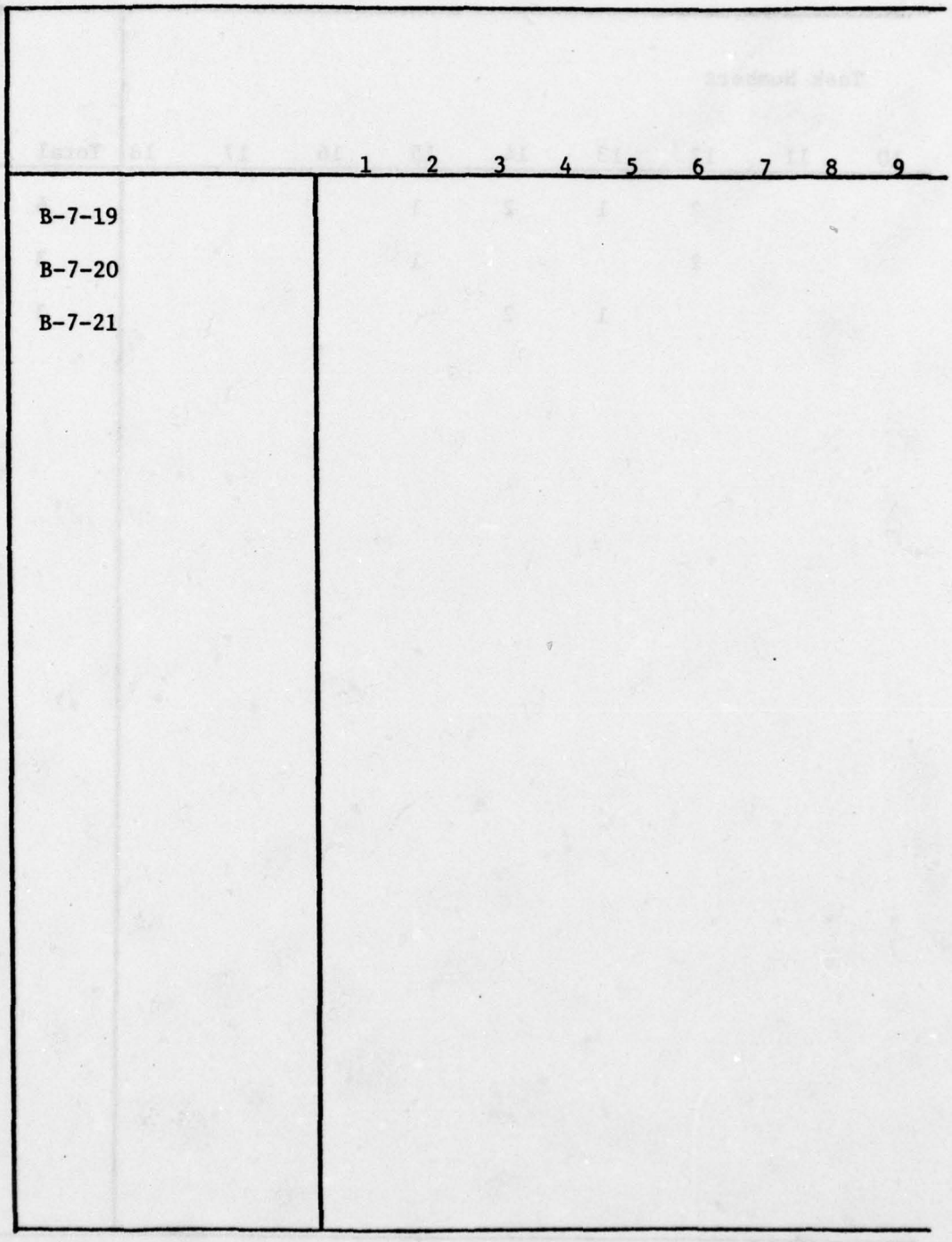

1 2 3 4 5 6 7 8 9
B-6-15
B-6-16
B-6-17
B-6-18
B-6-18-1
B-6-18-2
B-6-18-3
B-6-19
B-6-20

| Task Numbers | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | Total |
| | | | | | | | | | -- |
| | | | | | | | | | -- |
| | | | | | | | | | -- |
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| | | | | | | | | | -- |
| | | | | | | | | | -- |
| | | | | | | | | | -- |
| | | 3 | 2 | 2 | 2 | | | | 9 |
| | | | | | | | | | -- |

B-7 - Electronic Components

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Totals | 497 | 107 | 77 | 138 | 770 | 514 | 961 | 201 | 108 |
| Skill Numbers | | | | | | | | | |
| B-7-1 | 174 | 36 | 15 | 6 | 128 | 148 | 230 | 64 | 23 |
| B-7-2 | 19 | | | | 71 | 24 | 38 | 10 | 2 |
| B-7-3 | 87 | 10 | 18 | 35 | 156 | 81 | 15 | 17 | 19 |
| B-7-4 | 9 | 1 | | | | | | | |
| B-7-5 | 1 | | 4 | | | | | | |
| B-7-6 | 65 | 20 | | | | 4 | 23 | 12 | |
| B-7-7 | 40 | 3 | | | | 4 | 2 | 4 | 2 |
| B-7-8 | 24 | 9 | 12 | 25 | 110 | 35 | 18 | 11 | |
| B-7-9 | 26 | 9 | 12 | 26 | 155 | 67 | 285 | 22 | 22 |
| B-7-10 | 32 | 9 | 12 | 26 | 146 | 62 | 277 | 22 | 22 |
| B-7-11 | | | | 10 | 4 | | | 11 | |
| B-7-12 | 20 | 10 | 4 | 10 | | 89 | 73 | 28 | 18 |
| B-7-13 | | | | | | | | | |
| B-7-14 | | | | | | | | | |
| B-7-15 | | | | | | | | | |
| B-7-16 | | | | | | | | | |
| B-7-17 | | | | | | | | | |
| B-7-18 | | | | | | | | | |

| Task Numbers | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | Totals |
| 189 | 292 | 10 | 27 | 10 | 18 | 107 | 381 | 469 | 4,876 |
| 50 | 30 | 6 | 2 | 4 | 2 | 20 | 56 | 132 | 1,126 |
| 7 | 21 | | 1 | | | 2 | 6 | 19 | 220 |
| 20 | 7 | | 3 | | 2 | 17 | 6 | 6 | 499 |
| 3 | 6 | | | | | | | | 19 |
| | | | | | | | | | 5 |
| 11 | 28 | | 4 | | 2 | 19 | 57 | 41 | 286 |
| 1 | 27 | | 2 | | 1 | 6 | 9 | 8 | 109 |
| 15 | 12 | | 3 | 2 | | | 43 | 31 | 350 |
| 22 | 37 | | 2 | | 2 | 10 | 80 | 83 | 860 |
| 22 | 35 | | 2 | | 2 | 3 | 80 | 74 | 826 |
| | | | | | | | | | 25 |
| 38 | 35 | | 4 | | 4 | 20 | 38 | 71 | 462 |
| | 18 | | | | | 2 | | | 20 |
| | 18 | | | | | 2 | 2 | 2 | 24 |
| | 18 | | | | | 3 | 4 | 1 | 26 |
| | | | | | | | | | -- |
| | | | 1 | | 1 | 1 | | 1 | 4 |
| | | | 1 | | | 2 | | | 3 |


1 2 3 4 5 6 7 8 9
B-7-19
B-7-20
B-7-21

| Task Numbers | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | Total |
| | | 2 | 1 | 2 | 1 | | | | 6 |
| | | 2 | | | 1 | | | | 3 |
| | | | 1 | 2 | | | | | 3 |

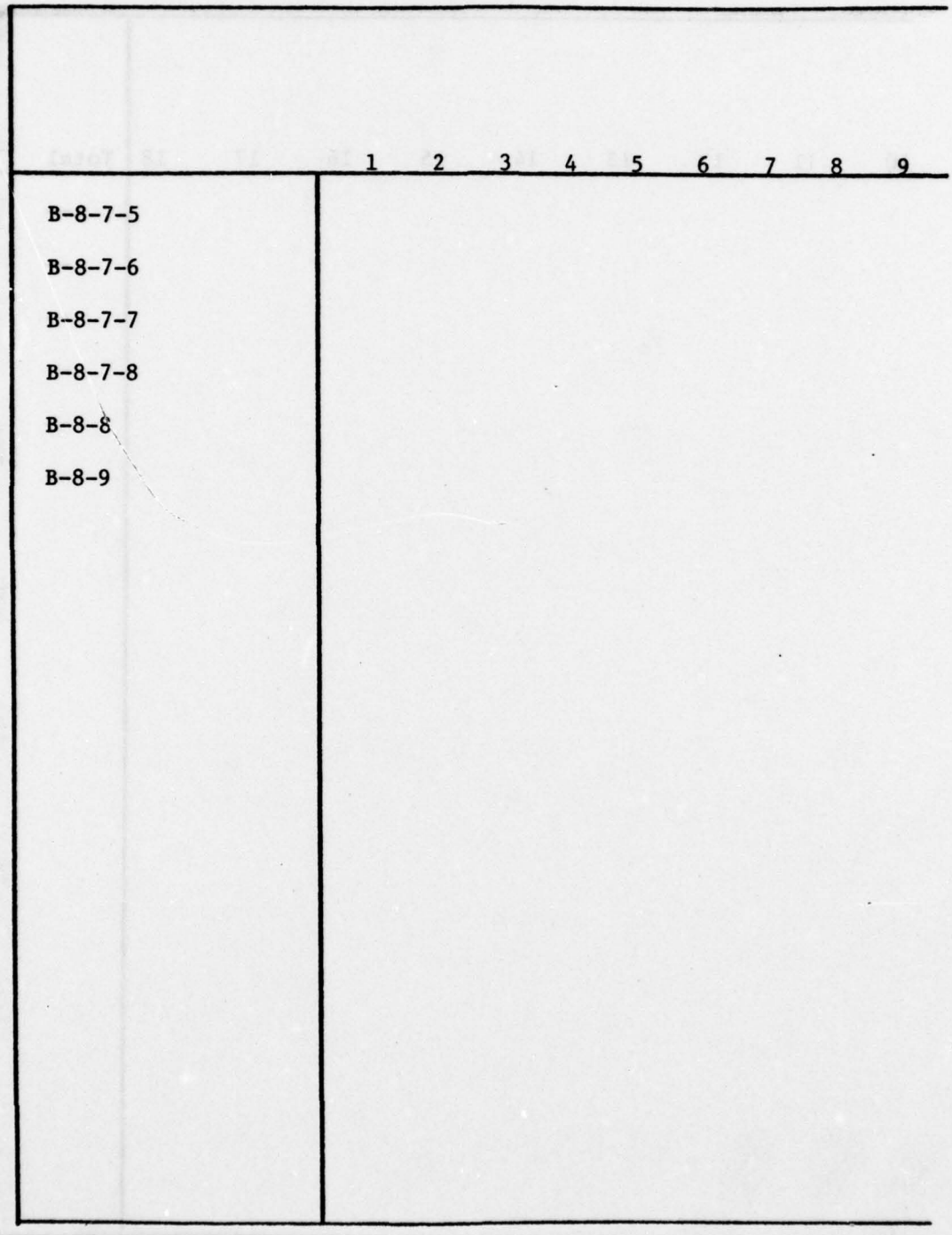
B-8 - Electronic Circuits

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Totals | 3 | 3 | 3 | 3 | 2 | 2 | 13 | 6 | 3 |
| Skill Numbers | | | | | | | | | |
| B-8-1 | | | | | | | | | |
| B-8-1-1 | | | | | | | | | |
| B-8-1-2 | | | | | | | | | |
| B-8-1-3 | | | | | | | | | |
| B-8-1-4 | | | | | | | | | |
| B-8-1-5 | | | | | | | | | |
| B-8-1-6 | | | | | | | | | |
| B-8-1-7 | | | | | | | | | |
| B-8-1-8 | | | | | | | | | |
| B-8-1-9 | | | | | | | 1 | | |
| B-8-1-10 | | | | | | | | | |
| B-8-1-11 | | | | | | | | | |
| B-8-1-12 | | | | | | | | | |
| B-8-2 | 1 | 1 | 1 | 1 | | | 6 | 3 | 1 |
| B-8-3 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 |
| B-8-4 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 1 |
| B-8-5 | | | | | | | | | |
| B-8-6 | | | | | | | | | |

| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | Totals |
|---|---|---|---|---|---|---|---|---|---|
| 6 | 29 | -- | -- | -- | -- | 20 | 20 | 20 | 133 |
| | | | | | | | | | |
| | 22 | | | | | 1 | | 1 | 24 |
| | | | | | | | 3 | 1 | 4 |
| | | | | | | | 2 | | 2 |
| | | | | | | 2 | | | 2 |
| | | | | | | 2 | 1 | 1 | 4 |
| | | | | | | | | 1 | 1 |
| | | | | | | | | 1 | 1 |
| | | | | | | | 2 | 1 | 3 |
| | | | | | | | | | 1 |
| | | | | | | 3 | | | 3 |
| | | | | | | 2 | | 2 | 4 |
| | | | | | | | | | - |
| 2 | 3 | | | | | 5 | 5 | 5 | 34 |
| 2 | 2 | | | | | 3 | 5 | 4 | 27 |
| 2 | 2 | | | | | 2 | 2 | 3 | 23 |
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| | | | | | | | | | -- |

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| B-8-6-1 | | | | | | | | | |
| B-8-6-2 | | | | | | | | | |
| B-8-6-3 | | | | | | | | | |
| B-8-6-4 | | | | | | | | | |
| B-8-6-5 | | | | | | | | | |
| B-8-6-6 | | | | | | | | | |
| B-8-6-7 | | | | | | | | | |
| B-8-6-8 | | | | | | | | | |
| B-8-6-9 | | | | | | | | | |
| B-8-6-10 | | | | | | | | | |
| B-8-6-11 | | | | | | | | | |
| B-8-6-12 | | | | | | | | | |
| B-8-6-13 | | | | | | | | | |
| B-8-6-14 | | | | | | | | | |
| B-8-7 | | | | | | | | | |
| B-8-7-1 | | | | | | | | | |
| B-8-7-2 | | | | | | | | | |
| B-8-7-3 | | | | | | | | | |
| B-8-7-4 | | | | | | | | | |

| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | Total |
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1 2 3 4 5 6 7 8 9
B-8-7-5
B-8-7-6
B-8-7-7
B-8-7-8
B-8-8
B-8-9

| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | -- |
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| | | | | | | | | | -- |
| | | | | | | | | | -- |
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| | | | | | | | | | -- |

B-9 - General Electrical Mechanical Equipment

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Totals | 12 | - | 14 | - | - | - | - | - | 17 |
| Skill Numbers | | | | | | | | | |
| B-9-1 | 6 | | 7 | | | | | | 12 |
| B-9-2 | 6 | | 7 | | | | | | |
| B-9-3 | | | | | | | | | |
| B-9-4 | | | | | | | | | 2 |
| B-9-5 | | | | | | | | | 3 |
| B-9-6 | | | | | | | | | |
| B-9-7 | | | | | | | | | |
| B-9-8 | | | | | | | | | |
| B-9-9 | | | | | | | | | |

| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | Total |
|---|---|---|---|---|---|---|---|---|---|
| -- | -- | 7 | 5 | 4 | 6 | -- | 3 | 3 | 71 |
| | | | | | | | | | 25 |
| | | | | | | | | | 13 |
| | | 3 | 3 | | 3 | | 3 | 3 | 15 |
| | | | | | | | | | 2 |
| | | | | | | | | | 3 |
| | | | | | | | | | - |
| | | 2 | 1 | 2 | 2 | | | | 7 |
| | | 2 | | | 1 | | | | 3 |
| | | | 1 | 2 | | | | | 3 |

| B-1 - Electronic Concepts | Task Numbers 19 | 20 | 21 | | 19 | 20 | 21 | | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Skill Numbers | | | | Skill Numbers | | | | Skill Numbers | | | |
| B-1-1 | x | x | x | B-1-16 | x | x | x | B-1-31 | | x | x |
| B-1-2 | | x | x | B-1-17 | x | x | x | B-1-32 | | x | x |
| B-1-3 | x | x | x | B-1-18 | | x | x | B-1-33 | x | x | x |
| B-1-4 | | x | x | B-1-19 | x | x | x | B-1-34 | x | | |
| B-1-5 | x | x | x | B-1-20 | | | x | B-1-35 | x | x | x |
| B-1-6 | x | x | x | B-1-21 | x | | x | B-1-36 | | x | x |
| B-1-7 | x | x | x | B-1-22 | x | | x | B-1-37 | | x | x |
| B-1-8 | x | | x | B-1-23 | | | x | B-1-38 | | x | x |
| B-1-9 | | x | x | B-1-24 | x | x | x | B-1-39 | | | x |
| B-1-10 | x | | x | B-1-25 | | | x | B-1-40 | | | x |
| B-1-11 | x | x | x | B-1-26 | x | x | x | B-1-41 | | | x |
| B-1-12 | x | x | x | B-1-27 | x | | | B-1-42 | | x | |
| B-1-13 | x | x | x | B-1-28 | | | x | | | | |
| B-1-14 | | x | x | B-1-29 | | | x | | | | |
| B-1-15 | | x | x | B-1-30 | | x | x | | | | |

| B-2-Tools | Task Numbers 19 | 20 | 21 | | Task Numbers 19 | 20 | 21 | B-3-Hardware | Task Numbers 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Skill Numbers | | | | | | | | Skill Numbers | | | |
| B-2-1 | | x | x | B-2-6 | | | | B-3-1 | | x | x |
| B-2-2 | x | x | x | B-2-7 | | | x | B-3-2 | | x | x |
| B-2-3-1 | x | x | x | B-2-8 | | x | x | B-3-3 | | x | x |
| B-2-3-2 | | x | x | B-2-9 | | x | | B-3-4 | | x | x |
| B-2-3-3 | | x | x | | | | | B-3-5 | | x | x |
| B-2-3-4 | | x | x | | | | | B-3-6 | x | x | x |
| B-2-3-5 | | x | x | | | | | B-3-7 | x | x | x |
| B-2-3-6 | | x | x | | | | | B-3-8 | | x | x |
| B-2-3-7 | | | x | | | | | B-3-9 | | x | x |
| B-2-4-1 | x | x | x | | | | | B-3-10 | | x | x |
| B-2-4-2 | x | x | x | | | | | B-3-11 | | x | x |
| B-2-4-3 | x | x | x | | | | | B-3-12 | | x | x |
| B-2-4-4 | x | x | x | | | | | B-3-13 | | x | x |
| B-2-4-5 | x | x | x | | | | | B-3-14 | | | x |
| B-2-5 | | | | | | | | B-3-15 | | | x |

| B-3-Hardware | Task Numbers 19 | 20 | 21 | B-4-Test Equipment | Task Numbers 19 | 20 | 21 | | Task Numbers 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Skill Numbers | | | | Skill Numbers | | | | | | | |
| B-3-16 | | | x | B-4-1 | | x | x | B-4-16 | | | |
| B-3-17 | | | x | B-4-2 | x | x | x | B-4-16-1 | | | |
| B-3-18 | | x | x | B-4-3 | | x | x | B-4-16-2 | | | |
| B-3-19 | | x | x | B-4-4 | | x | x | B-4-16-3 | | | |
| | | | | B-4-5 | | x | x | B-4-16-4 | | | |
| | | | | B-4-6 | | x | x | B-4-16-5 | | | |
| | | | | B-4-7 | | x | x | B-4-16-6 | | | |
| | | | | B-4-8 | | x | x | B-4-16-7 | | | |
| | | | | B-4-9 | | x | x | B-4-16-8 | | | |
| | | | | B-4-10 | | x | x | B-4-16-9 | | | |
| | | | | B-4-11 | | x | x | B-4-16-10 | | | |
| | | | | B-4-12 | | x | x | B-4-16-11 | | | |
| | | | | B-4-13 | | x | x | B-4-17 | x | x | x |
| | | | | B-4-14 | | x | x | B-4-18 | | | x |
| | | | | B-4-15 | x | x | x | B-4-19 | x | | x |

| B-4-Test Equipment | Task Numbers 19 | 20 | 21 |
|---|---|---|---|
| Skill Numbers | | | |
| B-4-20 | x | | x |
| B-4-21 | x | | x |

| B-5-Mechanical Skills | Task Numbers 19 | 20 | 21 |
|---|---|---|---|
| Skill Numbers | | | |
| B-5-1 | | x | x |
| B-5-2 | x | x | x |
| B-5-3 | | x | x |
| B-5-4 | | x | x |
| B-5-5 | x | x | x |
| B-5-6 | | x | x |
| B-5-7 | | x | x |
| B-5-8 | x | x | x |
| B-5-9 | | x | x |
| B-5-10 | | x | x |
| B-5-11 | | x | x |
| B-5-12 | | x | x |
| B-5-13 | | x | x |
| B-5-14 | | x | x |
| B-5-15 | x | x | x |

| | Task Numbers 19 | 20 | 21 |
|---|---|---|---|
| | | | |
| B-5-16 | x | x | x |
| B-5-17 | x | x | x |
| B-5-18 | | x | x |
| B-5-19 | | x | x |
| B-5-20 | | x | x |
| B-5-21 | x | x | x |
| B-5-22 | x | x | x |
| B-5-23 | x | x | x |
| B-5-24 | | | x |
| B-5-25 | | | x |
| B-5-26 | | x | x |
| B-5-27 | | | x |
| B-5-28 | | | x |
| B-5-29 | | | x |
| B-5-30 | | | x |

| B-5-Mechanical Skills | Task Numbers 19 | 20 | 21 |
|---|---|---|---|
| Skill Numbers | | | |
| B-5-31 | | | x |
| B-5-32 | x | x | x |
| B-5-33 | x | x | x |
| B-5-34 | x | x | x |
| B-5-35 | | x | x |

| B-6-Mathematic Skills | Task Numbers 19 | 20 | 21 |
|---|---|---|---|
| Skill Numbers | | | |
| B-6-1 | x | | |
| B-6-2 | x | x | x |
| B-6-3 | | x | x |
| B-6-4 | | | |
| B-6-5 | | | x |
| B-6-6 | | | x |
| B-6-7 | x | | |
| B-6-8 | x | | x |
| B-6-9 | | | |
| B-6-9-1 | | x | x |
| B-6-9-2 | | x | x |
| B-6-9-3 | | x | x |
| B-6-9-4 | | x | x |
| B-6-10 | x | x | x |
| B-6-11 | x | x | x |

| | 19 | 20 | 21 |
|---|---|---|---|
| B-6-12 | x | | |
| B-6-13 | x | | |
| B-6-14 | x | | |
| B-6-15 | x | | |
| B-6-16 | x | | |
| B-6-17 | x | | |
| B-6-18 | | | |
| B-6-18-1 | x | | |
| B-6-18-2 | x | | |
| B-6-18-3 | x | | |
| B-6-19 | | x | x |
| B-6-20 | | x | |

| B-7-Electronic Components | Task Numbers 19 | 20 | 21 | | Task Numbers 19 | 20 | 21 | B-8-Electronic Circuits | Task Numbers 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Skill Numbers | | | | | | | | Skill Numbers | | | |
| B-7-1 | x | x | x | B-7-16 | x | x | x | B-8-1 | | | |
| B-7-2 | x | x | x | B-7-17 | | x | x | B-8-1-1 | | x | x |
| B-7-3 | x | x | x | B-7-18 | | x | x | B-8-1-2 | | x | x |
| B-7-4 | | x | x | B-7-19 | | x | x | B-8-1-3 | | x | x |
| B-7-5 | | x | x | B-7-20 | | | x | B-8-1-4 | | x | x |
| B-7-6 | x | x | x | B-7-21 | | x | x | B-8-1-5 | | x | x |
| B-7-7 | x | x | x | | | | | B-8-1-6 | | | x |
| B-7-8 | x | x | x | | | | | B-8-1-7 | | | x |
| B-7-9 | x | x | x | | | | | B-8-1-8 | | | x |
| B-7-10 | x | x | x | | | | | B-8-1-9 | | x | x |
| B-7-11 | | | x | | | | | B-8-1-10 | | | x |
| B-7-12 | x | x | x | | | | | B-8-1-11 | | | x |
| B-7-13 | | x | x | | | | | B-8-1-12 | | | x |
| B-7-14 | | x | x | | | | | B-8-2 | x | x | x |
| B-7-15 | | x | x | | | | | B-8-3 | x | x | x |

| B-8-Electronic Circuits | Task Numbers 19 | 20 | 21 |
|---|---|---|---|
| Skill Numbers | | | |
| B-8-4 | x | x | x |
| B-8-5 | x | | x |
| B-8-6 | | | |
| B-8-6-1 | x | | |
| B-8-6-2 | x | | |
| B-8-6-3 | x | | |
| B-8-6-4 | x | | |
| B-8-6-5 | x | | |
| B-8-6-6 | x | | |
| B-8-6-7 | x | | |
| B-8-6-8 | x | | |
| B-8-6-9 | x | | |
| B-8-6-10 | x | | |
| B-8-6-11 | x | | |
| B-8-6-12 | x | | |

| | Task Numbers 19 | 20 | 21 |
|---|---|---|---|
| B-8-6-13 | x | | |
| B-8-6-14 | x | | |
| B-8-7 | | | |
| B-8-7-1 | | | x |
| B-8-7-2 | | | x |
| B-8-7-3 | | | x |
| B-8-7-4 | | | x |
| B-8-7-5 | | | x |
| B-8-7-6 | | | x |
| B-8-7-7 | | | x |
| B-8-7-8 | | | x |
| B-8-8 | | x | |
| B-8-9 | | x | |

| B-9-General Electrical Mechanical Equipment | Task Numbers 19 | 20 | 21 |
|---|---|---|---|
| Skill Numbers | | | |
| B-9-1 | | | |
| B-9-2 | | x | x |
| B-9-3 | x | x | x |
| B-9-4 | | x | x |
| B-9-5 | | x | x |
| B-9-6 | x | x | |
| B-9-7 | x | x | x |
| B-9-8 | | | x |
| B-9-9 | | | x |

## Appendix D

## Electronic Maintenance Job Description Survey

Electronic Maintenance Job Description Survey

## Introduction

This survey has been developed from the analysis of tasks from several electronic maintenance MOS('s). Its purpose is to obtain job description data that will be used to develop new or modify existing electronic maintenance courses conducted by the U.S. Army Schools. We realize that some of the items in this survey may describe skills, knowledge or activities that may not be important in your job, but they are included because they are important in other jobs. Much of the material used here was found to be used to some extent in many if not all the MOS('s) analyzed. You and many other electronic technicians are being asked to fill out the survey so that it can be determined how important each item is to successful performance on the job. The idea is to be able to develop courses where only job-important material is covered. Your sincere effort in answering each item will be appreciated. Those who will follow you in your MOS will thank you for your effort in providing this input to the development of improved maintenance course content.

PART I - GENERAL WORK HABITS AND SAFE OPERATING PROCEDURES.

For each item, indicate how important you feel it is to the overall success of your job. Use the scale 1 to 10, with 1 being the lowest and 10 the highest level of importance.

0 1 2 3 4 5 6 7 8 9 10

Not important — Extremely important

G1. Planning the job - determining what activities must be carried out, assembling the necessary tools, test equipment, schematics, technical manuals, and other references prior to starting the work. _____

G2. Detecting problem situations as soon as they develop. _____

G3. Analyzing problem situations that are blocking work progress. _____

G4. Taking action to overcome work situation difficulties. _____

G5. Using the proper tools to carry out a procedure. _____

G6. Using the proper test equipment. _____

G7. Using the appropriate materials in servicing equipment. _____

G8. Performing all necessary steps in removing and/or replacing components/parts. _____

G9. Using all required hardware (nuts, screws, washers, bolts, etc.) when replacing components/parts. _____

G10. Inspecting all tools for serviceability before using. _____

G11. Inspecting all test equipment for serviceability before using. _____

G12. Inspecting all materials before using. _____

G13. Inspecting all components/parts before using. _____

G14. Recognizing that components/parts are damaged. _____

G15. Replacing damaged components/parts. _____

G16. Assuming personal responsibility for all assigned and implied MOS duties. _____

G17. Performing each task thoroughly, and not taking shortcuts or jumping to conclusions. _____

G18. Double checking switch positions, cable connections. _____

G19. Doing maintenance work not directly assigned but that you determine must be performed. _____

G20. Replacing tools, test equipment and materials when work is finished. _____

G21. De-energizing (turning OFF) equipment when removing and replacing chassis and components. _____

G22. De-energizing equipment when connecting test equipment leads. _____

G23. Discharging capacitors when working with them in high voltage power supplies, regulators and transmitters. _____

G24. Properly grounding equipment before applying power. _____

G25. Keeping hands, arms and other parts of the body out of energized equipment. _____

G26. Not wearing hand jewelry and dangling necklaces, chains, etc. when working on energized equipment. _____

G27. Using the "one hand" rule when working with conductive materials. _____

G28. Keeping equipment components dry when working under inclement weather conditions. _____

G29. Not using water to put out electrical fires. _____

G30. Never working alone on energized equipment. _____

G31. Using appropriate safety devices and equipment (hooks, ropes, poles, rubber gloves, goggles, and first aid equipment) when called for. _____

G32. Immediately turning OFF power if electrical components become wet and arc. _____

G33. Not engaging in horseplay when performing maintenance on energized equipment. _____

G34. Not allowing test equipment leads, tools, wires, etc. to short circuit components. _____

G35. Inspecting switches and connector wires for serviceability (detecting bare wires, sparks, excessive heat). _____

G36. No cheating safety interlocks (except when reference procedures specifically call for this to be done). _____

G37. Wearing safety goggles and gloves when handling radioactive materials such as cathode ray tubes. _____

G38. Disposing of radioactive materials and glass tubes in the prescribed manner. _____

PART II - SPECIFIC SKILLS AND KNOWLEDGE.

For each item indicate whether or not you do what is described.

B1 Do you use the following terms in performing your MOS tasks?

| | | Yes | No |
|---|---|---|---|
| 1. | Voltage | ___ | ___ |
| 2. | Signal | ___ | ___ |
| 3. | Ground | ___ | ___ |
| 4. | Noise | ___ | ___ |
| 5. | Amplitude | ___ | ___ |
| 6. | Potential | ___ | ___ |
| 7. | Frequency | ___ | ___ |
| 8. | Bandwidth | ___ | ___ |
| 9. | Bandpass | ___ | ___ |
| 10. | Magnetism | ___ | ___ |
| 11. | Circuitry | ___ | ___ |
| 12. | Resistance | ___ | ___ |
| 13. | Impedance | ___ | ___ |
| 14. | Microwave | ___ | ___ |
| 15. | Parallax | ___ | ___ |
| 16. | Oscillation | ___ | ___ |
| 17. | Capacitance | ___ | ___ |
| 18. | Amplification | ___ | ___ |
| 19. | Power | ___ | ___ |
| 20. | Insulation | ___ | ___ |
| 21. | Conductance | ___ | ___ |
| 22. | Current | ___ | ___ |

B2 Do you use or refer to the following electrical measurement units?

| | Yes | No |
|---|---|---|
| 1. Volts | | |
| 2. Amperes | | |
| 3. Ohms | | |
| 4. Herz | | |
| 5. Farads | | |
| 6. Watts | | |
| 7. Henries | | |

B3 Do you work with the following electrical circuits?

| | Yes | No |
|---|---|---|
| 1. AC circuits | | |
| 2. DC circuits | | |

B4 Do you work with the following vacuum tube circuits?

| | Yes | No |
|---|---|---|
| 1. Amplifier circuits | | |
| 2. Tuned (resonant) circuits | | |
| 3. Cathode follower circuits | | |
| 4. Multivibrator circuits | | |
| 5. Power supply circuits | | |
| 6. Voltage regulator circuits | | |
| 7. Oscillator circuits | | |
| 8. Sweep generator circuits | | |
| 9. Timing (pulse) circuits | | |
| 10. Display circuits | | |
| 11. Clamping (limiter) circuits | | |
| 12. Noise generator circuits | | |

| B5 Do you work with the following solid state circuits? | Yes | No |
|---|---|---|
| 1. AND-gate circuits | | |
| 2. OR-gate circuits | | |
| 3. NOR-gate circuits | | |
| 4. NAND-gate circuits | | |
| 5. Flip-flop circuits | | |
| 6. Driver circuits | | |
| 7. Adder circuits | | |
| 8. Counter circuits | | |
| 9. Input circuits | | |
| 10. Output circuits | | |
| 11. Coupler circuits | | |

| B6 Do you work with the following microwave (RF) circuits? | Yes | No |
|---|---|---|
| 1. Transmission line circuits (using waveguide) | | |
| 2. Antenna circuits | | |
| 3. Amplitude modulation circuits | | |
| 4. Frequency modulation circuits | | |
| 5. Pulse modulation circuits | | |
| 6. Detector circuits | | |
| 7. Frequency convertor circuits | | |
| 8. Parallax circuits | | |

B7 Do you work with the following electrical items?

| | | Yes | No |
|---|---|---|---|
| 1. | Transmitters | ____ | ____ |
| 2. | Receivers | ____ | ____ |
| 3. | Cathode ray tubes | ____ | ____ |
| 4. | Vacuum tubes | ____ | ____ |
| 5. | Resistors | ____ | ____ |
| 6. | Capacitors | ____ | ____ |
| 7. | Circuit cards | ____ | ____ |
| 8. | Diodes | ____ | ____ |
| 9. | Transformers | ____ | ____ |
| 10. | Relays | ____ | ____ |
| 11. | Waveguides | ____ | ____ |
| 12. | Antennas | ____ | ____ |
| 13. | Electric motors | ____ | ____ |
| 14. | Switches | ____ | ____ |
| 15. | Fuses | ____ | ____ |
| 16. | Lamps | ____ | ____ |
| 17. | Connectors (plugs, jacks) | ____ | ____ |
| 18. | Power cables | ____ | ____ |
| 19. | Data cables | ____ | ____ |
| 20. | Coaxial cables | ____ | ____ |

B8 Do you use the following test equipment?

| | | Yes | No |
|---|---|---|---|
| 1. | Oscilloscope | ____ | ____ |
| 2. | Electronic Voltmeter | ____ | ____ |
| 3. | TS-505 A/U multimeter | ____ | ____ |
| 4. | TS-505 B/U multimeter | ____ | ____ |
| 5. | TS-505 C/U multimeter | ____ | ____ |
| 6. | TS-505 D/U multimeter | ____ | ____ |
| 7. | Multimeter, but don't remember number designation | ____ | ____ |
| 8. | Stop watch | ____ | ____ |
| 9. | Tube adapter | ____ | ____ |
| 10. | Tube tester - TV-7 | ____ | ____ |
| 11. | Digital volt meter | ____ | ____ |
| 12. | Wavemeter | ____ | ____ |
| 13. | Signal generator | ____ | ____ |
| 14. | Power measuring test set | ____ | ____ |
| 15. | Dummy load | ____ | ____ |

B9 Do you use the following High Frequency Console test equipment?

| | | Yes | No |
|---|---|---|---|
| 1. | A multimeter | ____ | ____ |
| 2. | B multimeter | ____ | ____ |
| 3. | Dual purpose generator | ____ | ____ |
| 4. | Oscilloscope | ____ | ____ |
| 5. | Multifunction generator | ____ | ____ |
| 6. | Modulator oscillator | ____ | ____ |
| 7. | 600 ohm attenuator | ____ | ____ |
| 8. | CW oscillator | ____ | ____ |
| 9. | Amplifier indicator | ____ | ____ |
| 10. | Thermal noise generator | ____ | ____ |
| 11. | Signal generator | ____ | ____ |
| 12. | 50 mhz counter | ____ | ____ |

T10 Do you use the following tools in your maintenance duties?

| | | Yes | No |
|---|---|---|---|
| 1. | Screwdrivers - flat tip | ____ | ____ |
| 2. | Screwdriver - cross tip (Phillips) | ____ | ____ |
| 3. | Screwdriver - jewelers | ____ | ____ |
| 4. | Hexagonhead wrenches (L bar, Allen) | ____ | ____ |
| 5. | Open end wrenches | ____ | ____ |
| 6. | Attenuator probes | ____ | ____ |
| 7. | Jumper leads | ____ | ____ |
| 8. | Rulers | ____ | ____ |
| 9. | Pliers | ____ | ____ |
| 10. | Wire strippers | ____ | ____ |
| 11. | Pocket knife | ____ | ____ |
| 12. | Torque wrench | ____ | ____ |
| 13. | Soldering irons | ____ | ____ |
| 14. | Soldering sets | ____ | ____ |
| 15. | Soldering aids | ____ | ____ |
| 16. | Heat sink | ____ | ____ |
| 17. | Thickness gauge | ____ | ____ |
| 18. | Dial indicators | ____ | ____ |
| 19. | Non-magnetic tools | ____ | ____ |
| 20. | Tuning wands | ____ | ____ |
| 21. | RF probes | ____ | ____ |
| 22. | Card extractors | ____ | ____ |

M11 Do you use or work with the following mechanical items?

| | | Yes | No |
|---|---|---|---|
| 1. | Gaskets | ____ | ____ |
| 2. | Nuts | ____ | ____ |
| 3. | Bolts | ____ | ____ |
| 4. | Index (locking) pins in gear assemblies. | ____ | ____ |
| 5. | Screws | ____ | ____ |
| 6. | Retaining clamps | ____ | ____ |
| 7. | Set screws | ____ | ____ |
| 8. | BNC/BSM/TEE connectors | ____ | ____ |
| 9. | Clamps | ____ | ____ |
| 10. | Wire | ____ | ____ |
| 11. | Dessicants | ____ | ____ |
| 12. | Filters (air and liquid) | ____ | ____ |
| 13. | Coolant fluids | ____ | ____ |
| 14. | Lubricants | ____ | ____ |
| 15. | Gears | ____ | ____ |
| 16. | Gear trains | ____ | ____ |
| 17. | Synchros | ____ | ____ |
| 18. | Pumps - fluid | ____ | ____ |
| 19. | Air compressors | ____ | ____ |
| 20. | Pressure gauges - fluid | ____ | ____ |
| 21. | Pressure gauges - air | ____ | ____ |
| 22. | Resolvers | ____ | ____ |

MC12 Do you use or refer to the following mathematical and measurement concepts?

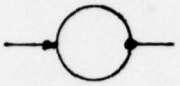
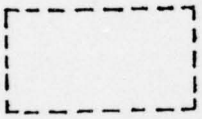
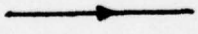
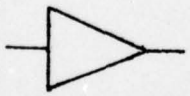
| | Yes | No |
|---|---|---|
| 1. Ratio | ____ | ____ |
| 2. Percentage (%) | ____ | ____ |
| 3. Positive (+)/Negative (-) values | ____ | ____ |
| 4. Symbols indicating arithmetic operations: | | |
| 1. + denotes add | ____ | ____ |
| 2. - denotes subtract | ____ | ____ |
| 3. x denotes multiply | ____ | ____ |
| 4. ÷ denotes divide | ____ | ____ |
| 5. = denotes equals | ____ | ____ |
| 6. $\pm$ denotes plus or minus | ____ | ____ |
| 5. Symbols representing powers of ten: | | |
| 1. uu micro micro | ____ | ____ |
| 2. n nano | ____ | ____ |
| 3. u micro | ____ | ____ |
| 4. m milli | ____ | ____ |
| 5. K Kilo | ____ | ____ |
| 6. M Mega | ____ | ____ |
| 7. G Giga | ____ | ____ |
| 6. Square root of a number | ____ | ____ |
| 7. Square of a number | ____ | ____ |
| 8. Algebra equations | | |
| (example: $3A^2 + 5B - C = X$) | ____ | ____ |
| 9. Basic geometry: | | |
| 1. Radius of a circle | ____ | ____ |

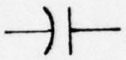
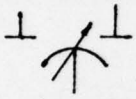
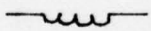
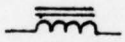
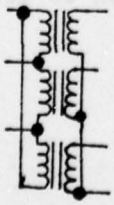
| | Yes | No |
|---|---|---|
| 2. Degrees in a circle | ____ | ____ |
| 3. Minutes in a degree | ____ | ____ |
| 4. Perimeter of a circle | ____ | ____ |
| 5. Intersect | ____ | ____ |
| 6. Rectangle | ____ | ____ |
| 7. Vertical | ____ | ____ |
| 8. Horizontal | ____ | ____ |
| 9. Right triangle | ____ | ____ |
| 10. Torque values (inch or foot pounds) | ____ | ____ |
| 11. Maximum/minimum | ____ | ____ |
| 12. Scales or graphs | ____ | ____ |
| 13. Time measurement: | | |
| 1. Minutes/seconds | ____ | ____ |
| 2. Micro - seconds | ____ | ____ |
| 3. Milli - seconds | ____ | ____ |
| 4. Nano - seconds | ____ | ____ |
| 14. Numbering systems: | | |
| 1. Binary | ____ | ____ |
| 2. Octal | ____ | ____ |
| 3. Hexadecimal | ____ | ____ |
| 15. Boolean algebra | ____ | ____ |
| 16. Logic diagrams | ____ | ____ |
| 17. Truth tables | ____ | ____ |
| 18. Parallax theory | ____ | ____ |
| 19. Rank order (preferential selection) | ____ | ____ |

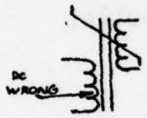
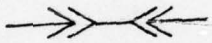
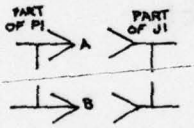
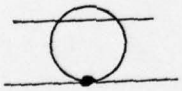
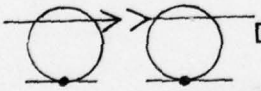
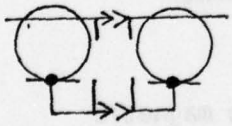
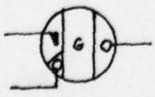
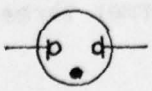
SC-13 Do you use, refer to or read the following electronic symbols and designations?

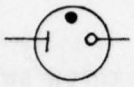
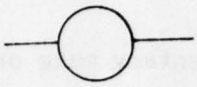
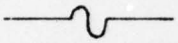
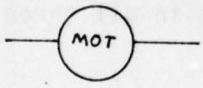
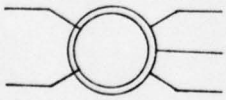
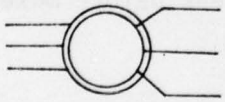
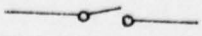
| | | | Yes | No |
|---|---|---|---|---|
| 1. | P | Power measured in watts. | ____ | ____ |
| 2. | E | Voltage | ____ | ____ |
| 3. | ac | Alternating current | ____ | ____ |
| 4. | dc | Direct current | ____ | ____ |
| 5. | I | Current measured in amperes. | ____ | ____ |
| 6. | R | Resistance measured in ohms. | ____ | ____ |
| 7. | C | Capacitance measured in farads. | ____ | ____ |
| 8. | L | Inductance measured in henries. | ____ | ____ |
| 9. | db | Decibels | ____ | ____ |
| 10. | Ø | Phase | ____ | ____ |
| 11. | RF | Radio frequency | ____ | ____ |

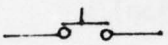
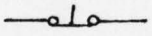
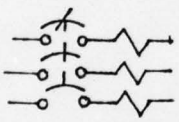
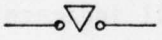
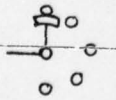
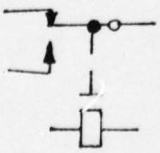
SC-14 Do you use and refer to the following schematic symbols?

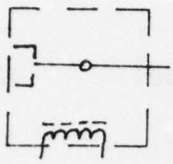
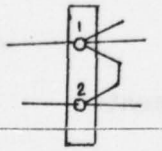
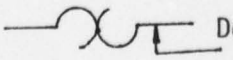
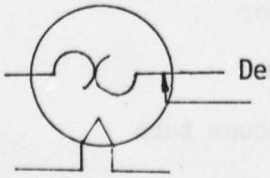
| | | | Yes | No |
|---|---|---|---|---|
| 1. |  | Denotes that component is adjustable | ____ | ____ |
| 2. |  | Denotes slip ring | ____ | ____ |
| 3. |  | Denotes buildup for variable resistors | ____ | ____ |
| 4. |  | Denotes mechanical linkage or shielding | ____ | ____ |
| 5. |  | Denotes general enclosure of functional grouping | ____ | ____ |
| 6. |  | Denotes minor signal, arrow points in direction of signal flow | ____ | ____ |
| 7. |  | Denotes major signal, arrow points in direction of signal flow | ____ | ____ |
| 8. |  | Denotes amplifier | ____ | ____ |
| 9. |  | Denotes system ground | ____ | ____ |
| 10. |  | Denotes chassis ground | ____ | ____ |
| 11. |  | Denotes common connector | ____ | ____ |
| 12. |  | Denotes loudspeaker | ____ | ____ |

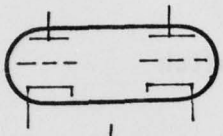
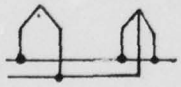
| | | | Yes | No |
|---|---|---|---|---|
| 13. |  | Denotes antenna or horn | ____ | ____ |
| 14. |  | Denotes parabolic antenna | ____ | ____ |
| 15. |  | Denotes female convenience outlet | ____ | ____ |
| 16. |  | Denotes capacitor | ____ | ____ |
| 17. |  | Denotes variable differential capacitor | ____ | ____ |
| 18. |  | Denotes electrolytic capacitor | ____ | ____ |
| 19. |  | Denotes coil | ____ | ____ |
| 20. |  | Denotes choke | ____ | ____ |
| 21. |  | Denotes air core transformer | ____ | ____ |
| 22. |  | Denotes transformer with magnetic core and electrostatic shield | ____ | ____ |
| 23. |  | Denotes iron core transformer | ____ | ____ |
| 24. |  | Denotes iron core transformer three phase delta to wye. | ____ | ____ |

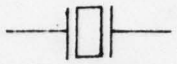
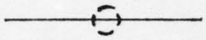
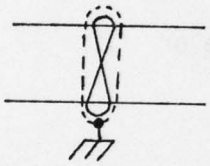
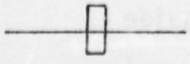
| | | | Yes | No |
|---|---|---|---|---|
| 25. |  | Denotes adjustable transformer | ____ | ____ |
| 26. |  | Denotes auto transformer | ____ | ____ |
| 27. |   | Denotes saturable reactor | ____ | ____ |
| 28. |  | Denotes female feed through connector | ____ | ____ |
| 29. |  | Denotes male-female connectors | ____ | ____ |
| 30. |   | Denotes mated connectors | ____ | ____ |
| 31. |  | Denotes coaxial connector | ____ | ____ |
| 32. |  | Denotes mated coaxial connectors | ____ | ____ |
| 33. |  | Denotes mated coaxial, outside connectors shown carried through | ____ | ____ |
| 34. |   | Denotes pilot lamp (letter indicates color) | ____ | ____ |
| 35. |   | Denotes pilot lamp with push to test | ____ | ____ |
| 36. |   | Denotes AC neon lamp | ____ | ____ |

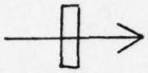
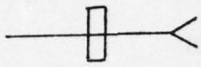
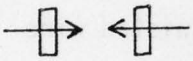
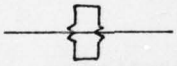
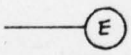
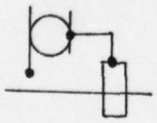
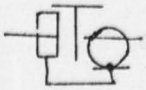
| | | | Yes | No |
|---|---|---|---|---|
| 37. |  | Denotes DC neon lamp | | |
| 38. |  | Denotes instrument meter (letter placed in center to indicate function). | | |
| 39. |  | Denotes fuse | | |
| 40. |   | Denotes generator | | |
| 41. |   | Denotes motor | | |
| 42. |  | Denotes synchro (letter will indicate type of device). | | |
| 43. |  | Denotes synchro, transmitter, receiver, or control transformer | | |
| 44. |  | Denotes synchro, differential transmitter or receiver | | |
| 45. |  | Denotes a handwheel | | |
| 46. |  | Denotes cams | | |
| 47. |  | Denotes limit cam | | |
| 48. |  | Denotes single pole single throw switch | | |

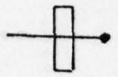
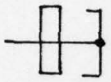
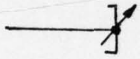
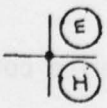
| | | | Yes | No |
|---|---|---|---|---|
| 49. |  | Denotes single pole double throw switch | _____ | _____ |
| 50. |  | Denotes push-button momentary make or spring return | _____ | _____ |
| 51. |  | Denotes push-button momentary break or spring return | _____ | _____ |
| 52. |  | Denotes three pole switch breaker with magnetic overload device in all three poles. | _____ | _____ |
| 53. |  | Denotes interlock | _____ | _____ |
| 54. |  | Denotes circuit breaker | _____ | _____ |
| 55. |  | Denotes rotary switch break before make | _____ | _____ |
| 56. |  | Denotes rotary switch make before break | _____ | _____ |
| 57. |  | Denotes relay (de-energized) | _____ | _____ |
| 58. |  | Denotes contactor relay (de-energized) | _____ | _____ |

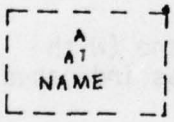
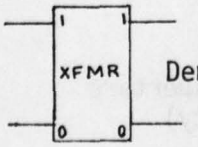
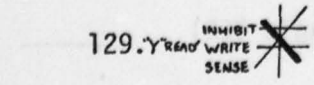
| | | | Yes | No |
|---|---|---|---|---|
| 59. |  | Denotes chopper relay | | |
| 60. |  | Denotes flow activate switch | | |
| 61. |  | Denotes liquid level activate switch | | |
| 62. |  | Denotes pressure or vacuum activate switch | | |
| 63. |  | Denotes transfer switch | | |
| 64. |  | Denotes thermal time delay relay | | |
| 65. |  | Denotes single terminal | | |
| 66. |  | Denotes shielded terminal | | |
| 67. |   | Denotes terminal board | | |
| 68. |  | Denotes test jack | | |
| 69. |  | Denotes break contact thermostat | | |
| 70. |  | Denotes break contact thermal relay | | |

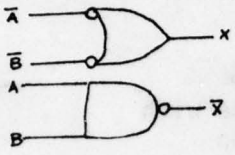
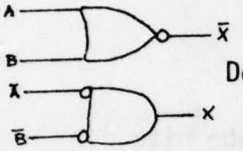
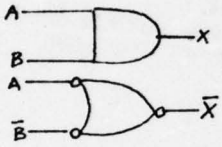
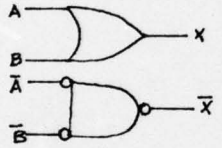
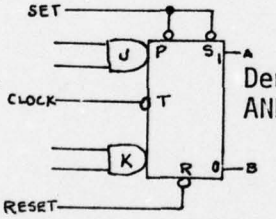
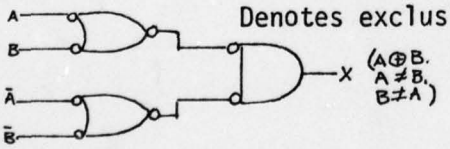
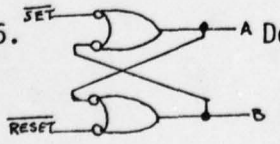
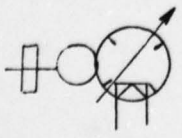
| | | | Yes | No |
|---|---|---|---|---|
| 71. |  | Denotes triode vacuum tube | ____ | ____ |
| 72. |  | Denotes dual triode vacuum tube | ____ | ____ |
| 73. |  | Denotes a thyratron vacuum tube | ____ | ____ |
| 74. |  | Denotes a vacuum tube dc voltage regulator | ____ | ____ |
| 75. |  | Denotes crystal diode | ____ | ____ |
| 76. |  | Denotes breakdown diode (Zener) | ____ | ____ |
| 77. |  | Denotes bi-polar voltage limiter, surge suppressor | ____ | ____ |
| 78. |  | Denotes vacuum tube diode | ____ | ____ |
| 79. |  | Denotes vacuum tube filaments (single and double) | ____ | ____ |
| 80. |  | Denotes NPN transistor | ____ | ____ |
| 81. |  | Denotes PNP transistor | ____ | ____ |
| 82. |  | Denotes a pentode vacuum tube | ____ | ____ |

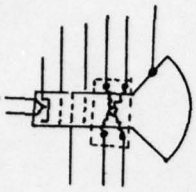
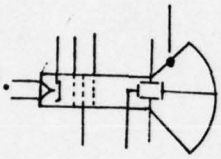
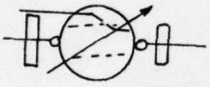
| | | | Yes | No |
|---|---|---|---|---|
| 83. |  | Denotes a crystal | ____ | ____ |
| 84. |  | Denotes single conductor | ____ | ____ |
| 85. |  | Denotes shielded conductor | ____ | ____ |
| 86. |  | Denotes shielded double twisted wire | ____ | ____ |
| 87. |  | Denotes common shield (separated for convenience of illustration). | ____ | ____ |
| 88. |  | Denotes connected conductors | ____ | ____ |
| 89. |  | Denotes conductors not connected | ____ | ____ |
| 90. |  | Denotes resistor | ____ | ____ |
| 91. |  | Denotes thermistor | ____ | ____ |
| 92. |  | Denotes symmetrical varistor | ____ | ____ |
| 93. |  | Denotes circular waveguide | ____ | ____ |
| 94. |  | Denotes rectangular waveguide | ____ | ____ |

| | | | Yes | No |
|---|---|---|---|---|
| 95. |  | Denotes coaxial waveguide | ____ | ____ |
| 96. |  | Denotes plain flange | ____ | ____ |
| 97. |  | Denotes choke flange | ____ | ____ |
| 98. |  | Denotes mated plain flange or rectangular waveguide | ____ | ____ |
| 99. |  | Denotes flexing waveguide | ____ | ____ |
| 100. |   | Denotes waveguide coupling by aperture (letter inside circle indicates plane) | ____ | ____ |
| 101. |   | Denotes aperture to space | ____ | ____ |
| 102. |  | Denotes probe to space | ____ | ____ |
| 103. |  | Denotes probe coaxial to rectangular waveguide | ____ | ____ |
| 104. |  | Denotes loop to space | ____ | ____ |
| 105. |  | Denotes mode transducer | ____ | ____ |
| 106. |  | Denotes rectangular waveguide transducer to coaxial | ____ | ____ |

| | | | Yes | No |
|---|---|---|---|---|
| 107. |  | Denotes waveguide shims | ____ | ____ |
| 108. |  | Denotes short termination | ____ | ____ |
| 109. |  | Denotes resistor termination | ____ | ____ |
| 110. |  | Denotes variable termination short | ____ | ____ |
| 111. |  | Denotes open circuit | ____ | ____ |
| 112. |  | Denotes single cavity resonator | ____ | ____ |
| 113. |  | Denotes fixed waveguide attenuator | ____ | ____ |
| 114. |  | Denotes variable waveguide attenuator | ____ | ____ |
| 115. |  | Denotes coupling by E plane (with aperture transmission loss indicated) | ____ | ____ |
| 116. |  | Denotes mechanical tuned cavity resonator | ____ | ____ |
| 117. |  | Denotes reflex klystron aperture coupled (adjustable cavity) | ____ | ____ |
| 118. |  | Denotes Hybrid junction (Magic TEE) | ____ | ____ |

| | | | Yes | No |
|---|---|---|---|---|
| 119. | • | Denotes the AND function | ____ | ____ |
| 120. | + | Denotes the OR function | ____ | ____ |
| 121. | ⊕ | Denotes the exclusive OR function | ____ | ____ |
| 122. | $\overline{\text{NAME}}$ | Denotes the superscript bar indicating the NOT function | ____ | ____ |
| 123. | ≃ | Denotes approximate equality | ____ | ____ |
| 124. | ≡ | Denotes an equivalence | ____ | ____ |
| 125. | NAME′ | Denotes prime which indicates a difference in delay between two signals | ____ | ____ |
| 126. | o | Denotes a normally low signal state | ____ | ____ |
| 127. |  | Denotes a module enclosure:<br>A. indicates location of parent module<br>A1 indicates Module reference designation and parent plate plug number Module name - describes functional use of module. | ____ | ____ |
| 128. |  | Denotes a transformer | ____ | ____ |
| 129. |  | Denotes a read/write memory ferrite core | ____ | ____ |

| | | Yes | No |
|---|---|---|---|
| 130. |  Denotes a NAND Gate | | |
| 131. |  Denotes a NOR Gate | | |
| 132. |  Denotes an AND Gate | | |
| 133. |  Denotes an OR Gate | | |
| 134. |  Denotes JK Flip Flop with an AND input | | |
| 135. |  Denotes exclusive OR Gates | | |
| 136. |  Denotes a R-S Flip-Flop (Latch) | | |
| 137. |  Denotes a tunable magnetron, aperture coupled. | | |

| | | Yes | No |
|---|---|---|---|
| 138. |  Denotes cathode ray tube with electrostatic deflection | ____ | ____ |
| 139. |  Denotes cathode ray tube with electromagnetic deflection | ____ | ____ |
| 140. |  Denotes TR tube | ____ | ____ |

| SC15 | Schematic reference designators: | | Yes | No |
|---|---|---|---|---|
| 1. | ØA | Designates A phase | ____ | ____ |
| 2. | ØB | Designates B phase | ____ | ____ |
| 3. | ØC | Designates C phase | ____ | ____ |
| 4. | $B^+$ | Designates plate voltage to a vacuum tube | ____ | ____ |
| 5. | B | Designates a motor, synchro or resolver | ____ | ____ |
| 6. | b | Designates the base of a transistor | ____ | ____ |
| 7. | C | Designates a capacitor | ____ | ____ |
| 8. | c | Designates the cathode of a tube or the collector of a transistor | ____ | ____ |
| 9. | CW | Designates clockwise direction | ____ | ____ |
| 10. | ccw | Designates counter clockwise direction | ____ | ____ |
| 11. | CR | Designates a crystal rectifier - crystal diode | ____ | ____ |
| 12. | crt | Designates a cathode ray tube | ____ | ____ |
| 13. | DS | Designates a lamp or light | ____ | ____ |
| 14. | del | Designates a delay | ____ | ____ |
| 15. | e | Designates the emitter of a transistor | ____ | ____ |
| 16. | fil | Designates filament voltage | ____ | ____ |

| | | | Yes | No |
|---|---|---|---|---|
| 17. | F | Designates a fuse | ____ | ____ |
| 18. | g | Designates the grid of a vacuum tube | ____ | ____ |
| 19. | Gnd | Designates ground | ____ | ____ |
| 20. | Hz | Designates Herz (cycles per second) | ____ | ____ |
| 21. | J | Designates a jack | ____ | ____ |
| 22. | K | Designates a relay | ____ | ____ |
| 23. | L | Designates a coil | ____ | ____ |
| 24. | k | Designates the cathode of a diode | ____ | ____ |
| 25. | M | Designates a meter, or motor | ____ | ____ |
| 26. | MG | Designates a motor generator | ____ | ____ |
| 27. | NU | Designates a nominal value | ____ | ____ |
| 28. | PRF | Designates pulses repetition frequency | ____ | ____ |
| 29. | P | Designates a plug | ____ | ____ |
| 30. | pps | Designates pulses per second | ____ | ____ |
| 31. | P | Designates plate of a vacuum tube | ____ | ____ |
| 32. | Q | Designates a transistor | ____ | ____ |
| 33. | R | Designates a resistor | ____ | ____ |

| | | | Yes | No |
|---|---|---|---|---|
| 34. | rpm | Designates revolutions per minute | _____ | _____ |
| 35. | RTN | Designates a return | _____ | _____ |
| 36. | S | Designates a switch | _____ | _____ |
| 37. | SB | Designates a slow blow fuse | _____ | _____ |
| 38. | T | Designates a transformer | _____ | _____ |
| 39. | TB | Designates a terminal board | _____ | _____ |
| 40. | vdc | Designates direct current voltage | _____ | _____ |
| 41. | vac | Designates alternating current voltage | _____ | _____ |
| 42. | V | Designates a vacuum tube | _____ | _____ |
| 43. | W | Designates a wire | _____ | _____ |
| 44. | w | Designates watts | _____ | _____ |
| 45. | X | Designates horizontal axis on a cathode ray tube | _____ | _____ |
| 46. | Y | Designates vertical axis on a cathode ray tube | _____ | _____ |

B16 Do you perform the following general maintenance procedures?

| | | Yes | No |
|---|---|---|---|
| 1. | Electrical alinement | ____ | ____ |
| 2. | Electrically ground equipment | ____ | ____ |
| 3. | Insulate equipment | ____ | ____ |
| 4. | Make adjustments for a null indication | ____ | ____ |
| 5. | Make adjustments until a signal indication is obtained | ____ | ____ |
| 6. | Inspect electronic equipment for physical damage, moisture and contaminants | ____ | ____ |
| 7. | Locate the physical position of chassis | ____ | ____ |
| 8. | Locate the physical position of components on a chassis | ____ | ____ |
| 9. | Locate test points on equipment | ____ | ____ |
| 10. | Locate ground points on equipment | ____ | ____ |
| 11. | Adjust controls to obtain proper indications | ____ | ____ |
| 12. | Select the appropriate technical manual, field manual, supply manual, etc., as references for maintenance procedures and information | ____ | ____ |
| 13. | Use flow charts | ____ | ____ |

I17 Does your job require that you obtain or use information in the following ways?

| | | Yes | No |
|---|---|---|---|
| 1. | Look for information indicating normal operating conditions. | _____ | _____ |
| 2. | Look for information indicating non-normal operating conditions. | _____ | _____ |
| 3. | Relate information you obtain from schematic diagrams to operational equipment. | _____ | _____ |
| 4. | Relate information you obtain from block diagrams to operational equipment. | _____ | _____ |
| 5. | Relate information you obtain from wiring diagrams to operational equipment. | _____ | _____ |
| 6. | Relate information you obtain from the description of procedures in a written document to operational equipment. | _____ | _____ |
| 7. | Interpret information you obtain from the use of test equipment. | _____ | _____ |
| 8. | Make decisions about what your next action will be based upon your interpretation of information. | _____ | _____ |
| 9. | Discriminate between signal and noise information. | _____ | _____ |

TH18 Do you refer to or apply the following theory information in your maintenance work?

| | | Yes | No |
|---|---|---|---|
| 1. | How a radar transmitter works. (operational functioning) | _____ | _____ |
| 2. | Why a radar transmitter works. (radio frequency RF theory) | _____ | _____ |
| 3. | How a radar receiver works (operational functioning). | _____ | _____ |
| 4. | Why a radar receiver works (radio frequency theory) | _____ | _____ |
| 5. | Problems created by magnetism when reading meters or adjusting resonant circuits, caused by the interaction of magnetic materials (iron, steel, etc.) with electrical fields. | _____ | _____ |
| 6. | Insulative value of common materials. | _____ | _____ |
| 7. | Conductive value of common materials. | _____ | _____ |
| 8. | Ohm's law. | _____ | _____ |
| 9. | How a vacuum tube works. | _____ | _____ |
| 10. | Why a vacuum tube works. | _____ | _____ |
| 11. | The resistance that devices or materials offer to the flow of current. | _____ | _____ |
| 12. | The capacity of a device for storing electricity. | _____ | _____ |
| 13. | How a transistor works. | _____ | _____ |
| 14. | Why a transistor works. | _____ | _____ |
| 15. | How a diode works. | _____ | _____ |
| 16. | Why a diode works. | _____ | _____ |
| 17. | How a transformer works. | _____ | _____ |
| 18. | Why a transformer works (magnetic induction theory). | _____ | _____ |
| 19. | How a relay works. | _____ | _____ |
| 20. | Why a relay works (electromagnetic or thermal theory). | _____ | _____ |

| | Yes | No |
|---|---|---|
| 21. How an electric motor works. | _____ | _____ |
| 22. Why an electric motor works (magnetic field theory). | _____ | _____ |
| 23. How an air compressor works. | _____ | _____ |
| 24. How a pump works. | _____ | _____ |
| 25. How an antenna works. | _____ | _____ |
| 26. Why an antenna works (RF transmission theory). | _____ | _____ |

EE19 If you work with transmitters do you do the following? (If you do not work with transmitters go to item EE20).

| | Yes | No |
|---|---|---|
| 1. Inspect them. | ____ | ____ |
| 2. Remove/replace them. | ____ | ____ |
| 3. Repair them. | ____ | ____ |
| 4. Check (test) operation of them. | ____ | ____ |
| 5. Service them. | ____ | ____ |
| 6. Troubleshoot (diagnose) them. | ____ | ____ |
| 7. Adjust them. | ____ | ____ |

EE20 If you work with receivers do you do the following? (If not go to EE21 )

| | | |
|---|---|---|
| 1. Inspect them. | ____ | ____ |
| 2. Remove/replace them. | ____ | ____ |
| 3. Repair them. | ____ | ____ |
| 4. Check (test) operation of them. | ____ | ____ |
| 5. Service them. | ____ | ____ |
| 6. Troubleshoot (diagnose) them. | ____ | ____ |
| 7. Adjust them. | ____ | ____ |

EE21 If you work with electric motors do you do the following? (If not go to EE22).

| | | |
|---|---|---|
| 1. Inspect them. | ____ | ____ |
| 2. Remove/replace them. | ____ | ____ |
| 3. Repair them. | ____ | ____ |
| 4. Check (test) operation of them. | ____ | ____ |

| | | Yes | No |
|---|---|---|---|
| 5. | Service them. | ____ | ____ |
| 6. | Troubleshoot (diagnose) them. | ____ | ____ |
| 7. | Adjust them. | ____ | ____ |

EC22 If you work with cathode ray tubes do you do the following? (If not, go on to EC23)

| | Yes | No |
|---|---|---|
| 1. Inspect them. | ____ | ____ |
| 2. Remove/replace them. | ____ | ____ |
| 3. Check (test) operation of them. | ____ | ____ |
| 4. Adjust them. | ____ | ____ |

EC23 If you work with vacuum tubes do you do the following? (If not, go on to EC24)

| | | |
|---|---|---|
| 1. Inspect them. | ____ | ____ |
| 2. Remove/replace them. | ____ | ____ |
| 3. Check (test) operation of them. | ____ | ____ |

EC24 If you work with resistors do you do the following? (If not, go on to EC25).

| | | |
|---|---|---|
| 1. Inspect them. | ____ | ____ |
| 2. Remove/replace them. | ____ | ____ |
| 3. Check (test) operation of them. | ____ | ____ |
| 4. Select them by color code. | ____ | ____ |

EC25 If you work with capacitors do you do the following? (If not, go on to EC26).

| | | |
|---|---|---|
| 1. Inspect them. | ____ | ____ |
| 2. Remove/replace them. | ____ | ____ |
| 3. Check (test) operation of them. | ____ | ____ |
| 4. Select them by color code. | ____ | ____ |

EC26 If you work with diodes do you do the following? (If not, go on to EC27).

| | Yes | No |
|---|---|---|
| 1. Inspect them. | ____ | ____ |
| 2. Remove them. | ____ | ____ |
| 3. Check (test) operation of them. | ____ | ____ |

EC27 If you work with transformers do you do the following? (If not, go on to EC28).

| | | |
|---|---|---|
| 1. Inspect them. | ____ | ____ |
| 2. Remove/replace them. | ____ | ____ |
| 3. Check (test) operation of them. | ____ | ____ |

EC28 If you work with relays do you do the following? (If not, go on to EC29).

| | | |
|---|---|---|
| 1. Inspect them. | ____ | ____ |
| 2. Remove/replace them. | ____ | ____ |
| 3. Check (test) operation of them. | ____ | ____ |

EC29 If you work with circuit cards, do you do the following? (If not, go on to EC30).

| | | |
|---|---|---|
| 1. Inspect them. | ____ | ____ |
| 2. Remove/replace them. | ____ | ____ |
| 3. Check (test) operation of them. | ____ | ____ |
| 4. Repair them. | ____ | ____ |

EC30 If you work with switches do you do the following? (If not, go on to EC31).

| | Yes | No |
|---|---|---|
| 1. Inspect them. | ____ | ____ |
| 2. Remove/replace them. | ____ | ____ |
| 3. Check (test) operation of them. | ____ | ____ |

EC31 If you work with fuses do you do the following? (If not, go on to EC32).

| | | |
|---|---|---|
| 1. Inspect them. | ____ | ____ |
| 2. Remove/replace them. | ____ | ____ |
| 3. Check (test) operation of them. | ____ | ____ |

EC32 If you work with lamps do you do the following? (If not, go on to EC33).

| | | |
|---|---|---|
| 1. Inspect them. | ____ | ____ |
| 2. Remove/replace them. | ____ | ____ |
| 3. Check (test) operation of them. | ____ | ____ |

EC33 If you work with connectors (plugs, jacks) do you do the following? (If not, go on to EC34).

| | | |
|---|---|---|
| 1. Inspect them. | ____ | ____ |
| 2. Remove/replace them. | ____ | ____ |
| 3. Check (test) operation of them. | ____ | ____ |
| 4. Repair them. | ____ | ____ |

EC34 If you work with power cables do you do the following? (If not, go on to EC35).

| | Yes | No |
|---|---|---|
| 1. Inspect them. | ____ | ____ |
| 2. Remove/replace them. | ____ | ____ |
| 3. Check (test) operation of them. | ____ | ____ |
| 4. Repair them. | ____ | ____ |
| 5. Fabricate them. | ____ | ____ |

EC35 If you work with data cables do you do the following? (If not, go on to EC36).

| | | |
|---|---|---|
| 1. Inspect them. | ____ | ____ |
| 2. Remove/replace them. | ____ | ____ |
| 3. Check (test) operation of them. | ____ | ____ |
| 4. Repair them. | ____ | ____ |
| 5. Fabricate them. | ____ | ____ |

EC36 If you work with coaxial cables do you do the following?

| | | |
|---|---|---|
| 1. Inspect them. | ____ | ____ |
| 2. Remove/replace them. | ____ | ____ |
| 3. Check (test) operation of them. | ____ | ____ |
| 4. Repair them. | ____ | ____ |
| 5. Fabricate them. | ____ | ____ |

## Background Data

MOS _____ Date _____

Name _____ Rank _____ Age _____
(Last, first, middle initial)

Unit _____ Time in present duty position _____ (months)

Total time on active duty _____ (months) Total time working in electronics _____ (months)

General Education: (circle highest year of school completed).
9, 10, 11, 12 High School Graduate
13, 14, Associates Degree _____ (list specialty)
15, 16, Bachelors Degree _____ (major)

Additional Degrees

## MOS INFORMATION

| | MOS | Months Held | How Awarded | | | Highest Rank Held |
|---|---|---|---|---|---|---|
| | | | School | OJT | Transition | |
| Primary | | | | | | |
| Duty | | | | | | |
| Additional or Former Electronic MOS(s) | | | | | | |
| | | | | | | |
| | | | | | | |

## ELECTRONIC TRAINING - MILITARY

| Army: | Year attended | MOS awarded | Length of course (weeks) |
|---|---|---|---|
| US Army Air Defense School | | | |
| | | | |
| | | | |
| US Army Missile and Munitions School | | | |
| | | | |
| | | | |
| Other US Army Schools (school name) | | | |
| | | | |
| | | | |
| | | | |

Army Correspondence Schools:

| Name of Course | School | Year Completed | Credit Hours |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

Other US Service Schools:

| Course Title | School | Year Completed | Credit Hours |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

ELECTRONIC TRAINING - MILITARY (continued)

Contractor Operated Schools (New Equipment Training):

| Course Title | System | Year Completed | Course length (weeks) |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

Did you attend COBET? _____ Yes _____ No

Where _____ When _____ Course length _____

## ELECTRONIC TRAINING - CIVILIAN

| High School (school name) | Course Title | Course length (weeks) | Year Completed |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

College:

| | | | |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

Other Civilian Schools:

| | | | |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

Industry Training (corporation name)

| | | | |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

## ELECTRONIC WORK EXPERIENCE

Military:

| Assigned Unit | Duty MOS | Months Assigned | Highest Rank | Location (US, Germany Korea, etc.) | Position Title (Repairman, Section Chief, Platoon Leader, CO, etc.) |
|---|---|---|---|---|---|
| Battery | | | | | |
| | | | | | |
| | | | | | |
| Direct Support | | | | | |
| | | | | | |
| | | | | | |
| General Support | | | | | |
| | | | | | |
| | | | | | |
| Depot | | | | | |
| | | | | | |
| | | | | | |

At Service Schools:
(Name of school)

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |

Other Units
(list units)

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |

## ELECTRONIC WORK EXPERIENCE (continued)

Civilian:

| Position Title (Check those applicable) | | Time Worked (in months) | Type of work performed. Briefly describe main duties, i.e.: fixed radios, assemble TV's, installed telephones, etc.) |
|---|---|---|---|
| Electronic: | | | |
| Technician | _____ | _____ | _____ |
| Repairman | _____ | _____ | _____ |
| Installer | _____ | _____ | _____ |
| Tester | _____ | _____ | _____ |
| Fabricator | _____ | _____ | _____ |
| Assembler | _____ | _____ | _____ |
| Designer | _____ | _____ | _____ |
| Other: | | | |
| _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ |

# Appendix E

## Questionnaire Response Data

The means of field response to importance of General Work Habits and Safe Operating Procedures.

| Statement Number | MOS | | | | Statement Number | MOS | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 24E | 24J | 24H | Combined | | 24E | 24J | 24H | Combined |
| G-1 | 8.9 | 8.3 | 8.6 | 8.64 | G-14 | 9.5 | 8.5 | 9.1 | 9.10 |
| G-2 | 9.6 | 8.9 | 8.4 | 9.08 | G-15 | 9.2 | 8.6 | 9.6 | 9.18 |
| G-3 | 9.0 | 9.0 | 9.0 | 9.02 | G-16 | 8.6 | 7.9 | 8.2 | 8.30 |
| G-4 | 8.9 | 8.9 | 8.8 | 8.90 | G-17 | 8.3 | 8.6 | 7.8 | 8.28 |
| G-5 | 8.8 | 8.2 | 8.8 | 8.66 | G-18 | 8.8 | 8.6 | 8.6 | 8.68 |
| G-6 | 9.2 | 9.0 | 9.2 | 9.18 | G-19 | 8.3 | 7.5 | 6.8 | 7.62 |
| G-7 | 8.7 | 8.4 | 8.8 | 8.66 | G-20 | 9.0 | 7.9 | 7.7 | 8.28 |
| G-8 | 8.8 | 8.4 | 8.7 | 8.68 | G-21 | 6.8 | 8.1 | 9.1 | 7.86 |
| G-9 | 8.9 | 8.2 | 8.0 | 8.46 | G-22 | 4.5 | 7.6 | 6.5 | 6.04 |
| G-10 | 6.5 | 6.6 | 7.4 | 6.82 | G-23 | 9.6 | 9.6 | 9.3 | 9.50 |
| G-11 | 8.9 | 8.4 | 8.6 | 8.68 | G-24 | 9.8 | 9.7 | 9.9 | 9.82 |
| G-12 | 8.9 | 7.8 | 7.0 | 8.00 | G-25 | 8.4 | 8.5 | 9.2 | 8.70 |
| G-13 | 9.0 | 8.3 | 7.5 | 8.36 | G-26 | 8.8 | 8.4 | 9.0 | 8.74 |

The means of field response to importance of General Work Habits and Safe Operating Procedures.

| Statement Number | MOS | | | |
|---|---|---|---|---|
| | 24E | 24J | 24H | Combined |
| G-27 | 8.2 | 8.1 | 7.9 | 8.08 |
| G-28 | 9.5 | 9.0 | 9.6 | 9.38 |
| G-29 | 9.9 | 8.7 | 9.3 | 9.34 |
| G-30 | 7.0 | 7.9 | 8.3 | 7.68 |
| G-31 | 9.0 | 7.9 | 7.9 | 8.34 |
| G-32 | 9.3 | 9.5 | 9.9 | 9.56 |
| G-33 | 9.7 | 9.3 | 9.9 | 9.62 |
| G-34 | 9.8 | 9.3 | 9.4 | 9.56 |
| G-35 | 9.6 | 8.5 | 8.3 | 8.90 |
| G-36 | 7.2 | 7.5 | 7.3 | 7.34 |
| G-37 | 7.0 | 7.7 | 7.4 | 7.34 |
| G-38 | 8.0 | 8.0 | 7.5 | 7.86 |

The percentage of respondee's performing described tasks.

| Task Number | MOS | | | | Task Number | MOS | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 24E | 24J | 24H | Combined | | 24E | 24J | 24H | Combined |
| B1 | | | | | | | | | |
| 1 | 100 | 100 | 100 | 100 | 15 | 95 | 93 | 46 | 80 |
| 2 | 100 | 100 | 100 | 100 | 16 | 100 | 100 | 100 | 100 |
| 3 | 100 | 100 | 100 | 100 | 17 | 85 | 100 | 100 | 94 |
| 4 | 100 | 100 | 100 | 100 | 18 | 100 | 100 | 100 | 100 |
| 5 | 95 | 100 | 100 | 98 | 19 | 100 | 100 | 86 | 96 |
| 6 | 65 | 100 | 93 | 84 | 20 | 100 | 93 | 100 | 98 |
| 7 | 100 | 100 | 100 | 100 | 21 | 85 | 93 | 100 | 92 |
| 8 | 80 | 100 | 80 | 86 | 22 | 100 | 100 | 100 | 100 |
| 9 | 40 | 93 | 80 | 68 | B2 | | | | |
| 10 | 80 | 86 | 60 | 76 | 1 | 100 | 100 | 100 | 100 |
| 11 | 90 | 100 | 100 | 96 | 2 | 95 | 93 | 86 | 92 |
| 12 | 90 | 100 | 100 | 96 | 3 | 100 | 100 | 100 | 100 |
| 13 | 75 | 93 | 100 | 88 | 4 | 80 | 100 | 100 | 92 |
| 14 | 60 | 73 | 33 | 56 | 5 | 55 | 100 | 93 | 80 |

| Task Number | MOS | | | |
|---|---|---|---|---|
| | 24E | 24J | 24H | Combined |
| B2 | | | | |
| 6 | 90 | 93 | 86 | 90 |
| 7 | 40 | 86 | 93 | 70 |
| B3 | | | | |
| 1 | 95 | 100 | 100 | 98 |
| 2 | 100 | 100 | 100 | 100 |
| B4 | | | | |
| 1 | 100 | 100 | 100 | 100 |
| 2 | 95 | 93 | 86 | 92 |
| 3 | 100 | 100 | 100 | 100 |
| 4 | 100 | 100 | 100 | 100 |
| 5 | 100 | 100 | 100 | 100 |
| 6 | 95 | 100 | 100 | 98 |
| 7 | 100 | 100 | 93 | 98 |
| 8 | 100 | 100 | 100 | 100 |
| 9 | 100 | 100 | 100 | 100 |
| 10 | 100 | 100 | 100 | 100 |
| 11 | 100 | 100 | 100 | 100 |

| Task Number | MOS | | | |
|---|---|---|---|---|
| | 24E | 24J | 24H | Combined |
| 12 | 100 | 100 | 86 | 96 |
| B5 | | | | |
| 1 | 65 | 40 | 100 | 68 |
| 2 | 65 | 40 | 100 | 68 |
| 3 | 55 | 40 | 100 | 64 |
| 4 | 65 | 40 | 100 | 68 |
| 5 | 80 | 60 | 100 | 80 |
| 6 | 70 | 73 | 100 | 80 |
| 7 | 40 | 66 | 100 | 66 |
| 8 | 65 | 86 | 100 | 82 |
| 9 | 90 | 93 | 100 | 94 |
| 10 | 90 | 93 | 100 | 94 |
| 11 | 90 | 100 | 100 | 96 |
| B6 | | | | |
| 1 | 95 | 86 | 26 | 72 |
| 2 | 95 | 93 | 33 | 76 |
| 3 | 80 | 93 | 46 | 74 |

| Task Number | MOS | | | |
|---|---|---|---|---|
| | 24E | 24J | 24H | Combined |
| 4 | 85 | 86 | 60 | 79 |
| 5 | 100 | 93 | 53 | 84 |
| 6 | 90 | 86 | 60 | 80 |
| 7 | 80 | 93 | 60 | 78 |
| 8 | 100 | 86 | 40 | 78 |
| B7 | | | | |
| 1 | 100 | 100 | 40 | 82 |
| 2 | 100 | 100 | 40 | 82 |
| 3 | 95 | 100 | 93 | 96 |
| 4 | 100 | 100 | 100 | 100 |
| 5 | 100 | 100 | 100 | 100 |
| 6 | 100 | 100 | 100 | 100 |
| 7 | 100 | 100 | 100 | 100 |
| 8 | 100 | 100 | 100 | 100 |
| 9 | 100 | 100 | 100 | 100 |
| 10 | 100 | 100 | 100 | 100 |
| 11 | 100 | 100 | 26 | 78 |

| Task Number | | | | |
|---|---|---|---|---|
| | 24E | 24J | 24H | Combined |
| 12 | 100 | 100 | 26 | 78 |
| 13 | 100 | 100 | 86 | 96 |
| 14 | 100 | 100 | 100 | 100 |
| 15 | 100 | 100 | 100 | 100 |
| 16 | 100 | 100 | 100 | 100 |
| 17 | 100 | 100 | 100 | 100 |
| 18 | 100 | 100 | 100 | 100 |
| 19 | 100 | 100 | 100 | 100 |
| 20 | 100 | 100 | 100 | 100 |
| B8 | | | | |
| 1 | 100 | 100 | 100 | 100 |
| 2 | 85 | 100 | 93 | 92 |
| 3 | 60 | 60 | 46 | 56 |
| 4 | 40 | 53 | 13 | 36 |
| 5 | 45 | 53 | 6 | 36 |
| 6 | 55 | 60 | 13 | 44 |
| 7 | 85 | 66 | 86 | 80 |

| Task Number | MOS | | | | Task Number | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 24E | 24J | 24H | Combined | | 24E | 24J | 24H | Combined |
| B8 | | | | | | | | | |
| 8 | 50 | 86 | 46 | 60 | 8 | 0 | 100 | 80 | 54 |
| 9 | 90 | 100 | 93 | 94 | 9 | 10 | 100 | 86 | 60 |
| 10 | 100 | 86 | 66 | 86 | 10 | 5 | 93 | 80 | 54 |
| 11 | 100 | 100 | 100 | 100 | 11 | 65 | 100 | 93 | 84 |
| 12 | 80 | 93 | 67 | 62 | 12 | 20 | 100 | 100 | 68 |
| 13 | 100 | 100 | 93 | 98 | | | | | |
| 14 | 95 | 100 | 46 | 82 | | | | | |
| 15 | 75 | 100 | 73 | 82 | | | | | |
| B9 | | | | | | | | | |
| 1 | 5 | 100 | 100 | 62 | | | | | |
| 2 | 0 | 100 | 100 | 60 | | | | | |
| 3 | 10 | 100 | 93 | 62 | | | | | |
| 4 | 50 | 100 | 100 | 60 | | | | | |
| 5 | 10 | 100 | 93 | 62 | | | | | |
| 6 | 0 | 100 | 86 | 56 | | | | | |
| 7 | 15 | 100 | 86 | 62 | | | | | |

| Task Number | MOS | | | | Task Number | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 24E | 24J | 24H | Combined | | 24E | 24J | 24H | Combined |
| T10 | | | | | | | | | |
| 1 | 100 | 100 | 100 | 100 | 17 | 40 | 40 | 26 | 36 |
| 2 | 100 | 100 | 100 | 100 | 18 | 50 | 60 | 26 | 46 |
| 3 | 100 | 100 | 100 | 100 | 19 | 100 | 66 | 66 | 80 |
| 4 | 100 | 93 | 86 | 94 | 20 | 95 | 86 | 66 | 84 |
| 5 | 95 | 93 | 100 | 96 | 21 | 60 | 100 | 66 | 74 |
| 6 | 95 | 100 | 100 | 98 | 22 | 40 | 93 | 100 | 74 |
| 7 | 95 | 100 | 93 | 96 | | | | | |
| 8 | 50 | 60 | 53 | 54 | | | | | |
| 9 | 100 | 100 | 100 | 100 | | | | | |
| 10 | 95 | 100 | 93 | 96 | | | | | |
| 11 | 95 | 100 | 93 | 96 | | | | | |
| 12 | 60 | 40 | 40 | 48 | | | | | |
| 13 | 100 | 100 | 100 | 100 | | | | | |
| 14 | 100 | 100 | 86 | 96 | | | | | |
| 15 | 100 | 100 | 93 | 98 | | | | | |
| 16 | 80 | 100 | 100 | 92 | | | | | |

| Task Number | MOS | | | | Task Number | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 24E | 24J | 24H | Combined | | 24E | 24J | 24H | Combined |
| M11 | | | | | | | | | |
| 1 | 95 | 73 | 40 | 72 | 17 | 100 | 100 | 100 | 100 |
| 2 | 100 | 93 | 100 | 98 | 18 | 90 | 80 | 100 | 68 |
| 3 | 100 | 93 | 100 | 98 | 19 | 100 | 80 | 26 | 76 |
| 4 | 85 | 66 | 100 | 80 | 20 | 100 | 93 | 40 | 76 |
| 5 | 100 | 93 | 100 | 98 | 21 | 100 | 86 | 26 | 74 |
| 6 | 100 | 86 | 100 | 96 | 22 | 90 | 86 | 26 | 92 |
| 7 | 95 | 93 | 100 | 92 | | | | | |
| 8 | 80 | 100 | 100 | 92 | | | | | |
| 9 | 100 | 100 | 100 | 94 | | | | | |
| 10 | 95 | 93 | 100 | 96 | | | | | |
| 11 | 100 | 100 | 33 | 80 | | | | | |
| 12 | 100 | 86 | 80 | 90 | | | | | |
| 13 | 100 | 93 | 33 | 78 | | | | | |
| 14 | 100 | 80 | 66 | 84 | | | | | |
| 15 | 100 | 86 | 93 | 94 | | | | | |
| 16 | 95 | 86 | 86 | 90 | | | | | |

| Task Number | MOS | | | | Task Number | MOS | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 24E | 24J | 24H | Combined | | 24E | 24J | 24H | Combined |
| MC12 | | | | | | | | | |
| 1 | 60 | 93 | 100 | 76 | 5 | 95 | 100 | 93 | 96 |
| 2 | 75 | 93 | 80 | 80 | 6 | 85 | 100 | 100 | 94 |
| 3 | 100 | 100 | 100 | 100 | 7 | 65 | 80 | 46 | 64 |
| 4 | | | | | 6 | 25 | 33 | 53 | 36 |
| 1 | 75 | 100 | 80 | 84 | 7 | 30 | 33 | 46 | 36 |
| 2 | 75 | 100 | 80 | 84 | 8 | 15 | 26 | 60 | 32 |
| 3 | 65 | 100 | 80 | 80 | 9 | | | | |
| 4 | 65 | 93 | 80 | 78 | 1 | 50 | 33 | 46 | 44 |
| 5 | 70 | 100 | 80 | 82 | 2 | 60 | 60 | 80 | 66 |
| 6 | 80 | 100 | 80 | 86 | 3 | 30 | 33 | 26 | 30 |
| 5 | | | | | 4 | 40 | 26 | 40 | 36 |
| 1 | 55 | 86 | 80 | 72 | 5 | 50 | 46 | 40 | 46 |
| 2 | 50 | 73 | 93 | 70 | 6 | 35 | 20 | 40 | 32 |
| 3 | 90 | 100 | 100 | 96 | 7 | 85 | 80 | 80 | 82 |
| 4 | 85 | 100 | 100 | 94 | 8 | 85 | 80 | 80 | 82 |

| Task Number | | MOS | | | | Task Number | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 24E | 24J | 24H | Combined | | 24E | 24J | 24H | Combined |
| MC12 | | | | | | | | | | |
| 9 | | | | | | 16 | 50 | 46 | 100 | 64 |
| | 9 | 35 | 53 | 66 | 50 | 17 | 35 | 46 | 100 | 58 |
| 10 | | 60 | 46 | 26 | 46 | 18 | 55 | 80 | 26 | 54 |
| 11 | | 95 | 100 | 93 | 96 | 19 | 40 | 40 | 26 | 36 |
| 12 | | 75 | 86 | 66 | 76 | | | | | |
| 13 | | | | | | | | | | |
| | 1 | 90 | 100 | 93 | 94 | | | | | |
| | 2 | 65 | 100 | 100 | 86 | | | | | |
| | 3 | 70 | 100 | 100 | 88 | | | | | |
| | 4 | 30 | 86 | 93 | 66 | | | | | |
| 14 | | | | | | | | | | |
| | 1 | 45 | 53 | 100 | 64 | | | | | |
| | 2 | 45 | 53 | 100 | 64 | | | | | |
| | 3 | 25 | 20 | 93 | 44 | | | | | |
| 15 | | 30 | 20 | 73 | 40 | | | | | |

| Task Number | MOS | | | | Task Number | MOS | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 24E | 24J | 24H | Combined | | 24E | 24J | 24H | Combined |
| SC-13 | | | | | | | | | |
| 1 | 90 | 100 | 80 | 90 | 4 | 95 | 93 | 93 | 94 |
| 2 | 95 | 100 | 100 | 98 | 5 | 95 | 100 | 93 | 96 |
| 3 | 95 | 100 | 100 | 98 | 6 | 95 | 100 | 93 | 96 |
| 4 | 90 | 100 | 100 | 98 | 7 | 95 | 100 | 100 | 98 |
| 5 | 95 | 100 | 100 | 96 | 8 | 95 | 100 | 100 | 98 |
| 6 | 85 | 100 | 100 | 98 | 9 | 100 | 100 | 100 | 100 |
| 7 | 65 | 100 | 100 | 94 | 10 | 100 | 93 | 100 | 98 |
| 8 | 95 | 93 | 93 | 82 | 11 | 70 | 86 | 73 | 76 |
| 9 | 95 | 93 | 80 | 90 | 12 | 95 | 73 | 73 | 82 |
| 10 | 95 | 100 | 100 | 98 | 13 | 90 | 100 | 53 | 82 |
| 11 | 95 | 100 | 80 | 92 | 14 | 85 | 93 | 20 | 68 |
| SC-14 | | | | | 15 | 100 | 100 | 80 | 94 |
| 1 | 95 | 100 | 100 | 98 | 16 | 95 | 100 | 100 | 98 |
| 2 | 100 | 93 | 26 | 76 | 17 | 90 | 93 | 60 | 82 |
| 3 | 85 | 100 | 100 | 94 | 18 | 85 | 93 | 80 | 86 |

| Task Number | MOS | | | | Task Number | MOS | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 24E | 24J | 24H | Combined | | 24E | 24J | 24H | Combined |
| SC-14 | | | | | | | | | |
| 19 | 100 | 100 | 100 | 100 | 34 | 95 | 100 | 93 | 96 |
| 20 | 100 | 100 | 66 | 90 | 35 | 85 | 80 | 73 | 80 |
| 21 | 100 | 100 | 100 | 100 | 36 | 100 | 93 | 86 | 94 |
| 22 | 75 | 80 | 86 | 80 | 37 | 85 | 93 | 80 | 86 |
| 23 | 100 | 100 | 93 | 98 | 38 | 95 | 86 | 93 | 92 |
| 24 | 80 | 86 | 60 | 76 | 39 | 100 | 100 | 100 | 100 |
| 25 | 80 | 66 | 73 | 74 | 40 | 90 | 100 | 73 | 88 |
| 26 | 70 | 86 | 60 | 72 | 41 | 95 | 100 | 93 | 96 |
| 27 | 40 | 60 | 13 | 38 | 42 | 90 | 100 | 73 | 88 |
| 28 | 85 | 100 | 86 | 90 | 43 | 95 | 100 | 100 | 98 |
| 29 | 95 | 100 | 93 | 96 | 44 | 100 | 100 | 100 | 100 |
| 30 | 95 | 100 | 100 | 98 | 45 | 100 | 100 | 86 | 96 |
| 31 | 90 | 100 | 86 | 92 | 46 | 100 | 93 | 66 | 88 |
| 32 | 95 | 100 | 93 | 96 | 47 | 80 | 86 | 40 | 70 |
| 33 | 95 | 100 | 93 | 96 | 48 | 100 | 100 | 100 | 100 |

| Task Number | MOS | | | | Task Number | MOS | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 24E | 24J | 24H | Combined | | 24E | 24J | 24H | Combined |
| SC-14 | | | | | | | | | |
| 49 | 95 | 100 | 100 | 98 | 64 | 65 | 93 | 87 | 30 |
| 50 | 95 | 100 | 100 | 98 | 65 | 100 | 100 | 100 | 100 |
| 51 | 100 | 100 | 100 | 100 | 66 | 100 | 100 | 100 | 100 |
| 52 | 65 | 93 | 86 | 80 | 67 | 85 | 100 | 93 | 92 |
| 53 | 100 | 100 | 100 | 100 | 68 | 85 | 93 | 67 | 82 |
| 54 | 100 | 100 | 100 | 100 | 69 | 100 | 100 | 100 | 100 |
| 55 | 85 | 100 | 93 | 92 | 70 | 100 | 100 | 100 | 100 |
| 56 | 100 | 93 | 66 | 82 | 71 | 100 | 100 | 100 | 100 |
| 57 | 100 | 100 | 100 | 100 | 72 | 100 | 100 | 100 | 100 |
| 58 | 100 | 100 | 100 | 100 | 73 | 100 | 100 | 80 | 94 |
| 59 | 80 | 87 | 40 | 70 | 74 | 95 | 93 | 93 | 94 |
| 60 | 100 | 100 | 100 | 100 | 75 | 100 | 100 | 100 | 100 |
| 61 | 95 | 100 | 100 | 98 | 76 | 100 | 100 | 100 | 100 |
| 62 | 95 | 100 | 100 | 98 | 77 | 95 | 93 | 80 | 90 |
| 63 | 100 | 100 | 100 | 100 | 78 | 95 | 93 | 93 | 94 |

| Task Number | MOS | | | | Task Number | MOS | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 24E | 24J | 24H | Combined | | 24E | 24J | 24H | Combined |
| SC-14 | | | | | | | | | |
| 79 | 100 | 100 | 100 | 100 | 94 | 80 | 100 | 13 | 66 |
| 80 | 85 | 100 | 100 | 94 | 95 | 75 | 86 | 33 | 66 |
| 81 | 85 | 100 | 100 | 94 | 96 | 50 | 73 | 13 | 46 |
| 82 | 85 | 100 | 100 | 94 | 97 | 50 | 66 | 13 | 44 |
| 83 | 85 | 100 | 60 | 82 | 98 | 55 | 73 | 13 | 48 |
| 84 | 85 | 100 | 86 | 90 | 99 | 60 | 80 | 6 | 50 |
| 85 | 90 | 100 | 93 | 94 | 100 | 35 | 40 | 6 | 28 |
| 86 | 90 | 100 | 100 | 96 | 101 | 40 | 53 | 13 | 36 |
| 87 | 90 | 93 | 73 | 86 | 102 | 55 | 46 | 13 | 40 |
| 88 | 80 | 93 | 86 | 86 | 103 | 55 | 66 | 6 | 44 |
| 89 | 80 | 93 | 86 | 86 | 104 | 50 | 60 | 6 | 40 |
| 90 | 90 | 100 | 100 | 96 | 105 | 50 | 53 | 6 | 38 |
| 91 | 80 | 93 | 86 | 86 | 106 | 50 | 53 | 6 | 38 |
| 92 | 70 | 73 | 26 | 58 | 107 | 30 | 73 | 6 | 36 |
| 93 | 65 | 66 | 13 | 50 | 108 | 25 | 60 | 6 | 30 |

| Task Number | MOS | | | | Task Number | MOS | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 24E | 24J | 24H | Combined | | 24E | 24J | 24H | Combined |
| SC-14 | | | | | | | | | |
| 109 | 55 | 66 | 13 | 46 | 124 | 65 | 60 | 53 | 60 |
| 110 | 45 | 40 | 6 | 32 | 125 | 30 | 26 | 66 | 40 |
| 111 | 75 | 86 | 33 | 66 | 126 | 35 | 33 | 66 | 44 |
| 112 | 55 | 73 | 13 | 48 | 127 | 56 | 86 | 86 | 74 |
| 113 | 75 | 80 | 13 | 50 | 128 | 65 | 80 | 86 | 76 |
| 114 | 60 | 80 | 13 | 52 | 129 | 25 | 20 | 100 | 46 |
| 115 | 50 | 26 | 6 | 30 | 130 | 20 | 33 | 100 | 68 |
| 116 | 65 | 73 | 20 | 54 | 131 | 70 | 33 | 100 | 68 |
| 117 | 65 | 60 | 26 | 52 | 132 | 70 | 33 | 100 | 68 |
| 118 | 40 | 40 | 6 | 30 | 133 | 70 | 33 | 100 | 68 |
| 119 | 60 | 40 | 100 | 66 | 134 | 60 | 33 | 100 | 64 |
| 120 | 60 | 40 | 100 | 66 | 135 | 60 | 33 | 100 | 64 |
| 121 | 55 | 33 | 100 | 62 | 136 | 45 | 33 | 100 | 58 |
| 122 | 30 | 20 | 86 | 44 | 137 | 65 | 46 | 13 | 44 |
| 123 | 70 | 53 | 73 | 60 | 138 | 90 | 80 | 86 | 86 |

| Task Number | MOS | | | |
|---|---|---|---|---|
| | 24E | 24J | 24H | Combined |
| SC-14 | | | | |
| 139 | 95 | 86 | 100 | 94 |
| 140 | 85 | 86 | 20 | 66 |

| Task Number | MOS | | | | Task Number | MOS | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 24E | 24J | 24H | Combined | | 24E | 24J | 24H | Combined |
| SC-15 | | | | | | | | | |
| 1 | 100 | 100 | 100 | 100 | 16 | 100 | 100 | 100 | 100 |
| 2 | 100 | 100 | 100 | 100 | 17 | 100 | 100 | 100 | 100 |
| 3 | 100 | 100 | 100 | 100 | 18 | 100 | 100 | 93 | 98 |
| 4 | 100 | 100 | 100 | 100 | 19 | 100 | 100 | 100 | 100 |
| 5 | 85 | 100 | 93 | 92 | 20 | 100 | 100 | 100 | 100 |
| 6 | 90 | 93 | 100 | 94 | 21 | 95 | 100 | 93 | 96 |
| 7 | 90 | 93 | 100 | 94 | 22 | 95 | 100 | 93 | 96 |
| 8 | 95 | 93 | 86 | 92 | 23 | 100 | 100 | 100 | 100 |
| 9 | 100 | 100 | 100 | 100 | 24 | 90 | 100 | 86 | 92 |
| 10 | 100 | 100 | 100 | 100 | 25 | 100 | 100 | 100 | 100 |
| 11 | 100 | 93 | 86 | 94 | 26 | 95 | 100 | 86 | 94 |
| 12 | 100 | 100 | 100 | 100 | 27 | 55 | 100 | 46 | 66 |
| 13 | 100 | 93 | 100 | 98 | 28 | 95 | 100 | 100 | 98 |
| 14 | 90 | 93 | 93 | 92 | 29 | 100 | 100 | 93 | 98 |
| 15 | 100 | 100 | 100 | 100 | 30 | 95 | 100 | 93 | 96 |

| Task Number | MOS | | | | Task Number | MOS | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 24E | 24J | 24H | Combined | | 24E | 24J | 24H | Combined |
| SC-15 | | | | | | | | | |
| 31 | 95 | 100 | 80 | 92 | 46 | 95 | 100 | 100 | 98 |
| 32 | 90 | 100 | 100 | 96 | | | | | |
| 33 | 95 | 100 | 93 | 96 | | | | | |
| 34 | 95 | 100 | 100 | 98 | | | | | |
| 35 | 95 | 100 | 93 | 96 | | | | | |
| 36 | 95 | 100 | 100 | 98 | | | | | |
| 37 | 95 | 100 | 86 | 94 | | | | | |
| 38 | 95 | 100 | 100 | 98 | | | | | |
| 39 | 100 | 100 | 93 | 98 | | | | | |
| 40 | 95 | 100 | 100 | 98 | | | | | |
| 41 | 95 | 100 | 100 | 98 | | | | | |
| 42 | 95 | 100 | 86 | 94 | | | | | |
| 43 | 90 | 86 | 60 | 80 | | | | | |
| 44 | 100 | 100 | 93 | 98 | | | | | |
| 45 | 95 | 100 | 100 | 98 | | | | | |

| Task Number | MOS | | | |
|---|---|---|---|---|
| | 24E | 24J | 24H | Combined |
| B16 | | | | |
| 1 | 100 | 100 | 100 | 100 |
| 2 | 100 | 100 | 93 | 98 |
| 3 | 90 | 100 | 86 | 86 |
| 4 | 100 | 80 | 86 | 96 |
| 5 | 100 | 100 | 100 | 100 |
| 6 | 100 | 100 | 100 | 100 |
| 7 | 100 | 100 | 100 | 100 |
| 8 | 95 | 100 | 100 | 98 |
| 9 | 100 | 100 | 100 | 100 |
| 10 | 100 | 100 | 100 | 100 |
| 11 | 100 | 100 | 100 | 100 |
| 12 | 100 | 100 | 100 | 100 |
| 13 | 45 | 100 | 73 | 62 |

| Task Number | MOS | | | |
|---|---|---|---|---|
| | 24E | 24J | 24H | Combined |
| I17 | | | | |
| 1 | 100 | 73 | 100 | 98 |
| 2 | 95 | 93 | 93 | 94 |
| 3 | 100 | 100 | 100 | 100 |
| 4 | 90 | 100 | 93 | 94 |
| 5 | 100 | 100 | 93 | 98 |
| 6 | 90 | 100 | 100 | 96 |
| 7 | 100 | 100 | 93 | 98 |
| 8 | 100 | 100 | 93 | 98 |
| 9 | 95 | 93 | 100 | 96 |

| Task Number | MOS | | | | Task Number | MOS | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 24E | 24J | 24H | Combined | | 24E | 24J | 24H | Combined |
| TH18 | | | | | | | | | |
| 1 | 90 | 100 | 26 | 74 | 16 | 70 | 80 | 73 | 74 |
| 2 | 85 | 73 | 26 | 64 | 17 | 95 | 100 | 93 | 96 |
| 3 | 90 | 100 | 20 | 72 | 18 | 75 | 73 | 66 | 72 |
| 4 | 85 | 73 | 20 | 62 | 19 | 95 | 100 | 93 | 96 |
| 5 | 80 | 86 | 46 | 72 | 20 | 75 | 80 | 66 | 74 |
| 6 | 70 | 53 | 53 | 60 | 21 | 100 | 93 | 80 | 92 |
| 7 | 75 | 73 | 53 | 68 | 22 | 80 | 73 | 60 | 72 |
| 8 | 90 | 93 | 93 | 92 | 23 | 90 | 86 | 33 | 72 |
| 9 | 85 | 100 | 93 | 92 | 24 | 85 | 86 | 33 | 70 |
| 10 | 65 | 73 | 66 | 68 | 25 | 95 | 100 | 20 | 74 |
| 11 | 80 | 93 | 93 | 68 | 26 | 80 | 80 | 6 | 58 |
| 12 | 85 | 93 | 93 | 90 | | | | | |
| 13 | 85 | 100 | 93 | 92 | | | | | |
| 14 | 70 | 73 | 66 | 70 | | | | | |
| 15 | 90 | 100 | 93 | 94 | | | | | |

| Task Number | MOS | | | |
|---|---|---|---|---|
| | 24E | 24J | 24H | Combined |
| EE19 | | | | |
| 1 | 100 | 100 | 20 | 76 |
| 2 | 90 | 80 | 20 | 66 |
| 3 | 80 | 93 | 26 | 68 |
| 4 | 100 | 100 | 26 | 78 |
| 5 | 95 | 93 | 20 | 72 |
| 6 | 100 | 100 | 26 | 78 |
| 7 | 100 | 100 | 26 | 78 |
| EE20 | | | | |
| 1 | 100 | 100 | 26 | 78 |
| 2 | 90 | 73 | 20 | 64 |
| 3 | 80 | 93 | 20 | 66 |
| 4 | 100 | 100 | 26 | 78 |
| 5 | 95 | 100 | 13 | 72 |
| 6 | 100 | 100 | 20 | 76 |
| 7 | 100 | 100 | 26 | 78 |

| Task Number | MOS | | | |
|---|---|---|---|---|
| | 24E | 24J | 24H | Combined |
| EE21 | | | | |
| 1 | 100 | 93 | 73 | 90 |
| 2 | 100 | 86 | 73 | 88 |
| 3 | 40 | 20 | 53 | 38 |
| 4 | 95 | 86 | 73 | 86 |
| 5 | 85 | 33 | 53 | 60 |
| 6 | 75 | 60 | 66 | 68 |
| 7 | 45 | 53 | 53 | 50 |
| EC22 | | | | |
| 1 | 100 | 100 | 93 | 98 |
| 2 | 100 | 100 | 86 | 96 |
| 3 | 100 | 86 | 93 | 94 |
| 4 | 80 | 46 | 60 | 64 |
| EC23 | | | | |
| 1 | 100 | 100 | 100 | 100 |
| 2 | 100 | 100 | 100 | 100 |

| Task Number | MOS | | | |
|---|---|---|---|---|
| | 24E | 24J | 24H | Combined |
| EC23 | | | | |
| 3 | 100 | 100 | 100 | 100 |
| EC24 | | | | |
| 1 | 100 | 100 | 100 | 100 |
| 2 | 95 | 100 | 100 | 98 |
| 3 | 95 | 100 | 93 | 96 |
| 4 | 85 | 100 | 100 | 94 |
| EC25 | | | | |
| 1 | 100 | 100 | 100 | 100 |
| 2 | 95 | 100 | 100 | 98 |
| 3 | 95 | 100 | 93 | 96 |
| 4 | 45 | 60 | 60 | 54 |
| EC26 | | | | |
| 1 | 95 | 100 | 100 | 98 |
| 2 | 95 | 100 | 100 | 98 |
| 3 | 95 | 100 | 100 | 98 |

| Task Number | MOS | | | |
|---|---|---|---|---|
| | 24E | 24J | 24H | Combined |
| EC27 | | | | |
| 1 | 95 | 100 | 100 | 98 |
| 2 | 100 | 100 | 100 | 100 |
| 3 | 95 | 100 | 93 | 96 |
| EC28 | | | | |
| 1 | 100 | 100 | 100 | 100 |
| 2 | 100 | 100 | 100 | 100 |
| 3 | 100 | 100 | 100 | 100 |
| EC29 | | | | |
| 1 | 100 | 100 | 100 | 100 |
| 2 | 100 | 100 | 100 | 100 |
| 3 | 100 | 100 | 100 | 100 |
| 4 | 20 | 33 | 46 | 32 |
| EC30 | | | | |
| 1 | 100 | 100 | 100 | 100 |
| 2 | 100 | 100 | 100 | 100 |

| Task Number | MOS | | | | Task Number | MOS | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 24E | 24J | 24H | Combined | | 24E | 24J | 24H | Combined |
| EC30 | | | | | EC34 | | | | |
| 3 | 100 | 100 | 100 | 100 | 2 | 90 | 100 | 100 | 96 |
| EC31 | | | | | 3 | 90 | 100 | 93 | 94 |
| 1 | 100 | 100 | 100 | 100 | 4 | 40 | 80 | 46 | 54 |
| 2 | 100 | 100 | 100 | 100 | 5 | 20 | 53 | 26 | 32 |
| 3 | 100 | 100 | 100 | 100 | EC35 | | | | |
| EC32 | | | | | 1 | 90 | 73 | 93 | 86 |
| 1 | 100 | 100 | 100 | 100 | 2 | 90 | 73 | 86 | 84 |
| 2 | 100 | 100 | 100 | 100 | 3 | 90 | 73 | 86 | 84 |
| 3 | 100 | 100 | 100 | 100 | 4 | 35 | 40 | 46 | 40 |
| EC33 | | | | | 5 | 15 | 13 | 26 | 18 |
| 1 | 100 | 100 | 100 | 100 | EC36 | | | | |
| 2 | 100 | 100 | 93 | 98 | 1 | 100 | 93 | 100 | 98 |
| 3 | 95 | 100 | 100 | 98 | 2 | 100 | 93 | 100 | 98 |
| 4 | 80 | 86 | 93 | 86 | 3 | 100 | 93 | 100 | 98 |
| EC34 | | | | | 4 | 90 | 93 | 86 | 90 |
| 1 | 90 | 100 | 100 | 96 | 5 | 70 | 86 | 66 | 74 |

# Appendix F

## Maintenance Supervisor Questionnaires

## Appendix F

## MAINTENANCE SUPERVISOR QUESTIONNAIRES

Qualification criteria questions:

1. When a new school graduate is assigned to your unit how long is it before he is given system maintenance responsibility on his own?
2. How do you determine when he is ready for such responsibility?
   a. What does he have to do to demonstrate to you that he can perform the required duties?
   b. Do you test him in any way? If so, how?
   c. What kinds of skills and knowledges must he have before you feel he can do the work?
3. When he first comes on site, are there any tasks that you absolutely will not allow him to perform? Which ones?
4. What pieces of equipment do you let him work on and which items do you tell him to keep away from?
5. Some mechanics and repairmen are considered to be more proficient in performing the maintenance function than others. Have you found this to be true?
6. Would you describe for me the best maintenance man you have had on the Hawk system?
7. Would you describe for me the least capable technician you have ever supervised?
8. Rate the following kinds of tasks in terms of their importance in rating maintenance personnel as fully qualified:

1. Much less important than the other kinds of tasks.

2. Somewhat less important than the other kinds of tasks.

3. No less or more important than the other kinds of tasks.

4. Somewhat more important than the other kinds of tasks.

5. Much more important than the other kinds of tasks.
   - Periodic Check Tasks
   - Preventive Maintenance Tasks
   - Malfunction Diagnosis Tasks
   - Corrective Maintenance Tasks

Appendix F

NAME RANK MOS

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This form has been developed from information provided by supervisors (NCO's and Warrant Officer's) and managers (Unit Commanding Officer's) of electronic maintenance technicians. The kinds of evaluation of a technician's job performance. This study is trying to determine to what degree these kinds of evaluation dimensions do in fact influence proficiency ratings.

Please indicate the degree to which the ratee performs each activity. Your rating should be based upon all of your observations of the man's behavior, not just of his maintenance work.

| 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Never | Less than half the time | About half of the half | More than half of the time | Always |

_____ 1. Quickly and correctly identifies malfunction causes.

_____ 2. Demonstrates clear understanding of job objectives and work standards.

_____ 3. Performs mechanical tasks correctly, using the proper tools.

_____ 4. Replaces tools and test equipment after performing maintenance activities.

_____ 5. Uses good work habits.

_____ 6. Works efficiently, not wasting resources (time, tools, materials).

_____ 7. Meets time schedules when he has control of conditions.

_____ 8. Learns quickly, having to be shown how to do something only once or twice.

_____ 9. Appropriately applies theory to equipment functioning.

_____ 10. Performs all work that needs to be done.

_____ 11. Uses all hardware (washers, nuts, bolts, screws) when replacing or installing components.

_____ 12. Is alert on the job, demonstrating an awareness of possible non-safe working conditions.

_____ 13. Has someone with him when working on energized equipment.

_____ 14. Follows safe operating procedures.

_____ 15. Interacts with others with little or no conflict.

_____ 16. He asks questions when in doubt, does not make wild guesses.

_____ 17. Assumes all job responsibilities.

| 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Never | Less than half the time | About half of the time | More than half of the time | Always |

_____ 18. He eagerly looks for work, and is willing to work.

_____ 19. Demonstrates emotional maturity, not over-reacting in problem or crisis situations--taking things in stride.

_____ 20. He persists in his work staying with a task until it is completed.

_____ 21. Demonstrates pride in his job by demanding work be done correctly and by discussing past successful job performance.

_____ 22. He is reliable and can be counted on to carry out assigned and implied duties.

_____ 23. Plans the job--determines what procedures he must carry out and obtains the necessary tools, test equipment, schematics, TM's and other references prior to starting the job.

_____ 24. He demonstrates a higher level of education than the average soldier.

_____ 25. Correctly completes all reports, requisitions, and other paperwork.

_____ 26. Reads schematics correctly.

_____ 27. He is logical in his approach to troubleshooting, not offering irrational explanations of problems.

_____ 28. Uses all test equipment available called for in the procedures.

_____ 29. Performs malfunction diagnosis deliberately and in an orderly fashion and does not jump to conclusions.

_____ 30. Manages work activities of others efficiently.

_____ 31. Does not take shortcuts.

_____ 32. He is honest; he has done all work he reports having completed.

| 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Never | Less than half the time | About half of the time | More than half of the time | Always |

_____ 33. Keeps supervisors correctly and completely informed as to work status.

_____ 34. He is ambitious, doing his job well in order to become eligible for promotion.

_____ 35. Correctly and quickly locates parts/components on equipment.

_____ 36. Uses correct technical references and does not rely on memory.

_____ 37. Takes care of tools and test equipment.

_____ 38. Performs all required steps, not omitting necessary procedures.

_____ 39. Explains problems and causes so others can understand.

_____ 40. He helps others, often volunteering to assist others with maintenance problems.

_____ 41. Has a high level of work endurance, working long periods of time if necessary.

_____ 42. Does not engage in horseplay when performing maintenance activities.

_____ 43. Performs all preventive maintenance tasks.

_____ 44. He does not evade work activities.

_____ 45. He demonstrates a wide range of interests.

_____ 46. Recognizes unusual conditions as special problems.

_____ 47. Does not carelessly touch or lean on energized components or allow others to do so.

_____ 48. When he cannot perform a work procedure or does not possess work related information, he willingly learns what is needed for successful job performance.

| 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Never | Less than half the time | About half of the time | More than half of the time | Always |

_____ 49. Keeps work area clean and protects equipment from spills, dirt, and moisture while performing maintenance activities.

_____ 50. Initiates work activities, not waiting to be told what has to be done.

_____ 51. Pays attention to instruction, having to be told only once to do something.

## Appendix F

### Evaluation Form for Electronic Maintenance Technicians

This form has been developed from information provided by supervisors (NCO's and Warrant Officer's) and managers (Unit Commanding Officer's) of electronic maintenance technicians. The kinds of evaluation information represented by these twenty items may influence a rater's evaluation of a technician's job performance. This study is trying to determine to what degree these kinds of evaluation dimensions do in fact influence proficiency ratings.

Please indicate the degree to which the ratee performs each activity. Your rating should be based upon all of your observations of the man's behavior, not just of his maintenance work.

---

NAME RANK MOS

| 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Never | Less than half the time | About half of the time | More than half of the time | Always |

_____ 1. Quickly and correctly identifies malfunction causes.

_____ 2. Performs all work that needs to be done.

_____ 3. Uses all hardware (washers, nuts, bolts, screws etc.) when replacing or installing components.

_____ 4. Is alert on the job, demonstrating an awareness of possible non-safe working conditions.

_____ 5. Follows safe operating procedures.

_____ 6. He asks questions when in doubt, does not make wild guesses.

_____ 7. He persists in his work, staying with a task until it is completed.

_____ 8. He is reliable and can be counted on to carry out assigned and implied duties.

_____ 9. Plans the task--determines what procedures he must carry out and obtains the necessary tools, test equipment, schematics, TM's and other references prior to starting the task.

_____ 10. Reads schematics correctly.

_____ 11. Uses all test equipment available called for in the procedures.

_____ 12. Performs malfunction diagnosis deliberately and in an orderly fashion and does not jump to conclusions.

_____ 13. He is honest he has done all work he reports having completed.

_____ 14. Keeps supervisors correctly and completely informed as to work status.

_____ 15. Uses correct technical references and does not rely on memory.

| 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Never | Less than half the time | About half of the time | More than half of the time | Always |

_____ 16. Takes care of tools and test equipment.

_____ 17. Performs required steps, not omitting necessary procedures.

_____ 18. Performs all preventive maintenance tasks.

_____ 19. Initiates work activities, not waiting to be told what has to be done.

_____ 20. Pays attention to instruction, having to be told only once to do something.

## Appendix G

## Basic Electronic's Skill and Knowledge Tests

## Test Administration Instructions

These instructions describe the procedures to be followed for the administration and scoring of a test for measuring electronic maintenance skills and knowledges that are basic (fundamental) to the performance of the job in MOS 24E, 24H and 24J. The test is divided into two general sections: a section with performance-oriented items using paper/pencil type questions; and a section with performance items similar to those actually performed on the job. The second section requires that certain preparations be carried out prior to test administration. This is necessary to insure that tests conditions are standard for each examinee.

### PREPARATION FOR THE TEST

To prepare for each administration of the test, you must accomplish the following:

1. When more than one examinee is to be tested at one time, plan the order in which sections of the test will be administered to each examinee.
2. Assemble all required equipment materials and tools, including question and answer forms and pencils.
3. Set up the performance test stations in the same manner for each examinee as follows on the next page.
4. For the test item requiring the identification of malfunctioning component, insert the faultry component before the examinee arrives at the testing site.
5. Check the location to insure safe operating conditions.

ADMINISTRATION OF THE TESTS

To administer the test, you must perform the following:

1. Explain the general purpose of the study.

This study is part of a research project that has the purpose of developing procedures for determining the subject matter for electronic training courses. The emphasis here is on basic electronic skills and knowledge. The test you are about to take was based upon analysis of the job performed in your MOS. The results of your performance on the test are to be used for research purposes only. Your specific results will not be shown to anyone. Neither your supervisor nor your battery commander will be shown the results. Do you have any questions about why you are here?

Answer any general questions, but delay answering questions about the specific nature of the test until after you have read the test instructions

2. Read the test instructions to the examinees as follows:

The test is divided into two sections. One is a paper/pencil test and the other a performance test. Specific instructions for each test item are written out in the test booklet. You will place your answer for each item in the space provided in the test booklet. For most of the items you only need make a check mark ( ) in the appropriate blank. The performance portion is timed. The written portion is not timed. As soon as you finish one section tell the test monitor and he will start you on the second section. All the equipment and materials needed for completing the performance test are provided. I will answer any administrative questions now or during the test.

Do you have any questions?

3. Start the test by saying, Go.
4. Observe the examinees doing the performance test. Answer any administrative questions, but do not answer questions about how to perform the required test activity.
5. Stop the examinee if he is about to initiate an action that will constitute a hazard to himself or to the equipment.
6. When an examinee finishes the first section of the test, get him started as soon as possible on the second part.

## SCORING THE TEST

To determine the total score for each examinee, you must do the following:

1. Score each item as correct or incorrect.

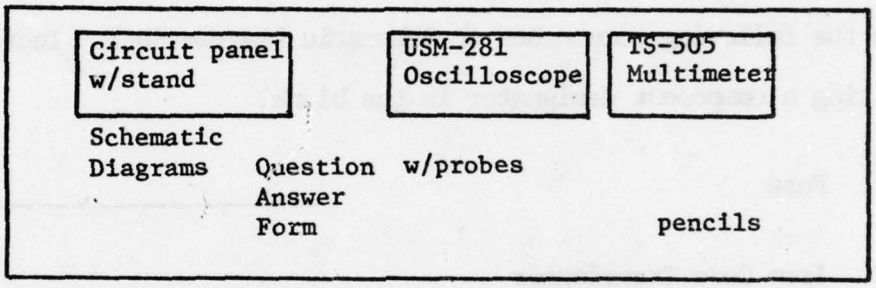
2. For each correct item weight them as follows:

| | | | |
|---|---|---|---|
| 1. | Schematic Reading | (Items 1-20) | = 1.84 points |
| 2. | Electronic Terms | (Items 21-40) | = 1.36 points |
| 3. | Determining Resistor Value | (Items 41&42) | = 1.00 points |
| 4. | Conversion of Measurement Value | (Items 43-47) | = 1.12 points |
| 5. | Continuity Checks Use of PSM-6 Multimeter | (Items 48-55) | = 1.50 points |
| 6. | Component Checks Use of Digital Voltmeter | (Items 56-63) | = 1.58 points |
| 7. | Use of TS-505 Multimeter | (Item 64) | = 1.42 points |
| 8. | Use of USM-281 Oscilloscope | (Item 65) | = 1.68 points |
| 9. | Troubleshooting | (Item 66) | = 1.82 points |

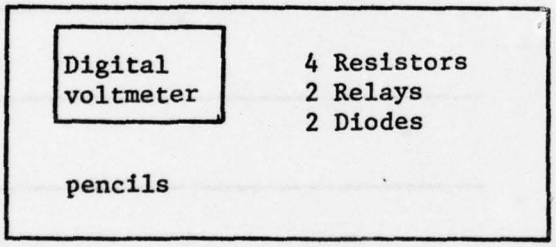
3. Add the total points to get the total score.

PERFORMANCE TEST STATION LAYOUT

Station 1

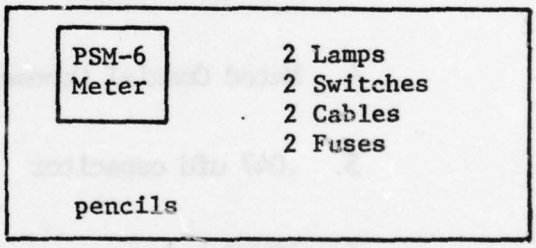



Station 2

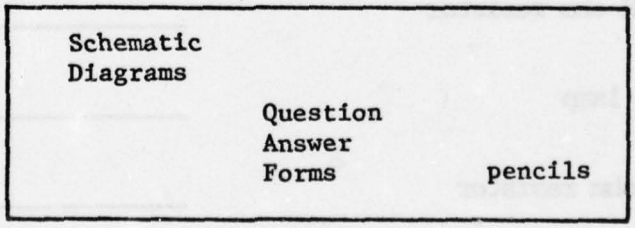



1

Station 3




Station 4




2

| Name | Rank | MOS | Electronic Work Experience (month) |
|---|---|---|---|

| Last MOS Evaluation Score | Where Stationed |
|---|---|

## SECTION I

### Written Examination

SCHEMATIC READING - 1

Locate the following components on Schematic Diagram SD-3. Indicate your answer by writing a component designator in the blank.

1. Fuse _____
2. Iron Core Transformer _____
3. Crystal Diode _____
4. Mated Coaxial Connector _____
5. .047 ufd capacitor _____
6. 10 MH inductor _____
7. 4.7 K ohm resistor _____
8. Neon lamp _____
9. 150 ohm resistor _____
10. .01 ufd capacitor _____

SCHEMATIC READING - 2

Using Schematic Diagram - SD-4 identify the function of each of the following components. Indicate your answer by selecting a function from the list and placing its letter in the blank beside the component.

| Function | Component |
|---|---|
| a. Adjusts output voltage | 11. DS-1 _____ |
| b. Filter capacitor | 12. T-1 _____ |
| c. Indicates power supply is on | 13. R-2 _____ |
| d. Diode limiter | 14. S-1 _____ |
| e. Surge suppressor | 15. K-2 _____ |
| f. Plate load resistor | 16. R-9 _____ |
| g. Filament transformer | 17. C-4 _____ |
| h. Provides overload protection | 18. CR-1 _____ |
| i. Enables power supply operation | 19. V-1 _____ |
| j. Dual Triode differential amplifier | 20. R-15 _____ |
| k. Part of a voltage divider | |
| l. Voltage regulator | |

ELECTRONIC TERMS - 1

For each of the following terms indicate its definition by placing the appropriate letter in the blank.

| Definitions | Terms |
|---|---|
| a. A device to open or close a circuit. | 21. Relay _____ |
| b. A remote control switching device. | 22. Transformer _____ |
| c. A voltage source. | 23. Switch _____ |
| d. A measure of conductance. | 24. Battery _____ |
| e. A component used to transfer electric energy from one circuit to another. | 25. Short Circuit _____ |
| f. A low resistance path for current. | 26. Continuity _____ |
| g. A component which has a controlled amount of resistance. | 27. Capacitance _____ |
| h. The property of a component to oppose current flow. | 28. Resistor _____ |
| i. A complete path for current flow. | 29. Capacitor _____ |
| j. A component which can store and release electric energy. | 30. Resistance _____ |
| k. A component which melts to open a circuit. | |
| l. The property of a component to store and release electric energy. | |

ELECTRONIC TERMS - 2

For each of the following terms match the appropriate statement by placing a letter in the blank beside the term.

a. Ohm

b. Has a high resistance.

c. Omega

d. Potentiometer

e. Watt

f. Has a low resistance.

g. Has no resistance at all.

h. Ampere

i. A broken path in a circuit.

j. A double-acting switch.

k. A device that melts to open a circuit.

l. A device that opens a circuit when it is overheated.

m. A condition of a circuit breaker which restores current flow.

31. Good conductor _____

32. Unit of power _____

33. Good insulator _____

34. Unit of resistance _____

35. Unit of current _____

36. Variable resistor _____

37. Fuse _____

38. Thermal circuit breaker _____

39. Reset _____

40. Open _____

DETERMINING RESISTOR VALUE

Determine resistance value and tolerance of the following resistors by reading their color code.

41. Band 1 - brown
    Band 2 - blue
    Band 3 - red — Value _____
    Band 4 - silver — Tolerance _____

42. Band 1 - orange
    Band 2 - green
    Band 3 - yellow — Value _____
    Band 4 - gold — Tolerance _____

CONVERSION OF MEASUREMENT VALUE

Convert the following measurements from the first scale to the second scale.

43. 1,000 volts is equal to: _____ kilovolts

44. 2.8 kilohms is equal to: _____ ohms

45. 250 milliamperes is equal to: _____ amperes

46. 750 milliseconds is equal to: _____ seconds

47. 0.2 volt is equal to: _____ millivolts

## SECTION II

### Performance Test

CONTINUITY CHECKS (Time limit 10 minutes)

Perform a continuity check on the following components using the PSM-6 multimeter. Indicate whether the component is GOOD or BAD by placing a check mark (✓) in the blank space to the right of your answer.

48. Lamp DS-1 GOOD _____ BAD _____

49. Lamp DS-2 GOOD _____ BAD _____

50. Switch S1 GOOD _____ BAD _____

51. Switch S2 GOOD _____ BAD _____

52. Cable C1 GOOD _____ BAD _____

53. Cable C2 GOOD _____ BAD _____

54. Fuse F1 GOOD _____ BAD _____

55. Fuse F2 GOOD _____ BAD _____

Time Limit 10 Minutes

COMPONENT CHECK

Check the following components to determine whether each is GOOD or BAD. Use the Digital Voltmeter to perform the test. Indicate your answer by placing a check mark (✓) in the appropriate blank.

56. Diode CR1 GOOD _____ BAD _____

57. Diode CR2 GOOD _____ BAD _____

58. Relay K1 GOOD _____ BAD _____

59. Relay K2 GOOD _____ BAD _____

RESISTANCE DETERMINATION

Measure the resistance of the following resistors using the Digital Voltmeter. Indicate your answer by writing a value in the blank beside each component designation.

60. Resistor R1 _____

61. Resistor R2 _____

62. Resistor R3 _____

63. Resistor R4 _____

## CIRCUIT MALFUNCTION DIAGNOSIS

(Time limit 5 minutes)

64. Check circuit CKT #1 for proper functioning using the TS-505 Multimeter. Indicate whether you get the proper voltage at the output test point. The schematic diagram for CKT #1 is provided for your use.

Correct Voltage Yes _____ No _____

(Time limit 5 minutes)

65. Check circuit CKT #2 for proper functioning using the USM-281 Oscilloscope. The circuit schematic is provided for your use.

Correct Waveform Yes _____ No _____

(Time limit 15 minutes)

66. If your answer to Question 65 is NO, identify the source of malfunction. Indicate your answer by writing a component number in the blank. The circuit schematic diagram is provided for your use.

Malfunction _____

DATA REQUIRED BY THE PRIVACY ACT OF 1974
(5 U.S.C. 552a)

| TITLE OF FORM | PRESCRIBING DIRECTIVE |
|---|---|
| Basic Electronic Performance Test and Evaluation | AR 70-1 |

1. AUTHORITY

10 USC Sec 4503

2. PRINCIPAL PURPOSE(S)

The data collected with the attached form are to be used for research purposes only.

3. ROUTINE USES

This is an experimental personnel data collection form developed by the U. S. Army Research Institute for the Behavioral and Social Sciences pursuant to its research mission as prescribed in AR 70-1. When identifiers (name or Social Security Number) are requested they are to be used for administrative and statistical control purposes only. Full confidentiality of the responses will be maintained in the processing of these data.

4. MANDATORY OR VOLUNTARY DISCLOSURE AND EFFECT ON INDIVIDUAL NOT PROVIDING INFORMATION

Your participation in this research is strictly voluntary. Individuals are encouraged to provide complete and accurate information in the interests of the research, but there will be no effect on individuals for not providing all or any part of the information. This notice may be detached from the rest of the form and retained by the individual if so desired.

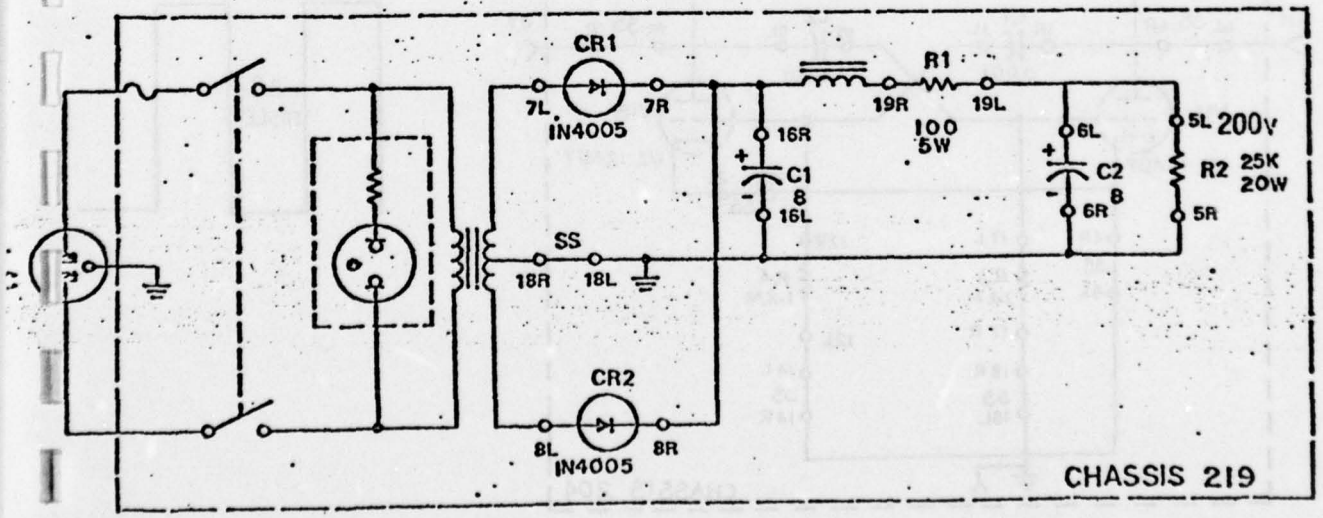
CKT# 1

The printed wiring surface of the circuit board faces outward from the rear of the chassis and is clearly visible. The jacks in the circuit board are arranged in two vertical columns providing 20 component positions. A complete position designation for any component position includes a number (1 to 20) plus the designation L or R which identifies each end of the component. All components are mounted on plastic strips with banana plugs on each end. Turn power off prior to removing or replacing component strips.

SS indicates - shorting strip

Component Layout

| | |
|---|---|
| 1R-1 | 11R-L |
| 2 | 12 |
| 3 | 13 |
| 4 | 14 |
| 5 | 15 |
| 6 | 16 |
| 7 | 17 |
| 8 | 18 |
| 9 | 19 |
| 10 | 20 |



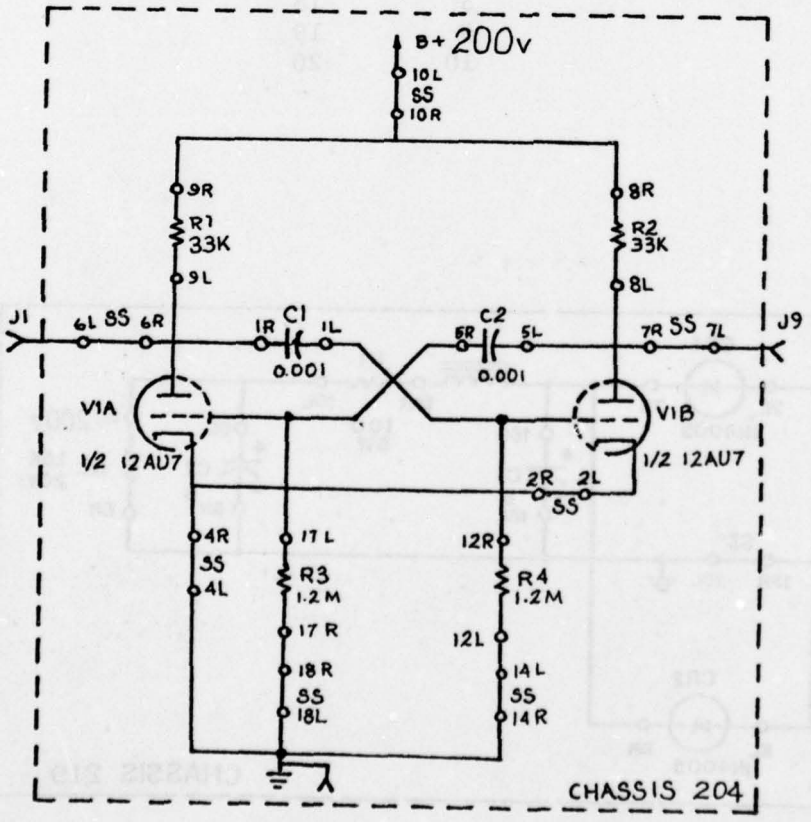
CKT# 2

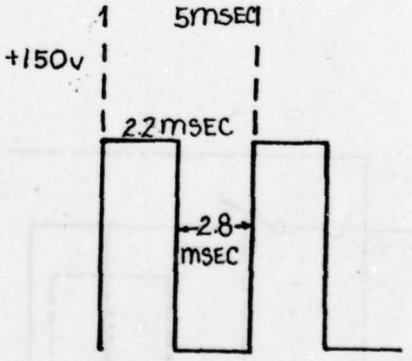
The printed wiring surface of the circuit board faces outward from the rear of the chassis and is clearly visible. The jacks in the circuit board are arranged in two vertical columns providing 20 component positions. A complete position designation for any component position includes a number (1 to 20) plus the designation L or R which identifies each end of the component. All components are mounted on plastic strips with banana plugs on each end. Turn power off prior to removing or replacing component strips.

SS indicates - shorting strip

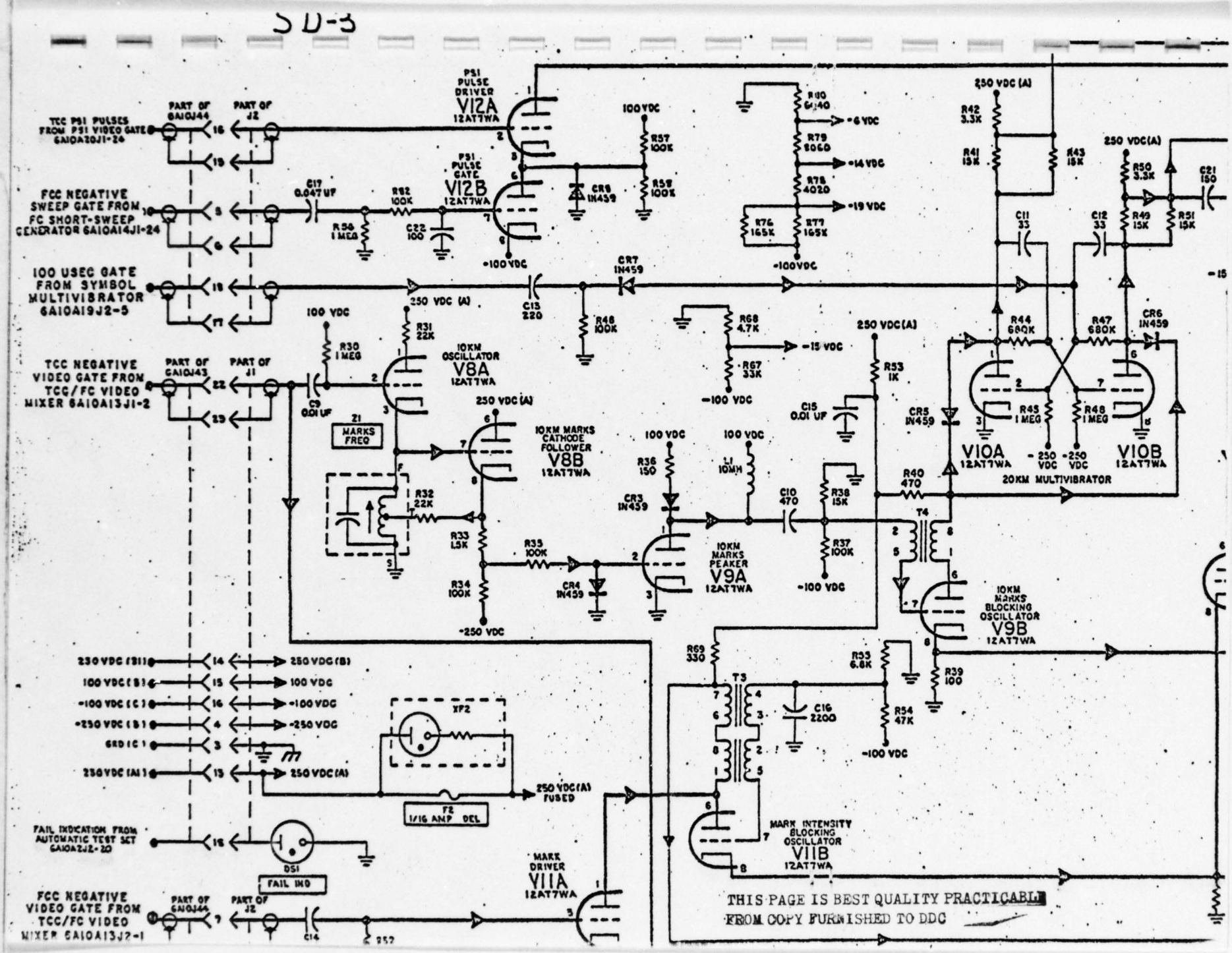
Component Layout

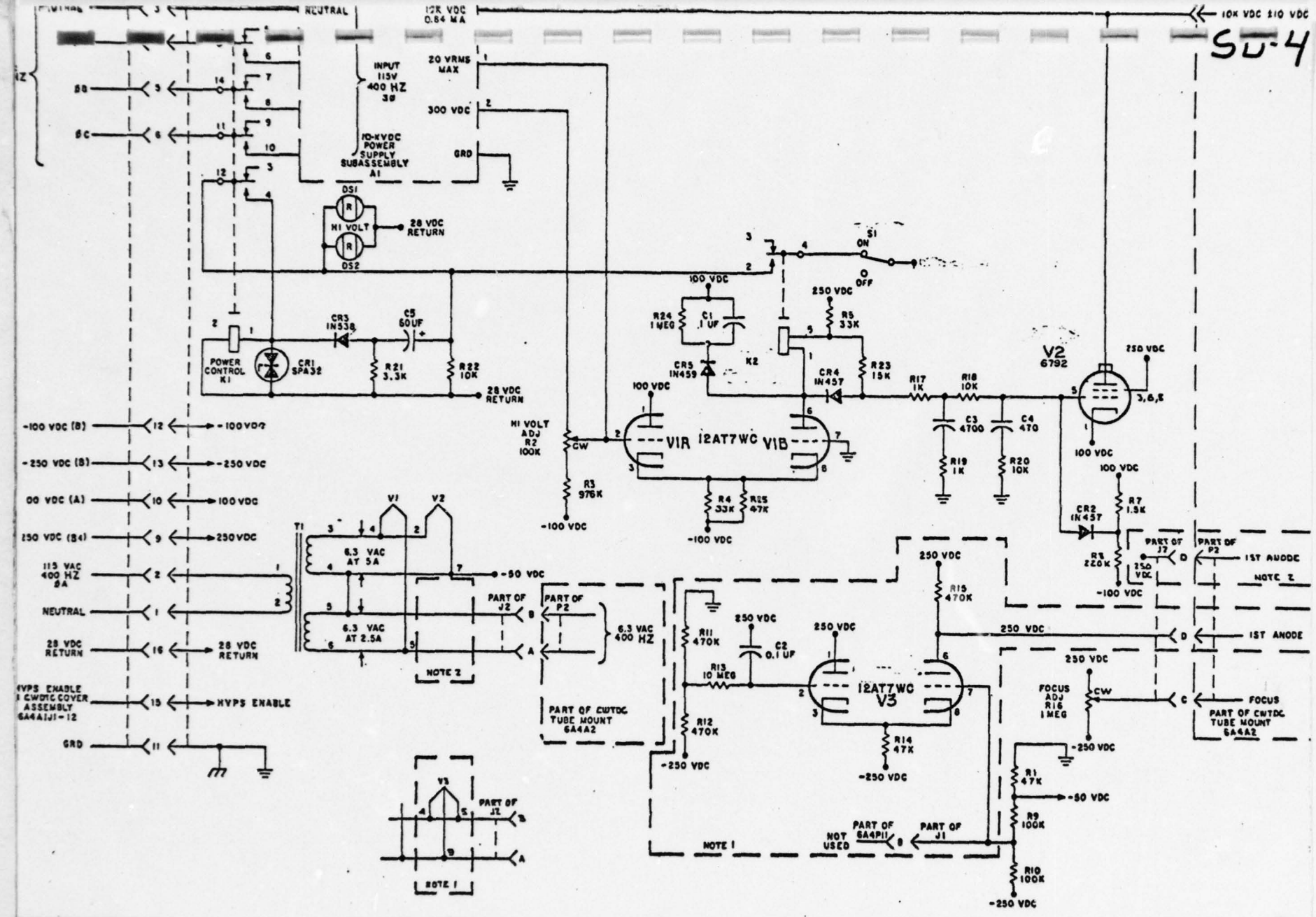
| | |
|---|---|
| 1R-L | 11R-1 |
| 2 | 12 |
| 3 | 13 |
| 4 | 14 |
| 5 | 15 |
| 6 | 16 |
| 7 | 17 |
| 8 | 18 |
| 9 | 19 |
| 10 | 20 |



SD-3


PSI PULSE DRIVER V12A 12AT7WA
PSI PULSE GATE V12B 12AT7WA
TCC PSI PULSES FROM PSI VIDEO GATE GAIOA20J1-24
FCC NEGATIVE SWEEP GATE FROM FC SHORT-SWEEP GENERATOR GAIOAI4JI-24
100 USEC GATE FROM SYMBOL MULTIVIBRATOR GAIOAI9J2-5
TCC NEGATIVE VIDEO GATE FROM TCC/FC VIDEO MIXER GAIOAI3JI-2
FCC NEGATIVE VIDEO GATE FROM TCC/FC VIDEO MIXER GAIOAI3J2-1
10KM OSCILLATOR V8A 12AT7WA
10KM MARKS CATHODE FOLLOWER V8B 12AT7WA
10KM MARKS PEAKER V9A 12AT7WA
10KM MARKS BLOCKING OSCILLATOR V9B 12AT7WA
20KM MULTIVIBRATOR V10A 12AT7WA V10B 12AT7WA
MARK INTENSITY BLOCKING OSCILLATOR V11B 12AT7WA
MARK DRIVER V11A 12AT7WA
MARKS FREQ
FAIL INDICATION FROM AUTOMATIC TEST SET GAIOA2J2-20
FAIL IND
250 VDC(A) FUSED
F2 1/16 AMP DEL
THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC




THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

# Appendix H

## Average Test Performance for Individual Technicians

Appendix H
Average Test Performance for Individual Technicians (24E)

| Rank | Exp. | MOS Score | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Rating | Weighted Test Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E-3 | 5 | | 80 | 95 | 0 | 60 | 88 | 13 | 0 | 10 | 0 | 74 | 664 |
| | 10 | | 80 | 95 | 0 | 40 | 10 | 50 | 0 | 10 | 0 | 37 | 718 |
| | 4 | | 90 | 30 | 0 | 0 | 10 | 25 | 10 | 10 | 0 | 59 | 706 |
| | 5 | | 80 | 90 | 10 | 40 | 10 | 88 | 0 | 0 | 0 | 73 | 711 |
| | 5 | | 65 | 30 | 0 | 0 | 63 | 63 | 0 | 0 | 0 | 74 | 354 |
| | 5 | | 85 | 85 | 0 | 0 | 75 | 75 | 10 | 0 | 10 | 24 | 827 |
| | 5 | | 95 | 30 | 0 | 80 | 10 | 50 | 10 | 0 | 0 | 69 | 676 |
| | 5 | | 80 | 45 | 0 | 20 | 63 | 50 | 0 | 10 | 0 | 72 | 572 |
| | 8 | | 95 | 85 | 50 | 40 | 10 | 25 | 10 | 10 | 0 | 23 | 885 |
| | 11 | | 90 | 95 | 0 | 10 | 10 | 50 | 0 | 0 | 10 | 48 | 818 |
| | 5 | | 95 | 80 | 0 | 40 | 10 | 50 | 10 | 10 | 0 | 74 | 867 |
| | 4 | | 10 | 90 | 0 | 60 | 75 | 50 | 10 | 10 | 0 | 74 | 875 |
| E-4 | 10 | | 70 | 60 | 0 | 40 | 10 | 38 | 0 | 10 | 0 | 70 | 633 |
| | 15 | | 90 | 85 | 0 | 40 | 10 | 88 | 0 | 10 | 0 | 41 | 783 |
| | 15 | | 90 | 70 | 0 | 80 | 75 | 10 | 0 | 10 | 0 | 75 | 789 |
| | 14 | | 80 | 65 | 0 | 20 | 10 | 75 | 10 | 10 | 0 | 76 | 837 |

## Appendix H
## Average Test Performance for Individual Technicians (24E)

| Rank | Exp. | MOS Score | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Rating | Weighted Test Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E-5 | 36 | 99 | 75 | 40 | 0 | 0 | 10 | 63 | 10 | 0 | 0 | 72 | 584 |
| | 30 | 100 | 90 | 50 | 0 | 0 | 10 | 38 | 10 | 0 | 10 | 78 | 768 |
| | 33 | 115 | 85 | 50 | 0 | 20 | 88 | 63 | 0 | 10 | 0 | 74 | 646 |
| | 16 | 139 | 95 | 95 | 0 | 80 | 10 | 50 | 0 | 10 | 10 | 71 | 973 |
| | 48 | 119 | 80 | 65 | 0 | 40 | 10 | 25 | 10 | 0 | 0 | 60 | 612 |
| | 47 | 96 | 80 | 80 | 0 | 0 | 10 | 13 | 0 | 0 | 10 | 69 | 617 |
| E-6-7 | 145 | 103 | 80 | 85 | 50 | 60 | 10 | 10 | 0 | 0 | 10 | 80 | 870 |
| | 60 | 110 | 80 | 65 | 0 | 10 | 10 | 40 | 10 | 10 | 0 | 80 | 871 |
| | 126 | 98 | 10 | 10 | 50 | 40 | 10 | 80 | 10 | 10 | 0 | 36 | 1001 |
| | 27 | 98 | 90 | 65 | 50 | 40 | 75 | 75 | 10 | 10 | 0 | 77 | 890 |
| | 120 | 100 | 95 | 90 | 0 | 60 | 88 | 75 | 10 | 10 | 0 | 67 | 925 |
| | 69 | 110 | 80 | 90 | 0 | 60 | 10 | 88 | 0 | 0 | 0 | 75 | 626 |

Appendix H
Average Test Performance for Individual Technicians (24H)

| Rank | Exp. | MOS Score | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Rating | Weighted Test Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E-3 | 8 | | 95 | 70 | 50 | 80 | 100 | 75 | 100 | 100 | 0 | 80 | 988 |
| | 2 | | 70 | 75 | 0 | 60 | 100 | 38 | 100 | 100 | 100 | 35 | 1000 |
| E-4 | 12 | 115 | 95 | 85 | 0 | 100 | 100 | 38 | 100 | 100 | 100 | 71 | 1104 |
| | 21 | | 95 | 85 | 0 | 40 | 100 | 88 | 0 | 0 | 0 | 63 | 624 |
| | 2 | | 90 | 90 | 0 | 100 | 100 | 63 | 100 | 100 | 0 | 74 | 959 |
| | 4 | | 95 | 90 | 100 | 60 | 100 | 88 | 0 | 100 | 0 | 50 | 921 |
| | 17 | | 90 | 95 | 100 | 100 | 100 | 10 | 100 | 100 | 0 | 57 | 1125 |
| E-5 | 21 | 125 | 95 | 80 | 0 | 10 | 100 | 75 | 10 | 100 | 0 | 80 | 974 |
| | 2 | | 90 | 100 | 100 | 10 | 100 | 75 | 0 | 100 | 100 | 75 | 1132 |
| | 20 | | 85 | 85 | 0 | 40 | 88 | 100 | 0 | 100 | 100 | 39 | 957 |
| | 37 | 125 | 90 | 70 | 100 | 10 | 100 | 63 | 10 | 100 | 0 | 42 | 890 |
| | 61 | 118 | 85 | 80 | 0 | 60 | 100 | 75 | 0 | 100 | 0 | 34 | 781 |
| E-6 | 100 | 115 | 75 | 95 | 0 | 60 | 88 | 50 | 10 | 10 | 0 | 75 | 855 |
| | 21 | 138 | 75 | 85 | 50 | 10 | 75 | 75 | 10 | 10 | 0 | 69 | 932 |
| | 47 | 133 | 95 | 80 | 0 | 10 | 88 | 75 | 0 | 0 | 10 | 76 | 828 |
| | 48 | 100 | 95 | 75 | 10 | 10 | 10 | 88 | 10 | 0 | 10 | 65 | 1102 |

## Appendix H
## Average Test Performance for Individual Technicians (24J)

| Rank | Exp. | MOS Score | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Rating | Weighted Test Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E-4 | 18 | | 95 | 90 | 10 | 40 | 10 | 75 | 10 | 10 | 0 | 40 | 1021 |
| | 18 | | 90 | 60 | 0 | 60 | 88 | 88 | 10 | 0 | 0 | 45 | 727 |
| | 20 | | 85 | 95 | 10 | 10 | 10 | 75 | 10 | 10 | 0 | 41 | 1076 |
| | 15 | | 95 | 85 | 0 | 80 | 10 | 10 | 0 | 0 | 0 | 70 | 688 |
| | 20 | | 90 | 80 | 50 | 40 | 10 | 38 | 0 | 0 | 0 | 77 | 579 |
| E-5 | 45 | 134 | 90 | 10 | 10 | 10 | 10 | 88 | 10 | 0 | 0 | 80 | 1045 |
| | 10 | | 10 | 85 | 10 | 80 | 10 | 56 | 0 | 0 | 10 | 78 | 910 |
| | 22 | | 95 | 90 | 10 | 10 | 10 | 10 | 10 | 10 | 0 | 80 | 1127 |
| | 48 | 90 | 95 | 85 | 10 | 20 | 10 | 50 | 10 | 0 | 0 | 54 | 784 |
| | 72 | 88 | 95 | 80 | 10 | 40 | 10 | 88 | 10 | 10 | 10 | 31 | 1209 |
| | 36 | 140 | 95 | 45 | 10 | 0 | 10 | 56 | 10 | 10 | 0 | 34 | 884 |
| | 46 | 115 | 10 | 95 | 50 | 10 | 10 | 88 | 10 | 10 | 10 | 45 | 1256 |
| E-6 | 100 | 123 | 95 | 95 | 10 | 10 | 88 | 75 | 10 | 10 | 10 | 80 | 1259 |
| | 72 | 98 | 95 | 95 | 10 | 80 | 10 | 75 | 0 | 0 | 0 | 69 | 762 |
| | 60 | 98 | 90 | 80 | 0 | 20 | 88 | 75 | 10 | 0 | 10 | 62 | 871 |

# Appendix I

## Guidelines For Using

## The Task Inventory Matrix (TIM)

## and

## The Task Analytical Process Model (TAPM)

## Guidelines for Using the Task Inventory Matrix (TIM) and the Task Analytical Process Model (TAPM)

Your work during this project will be to perform a detailed task analysis of selected tasks in your MOS. A process will be used that was developed during an Army Research Institute sponsored research project. The emphasis is to identify Basic Skills and Knowledge used by maintenance personnel on-the-job, using the Task Analytical Process Model (TAPM).

The work to be performed during this project is:

1. Construct a Task Inventory Matrix by:
   a. Using the appropriate Technical Manuals and other pertinent publications.
   b. Using your own subject matter expertise.
2. Administer the TIM to job incumbents in the MOS.
3. Analyze the TIM results.
4. Select specific Tasks to be analyzed in detail.
5. Validate the procedures for performing the selected tasks by:
   a. Reviewing Technical Documentation
   b. Personally performing the task
   c. Observing a maintenance man performing the task.
6. Analyze the Task elements by using the TAPM procedures.
   a. Interview
   b. Observation
   c. Review of a written step by step validated procedure.
7. Compile the results of the Task Analysis.
8. Review the list of skills and knowledge.

### Background

The U.S. Army had been concerned about the problem of how much training and what kind of training the average soldier needs to be able to perform successfully as an electronic technician.

Generally, the answer has been determined to be that he needs at least two kinds of training. First, he must have a working knowledge of electronics, and second he must have a working knowledge of the maintenance tasks required for the system for which he is responsible. These two categories of training have been called BE (Basic Electronics) and systems training respectively.

The question of how much training is needed has tended to look at the depth of understanding that is necessary to perform the job successfully. A problem has existed almost as long as has this question in that the official definition of "perform successfully" has been disputed by field management personnel. The unit commander is driven by pressures to keep his unit equipment operational as much of the time as possible, regardless of the situations. Over the years, his definition has been that a good technician is one who can keep the system operational. It matters not that the technician must perform unauthorized tasks to accomplish this, or that he must fabricate a temporary fix in substitute for a non-available component.

The technician who can perform beyond the normal and authorized level of effort in earlier times was not rare. Early in the history of Air Defense systems, reference publications were more often than not incomplete, inaccurate, or not accessible. It became necessary to acquire not only functional knowledge and skills, but also theoretical knowledge and skills. The successful technician not only knew how a piece of equipment worked, he also found out why. He often had the performance capabilities of a design engineer.

These conditions have created a historically derived perceptual set that technicians can always use a more theoretical understanding of why an electronic system operates. This set has led to considerable research over the past two decades. Much of the work has been focused on how best to teach BE. The Functional Context approach to training was designed as a way of increasing the meaningfulness of BE. The Hawkeye approach inte-

grated basic troubleshooting concpets into a job aid. The multi-level training design was another attempt to integrate theory, training, and experience in the development of technical expertise. However, front-end-loading of electronic training with BE has tended to prevail in some form. The traditional instructor taught class and laboratory approach has been the most often used. The development of a common BE preparation course, COBET, given prior to a more specific BE concept course was attempted, but was not successful.

Numerous studies have been done over the past three decades by all of the military services in an effort to reduce complexity and cost of electronic maintenance training while producing more competent technicians. These studies have demonstrated repeatedly that enormous savings in training time and money are possible.

Part of the savings which these and other studies have demonstrated resulted from changes in the instructional approach and mode of presentation or from the use of simulators to provide more valid task practice. Novel types of performance aids have also been developed which simplified the tasks and made them both easier to perform and easier to learn. Yet, a common thread runs through them all, in fact, they are based on a careful examination of what the job incumbent does on the job and a restriction of course content to only material functionally related to job content. In almost every case, it has been possible through a systematic task identification and analysis to define a list of skills and knowledge necessary and sufficient for job task performance which limited training content to that list.

The purpose of this project is to determine the fundamental skills and knowledge required in the performance of your maintenance tasks. Accordingly, the following objectives are established for achieving this purpose:

1. Identify the task content of your job.

2. Identify requisite skills and knowledge for the electronic maintenance tasks.
3. Validate the electronic maintenance skills and knowledge.

## Task Analytical Process Model Procedures

There are three steps in the process of analyzing task elements to the skills and knowledge level:

A. Construct a Task Inventory Matrix
B. Conduct the Task Element Analysis
C. Validate the Skills and Knowledge

The TAPM process is a logical analysis based upon experts job knowledge. All tasks however need not be analyzed in detail. Certain tasks should be selected for the detailed analysis and the remainder of tasks reviewed for unique skills and knowledges. To insure that the SME has not based his analysis on unique knowledge, a job description survey is constructed and administered to other technicians holding the same MOS. Details of the procedures are presented on the following pages. Follow the step by step process using the referenced examples.

A. Task Inventory Matrix

1. Construction of a Task Inventory Matrix

   a. Assemble the appropriate Technical Manuals
      TM-9-1430____12-1
      TM-9-1430____24P
   b. Select major item of equipment to be analyzed.
   c. Using the maintenance allocation chart in the operator manual and the maintenance code in the parts manual, list the equipment items down to the lowest level of authorized repair. The listing of equipment should be made in a hardware grouping. For certain items it may be more appropriate to utilize a functional grouping. Criticality information can also be coded on TIM (see step 4b).

d. Test equipment that is used to perform maintenance and/or maintenance services on the end item should also be included in the TIM.

e. Determine the kinds of tasks that maintenance mechanics and repairmen perform on the equipment. This information may be obtained from the publications and your experience. Previous experience has determined there are four general categories of maintenance activities. A list of suggested task verbs and algorithms is at Table 1. An example of the TIM is at (pages 16 & 17).

f. A respondent data sheet or background information sheet should also be constructed and administered to provide information that is appropriate to the interpretation of the TIM results (example at page 15).

2. Administer the TIM

a. It is important to administer the TIM only to individuals who have had job experience in a real world environment. (Hands/on On site or in a DSU). The experience of an individual will determine their responses and we want to know what they "do" on the job.

b. Instructions to the TIM respondees must be written and included. You must explain to the responder how to complete the TIM. Administration should be completed on an individual using a one to one interview method. The written instructions are necessary to insure uniformity of interview procedures. Instructions may include a coding program to aid in TIM analysis, i.e.. If you have performed the task on the hardware item less than 10 times write the proper number. If you have performed the task more than 10 times write an X in the square.

3. Analyze the TIM results.

a. Compile the results of the TIM responses for all respondents by hardware item.

Table 1

Maintenance Task Verbs

| | |
|---|---|
| Inspect: | To determine the serviceability of an item by examining its physical, mechanical and/or electrical characteristics and comparing the state of these characteristics with established standards. (Also to examine and to perform preventive maintenance.) |
| Test: | To verify serviceability of an item by measuring its mechanical and/or electrical characteristics and comparing these measurements with established standards. (Also to detect functional failure, to evaluate and to check). |
| Diagnose: | To isolate a malfunctioning item (component, module, subassembly or assembly) that is the source of operational failure. (Also to troubleshoot.) |
| Service: | To perform operations, such as cleaning, charging, and adding fuel, lubricants, cooling agents and air, on a periodic schedule to keep a system in proper operating condition. (Also to perform preventive maintenance.) |
| Adjust: | To bring an operating characteristic of an item into prescribed limits by setting variable controls to the specific, proper or exact positions. |
| Align: | To adjust specified variable elements of an item to bring about optimum or desired functional performance. |
| Calibrate: | To detect and adjust any discrepancy in the accuracy of on instrument (measurement or diagnostic equipment) when compared to an instrument which is a certified standard of known accuracy. |
| Install: | To seat or fix into position an item (component, module, subassembly or assembly) in a manner to allow the proper functioning of equipment or a system. (Also to emplace.) |
| Replace: | To remove a non-functioning item and to substitute a serviceable like-type part, subassembly, module (component or assembly) in a manner to allow the proper functioning of an equipment/system. (Also to assemble and disassemble.) |
| Repair: | To restore an item to serviceable condition. Consists of maintenance services (inspect, test, service, adjust, align, calibrate, replace) or other maintenance actions (welding, grinding, riveting, straightening, facing, remachining, or resurfacing) to correct specific damage, |

fault, malfunction, or failure in a part, subassembly, module/component/assembly, end item or system.

Overhaul: To restore an item to a completely serviceable/operational condition as prescribed by maintenance standards. This is normally the highest degree of maintenance performed by the Army. Overhaul does not normally return an item to like new condition.

Rebuild: To restore unserviceable equipment to a like-new condition in appearance, performance, and life expectancy. This is accomplished through complete disassembly of the item, inspection of all parts or components, repair or replacement of worn or unserviceable elements (items) according to original manufacturing tolerances and specifications, and subsequent reassembly of the item. Rebuild is the highest degree of material maintenance applied to Army equipment.

Table 1 (cont.)

| VERB | ALGORITHM |
|---|---|
| Abide by | Attitudes |
| Accepting | Attitudes |
| Accommodate | Problem Solving |
| Aquire | Steering & Guiding Continuous Movement |
| Activate | Motor Chaining |
| Adapt | Problem Solving |
| Adjust | Motor Chaining |
| Adjust to | Problem Solving |
| Advise | Communicating |
| Aim | Steering & Guiding Continuous Movement |
| Align | Motor Chaining |
| Allocate | Classifying |
| Analyze | Rule Using |
| Answer | Communicating |
| Anticipate | Rule Using |
| Apply | Rule Using |
| Arrange | Classifying |
| Assemble (Dis) | Motor Chaining |
| Assign | Classifying |
| Associate | Identifying Symbols |
| Attend | Monitoring |
| Calculate | Rule Using |
| Catalogue | Classifying |
| Categorize | Classifying |
| Characterize | Classifying |
| Check | Rule Using |
| Choose | Decision Making |
| Cite | Verbal Chaining |
| Classify | Classifying |
| Clean | Motor Chaining |
| Close/Open | Motor Chaining |

Table 1 (cont.)

| VERB | ALGORITHM |
|---|---|
| Collect | Classifying |
| Compare | Identifying Symbols |
| Compensate | Steering & Guiding Continuous Movement |
| Compile | Classifying |
| Comply with | Attitudes |
| Compose | Problem Solving |
| Compute | Rule Using |
| Conclude | Rule Using |
| Conform to | Attitudes |
| Connect (Dis) | Motor Chaining |
| Construct | Problem Solving |
| Contrast | Identifying Symbols |
| Contrive | Problem Solving |
| Control | Steering & Guiding Continuous Movement |
| Converse | Communicating |
| Convert | Rule Using |
| Coordinate | Rule Using |
| Copy | Motor Chaining |
| Correlate | Decision Making |
| Create | Problem Solving |
| Cut | Cross Motor Skills |
| Deduce | Rule Using |
| Demonstrate | Rule Using |
| Design | Problem Solving |
| Detect | Monitoring |
| Determine | Decision Making |
| Develop | Problem Solving |
| Devise | Problem Solving |
| Diagnose | Decision Making |
| Diagram | Rule Using |
| Differentiate | Identifying Symbols |
| Direct | Communicating |

Table 1 (cont.)

| VERB | ALGORITHM |
|---|---|
| Discern | Identifying Symbols |
| Discover | Problem Solving |
| Distinguish | Identifying Symbols |
| Divide | Classifying |
| Draft | Gross Motor Skills |
| Draw | Gross Motor Skills |
| Drive | Steering & Guiding Continuous Movement |
| Energize (De) | Motor Chaining |
| Enumerate | Verbal Chaining |
| Equate | Rule Using |
| Estimate | Rule Using |
| Evaluate | Rule Using |
| Examine | Rule Using |
| Explain | Rule Using |
| Express | Communicating |
| Extrapolate | Rule Using |
| Figure | Rule Using |
| File | Classifying |
| Fly | Steering & Guiding Continuous Movement |
| Generalize | Rule Using |
| Grade | Classifying |
| Grasp | Gross Motor Skills |
| Group | Classifying |
| Guide | Steering & Guiding Continuous Movement |
| Identify | Identify Symbols |
| Illustrate | Rule Using |
| Index | Classifying |
| Indicate | Identifying Symbols |
| Infer | Rule Using |
| Inform | Communicating |
| Inspect | Motor Chaining |
| Install | Motor Chaining |

Table 1 (cont.)

| VERB | ALGORITHM |
|---|---|
| Instruct | Communicating |
| Interpolate | Rule Using |
| Interpret | Rule Using |
| Interview | Communicating |
| Invent | Problem Solving |
| Inventory | Classifying |
| Isolate | Decision Making |
| Itemize | Verbal Chaining |
| Judge | Classifying |
| Label | Identifying Symbols |
| Lead | Steering & Guiding Continuous Movement |
| Lift | Gross Motor Skills |
| List | Verbal Chaining |
| Listen | Communicating |
| Listen for | Monitoring |
| Load | Motor Chaining |
| Locate | Identifying Symbols |
| Look for | Monitoring |
| Loosen | Gross Motor Skills |
| Lubricate | Motor Chaining |
| Maintain | Motor Chaining |
| Maneuver | Steering & Guiding Continuous Movement |
| Manipulate | Steering & Guiding Continuous Movement |
| March | Gross Motor Skills |
| Mate | Identifying Symbols |
| Match | Identifying Symbols |
| Mix | Gross Motor Skills |
| Monitor | Monitoring |
| Name | Identifying Symbols |
| Navigate | Steering & Guiding Continuous Movement |
| Observe | Monitoring |
| Operate | Motor Chaining |

Table 1 (cont.)

| VERB | ALGORITHM |
|---|---|
| Order | Communicating |
| Organize | Rule Using |
| Pick | Identifying Symbols |
| Pick up | Gross Motor Skills |
| Pilot | Steering & Guiding Continuous Movement |
| Plan | Rule Using |
| Predict | Rule Using |
| Prepare | Rule Using |
| Prescribe | Rule Using |
| Press | Gross Motor Skills |
| Program | Rule Using |
| Project | Rule Using |
| Pull | Gross Motor Skills |
| Push | Gross Motor Skills |
| Quote | Verbal Chaining |
| Rank | Classifying |
| Rate | Classifying |
| Reason | Problem Solving |
| Recall | Verbal Chaining |
| Recognize | Identifying Symbols |
| Regulate | Steering & Guiding Continuous Movement |
| Reiterate | Verbal Chaining |
| Relate | Verbal Chaining |
| Remove/Replace | Motor Chaining |
| Repeat | Verbal Chaining |
| Report | Communicating |
| Resist | Rule Using |
| Resolve | Problem Solving |
| Respond | Identifying Symbols |
| Restate | Verbal Chaining |
| Rotate | Gross Motor Skills |
| Run | Gross Motor Skills |

Table 1 (cont.)

| VERB | ALGORITHM |
|---|---|
| Schedule | Rule Using |
| Select | Decision Making |
| Service | Motor Chaining |
| Set | Motor Chaining |
| Set Up | Motor Chaining |
| Sew | Gross Motor Skills |
| Sharpen | Gross Motor Skills |
| Signal | Gross Motor Skills |
| Sing | Communicating |
| Slide | Gross Motor Skills |
| Solve | Rule Using |
| Sort | Classifying |
| Speak | Communicating |
| Specify | Identifying Symbols |
| Splice | Gross Motor Skills |
| Steer | Steering & Guiding Continuous Movement |
| Stencil | Gross Motor Skills |
| Study | Problem Solving |
| Stow | Motor Chaining |
| Swim | Gross Motor Skills |
| Synthesize | Problem Solving |
| Testify | Communicating |
| Think Through | Problem Solving |
| Tighten | Gross Motor Skills |
| Trace | Gross Motor Skills |
| Track | Steering & Guiding Continuous Movement |
| Transcribe | Rule Using |
| Translate | Rule Using |
| Trouble Shoot | Decision Making |
| Tune | Motor Chaining |
| Turn on/off | Motor Chaining |
| Twist | Gross Motor Skills |

Table 1 (cont.)

| VERB | ALGORITHM |
|---|---|
| Verify | Rule Using |
| Wait | Monitoring |
| Watch | Monitoring |
| Weld | Motor Chaining |
| Write | Motor Chaining |

DATE _____

NAME (LAST, FIRST, MIDDLE INITIAL) _____ GRADE _____ AGE _____

DUTY MOS _____ ORGANIZATION _____

TIME IN PRESENT JOB _____ TOTAL TIME IN SERVICE _____

TOTAL TIME IN ELECTRONICS FIELD

HIGHEST SCHOOL GRADE OR COLLEGE YEAR COMPLETED

HOW MUCH TIME DO YOU SPEND PERFORMING SUPERVISORY OR ADMINISTRATIVE FUNCTIONS?

_____NONE OF MY TIME.
_____1-25% OF MY TIME.
_____26-50% OF MY TIME.
_____51-75% OF MY TIME.
_____76-100% OF MY TIME.

HOW MUCH TIME DO YOU SPEND PERFORMING "HANDS ON" MAINTENANCE OF EQUIPMENT?

_____NONE OF MY TIME.
_____1-25% OF MY TIME.
_____26-50% OF MY TIME.
_____51-75% OF MY TIME.
_____75-100% OF MY TIME.

LIST THE TYPE OF TEST EQUIPMENT YOU USE ON THE JOB (PLEASE LIST FROM MOST FREQUENTLY USED DOWN TO LEAST FREQUENTLY USED).

WHERE DID YOU LEARN TO USE THE TEST EQUIPMENT (MOS SCHOOL, OTHER SCHOOL, OR OJT)?

WHAT MAINTENANCE ACTIVITIES DO YOU PERFORM THAT WERE NOT TAUGHT IN SCHOOL OR SHOULD HAVE BEEN GIVEN MORE EMPHASIS?

## The Task Inventory Matrix

The first column indicates the Functional Group number of the System Hardware item as referenced in the appropriate Technical Manual.

The second column indicates the total like items contained within the major item. No entry in this column indicates quantity of one.

The third column contains the short name of the Hardware item.

The fourth through seventh columns contain types of maintenance activities.

The last column is divided into two parts indicating the effect the Hardware item will have on the End item and the missile system if defective.

The column is divided into two parts for each item. The upper portion indicates the condition of the end item with the lower portion indicating the condition of the system when the particular hardware item is not functioning correctly or is missing.

R = Red indicating the end item or system is not operational if this hardware item is not functioning.

A = Amber indicating the end item or system is capable of limited operation if this hardware item is not functioning.

G = Green indicating the end item or system operation is not significantly degraded if this item is not functioning.

| Functional Group Number | | Total in Major Item | System Hardware Item | Preventive Maintenance | Periodic Checks | Corrective Maintenance | Diagnosis Troubleshooting |
|---|---|---|---|---|---|---|---|
| 0100 | | | Battery Control Central | | | | |
| 1200 | | | Power Distribution Control | | | | |
| 1300 | | | Synchro Buss Assembly | | | | |
| 1400 | | | Tactical Control Console | | | | |
| | 1410 | | Relay Chassis | | | | |
| | 1430 | 8 | Deflection Amplifier X and Y | | | | |
| | 1470 | 3 | 14 KV Power Supply | | | | |
| | 1500 | 4 | Fan and Dimmer Assembly | | | | |
| | 1540 | | Relay Assembly | | | | |
| | 1600 | 3 | Video Amplifier | | | | |
| | 1680 | | Defogging Relay Assembly | | | | |
| | 1700 | | Indicator Control | | | | |
| | 1750 | | Coordinate Data Control | | | | |

b. Compare the relevant background information of the respondents, (relevant information, may be years of experience, location of site duty, DS/GS assignments, age, rank) to their TIM responses.

c. Use the above information to determine reasons for variance between respondents.

4. Select specific tasks to be analyzed in detail.

a. The TIM provides the density data in terms of most often performed tasks by a majority of the technicians.

b. Criticality data can be obtained from two sources.

(1) Operational readiness criteria from AR220-1 Missile System Availability Indicator.

(2) TM-9-1425-525 ESC (to be applied to each equipment item rather than to each task). The rationale is that if a preventive maintenance task and periodic checks are not performed a debilitating problem might occur or go undetected that could lead to red-lining the system and if a problem does occur to cause a system to go down, troubleshooting and corrective maintenance must be performed to get the system back on the air. Therefore, if a technician cannot perform any maintenance task when it must be performed, the operational readiness criteria for classifying equipment status comes into play.

(3) The U.S. Army Missile Material Readiness Command collects malfunction and time to repair data for Improved HAWK battalions in Europe over the last few years. (This report is most helpful in narrowing the list of critical tasks). Example of such a list on page 19.

c. Review the higher density tasks from the TIM results. An example is at page 20.

d. Designate those tasks that require the same kinds of maintenance procedures as several other tasks.

e. Using the information from 4a, b, c, and d. Compile a final list of tasks selected for analysis. (An example of such a list is at page 21).

f. The number tasks actually selected for <u>performance of the detailed</u> element analysis will be determined by time and availability of equipment, material and personnel to this project.

Extract From Data Bank US Army Missile Materiel Readiness Command

(182 days) April 1-Sept. 30, 1977 (213 days) Mar 1-Sept. 30, 1977

Major Item IPAR

| Functional Group Number | Nomenclature | Org. Fail-232 NO Failed | Org. Fail-232 % of Failed | Org. Fail-232 MMTR | DSU Failed 338 NO Failed | DSU Failed 338 % of Failed | DSU Failed 338 MMTR |
|---|---|---|---|---|---|---|---|
| 4600 | Pressurization Unit | 31 | 13.3 | .86 | 43 | 12.7 | 3.69 |
| 1250 | Cooler Liquid | 23 | 9.9 | 1.42 | 24 | 7.1 | 2.25 |
| 2425 | Delay Amplifier | 16 | 6.9 | 1.71 | 34 | 10.1 | 2.9 |
| 2415 | Carrier Generator | 15 | 6.4 | 1.33 | 32 | 9.5 | 3.6 |
| 3550 | High Voltage Power Supply | 14 | 6.0 | 2.66 | 23 | 6.8 | 2.2 |
| 2465 | Video Integrator | 9 | 3.8 | 1.51 | 13 | 3.9 | .53 |
| 4920 | Modulator Sub. Assy. | 8 | 3.4 | 1.64 | 10 | 3.0 | 1.95 |
| 2455 | MTI Amp. | 7 | 30 | 170 | 12 | 3.6 | 4.08 |
| | | 123 | 53% | | 191 | 56.5% | |

MOS 24J

The IPAR chassis that eighty to one hundred percent of the MOS 24J respondents performed maintenance tasks on at least ten times are listed below.

| Functional Group Number | Chassis Name | Functional Group Number | Chassis Name |
|---|---|---|---|
| 1060 | Dickie Fix Amplifier | 2455 | MTI Amplifier |
| 1070 | Dickie Fix-Fix Amplifier | 2605 | Voltage Regulator |
| 1090 | Interference Blanker | 2620 | Reference Voltage Regulator |
| 1120 | Back Bias Amplifier | 4250 | Trigger Pulse Amplifier |
| 2245 | Rangemark Generator | | |
| 2405 | MTI Video Amp and MOB | | |
| 2415 | Carrier Generator | | |
| 2425 | Delay Amp (Long and Short) | | |
| 2435 | Coho Oscillator | | |

Tasks Selected for Detailed Analysis

| Task Number | Number Simular Task | MOS | |
|---|---|---|---|
| 1 | 24 | 24E<br>24J | Electrically aline the stabilizing system, STALO, and preselector in the Improved Pulse Acquisition Radar. (IPAR) |
| 2 | 4 | 24E<br>24J | Aline the STALO Automatic Frequency Control (AFC) in the IPAR. |
| 3 | 24 | 24E<br>24J | Aline the Scan Servo Assembly in the Improved Battery Control Central (IBCC). |
| 4 | 6 | 24E<br>(24H) | Replace and check out the Cathode Ray Tubes (CRT) in the IBCC. |
| 5 | 4 | 24E | Check Firing Console using Weekly check procedures in the IBCC. |
| 6 | 12 | 24J<br>24H | Test the High Frequency Console using the self test procedures. |
| 7 | 6 | 24H | Test the Display Generator at the High Frequency Console. |
| 8 | 4 | 24H | Test the Range Speed Indicator at the High Frequency Console. |
| 9 | 30 | 24H | Test the Scan Servo Assembly at the High Frequency Console. |
| 10 | 35 | 24J | Test the AFC Amplifier at the High Frequency Console. |
| 11 | 40 | 24J | Test the IF pre-amplifier at the High Frequency Console. |
| 12 | 0 | 24J<br>24E | Replace the heat exchanger. |
| 13 | 1 | 24J | Repair the heat exchanger. |
| 14 | 2 | 24E | Replace the pressurization unit. |
| 15 | 0 | 24J | Repair the pressurization unit. |

5. Validate the procedures for performing the selected task.

   a. A detailed step by step procedure must be written for each task and validated by:

      (1) Your actual complete performance of the task.

      (2) Your observation of a complete performance of the task.

   b. Where the technical documentation of the task is a complete step by step procedure and has been validated (as in 5 a (1) or 5 a (2)) this procedure may be used in lieu of re-writing. The emphasis is that a 100% validation must be performed.

B. Task Element Analysis

1. Analyze the task elements by using the TAPM procedures.

   a. The TAPM provides a systematic approach to performing a detailed task element analysis. The assumptions that must be made in using this process are:

      (1) The task element descriptions are valid.

      (2) The task element descriptions are complete.

      (3) The user must have sufficient job knowledge to (ask) answer the process questions.

      (4) The user does not have to be knowledgeable in the instructional development process.

      (5) The user must be able to make decisions about general and special skills of the general public.

   b. The detailed process begins with the initiation of the task and is carried through to task completion.

      (1) The input element consists of initiating cues for the task and situation conditions. The cues indicated first that the task must now be carried out and second what standards must be met. The situation conditions will indicate what special considerations must be made in carrying out the task. (In your case the task has been selected as a result of the task selection process utilizing the analysis of the TIM).

      (2) The processing element of the model includes the detailed activities that must be performed to complete the task. It includes the tools, equipment materials, facilities, support, and personnel that will be used to carry out the task.

(3) The output element consists of the finished product. This may be in the form of a repaired, checked, serviced or replaced equipment item. A comparison of the output against the input standards will lead to decision as to whether the task is complete.

2. Sequence of task element analysis.

   Use the following flow chart to analyze the selected tasks in your MOS.

3. A suggested coding procedure for developing a list of skills and knowledge.

   a. Identify a skill or knowledge, list it, then as the skill or knowledge reoccurs merely indicate by use of a tic mark.

   b. Compile the categories for summarization rather than making a decision for each statement as you are going through the analysis.

   c. Develop a tally sheet form for the first task you analyze and add column for each new task you analyze. Extend the list of skills and knowledge as they are derived from the analysis.of the additional tasks.

   Examples of a skills and knowledge clustering and tally sheet are provided at pages 35, 36, 37, 38, and 39.

4. Compile the results of the task analysis.

   a. Add the density of each skill and knowledge by task.

   b. List the skills and knowledge in their respective categories by task.

   c. If validation is desired you can cluster the skills and knowledge summary by topic groups to facilitate construction of a validation questionnaire. This step is helpful for review prior to making course development decisions.

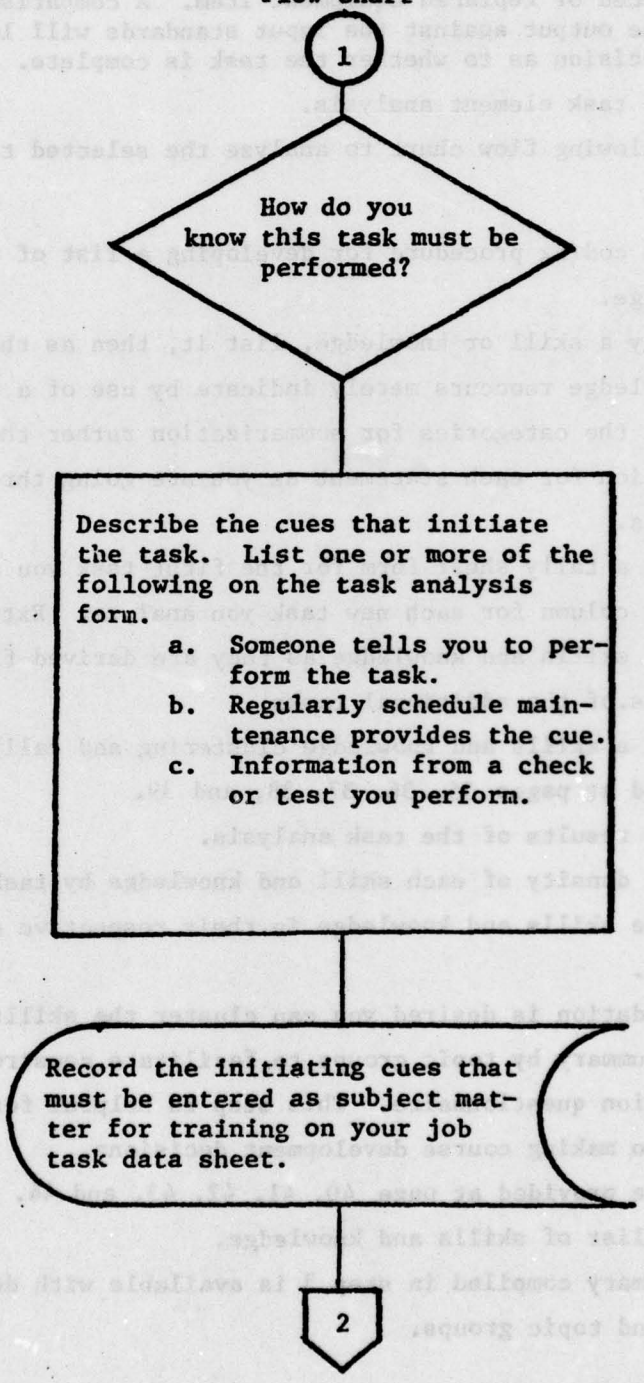
   Examples are provided at page 40, 41, 42, 43, and 44.

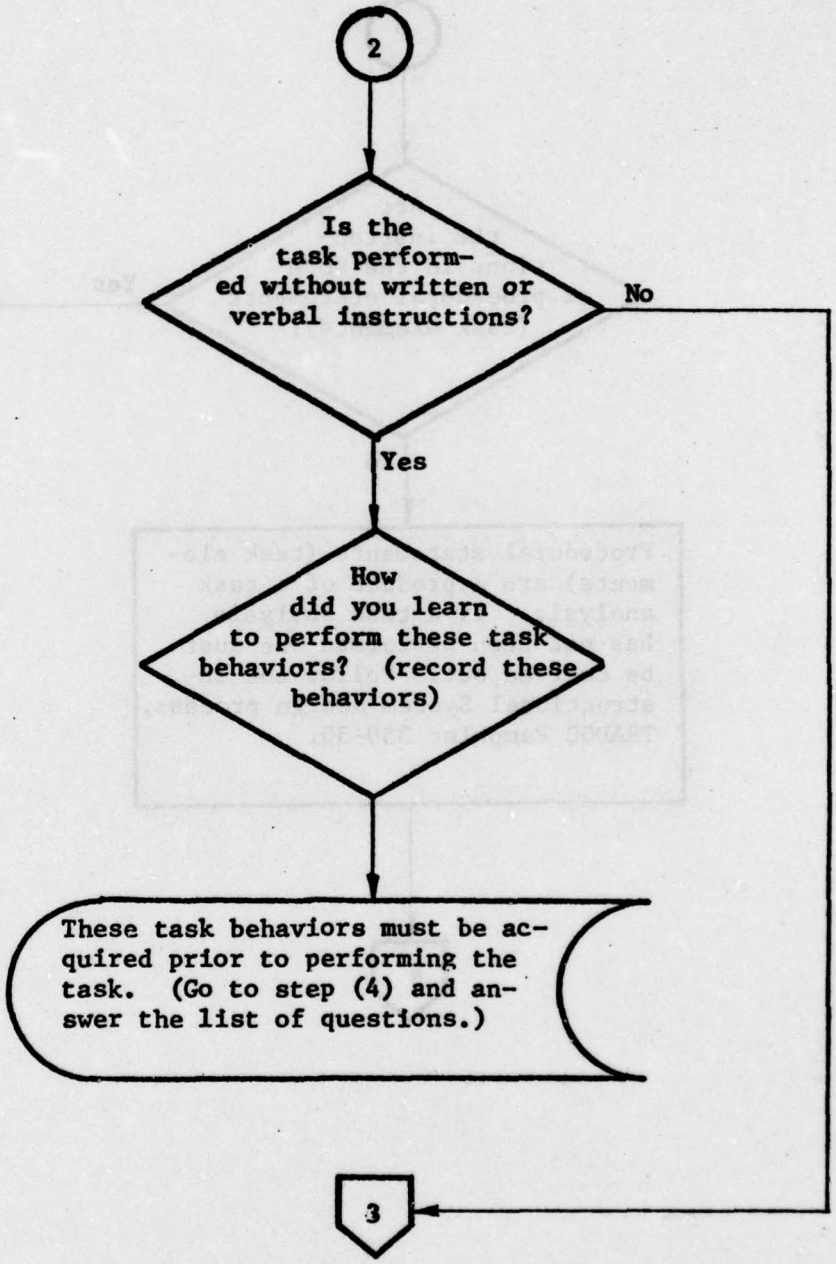
5. Review the list of skills and knowledge.

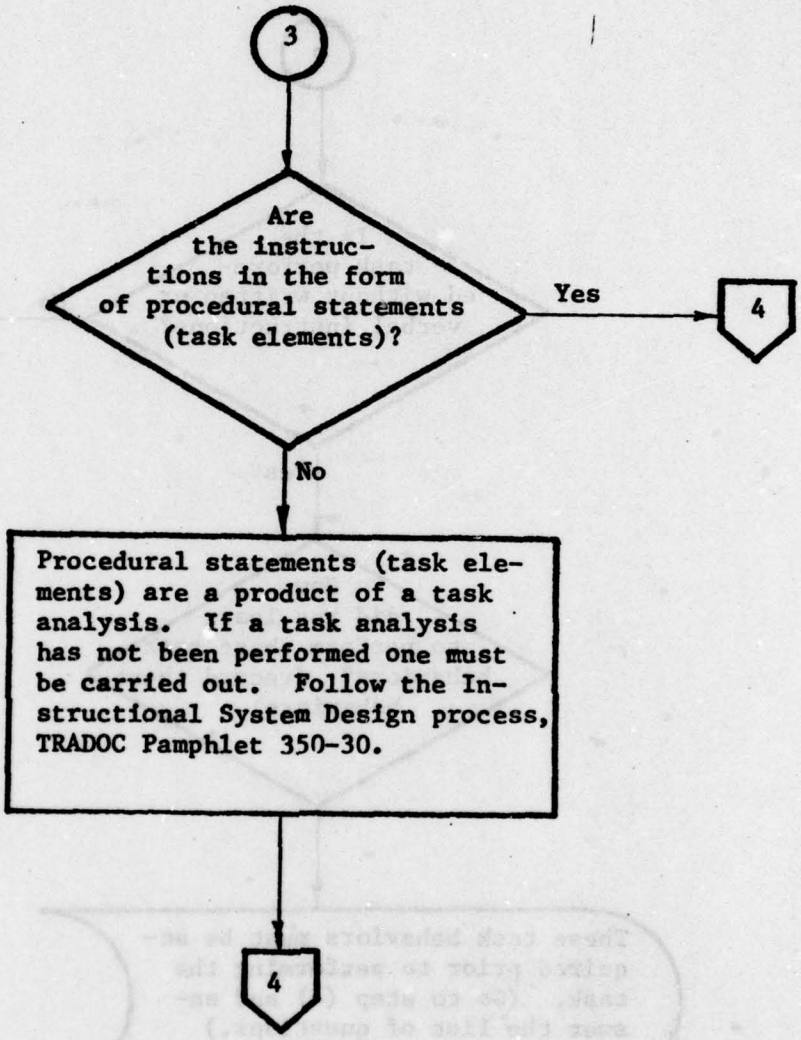
   a. The summary compiled in step 3 is available with density results and topic groups.

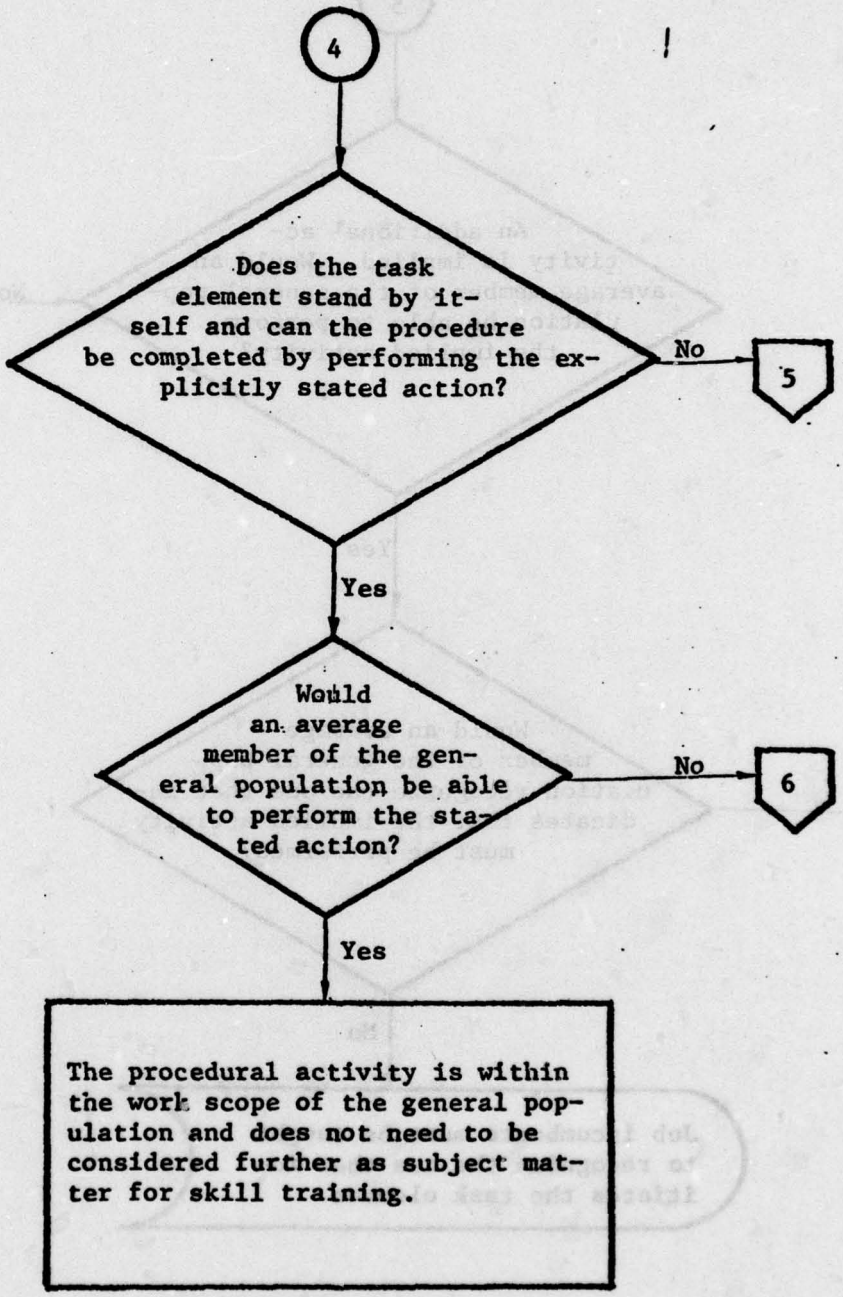
Task Analytical Process Model

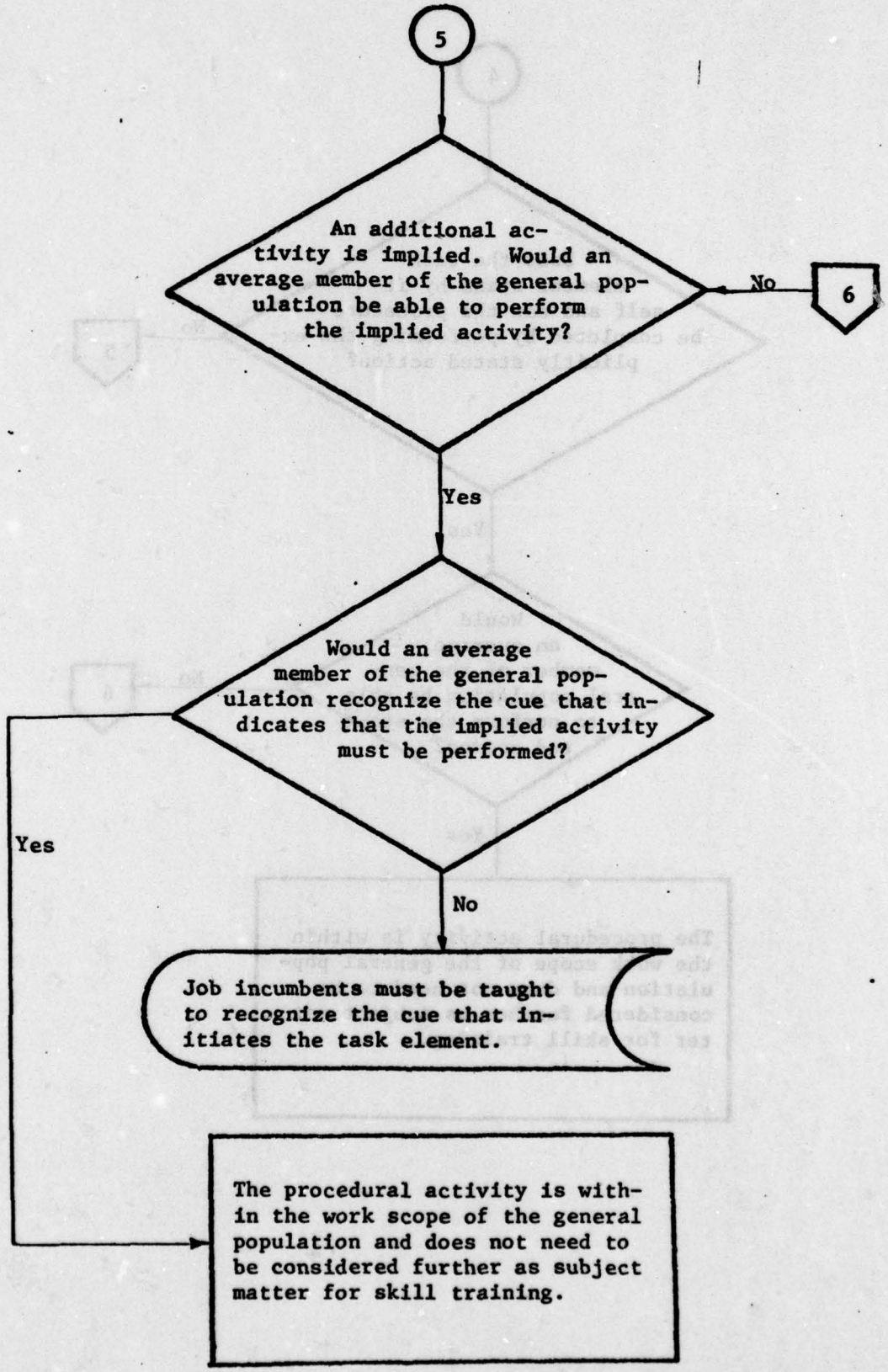
Flow Chart

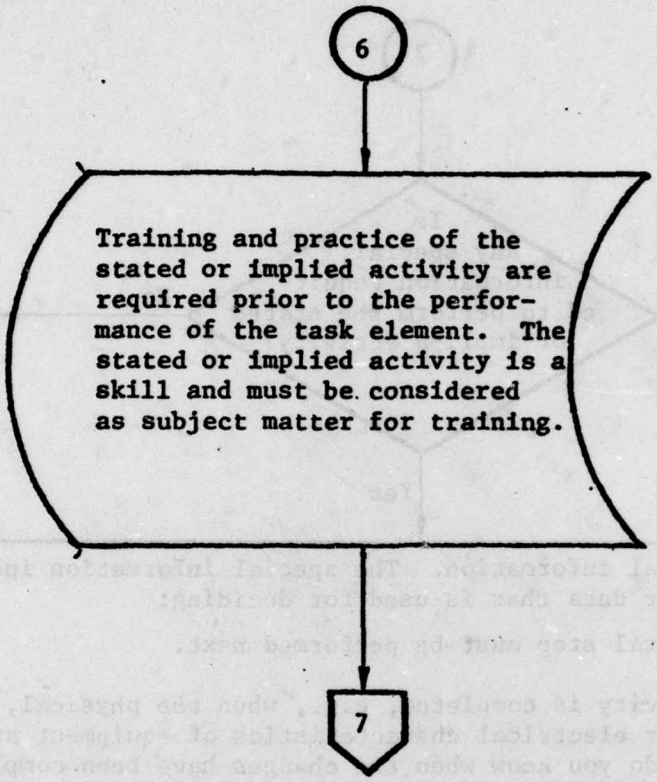


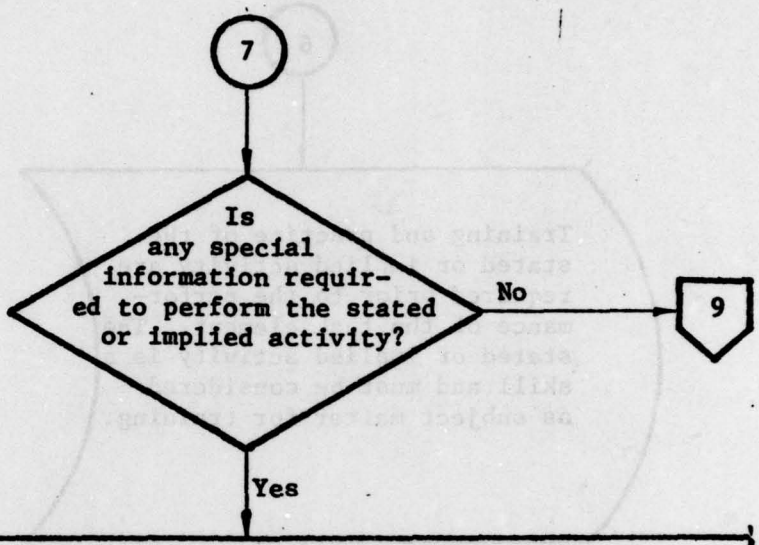

2
Is the task performed without written or verbal instructions?
No
Yes
How did you learn to perform these task behaviors? (record these behaviors)
These task behaviors must be acquired prior to performing the task. (Go to step (4) and answer the list of questions.)
3


3
Are the instruc-tions in the form of procedural statements (task elements)?
Yes
4
No
Procedural statements (task elements) are a product of a task analysis. If a task analysis has not been performed one must be carried out. Follow the Instructional System Design process, TRADOC Pamphlet 350-30.
4


4
Does the task element stand by itself and can the procedure be completed by performing the explicitly stated action?
No
5
Yes
Would an average member of the general population be able to perform the stated action?
No
6
Yes
The procedural activity is within the work scope of the general population and does not need to be considered further as subject matter for skill training.


5
An additional activity is implied. Would an average member of the general population be able to perform the implied activity?
No
6
Yes
Would an average member of the general population recognize the cue that indicates that the implied activity must be performed?
Yes
No
Job incumbents must be taught to recognize the cue that initiates the task element.
The procedural activity is within the work scope of the general population and does not need to be considered further as subject matter for skill training.


6
Training and practice of the stated or implied activity are required prior to the performance of the task element. The stated or implied activity is a skill and must be considered as subject matter for training.
7




Record the special information. The special information includes any indication or data that is used for deciding:

1. What procedural step must be performed next.

2. When an activity is completed, e.g., when the physical, mechanical or electrical characteristics of equipment are changed, how do you know when the changes have been completed? When the position of a switch has been changed the status or characteristics of the equipment item should be altered. The knowledge of what the expected changes should be is used to evaluate the result of turning the switch.

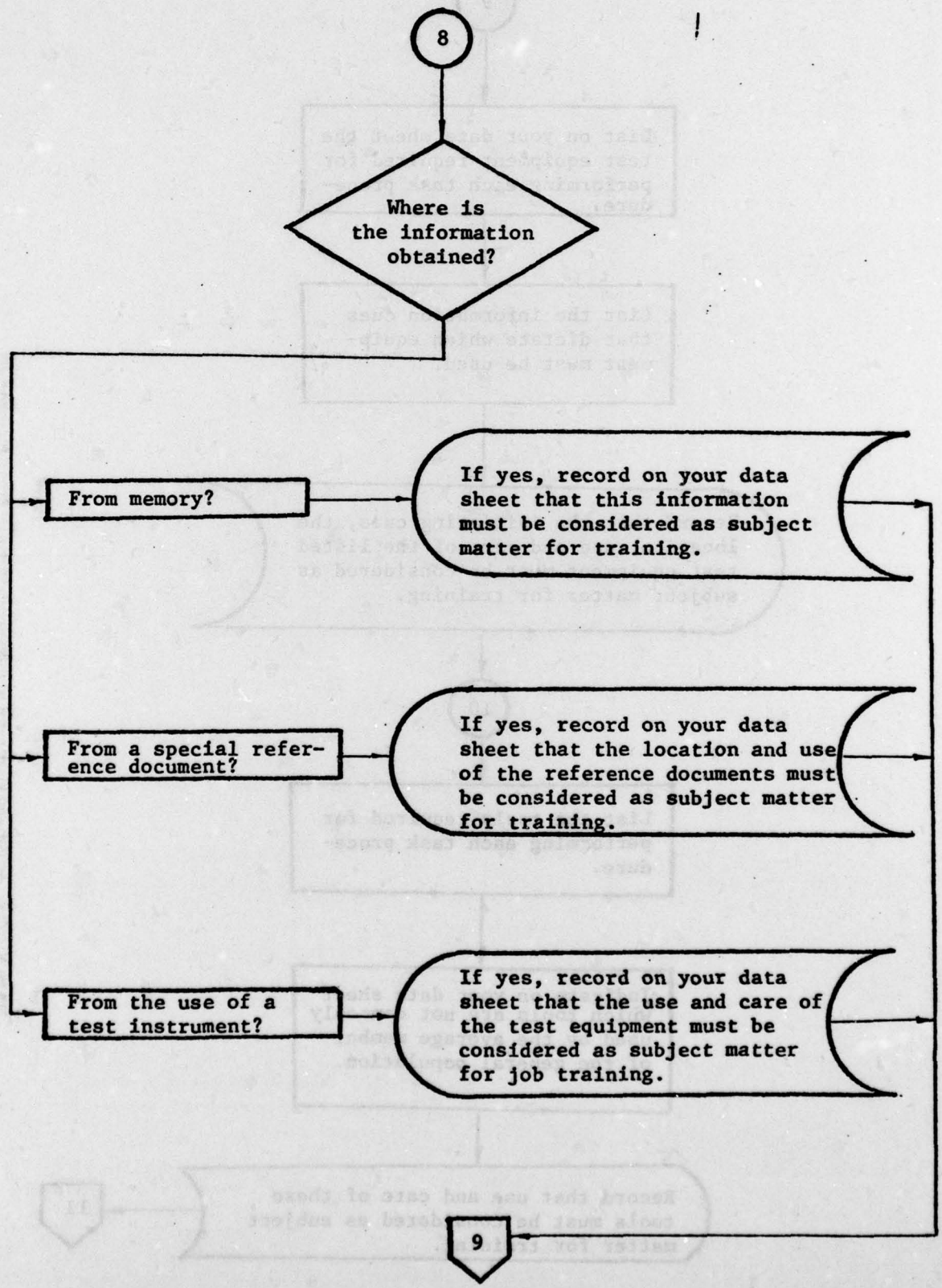
3. That a malfunction has occurred. If the expected status or characteristics change does not occur, something is not functioning properly.

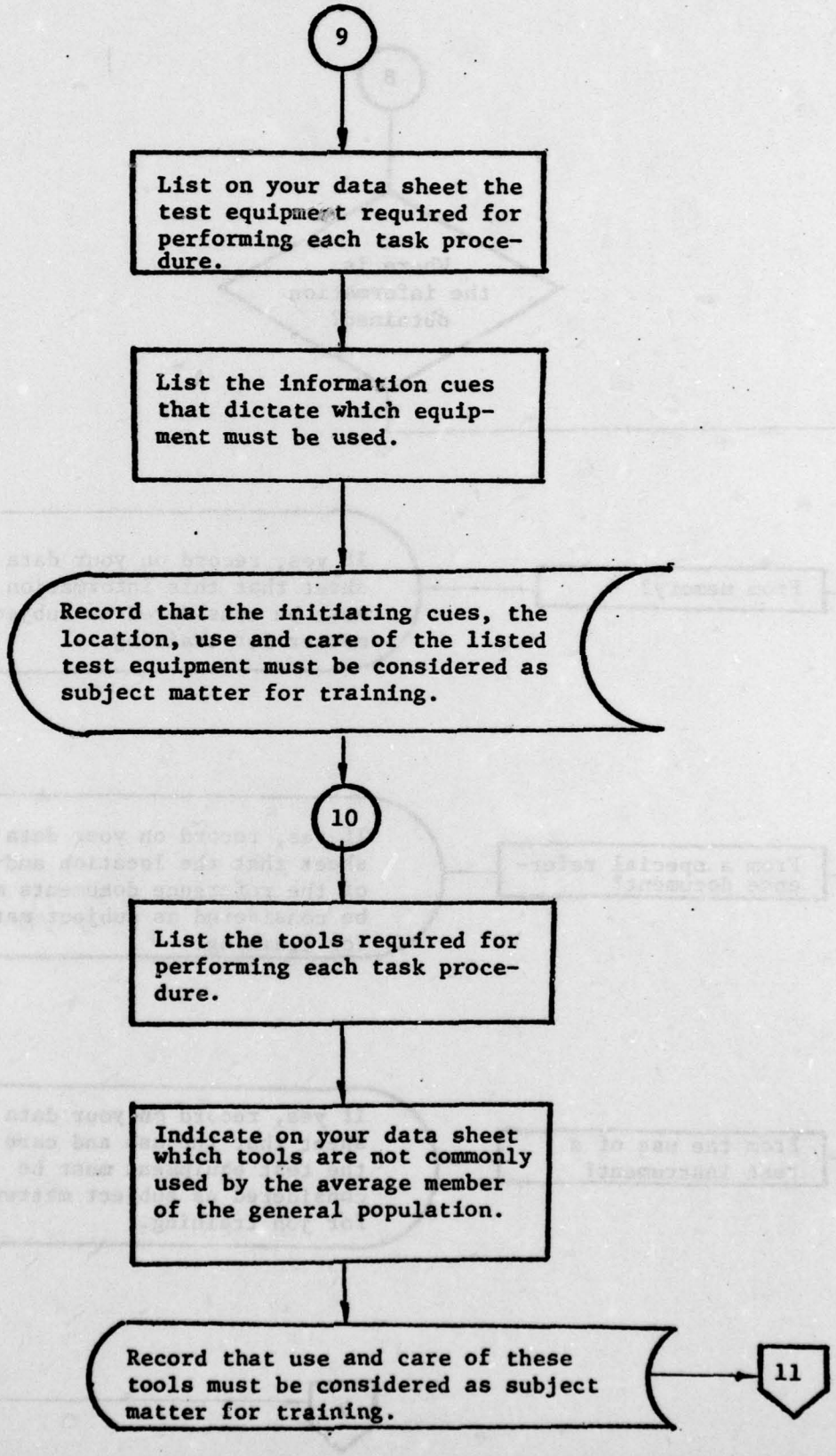
4. What the source of the problem may be. Does the evaluation of the information indicating a malfunction require a knowledge of:

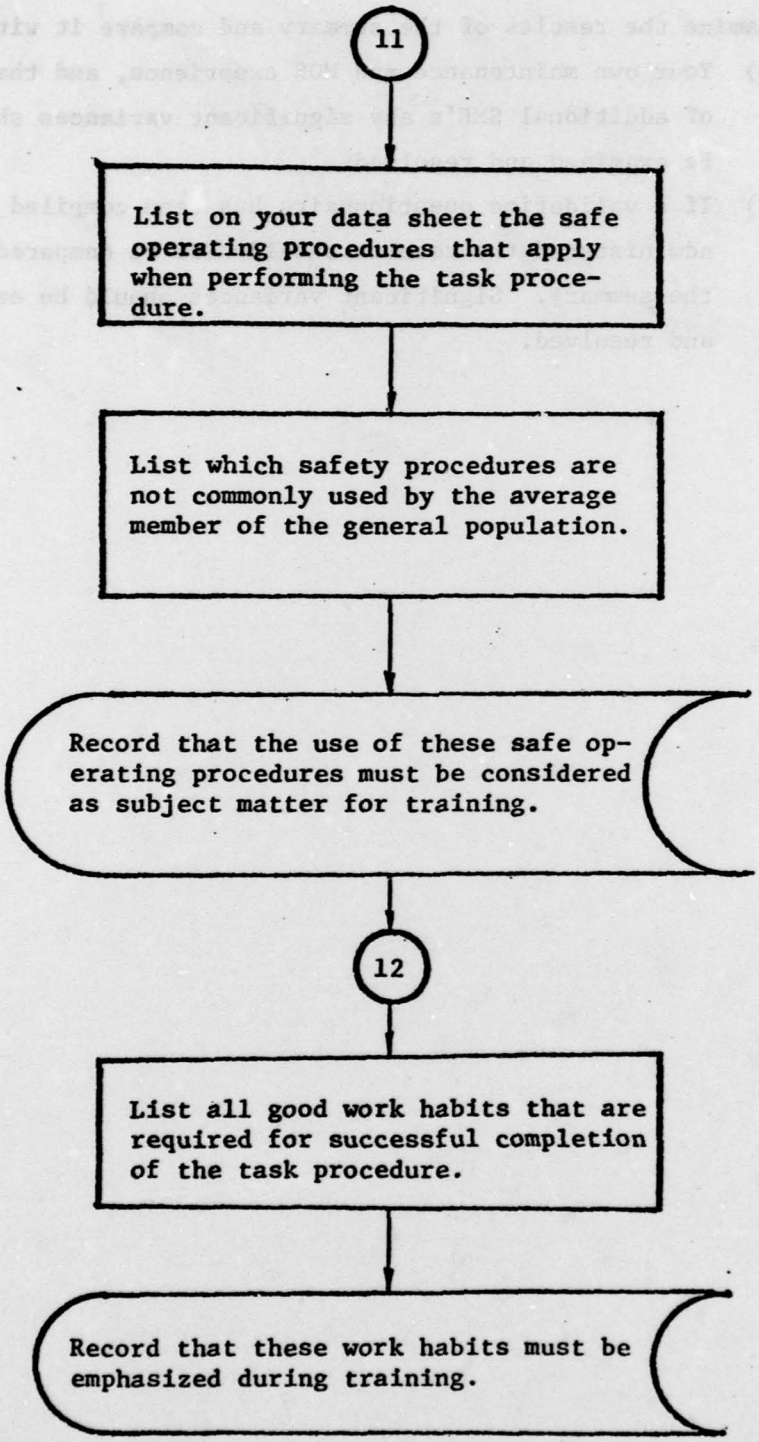
    a. How the equipment functionally operates? and/or

    b. Why the equipment theoretically operates?




8
Where is the information obtained?
From memory?
If yes, record on your data sheet that this information must be considered as subject matter for training.
From a special reference document?
If yes, record on your data sheet that the location and use of the reference documents must be considered as subject matter for training.
From the use of a test instrument?
If yes, record on your data sheet that the use and care of the test equipment must be considered as subject matter for job training.
9


9
List on your data sheet the test equipment required for performing each task procedure.
List the information cues that dictate which equipment must be used.
Record that the initiating cues, the location, use and care of the listed test equipment must be considered as subject matter for training.
10
List the tools required for performing each task procedure.
Indicate on your data sheet which tools are not commonly used by the average member of the general population.
Record that use and care of these tools must be considered as subject matter for training.
11


11
List on your data sheet the safe operating procedures that apply when performing the task procedure.
List which safety procedures are not commonly used by the average member of the general population.
Record that the use of these safe operating procedures must be considered as subject matter for training.
12
List all good work habits that are required for successful completion of the task procedure.
Record that these work habits must be emphasized during training.

b. Examine the results of the summary and compare it with:

(A) Your own maintenance and MOS experience, and that of additional SME's any significant variances should be examined and resolved.

(B) If a validation questionnaire has been compiled and administered the results should also be compared with the summary. Significant variances should be examined and resolved.

Skills and Knowledge

Inventory

Uses Hand Tools

- Screwdrivers - flat tip
- Screwdrivers - cross tip (Phillips)
- Hexagon headed - L shaped (Allen wrenches)
- Open end wrenches
- Rulers
- Pliers
- Torque wrenches
- Thickness Guage
- Dial indicators
- Non magnetic tools and tuning wands

Uses Soldering Sets

- Soldering Irons
- Soldering Aids
- Heat Syncs
- Solder
- Flux

Uses Electrical Test Components

- RF Probes
- Card Extractors
- Attenuator Probes
- Jumper Leads

Hardware

- Gaskets (check, remove, replace)
- Nuts and bolts (identify, check, remove, replace)
- Identifies threaded - unthreaded holes

Hardware (cont.)

Index pins, (identify size and use)
Retaining clamps and screws (identify size, use, remove, repair, replace)
Turnlock fasteners
Set screws
Coaxial cables (connect, disconnect, check, repair, identify size and use)
TEE connectors (connect, disconnect, check, repair, identify size and use)
BSM connectors (connect, disconnect, check, repair, identify size and use)
Fuses (identify size, use remove, replace, check)
Lamps (light bulbs) (identify size, use remove, replace, check)
Wire (identify size, use, remove, replace)
Waveguides (identify size, use, remove, replace, repair, clean)
Dessicant (identify type, use, replace, repair container)
Filters - air and liquid (remove, clean, replace, identify size, use)
Coolant fluid and lubricants (identify type, uses, drain, refill)
Coaxial connectors (connect, disconnect, check, repair, identify size, use.)
Plugs, connectors, and jacks (connect, disconnect, check, repair, identify size, use)

Test Equipment

Uses - Multimeter URM 64A Signal Generator
Uses - Oscilloscope, USM 281C
Uses - Electronic Voltmeter, 300M
Uses TS-505 A/U multimeter
Uses TS-505 B/U multimeter
Uses TS-505 C/U multimeter
Uses TS-505 D/U multimeter

Test Equipment (cont.)

Uses - Multimeter URM 64A Signal Generator

Uses - Oscilloscope, USM 281C

Uses - Electronic Voltmeter, 300M

Uses TS-505 A/U multimeter

Uses TS-505 B/U multimeter

Uses TS-505 C/U multimeter

Uses TS-505 D/U multimeter

Uses AN/PSM6 multimeter

Insulates multimeter from metal portion of radar.

Recalls that case of the TS-505 A/U - B/U -C/U multimeters have a high positive potential.

Does not touch the case of the TS-505 A/U, B/U or C/U multimeter after leads are connected to test jack.

Grounds the TS-505 D/U multimeter when it is to be used and does not need to insulate it.

Set up meters for operation.

Determines oscillation as a movement at a steady rate between two limits.

Operate a stop watch.

Interprets meter reading as input decision for subsequent action.

Uses high frequency console/test equipment.

Multimeter A & B

Test Equipment (cont.)

Dual Pulse Generator

Oscilloscope

Multifunction Generator

Modulator Oscillator

600 Ohm Attenuators

Electronic Components

Uses (removes, replaces, selects) switches.

Adjusts variable resistors.

Locates physical position of components and chassis.

Aligns synchros.

Data and power cables (removes, replaces, checks, cleans)

Locates test points on equipment.

Locates ground points on equipment.

Adjusts controls to obtain proper indication.

Applies corrective action when indications of improper conditions occur.

Checks and replaces Cathode Ray Tubes (CRT).

Makes corrections and disconnections of various types of multi connector power, data and coaxial cables.

Capacitors (checks, removes, replaces.)

TALLY SHEET

SKILLS AND KNOWLEDGE ANALYSIS

| SKILL OR KNOWLEDGE | CATEGORY | TASK #1 | TOTAL | TASK #2 | TOTAL | TASK #3 | TOTAL |
|---|---|---|---|---|---|---|---|
| Performs alinement | B1 | | 9 | | 3 | | |
| Performs addition | B6 | | | | 4 | | |
| Uses schematics | B8 | | | | 6 | | |
| Installs gasket | B3 | | | | | | 3 |
| Uses wrench open end | B2 | | | | | | 3 |
| Uses electronic voltmeter | B4 | | 9 | | | | |
| Obtains minimum meter indication | B4 | | 9 | | | | |
| Removes & installs index pins correctly | B5 | | 3 | | | | |
| Uses (remove, replace, select) switches | B7 | | 6 | | 3 | | 4 |

Job Description Questionnaire
Basic Electronic and
Mechanical Skills and Knowledge

B2 Do you use or refer to the following electrical measurement units?

| | Yes | No |
|---|---|---|
| 1. Volts | | |
| 2. Amperes | | |
| 3. Ohms | | |
| 4. Herz | | |
| 5. Farads | | |
| 6. Watts | | |
| 7. Henries | | |

B3 Do you work with the following electrical circuits?

| | Yes | No |
|---|---|---|
| 1. AC circuits | | |
| 2. DC circuits | | |

B4 Do you work with the following vacuum tube circuits?

| | Yes | No |
|---|---|---|
| 1. Amplifier circuits | | |
| 2. Tuned (resonant) circuits | | |
| 3. Cathode follower circuits | | |
| 4. Multivibrator circuits | | |

B4 (cont.)

| | Yes | No |
|---|---|---|
| 5. Power supply circuits | | |
| 6. Voltage regulator | | |
| 7. Oscillator circuits | | |
| 8. Sweep generator circuits | | |
| 9. Timing (pulse) circuits | | |
| 10. Display circuits | | |
| 11. Clamping (limiter) circuits | | |
| 12. Noise generator circuits | | |

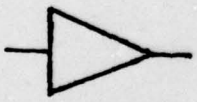
T10 Do you use the following tools in your maintenance duties?

| | Yes | No |
|---|---|---|
| 1. Screwdrivers - flat tip | | |
| 2. Screwdriver - cross tip (Phillips) | | |
| 3. Screwdriver - jewelers | | |
| 4. Hexagonhead wrenches (L bar, Allen) | | |
| 5. Open end wrenches | | |
| 6. Attenuator probes | | |
| 7. Jumper leads | | |
| 8. Rulers | | |
| 9. Pliers | | |
| 10. Wire strippers | | |

T10 (cont.)

| | Yes | No |
|---|---|---|
| 11. Pocket knife | | |
| 12. Torque wrench | | |
| 13. Soldering irons | | |
| 14. Soldering sets | | |
| 15. Soldering aids | | |
| 16. Heat sink | | |
| 17. Thickness gauge | | |
| 18. Dial indicators | | |
| 19. Non-magnetic tools | | |
| 20. Tuning wands | | |
| 21. RF probes | | |
| 22. Card extractors | | |

SC-14 Do you use and refer to the following schematic symbols?

| | | | Yes | No |
|---|---|---|---|---|
| 1. |  | Denotes that component is adjustable | ____ | ____ |
| 2. |  | Denotes slip ring | ____ | ____ |
| 3. |  | Denotes buildup for variable resistors | ____ | ____ |
| 4. |  | Denotes mechanical linkage or shielding | ____ | ____ |
| 5. |  | Denotes general enclosure of functional grouping | ____ | ____ |
| 6. |  | Denotes minor signal, arrow points in direction of signal flow | ____ | ____ |
| 7. |  | Denotes major signal, arrow points in direction of signal flow | ____ | ____ |
| 8. |  | Denotes amplifier | ____ | ____ |
| 9. |  | Denotes system ground | ____ | ____ |
| 10. |  | Denotes chassis ground | ____ | ____ |
| 11. |  | Denotes common connector | ____ | ____ |
| 12. |  | Denotes loudspeaker | ____ | ____ |

EC34 If you work with power cables do you do the following? (If not, go on to EC35).

| | Yes | No |
|---|---|---|
| 1. Inspect them. | | |
| 2. Remove/replace them. | | |
| 3. Check (test) operation of them. | | |
| 4. Repair them. | | |
| 5. Fabricate them. | | |

EC35 If you work with data cables do you do the following? (If not, go on to EC36).

| | | |
|---|---|---|
| 1. Inspect them. | | |
| 2. Remove/replace them. | | |
| 3. Check (test) operation of them. | | |
| 4. Repair them. | | |
| 5. Fabricate them. | | |

EC36 If you work with coaxial cables do you do the following?

| | | |
|---|---|---|
| 1. Inspect them. | | |
| 2. Remove/replace them. | | |
| 3. Check (test) operation of them. | | |
| 4. Repair them. | | |
| 5. Fabricate them. | | |