

THE JOB TASK ANALYSIS/SKILLS AND KNOWLEDGE MARRIAGE (PART 1)

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As job/task analysis methodology continues to advance in sophistication, the computer takes over an ever greater share of the work of analysis, leaving less and less of formerly judgemental areas to assumption. But, assumption still functions where job "skills and knowledges" are assigned as underlying or component to tasks in inventories.

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So far, in front-end analysis of the workplace, task interrelationships, rankings by complexity, and degrees of commonality can be readily determined by the computer. If task 00165 in package 017 proves common to 16 others in an inventory of 2500, has a complexity index of 1.25, and embodies all the subordinate work behaviors of 137 other tasks, the computer can record these features and position the subject task appropriately in an output hierarchy. It can also sort on the basis of identifying or descriptive data included in the task record in the inventory. Such processing gets pretty far down into specifics of work behaviors underlying tasks, but it doesn't affix identified manipulative or processing skills and static-descriptive or process-associated knowledge (information) elements to those tasks.

→ This paper (Part I) describes a matrix of "skills and knowledge" elements to augment a model front-end job/task analysis subsystem (NEPDIS--Naval Enlisted Professional Development Information System) and discusses such alternatives as adding these data to the master job/task inventory or providing an ancillary "skills and knowledge" inventory for use of the training program developer.
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As "front-end" job/task analysis methodologies have progressed and continued to advance in sophistication, the computer takes over an even greater share of the work of analysis, leaving less and less of formerly judgemental areas to panel-of-experts analysis, evaluation, and cataloguing. Identification and description of tasks in inventories appear fairly concrete, as they do for such task component work behaviors as task elements (Johnson and Richmann, 1975). What analysis is possible so far with the task (and its accompanying descriptive factors) as the sole data source has yielded task complexity indexes, hierarchies expressive of task interrelationships, and task commonality indicators within and among occupational fields. With such outputs of job/task analysis producible by computer programming, assumption and subject-matter expert (SME) consensus might well be expected to fade into the background. However, assumption still functions where such work behaviors as job "skills and knowledges" are or must be assigned as underlying or component to tasks in inventories.

In Navy manpower management, ship and squadron manning documents and job (billet) descriptions are dependent in the main upon extensive, detailed, and comprehensive inventories of operational, maintenance, administrative, military watchstanding, and other tasks (as well as ship, systems, and equipment data). Personnel distribution, rating assignment, advancement, and training (especially training) depend upon inventories of skills as well as tasks; and the training community needs to take the job/task inventory "audit trail" down farther still--to the level where "job knowledge" can be associated directly with "job skills" to support job tasks.

This paper (Part I) describes an attempt to produce a matrix of "job skills and knowledges" elements to augment model front-end job/task analysis subsystem currently under development by the staff of the Chief of Naval Education and Training (CNET) and Training Analysis and Evaluation Group (TEAG) elements in Pensacola, Florida. The subsystem model is the Training Analysis Subsystem of the Naval Enlisted Professional Development Information System (NEPDIS) (Davis, 1976, 1977, 1977a, 1977b).

The NEPDIS model currently stores some 23,000 Naval Avionics rating tasks in its inventory. Occupational data acquisition was accomplished for other ratings in the Naval aviation community, ten in all, but these data are not yet in the computer. As a result, occupational data stored and analyzed to date by NEPDIS remain in the major functional category of Maintenance. A typical listing of an avionics maintenance task is shown in Figure 1.

With computerized analysis of such data as typified by this entry in the Aviation Electrician's Mate (AE) job/task inventory under NEPDIS, tasks may be ranked by complexity; and degrees of commonality (from the identical to an agreed-upon level of similarity) (Davis and Perry, 1980) may be established. Task interrelationships may also be established. Some tasks obviously contain many component work behaviors that are also contained in other tasks of lesser complexity and scope; some tasks duplicate the work behaviors of others, sometimes regardless of the task titles involved. Tasks shown to "embody" other (subordinate or component) tasks are termed "Omnibus" tasks; the tasks shown to be component to the Omnibus tasks are termed "Embodied" tasks (Figure 2). In the NEPDIS job/task inventory (JTI) AE task 00165 in package 017 may be shown to have a complexity index of 1.25, prove common to 28 others in a one-rating

inventory of 3700 tasks, and embody all the component work behaviors of 137 other tasks. The computer can record these features after producing them via analysis, and it can position the subject task appropriately in any specified output hierarchy. It can also sort on the basis of identifying or descriptive data included in the task record in the inventory (Ansbro, 1978). Such processing gets pretty far down into the specifics of work behaviors underlying tasks, but it doesn't extend beyond identifying job-related skills. Figure 3 shows task "signature block" (work-behavior descriptive data) printed out. The five skill areas included in the task signature block contain statements of work behavior that would appear to be as descriptive of elements (or components) of a task as of the skills that they represent. They are definitive, small in compass, and specific to (and therefore underly) task performance; therefore attached to other descriptive data for the task.

Herein lies a problem for the training program developer or curriculum designer. To design a training course, he needs an inventory of tasks to describe course graduate job performance capabilities and to provide realistic practical exercises and performance tests. Successful student/graduate task performance when matched with on-job (billet) requirements in the fleet (also tasks) serves as a reasonable predictor of successful performance on the job.

However, can a course cover all the tasks that the graduate must perform on the job in his fleet assignment? The best that we can hope for is coverage of these tasks that best represent fleet requirements. The analysis that results from this realization requires intricate grouping and cataloguing of work behaviors. Selection of representative tasks really involves selection of those underlying behaviors component to or most widely transferable among tasks assumed to be representative of fleet job requirements.

The transferable component/supporting work behaviors underlying task performance are skills. Skills, stated in behavioral action language, resemble tasks. Indeed, the workplace and the schoolhouse both use task and skill terminology almost interchangeably. As an example, welding is described as a transferable skill, since welding something to something else is component to performing many metal fabrication and repair tasks. However, depending upon how a work-behavior statement reads ("weld fire-hose support bracket to bulk-head"), welding may be regarded as the action part of a task statement. Welding as a major work behavior can also be regarded as more encompassing than a task; it can represent an entire worker career, or the sole mission or output of a shop or department. Soldering, somewhat similar technically, but a considerably smaller skill, is usually termed just that--a skill. Viewed from a task-descriptive orientation, it is also a task element. But, because of its simplicity, subordinate/component nature, and wide applicability (therefore transferability) to task performance, it is generally considered to be a skill, and in the occupational field(s) of electricity/electronics, a basic one, at that.

On the premise that if the schoolhouse is to train the graduate to perform on the job in the fleet, the instructional program/course designer must attempt to replicate the best representative and most critical tasks from that target environment; then, he must ferret out, verify and train on those skills found to be component to those tasks selected for training and transferable to those known to exist in the workplace but not selected for training. Therefore, the

training community needs extensive and comprehensive JTIs with task-descriptive data as fully fleshed out as possible; and it is certainly more than merely convenient to have skills appropriately identified as such. Further, in any career continuum, it must follow that in the earlier training programs (basic, apprentice, initial job-entry), the concentration of training effort is on skills, transferable to the job environment where they may be applied and refined in a work-and-OJT setting. Advanced specialized training still teaches skills, but task performance figures somewhat more prominently, as higher level technician training more closely approximates the real-world environment of the graduate's ultimate work site.

As mentioned earlier, skill statements resemble task (and task element) statements: There are action verbs, objects of action, and job-environment conditions and work-performance standards. It is necessary to make one clear distinction if there is to be any observable difference between these statements (in an inventory). In the task statement, the object of the action is specific: a clearly identified or coded item (system or subsystem component, equipment item, part, form, machine, instrument, etc.) In the skill statement, the object of the action is not a specific item; it can be typical of a group or class, a "generic" item (mild steel plate, galvanized sheet metal ducting, bar stock, tubing, circuit wiring, solid state printed circuits, etc.), even a synthesized or composite item generated for such a purpose as training or practice of an identified skill action. As tasks fall into hierarchies, so also do skills. A "troubleshooting" task (in NEPDIS: "Isolate Fault/Troubleshoot -----object") employs subordinate (component) "troubleshooting" skills: selecting/using references, selecting/using tools, selecting/using support materials, selecting/using support equipment, and selecting/using test equipment.

The principal mechanistic reason for making these task/skill distinctions in the NEPDIS Training Analysis subsystem is the need for the computer to recognize the distinctions in its progress through analysis toward such outputs as billet-specific task inventories and rating-specific skill inventories. NEPDIS front-end analysis was designed to be totally computer-served and to conduct all job/task/skill analysis for designated users at the "front-end"; hence, the emphasis on coding, detailed identification and descriptive factors, and other aspects of an audit trail from task identification through reference source.

Job knowledge, or the task/skill performance enabling base (information/data); lies at the bottom of the audit trail. Information from all reference sources pertinent to task/skill performance can be assumed to fit into a relatively simple matrix, an example of which is shown in Figure 4. A NEPDIS-conducted literature search based on reference text support of occupational data already in the JTI indicated substantial reference support for the details of task and task element performance. However, little text support for those behaviors identified as component skills was found in these references. For instance, what to solder and at what point to solder, and what tools and materials applied to the task element were amply covered by reference. How to solder was not. Hence, in a Navy-designed front-end job/task analysis subsystem built to support Instructional Systems Development (ISD), the subsystem developers discovered that in some instances they had provided themselves with relatively light direct reference text support for developing the essentials of some skills training. By tracking back through the appropriate job

task-oriented references and by recourse to rating-specific texts and existing skills-training school texts, the necessary reference support can be found. But it is not direct, and it is not totally and specifically contained within the master JTI for the rating or occupational field.

NEPDIS front-end analysis had been designed with the avowed intent of keeping all the job/task (and skill) analysis at the front end. An instructional systems developer was to receive all the various inventories (subsystem outputs) needed to develop curricula/instructional programs, etc. without having to "go back to the front end" himself to analyze or further analyze data; especially, he should not have to collect raw data.

One simple solution is to add such text references in the appropriate spot in the task identification block in the master JTI. Another is to provide a brief structured addendum to the master JTI, this item strictly for the use of training program development personnel. Figure 5 illustrates the general scope of basic supporting information useful to the developer of skills training. In essence, this example would suggest the beginning of an adjunct task/skills performance-supporting information inventory or skills and knowledge library.

A third alternative is to construct a matrix such as the one shown (in concept) in Figure 4, and code it to the task signature block in the JTI. The matrix generally illustrates the task support hierarchy: from the top down, task performance is supported by any number of task elements; the task elements are supported by (and incorporate) manipulative and/or information-processing skills; and these skills are supported by static descriptive and process-associated knowledge items (the enabling information base). For practical incorporation into the JTI, identified skills can be cross-coded to task identification codes, and bodies of information identified as skill-supporting items.

The alternatives mentioned above represent current NEPDIS effort to marry the already definitive job task information in the JTIs with equally definitive supporting skill and knowledge data. The intent also is to maintain a visible and easily followed audit trail throughout the Training Analysis Subsystem.

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Davis, D. D., Perry, N. N. "Determining Task Commonality in Navy Training- Two Methods Examined." Proceedings - 22nd Annual Conference of the Military Testing Association, Toronto, Ontario, Canada, 1980, 229-237.

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RATING - AE PACKAGE - 0001 TASK - 0020 DUTY SUBCATEGORY - 01

TASK STATEMENT - PERFORM MAINTENANCE CHECK ON ROTATING BEACON ASSEMBLY 44126

PLATFORM - P-3 A/B (APBC)
 SYSTEM - LIGHTING SYSTEM (44000)
 EQUIPMENT - EXTERIOR LIGHTING (44100)
 COMPONENT - ROTATING BEACON ASSEMBLY (44126)

COMPLEXITY - 1.67

MAJOR ACTION CATEGORY - MAINTAIN
 DUTY SUBCATEGORY (01) - CHECK/TEST/INSPECT
 TASK ACTION (PMC) - PERFORM MAINTENANCE CHECK

CUE.....REPAIR COMPLETE
 STANDARD.....IAW REFERENCE PUBLICATION
 REFERENCE.....NA-01-75PAW-2-12
 TOOL.....COMMON HAND TOOLS, SPECIAL HAND TOOLS
 SUPPORT MATERIAL.....FUSE/SWITCH
 SUPPORT EQUIPMENT.....POWER UNIT 28V 400HZ
 TEST EQUIPMENT.....RPM GAUGE, AMMETER, MULTIMETER

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
GENERAL.....	2	1	1	1	1	1	1	1	2	0	0	0	0	0
DUTY SUB 01.....	2	3	2	0	1	3	1	0	0	1	0	0	0	0
SKILL 1 (REFERENCE).....	2	1	1	1	0	0	0	0	0	0	0	0	0	0
SKILL 2 (TOOL).....	3	2	1	0	0	0	0	0	0	0	0	0	0	0
SKILL 3 (SUPPORT MATRL).....	2	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILL 4 (SUPPORT EQUIP).....	1	1	1	0	3	0	0	0	0	0	0	0	0	0
SKILL 5 (TEST EQUIP).....	3	2	2	3	2	2	2	1	3	0	0	0	0	0

FIGURE 1. NEPDIS TASK LISTING: AVIONICS; TASK IN AVIATION ELECTRICIAN'S MATE JOB/TASK INVENTORY

SKILL AREA: (1) USE REFERENCES

3. LOCATE DATA (WITHIN REFERENCES)

- A. INFORMATION IS INDEXED AND SEQUENTIALLY ARRANGED WITHIN ONE REFERENCE.

SKILL AREA: (2) USE TOOLS

1. SELECT TOOLS (TYPE AND SIZE)

- C. ONE SPECIFIC TYPE AND SIZE MUST BE USED. A SUBSTITUTE CANNOT BE USED; E.G., TOOL FOR ADJUSTING THE IRON CORE OF AN INDUCTOR, SPANNER WRENCH.

SKILL AREA: (3) USE SUPPORT MATERIALS

1. SELECT SUPPORT MATERIALS (SPECIFICATIONS)

- B. SPECIFICATIONS GIVEN; SEVERAL SUBSTITUTES PERMITTED; E.G., CLEANING SOLVENT (FED. SPEC. NO. P-S-661 OR PD-680).

SKILL AREA: (4) USE SUPPORT EQUIPMENT

3. MANIPULATE CONTROLS (NUMBER AND TYPE)

- A. SINGLE CONTROL - SINGLE TYPE; E.G., ON/OFF SWITCH, VALVE.

6. OPERATE SUPPORT EQUIPMENT (TYPE OPERATION)

- C. POWERED OPERATION - REQUIRES CONNECTION; E.G., NC-8, MOBILE AIR CONDITIONING UNIT, CRANE, AIR BOWSER.

SKILL AREA: (5) USE TEST EQUIPMENT

1. SELECT TEST EQUIPMENT (REQUIREMENT)

- C. REQUIRES MORE THAN ONE ITEM OF TEST EQUIPMENT - EACH SERVES MORE THAN ONE PURPOSE, E.G., MULTIMETER, TEST SET, AND OSCILLOSCOPE.

4. OPERATE TEST EQUIPMENT

- C. MUST BE CONNECTED TO SYSTEM AND REQUIRES MANUAL STEP-BY-STEP PROCEDURES TO OBTAIN READINGS.

FIGURE 3. SAMPLE SKILL-AREA CITATIONS PRINTED OUT IN NARRATIVE (AVIATION ELECTRICIAN'S MATE JOB/TASK INVENTORY)

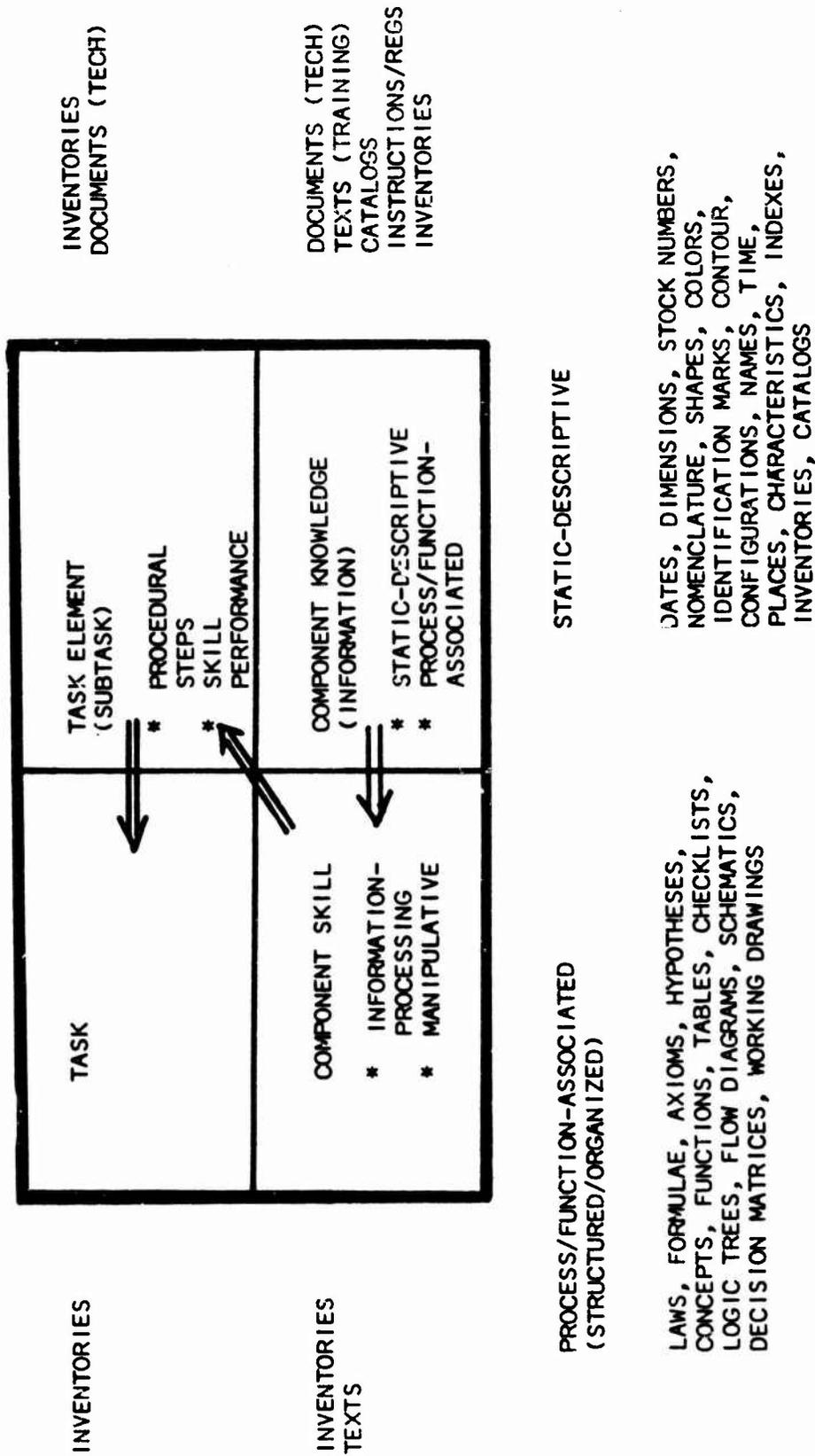


FIGURE 4. RELATIONSHIP OF INFORMATION BASE TO TASK/SKILL PERFORMANCE

SKILL DATA LAYOUT

ACTION: SOLDER

SKILL: SOLDERING (MANIPULATIVE)

GENERIC OBJECT(S)

SHEET METAL(S)
CASTINGS
ELECTRICAL/ELECTRONIC CONNECTIONS
HAND-WIRED CHASSIS COMPONENTS
PRINTED CIRCUIT COMPONENTS
DISPARATE METALS

APPLICATIONS

FASTENING:

SHEET METAL TO SHEET METAL
CASTINGS TO CASTINGS
WIRES TO CONNECTORS (CLIPS, TABS, ETC)

MICROMINIATURE CIRCUIT ASSEMBLY/DISASSEMBLY

METALS INVOLVED

GALVANIZED IRON SHEET
BRASS, COPPER, ALUMINUM SHEET
BRASS, COPPER, BRONZE, ALUMINUM CASTING
SILVER, PANTER, POTMETAL CASTING
COPPER, ALUMINUM WIRE

TOOLS

SOLDERING IRON, ELECTRIC:

LARGE HIGH-WATTAGE (SHEET METAL, DUCTING,
HOOPING) GUN-TYPE, 100-300 WATT AC
PENCIL, 37-40 WATT AC

HEAT BLOWER, ELECTRIC, 2000 WATT AC
TORCH, PROPANE/BUTANE
DE-SOLDERING KIT (SOLDER SUCKER, IRON)

SUPPORT MATERIALS

SOLDER:

TIN, LEAD, ZINC COMBINATIONS
(OR ALLOYS):
60/40, 50/50, 40/60
ACID-CORE, ROSIN-CORE
SILFOSS (SILVER SOLDER)
ALUMINUM

FLUX, SOLDERING PASTE, MURIATIC ACID
FILE, ABRASIVE CLOTH, SANDPAPER
BRUSH, CLEANING CLOTHS, PAPER TOWELS

SUPPORT EQUIPMENT

HEAT SINK
CLAMPS ("C" TYPE, SPRING LOADED,
VISE GRIP)
MAGNIFYING GLASS
ASSEMBLY JIG
INSULATED IRON/GUN REST
HEAVY-GAUGE EXTENSION CORD
ABC-TYPE FIRE EXTINGUISHER

TEST EQUIPMENT

GENERAL PURPOSE (MULTIMETER ETC.)

REFERENCES

NAVEDTRA 1074-D, RHM-AVIATION ELEC-
TRICIAN'S MATE 1 & 2
MODULE 8, BASIC ELECTRICITY & ELEC-
TRONICS COURSE
TRAINEE GUIDE, AVIATION ELECTRICIAN'S
MATE "A" SCHOOL COJ.

FIGURE 5. SKILL-SUPPORTING INFORMATION PACKAGE
FOR THE TRAINING PROGRAM DEVELOPER

MODEL COMPONENT WORK BEHAVIORS (PROCEDURES)

- CHECK APPROPRIATE REFERENCE FOR SPECS/REQUIREMENTS OF SOLDERING TASK.
- SELECT TOOLS, SUPPORT MATERIALS, SUPPORT EQUIPMENT, SOLDER (BY DETERMINING METALLOGY REQUIREMENTS FROM REFERENCE) (APPLICATION OF COGNITIVE).
- PREPARE WORK ENVIRONMENT (REFERENCE TO JOB DATA, SAFETY REQUIREMENTS, ETC.)
CONNECT/WARM UP IRONS.
- CLEAN JOINGS/PREPARE SURFACES FOR SOLDERING, COAT WITH FLUX
- SET UP WORK ON BENCH, IN JIG, OR IN PLACE IN MAJOR ASSEMBLY.
- APPLY CLAMPS, HEAT SINKS AS APPROPRIATE.
- MANIPULATE SOLDERING TOOL, SOLDER TO PRODUCE SOLDERED SEAM/JOINT/
CONNECTION.
- INSPECT SOLDERED SEAM, JOINT, CONNECTION (USING OBSERVATIONS SPECIFIED
IN REFERENCES).
- EVALUATE, TEST COMPLETED TASK PRODUCT (USE TEST EQUIPMENT TO CHECK
CONTINUITY THROUGH SOLDERED CONNECTION, APPLY BENDING OR OTHER STRENGTH
TEST, APPLY MEASURES, QUANTITY-OF-SOLDER OR ANY OTHER SPECIFIED STANDARD
OF MEASUREMENT OR EVALUATION).
- REMEDIATE, IF NECESSARY. RE-DO STEPS PROVEN ERRONEOUS, REJECT ITEM,
DO ENTIRE TASK OVER, ETC.).

FIGURE 5 (CONTINUED). SKILL-SUPPORTING INFORMATION PACKAGE
FOR THE TRAINING PROGRAM DEVELOPER