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PROPOSED REVISIONS TO
TECHNICAL MANUAL SPECIFICATION

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QUALITY ASSURANCE PROCEDURES

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Naval Ship Engineering Center
Norfolk Division

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PROPOSED REVISIONS TO
TECHNICAL MANUAL SPECIFICATION

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QUALITY ASSURANCE PROCEDURES

INTRODUCTION. Good technical manuals result from the application of good specifications and adequate quality control, both by the contractor and by the government. This obvious platitude is difficult to achieve. This paper explains how a proposed revision to MIL-M-15071E and how proposed quality assurance procedures are designed to achieve better technical manuals.

SCOPE OF PRESENTATION. This presentation is directed to three major points:

1. A brief description of the proposed specification family.
2. A brief description of some of the specifications' features, over and above those in the current version technical manual specification, MIL-M-15071E.
3. A brief description of a quality assurance program to achieve better manuals.
4. Conclusions.

DESCRIPTION OF SPECIFICATION FAMILY. The proposed revision to MIL-M-15071E consists of six documents, as listed:

- | | |
|------------------------|----------------------------------------------------------------------------------------------------------------------|
| 1. MIL-M-0000/1(SHIPS) | Military Specification, Manuals, Electronic <u>Subsystems</u> , Content Requirements for |
| 2. MIL-M-0000/2(SHIPS) | Military Specification, Manuals, Electronic <u>Equipment</u> , Content Requirements for |
| 3. MIL-M-0000/3(SHIPS) | Military Specification, Manuals, Electronic Subsystems and Equipment, <u>General Requirements</u> for preparation of |
| 4. MIL-M-0000/4(SHIPS) | Military Specification, Manuals, Requirements for Documentation of <u>Engineering Data</u> |

- | | |
|-------------------|------------------------------------------------------------------------|
| 5. NAVSHIPS _____ | Preparation Guide for Electronic
<u>Subsystem</u> Technical Manuals |
| 6. NAVSHIPS _____ | Preparation Guide for Electronic
<u>Equipment</u> Technical Manuals |

A brief description will now be given for each of the above documents which comprise the specification family.

MIL-M-0000/1 - This specification sets forth the content requirements for essential information to install, operate and maintain an electronic subsystem. Also, data suitable for use in training of Navy personnel in subsystems operation and maintenance. This specification would be used for developing technical manuals for such subsystems as ASW, SMS, ECM, CATTC, NTDS, and so forth. Manuals resulting from the application of this specification will serve to interface the equipment manuals with a minimum of redundancy, and in most cases the manuals resulting from use of this specification should not exceed one or two volumes.

MIL-M-0000/2 - This specification sets forth the content requirements for essential information necessary to install, operate and maintain shipboard electronic equipment. Also, it provides data suitable for use in training, operation and maintenance personnel. This specification evolved from MIL-M-15071E and is traditional in format, other than for improved chapter arrangements, improved trouble-shooting features and parts callout techniques which result in fewer illustrations.

MIL-M-0000/3 - This specification sets forth the general requirements for format, layout, printing, and production of the subsystem and equipment manuals which are developed from the content and requirement specifications, MIL-M-0000/1 and MIL-M-0000/2, which have just been described.

MIL-M-0000/4 - This specification sets forth the requirements for providing the engineering data needed by technical writers to develop adequate equipment and subsystem manuals. This engineering data, normally, is not an additional

requirement placed upon the contractor, but rather, the correlation and orderly display of data which the contractor develops when the maintainability, reliability, and electronic equipment specifications are invoked.

Subsystem Preparation Guide - This preparation guide provides a model which interprets the subsystem requirements of MIL-M-0000/1 and MIL-M-0000/3 to graphically exemplify the specification requirements to the contractor.

Equipment Preparation Guide - This preparation guide provides a model which interprets the equipment requirements of MIL-M-0000/2 and MIL-M-0000/3 to graphically exemplify the specification requirements to the contractor.

FEATURES OF SPECIFICATION FAMILY

A description will follow of some of the features of the proposed specification family, which are over and above those contained in the existing technical manual specification, MIL-M-15071E.

SUBSYSTEM COVERAGE. Technical manual specification, MIL-M-15071E is designed for equipment coverage, and provides practically no coverage for system, or subsystem manuals. There is now wide acceptance that a subsystem specification is needed. The proposed MIL-M-0000/1 will fill this need. It is designed for cost effectiveness, minimal redundancy with equipment manuals, and minimal bulk. Subsystem manual requirements are difficult to specify; and can be costly, particularly if they are allowed to become too large and contain redundant information. The cost effectiveness of a particular subsystem manual is contingent upon the relative need for the manual, the size, the number of individual configurations, etc. For this reason, it was recommended that the implementation of MIL-M-0000/1 be on an evaluation basis.

MAN/MANUAL INTERFACE AND USEABILITY. A manual must be more than a catalog of information. Many of today's manuals have adequate information; the principal trouble is that they are not useable. The users complain that they cannot readily find what they are looking for, or if they can find it, it is not in a simplified form suitable for rapid use. The specifications are organized and structured to satisfy the user. For example, the specifications contain the following useability features:

Chapter Arrangement. The maintenance information is grouped into chapters which clearly establish the boundaries of the information categories. There is a scheduled maintenance chapter, a trouble-shooting chapter, and a corrective maintenance chapter, each of which contains information appropriate to their titles and each chapter is adequately cross-referenced. This approach was not taken in MIL-M-15071E and is one of the factors which make manuals developed from the specification difficult to use.

Referencing. A logical sequence of referencing is used so that the technician is not dead-ended in the middle of a maintenance procedure. Signal flow diagrams are referenced to the functional descriptions and to the supporting schematic diagrams, on a block by block basis, whenever new or unusual circuits are employed. When the technician does not understand a strange circuit, he is thus referenced to a functional description, or if he has determined through the tests given on the signal flow diagram that a particular unit is defective, he may refer directly to the supporting schematic for fault localization to the defective part.

Physical Properties. Full regard is given to the physical properties of the manual which the human factors experts tell us are so important. For example, the minimum type size is legible with 5 foot candles of illumination.

The technician can quickly use the technical manual since he is not required to learn any additional symbols over those established in present military standards. Abbreviations, acronyms, and mnemonics are held to a minimum. Clear language is used on the signal flow diagrams, text and schematics. Of course, this will reduce the already over burdensome training requirement. The volumes are convenient in size, and the structure and breakdown of the larger manuals into volumes is user oriented. For example, the operators chapter is made a separate volume in larger manuals. Volumes are sized for convenience and to be fully compatible with American standards for shelving or filing cabinets.

Illustrated Parts List. An illustrated parts list utilizing the improved grid line callout provides convenient and quick referencing between the parts description and the parts location. Each part which cannot normally be repaired or replaced by forces afloat is identified in the parts list to show that it is to be repaired or replaced by shore facilities. These features are not incorporated in MIL-M-15071E.

Accuracy and Coverage. Traditionally, and for many reasons, technical manuals have not provided simple and useful coverage of the more complex technical requirements and have not gained user confidence because of too many technical errors and omissions. This is in part due to the difficulty the writers have in securing adequate and specific engineering data. The writers lay no claim to being all knowledgeable and to being able to regenerate technical data which teams of designers have labored over. The writers must be supplied adequate engineering data at the offset, as a basis for the technical manual development. For this reason, the specification family includes a specification for engineering data, MIL-M-0000/4. This data complements RE drawings and the provisioning technical documentation. It

specifies the type of engineering analyses required and defines the data elements which make up the maintenance plan. It includes, in summary form, maintainability and reliability information and other engineering data relating to installation and maintenance which are normally developed by the equipment manufacturer and paid for by the government, but not always made available to the government or technical manual writers. The technical manual writers will use this data together with the provisioning technical documentation, design drawings, and other data to develop the manual. In this way a greater assurance for technical accuracy and coverage is possible.

IMPROVED TROUBLE-SHOOTING FEATURES. It is in the area of trouble-shooting that the proposed specification differs significantly from MIL-M-15071E. Based upon the recommendations of MOTU personnel and senior electronic technicians, specific requirements for trouble-shooting aids have been incorporated. These aids, which are more adequately and completely defined than in MIL-M-15071E, are:

1. Trouble-shooting index
2. Functional signal flow diagrams with test procedures referenced
3. Relay control diagrams
4. Dependency diagrams
5. Digital logic diagrams
6. Mechanical (liquid, gaseous) functional diagrams

All trouble-shooting aids and test procedures contain cross references which quickly lead from one diagram to a specific point on another diagram. Many manuals today require hours to trace a signal output from one unit to the signal input of a following unit. Some manuals today require days, if not weeks, to decipher how the control relays relate to each other and to the

3 controlled functions in a particular time sequence. This makes a difficult task more so, frustrates our technicians, increases mean downtime and contributes to low equipment availability. The foregoing statements are based on cases which have been studied and clauses have been written into the new specification which if enforced through an adequate quality assurance program, will minimize this unnecessary maintenance burden. Many other trouble-shooting features are included, some of which are discussed under subjects which follow.

PMS INTERFACE FEATURES. The specifications have been especially designed to include features to make the manual suitable for the easy development of Maintenance Requirement Cards to support the Planned Maintenance System. The equipment manufacturer has the full background and is a logical source for developing MRC data. All of the data elements which are specified on the cards may be lifted directly from the technical manual. These elements in turn are based upon the engineering data specification and this in-depth support should materially reduce MRC development cost and at the same time improve the quality of the procedures. All MRC information is included in the single chapter entitled "Scheduled Maintenance." In addition, and this is most important, the scheduled maintenance is married on an item by item basis with the corrective maintenance chapter. This means that, whenever a scheduled test results in an observation which indicates the equipment or system malfunction, the technician is referenced at this point to a specific signal flow diagram on other trouble-shooting aid. Useability and access are the key concepts here. This coverage is not called out in MIL-M-15071E.

MAINTENANCE BURDEN REDUCTION FEATURES. Technical manuals derived from these specifications should materially reduce the installation and maintenance workload in a number of individual and accumulative ways. For example:

1. The standardization in installations resulting from the improved installation chapter should actually reduce the maintenance workload at the offset, since it is common knowledge that many of today's chronic maintenance problems are built-in, at the time of installation.

2. The scheduled maintenance burden is reduced because the periodicities are minimal, and are based upon maintainability and reliability concepts. The minimum period for performing the service and testing is thus established, and unnecessary work is avoided.

3. The manual is more useable. Less time is lost in tracing signals from one diagram to another, as previously discussed.

4. Time is saved by directly referencing the malfunctions noted during scheduled maintenance testing to the trouble-shooting procedures.

5. Alignments are called out only when the need for such is the direct result of a test.

6. Parts may be rapidly located and identified.

OTHER FEATURES. There are many other features which relate to improved content, better and more thorough definition of requirements; for example, fuse tables, parts list features, cost effectiveness, etc.

QUALITY ASSURANCE

COMPLETE PROGRAM. Quality assurance of a technical manual starts with the specification and encompasses a program which leads through the life cycle of the manual. It includes; procurement requests, contractor selection, manual development, review, printing and periodic updating. The quality assurance program consists of two major efforts, that of the contractor, and that of the Navy. The contractor is required to develop and adhere to a disciplined program which includes validation. The Navy also should maintain

a strict program thru the procurement cycle which includes a number of reviews, one of which is the verification. The discussion which follows relates to the Navy's review of selected contractor products and to each of the review areas which must be examined in a total coordinated effort.

REVIEW PRODUCTS. To gain assurance that a quality technical manual is being developed, the technical manuals must be reviewed by the Navy at various stages during the manual development. These stages should include reviews of the following products:

1. Sample data package
2. Review manuscript
3. Reproducible copy
4. Printer's proof
5. Printed manual

Each of the above products should receive reviews which differ in nature, but which are destined to yield a final manual that is adequate for all users; that is, a manual that is complete, correct, clear, has easily accessible data, and has a high degree of "useability."

REVIEW AREA. One method of reviewing a technical manual is commonly referred to as a desk review, where an individual pages through the manuscript, hunting for mistakes and format discrepancies. This procedure, at best, is unlikely to yield a quality manual.

The preferred method consists of an integrated review program where each of the five development stage products, previously outlined, receives an appropriate specialized review by selected team members. The reviews are coordinated, each with specific objectives, and are tailored to the development stages. They consist of applicable reviews selected from the below listing:

- | | |
|--------------------------------|------------------------------------|
| 1. Technical review | 5. Mechanical aspects review |
| 2. Editorial review | 6. Verification Review |
| 3. Test equipment review | 7. Users review of complete manual |
| 4. Installation chapter review | |

The nature and purpose of each of the above reviews will now be described, as it relates to each of the contractor's five products receiving review.

SAMPLE DATA PACKAGE. Contracts for technical manuals should include the requirement for the delivery of a sample data package early in the development program. This package samples, at the offset, the contractor's understanding and interpretation of the specification and his ability to perform satisfactorily. This sample data package, which includes sample diagrams, illustrations, and text, receives a critical, in-depth review by the equipment engineer and by the documentation codes, since it will serve as a standard for the development of the manuscript. Care is exercised at this stage not to do the contractor's work, lest he later submit his review manuscript in a partially edited form, for the Navy reviewers to "catch" obvious mistakes, and thus give the reviewer a false sense of satisfaction.

REVIEW MANUSCRIPT. Applicable portions of the review manuscript are subjected to reviews by personnel highly qualified in specific areas.

1. Technical Review. The project engineer should be responsible for determinations which include the following:

- a. Does the manuscript accurately and completely describe the equipment to the baseline configuration specified?
- b. Are the operating procedures adequate? *

* Adequate means complete, correct, clear, useful.

IMPROVED AVAILABILITY A_0

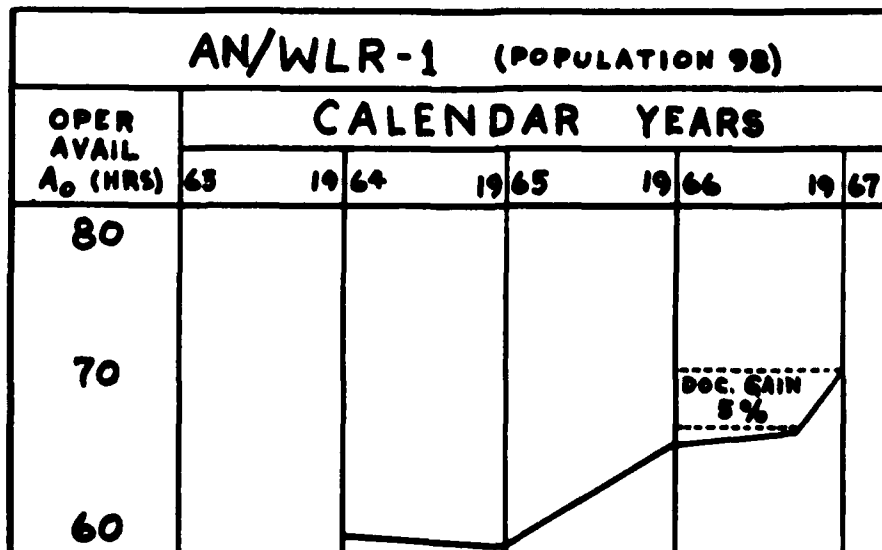
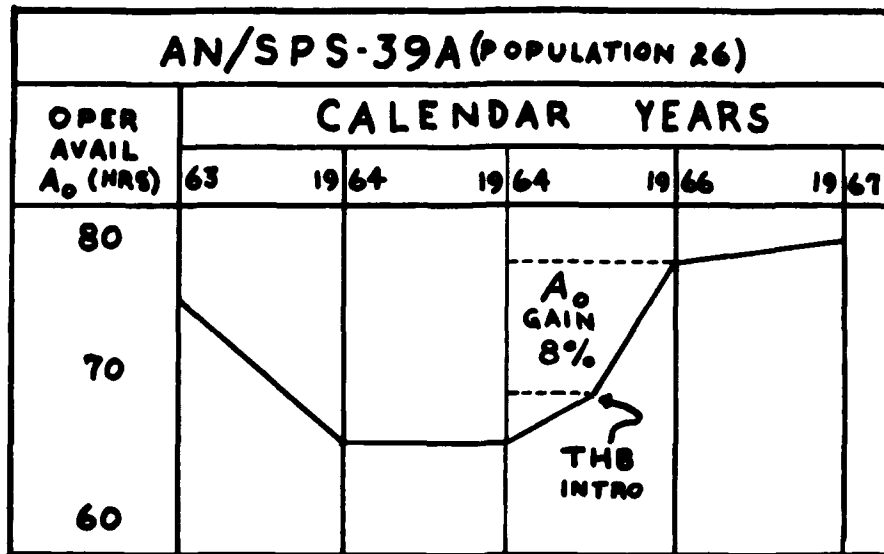


Fig. 3

CONCLUSIONS

SPECIFICATION FEATURES. The proposed specification family has improvements over MIL-M-15071E in a number of important areas which include:

1. A specification for subsystem technical manual coverage.
2. Man/manual interface features which result in improved useability.
3. Improved trouble-shooting features.
4. Planned Maintenance System Interface features.
5. Maintenance burden reduction features.

TECHNICAL MANUAL QUALITY ASSURANCE.

1. NAVSHIPS INSTRUCTION 4355.29 of 10 July 1967 is good, but it must be supported by adequate Navy technical manual review techniques.
2. These review techniques require an average of two manhours per page.
3. Procurements should require contractors to submit five review products, as shown in figure 1.
4. That the cost of quality assurance is insignificant in comparison to the increased maintenance cost resulting from inadequate technical manuals.
5. Operational availability of equipments can be improved by providing good technical manuals.

IMPROVED AVAILABILITY A_0

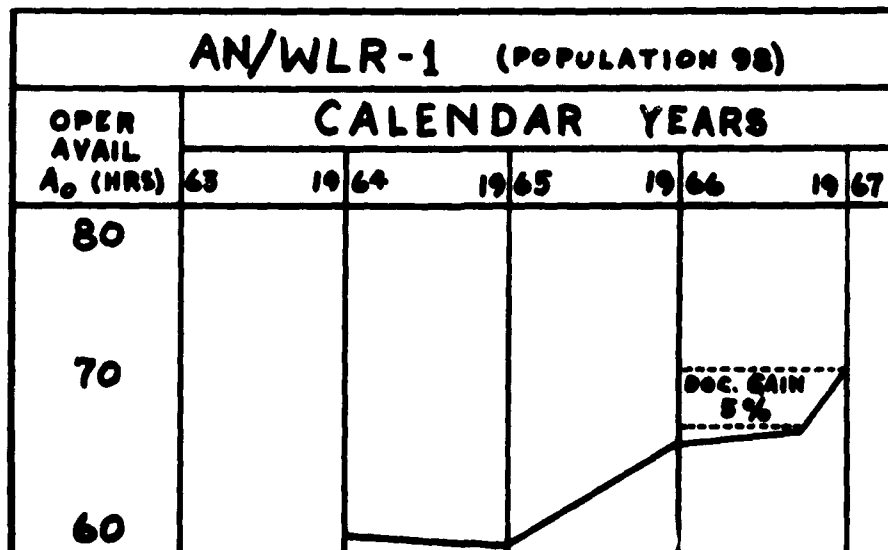
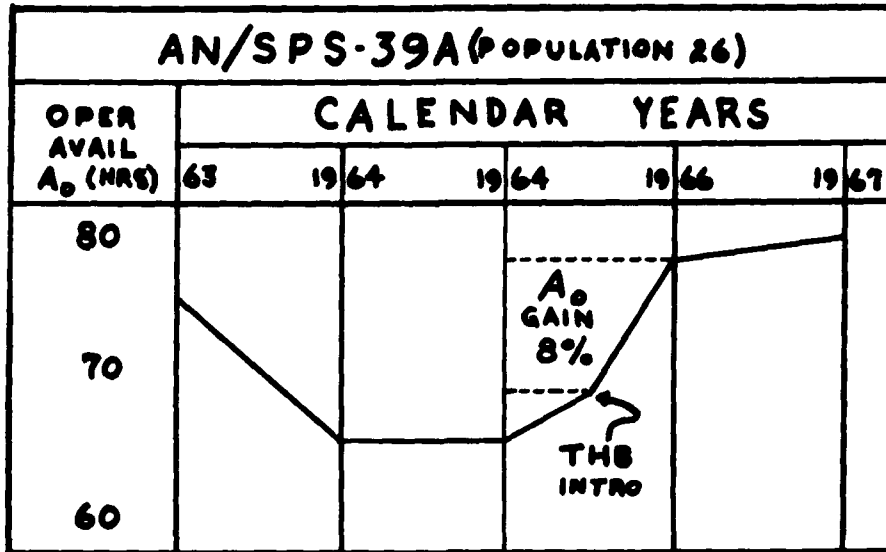


Fig. 3

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- 8
1. Reduction in rewrite needs
 2. Reduction in maintenance cost
 3. Increased operational availability

A program is now in process for rewriting about 50 technical manuals for NAVSHIPS electronic equipments at a cost of \$4,640,000. An initial review effort on this same group of manuals, at \$12 per page, would have cost about \$460,000. If the procurement specification had been adequate, and if this \$12 per page review investment had been made, a savings of \$4,180,000 would have resulted.

Figure 2 shows the maintenance costs for the AN/SPS-39A and AN/WLR-1 population, compiled from MDCS data, before and after the introduction of the improved manuals. Again, an initial review effort of \$12 per page on the original manual would have resulted in a savings of \$6,954,520 in maintenance costs for these equipments, since their introduction.

Intangible benefits also result from improved operational availability. Figure 3 shows the improvement in operation availability for the AN/SPS-39A and AN/WLR-1 resulting from the introduction of improved manuals in the Fleet.

EFFICACY OF NAVSHIPS QUALITY ASSURANCE INSTRUCTION. The instruction, NAVSHIPS INSTRUCTION 4355.29 of 10 July 1967, concerning the Quality Assurance of technical manuals stipulates that procurement requests will be good, that contractor laxity will not be tolerated, and that validation and verification will be accomplished, etc. These are good requirements, however, if this instruction is not reinforced with an improved specification and a disciplined review program, such as has been described, it is not apt to produce the intended result. To produce the desired results will require that a group be staffed and specifically charged with review responsibility of technical manuals.

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ANNUAL MAINTENANCE COSTS

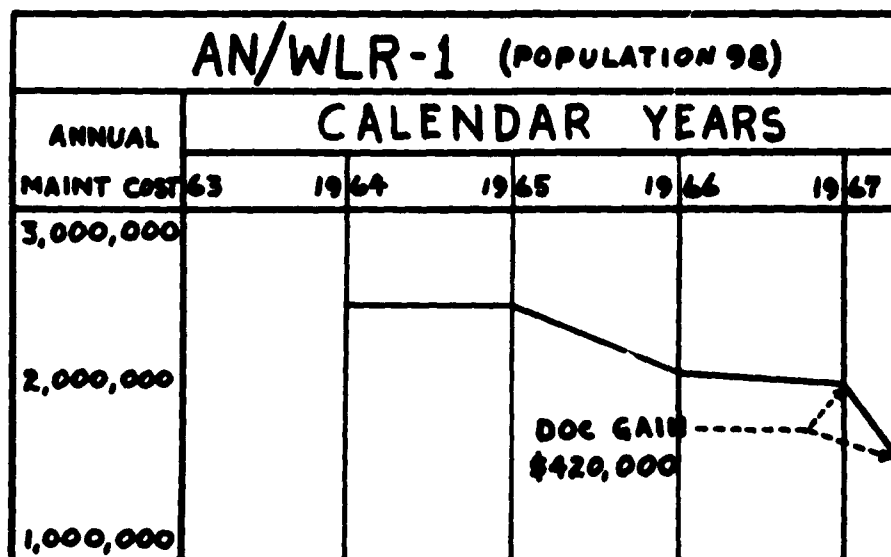
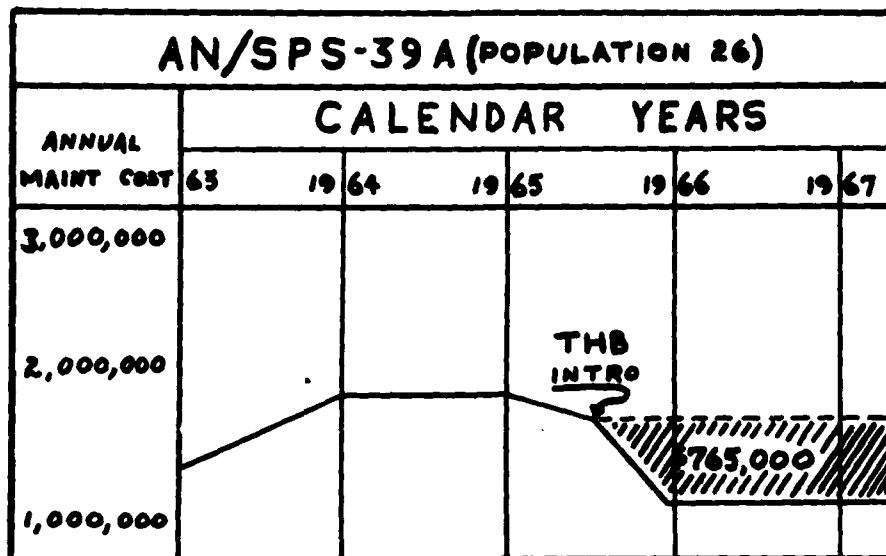


Fig. 2

PRINTER'S PROOF. The documentation personnel will require the printer to provide an advance collated printer's proof of the technical manual which will be given a review for quality of printing, pagination, and other printing quality control aspects.

TRIAL PERIOD IN THE FLEET AT CONTRACTOR'S RISK. Even with the best reviews, assurance that a quality manual has been purchased is not certain until it has received a user's trial in the Fleet. For this reason, a clause should be written into technical manual contracts which requires the contractor to correct, at his expense, any deficiencies discovered during a ten-month trial period in the Fleet. This is considered one of the best useability checks, and a quality assurance clause which should produce a tangible product. If the contractor does a good job at first, his no-cost-to-the-government change will be modest.

ANALYSIS OF REVIEW COSTS AND TIME. It has been determined from a sample of recent procurements that NAVSHIPS is paying approximately \$120 per page for technical manual revisions. The coordinated review of the contractor products, by personnel with the specialized skills, required an average of two manhours/page. Some manuals require more time, some less. Their effort rounds out to about \$12 per page for total Navy review costs and is approximately ten percent of the procurement cost. An analysis of the two manhour per page effort reveals the distribution of effort as shown on figure 1. This figure is used for guidance with the recognition that some manuals require more review time than others, and that a particular manual may require more review time in a selected area.

BENEFITS OF ADEQUATE REVIEW. Adequate review of manuals will result in savings in three areas:

TECHNICAL MANUAL REVIEW TIME AND COST ANALYSIS

Review Product Type of Review	Manhours/100 Pages	Dollars/100 Pages
Technical Data Package		
Technical	10	50
Editorial	10	50
Manuscript		
Technical	90	450
Editorial	40	200
Test Equipment	16	80
Installation Standards	16	80
Mechanical Standards	10	50
Verification	30	150
Reproducible		
Editorial	8	40
Printer's Proof		
Editorial	2	10
Printed Manual		
10 month user's review	--	---
Change 1		
Technical	4	20
Editorial	4	20
totals	240 Manhours	\$1,200

Figure 1

- c. Are the scheduled maintenance procedures adequate?
- d. Have all repair, replacement and alignment procedures been included and are they adequate?
- e. Is the installation checkout procedure adequate?
- f. Are the signal flow diagrams and schematics adequate?
- g. Does the parts list adequately reveal the maintenance concept?

2. Editorial Review. The documentation engineer should be responsible for determinations which include the following:

- a. Is the contractor conforming with all requirements of the specification and contract?
- b. Is the level of writing such that the assigned operator and technician can easily use the manual to support them in the operation and maintenance burden?
- c. Is the manual suitable for use in classroom training?
- d. Is the accessibility of the data such that the technician may have quick access to the required procedures when a malfunction originates in the equipment?
- e. Do we have confidence that each of the equipment's functions are adequately covered in the functional description, trouble-shooting, and repair chapters?
- f. Do we have confidence that the schematics, parts list, and parts callout are in agreement?
- g. Is the quality of the artwork adequate? Is the format in accordance with specifications?

3. Test Equipment Review. The portions of the technical manual dealing with test procedures and which specify test equipment should receive a close examination by test equipment engineers. Their review includes the determination:

a. Is the test equipment suit adequate to perform the measurements required?

b. Are the testing procedures correct and appropriate?

4. Installation Chapter Review. The installation chapter should receive a close examination by engineers qualified in installation design. This review will include the determinations:

a. Is the installation guidance adequate?

b. Are the installation control drawings adequate?

5. Mechanical Review. The mechanical aspects of the technical manual should receive the scrutiny of mechanical engineers. Cooling, hydraulic, gearing, lubrication, etc., requirements receive critical review. This review will include the determination:

a. Are all mechanical aspects adequately covered?

6. Verification Review. The verification is conducted by government technical and documentation personnel (with contractor participation, and will include the following determinations:

a. Does the manual interface accurately with the hardware with regard to operating, scheduled maintenance, and corrective maintenance procedures?

b. Does the manual reflect the hardware configuration and accurately describe it down to the lowest part?

c. Is the manual written to permit rapid access from hardware to manual to support maintenance and operating questions which are systematic of the hardware?

REPRODUCIBLE PROOF. The documentation personnel should review the reproducible proof to assure that all required corrections, based upon the manuscript review, are incorporated in the reproduction copy.