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MIL-HDBK-792 (AR)
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MILITARY HANDBOOK

PROVE OUT
OF
PRODUCTION FACILITIES

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MIL-HDBK-792 (AR)

DEPARTMENT OF DEFENSE

WASHINGTON, DC 20301

Prove-Out of Production Facilities

1. This military handbook is approved for use by the U.S. Army Materiel Command, Department of the Army, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use improving the document should be addressed to Commander, U.S. Army Production Base Modernization Activity, ATTN: AMSMC-PBT-P (D), Picatinny Arsenal, NJ 07806-5000, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FOREWORD

1. This Military Handbook was prepared to provide those activities engaged in the establishment and moderization of production facilities or equipment with a statistically based methodology for prove-out of such facilities. It contains background, policies, responsibilities, and procedures for implementing prove- out of production facilities or equipment.

2. The intent of this handbook is to provide structured guidelines based on a prove-out methodology oriented to manufacturing processes and equipment rather than systems/materiel/items. The handbook is organized to present the user with a general "how-to" methodology which can be tailored to best suit specific applications from a broad spectrum of facilities and equipment projects.

3. Prove-out, as covered in this handbook, focuses on the production rate capability of the ultimate full scale production facility. The term "prove-out" is often used generically to describe various assessments and evaluations performed throughout the acquisition life cycle. Such "prove-outs" from a producibility perspective are generally concerned with new or critical processes and equipment where production feasibility and resultant item performance must be evaluated as a part of prudent resource management. These "prove-outs" usually occur well before the establishment of a full scale production facility and are defined within the context of the specific item or system life cycle plan to assure compliance with Army Streamlined Acquisition Process and associated Industrial Preparedness Planning milestones. Eventually, the data generated by prove-out of the full scale production facility as described herein can serve to verify the results of earlier "prove-out" assessments.

4. It should be noted that the basic prove-out methodology given in this handbook is generic to any manufacturing facility. The U.S. Army Production Base Modernization Activity, Picatinny Arsenal, New Jersey, developed and successfully implemented this methodology within the ammunition community which includes the full spectrum of fundamental manufacturing processes. Both Government and commercial contractor facilities have successfull employed this prove-out methodology.

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1. SCOPE

1.1 Scope.

This handbook covers a statistically based methodology for prove-out of production or manufacturing facilities. This handbook will serve as the guidance document of both Government and contractor personnel engaged in production facility prove-out.

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2. REFERENCED DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks.

Unless otherwise specified, the following specifications, standards, and handbooks of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DODISS) specified in the solicitation form a part of this handbook to the extent specified herein.

SPECIFICATIONS

Military
MIL-Q-9858 - Quality Program Requirements

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Naval Publications and Forms Center, Attn: NPODS, 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

2.1.2 Other Government documents, drawings and publications.

The following other Government documents and publications form a part of this handbook to the extent specified herein.

AR 700-90 - Army Industrial Preparedness Program

AR 70-72 - Production Management

(Application for copies should be addressed to the Department of the ARMY, Publications Distribution Center, 2800 Eastern Boulevard, Baltimore, MD 21220-2896.)

AMC-R 70-65 - Production Management

(Application for copies should be addressed to the Headquarters, US Army Materiel Command, Attn: AMXDO-ST, 5001 Eisenhower Avenue, Alexandria, VA 22333-0001.)

Tech Report ARPAD-SP-78001 - Generalized Production Line Modeling Routine (GENMOD)

(Application for copies should be addressed to the Commander, US Army Armament Research, Development and Engineering Center, Attn: SMCAR-MSI, Picatinny Arsenal, NJ 07806-5000.)

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3. DEFINITIONS

3.1 Availability.

The probability that a system/equipment used under stated conditions, without consideration for any scheduled or preventive maintenance, shall operate satisfactorily at any given time. It excludes ready time, preventive maintenance downtime, supply downtime, and waiting or administrative downtime.

3.2 Demonstration Test Specifications (DTS).

A specification, normally prepared by the Government, which details the requirements to be met during the DT.

3.3 Demonstration Test Plan (DTP).

A document detailing the procedures under which the system capability will be demonstrated and evaluated based on the DTS.

3.4 Demonstration Test (DT).

A test conducted to verify or demonstrate the capability of a production facility or production line to produce end items at the intended production rate.

3.5 Demonstration Test Report (DTR).

A report which provides a record of the demonstration test results, identified deficiencies, conclusions, and recommendations for improvements and corrective actions, as applicable.

3.6 Maintainability.

A characteristic of design which is expressed as the probability that a system/equipment will be restored to a specified condition within a given period of time, when the maintenance is performed in accordance with prescribed procedures and resources.

3.7 Prove-Out.

The phase during which system debugging and demonstration testing takes place.

3.8 Quality Assurance (QA).

A planned and systematic pattern of all actions necessary to provide adequate confidence that items or products produced at the facility conform to established technical standards.

3.9 Reliability.

A characteristic of design which is expressed as the probability that a system/equipment will perform its intended function, for a specified interval, under stated conditions.

3.10 System.

Production lines or major portions of such lines are considered to be systems and are differentiated from projects for individual or small groups of equipment.

3.11 System Debugging.

The learning phase a facility has to go through after equipment acceptance while building up to the rate required for initiation of the DT.

3.12 Turnkey Facility.

One step procurement for the design, construction, equipment installation, and prove-out (as applicable) of a facility with a single contractor solely responsible for all efforts.

3.13 Definitions of Acronyms used in this Handbook.

The following acronyms listed in this Military Handbook are defined as follows:

a. AMSDL - Acquisition Management Systems and Data Requirements Control List.
b. CDRL - Contract Data Requirements List.
c. DOD - Department of Defense.
d. DODISS - Department of Defense Index of Specifications and Standards.
e. DTS - Demonstration Test Specification.
f. DTP - Demonstration Test Plan.
g. DT - Demonstration Test.
h. DTR - Demonstration Test Report
i. FAR - Federal Acquisition Regulation.
j. GPO - Government Printing Office.
k. IPF - Initial Production Facility.
l. MTTR - Mean Time To Repair
m. MTBF - Meantime Between Failure
n. PES - Production Evaluation Specification
o. RAM - Reliability, Availability, and Maintainability.
p. SOW - Statement of Work
q. SPC - Statistical Process Control
r. TDP - Technical Data Package

4. GENERAL POLICY

4.1 Introduction.

The prove-out approach presented in this handbook is a statistically based methodology developed to control the risk of establishing a production facility (or production lines) that will not satisfy production rate requirements. This is especially important from a readiness perspective within DOD where production facilities may be sized against anticipated needs during conflict but operated at lower rates during peacetime. Data from prove-out of the full scale production facility can be used to verify mobilization, surge and peacetime production capacities. The keystone of prove-out is a system Demonstration Test (DT) conducted in accordance with a Demonstration Test Specification (DTS), with reported results in a Demonstration Test Report (DTR). The contractor is to prepare a Demonstration Test Plan (DTP) in accordance with the Government prepared DTS, obtain Government approval of the plan, assure the DT is conducted, and report the results in the DTR.

4.2 Application.

General guidelines for prove-out applicability are outlined below. Since production facilities projects encompass a broad spectrum of manufacturing processes and equipment sometimes exhibiting unique characteristics, prove-out should be tailored to best suit each specific project. The methodologies in this handbook should be used as building blocks in conjunction with sound engineering and managerial judgement to establish tailored prove-out plans. As a minimum, the statistical methodology of Appendix A can be used to provide quantitative evaluation of alternative prove-out plans for specific projects. Other prove-out elements described herein may be included or modified as well. In this manner, a consistent approach to developing prove-out requirements for production facilities is established.

a. Prove-out will apply to all facilities projects except those for individual pieces or small groups of related equipment. However, the statistical methodology of Appendix A (with less formal DTS, DTP, DTR documents) is valid for production rate analysis of individual pieces or small groups of related equipment.

b. A DTS and DTP will be prepared for each project where a demonstration test will be conducted. Each will be tailored to be cost effective and to fit specific project parameters.

c. Prove-out will consist of system debugging (where applicable) and demonstration testing. Individual equipment debugging and acceptance will take place prior to initiation of prove-out. Integration of the facility into the production base for ongoing production will normally follow prove-out. A comparison of prove-out events against the facilities life- cycle is shown in figure 1. Also, a general sequence of prove-out events as related to production build-up is shown in figure 2. Facilities and prove-out planning must also be integrated with specific end item acquisition plans.

4.3 Objectives.

a. Establish facility production rate capability inclusive of associated reliability, availability and maintainability (RAM) characteristics.

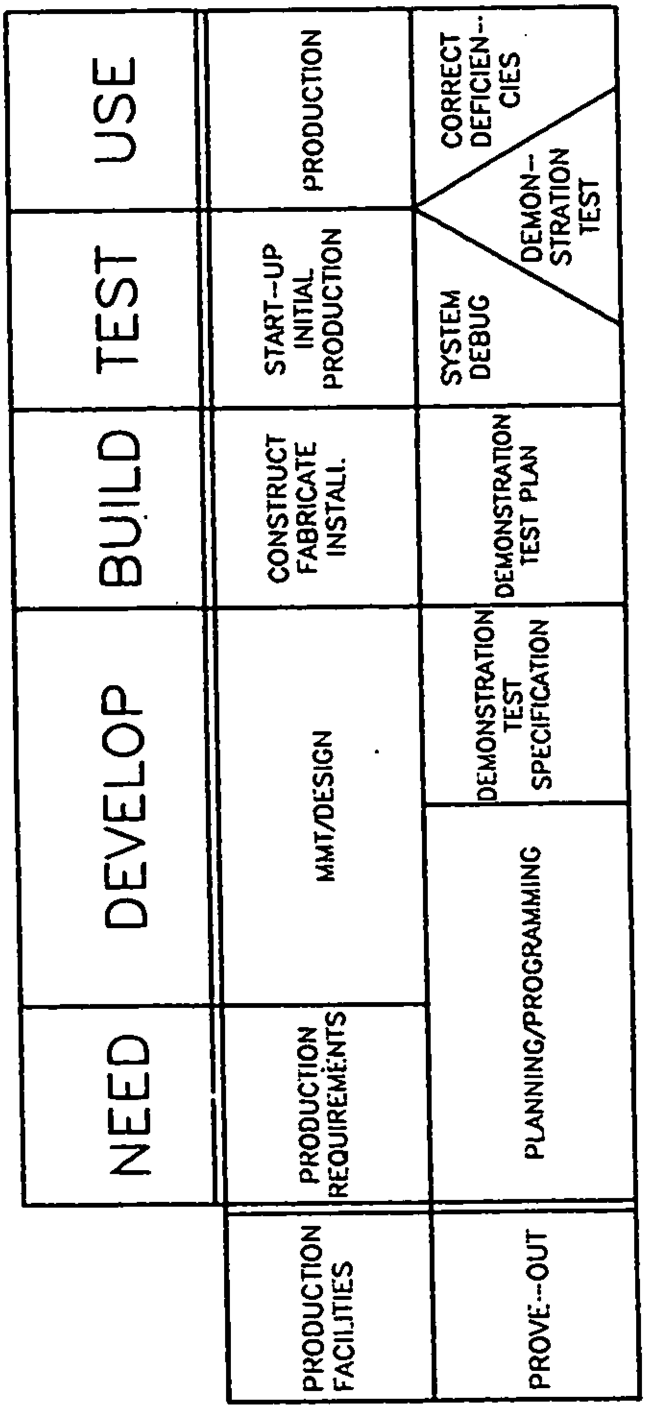


FIGURE 1. FACILITY/PROVE-OUT LIFE CYCLE COMPARISON

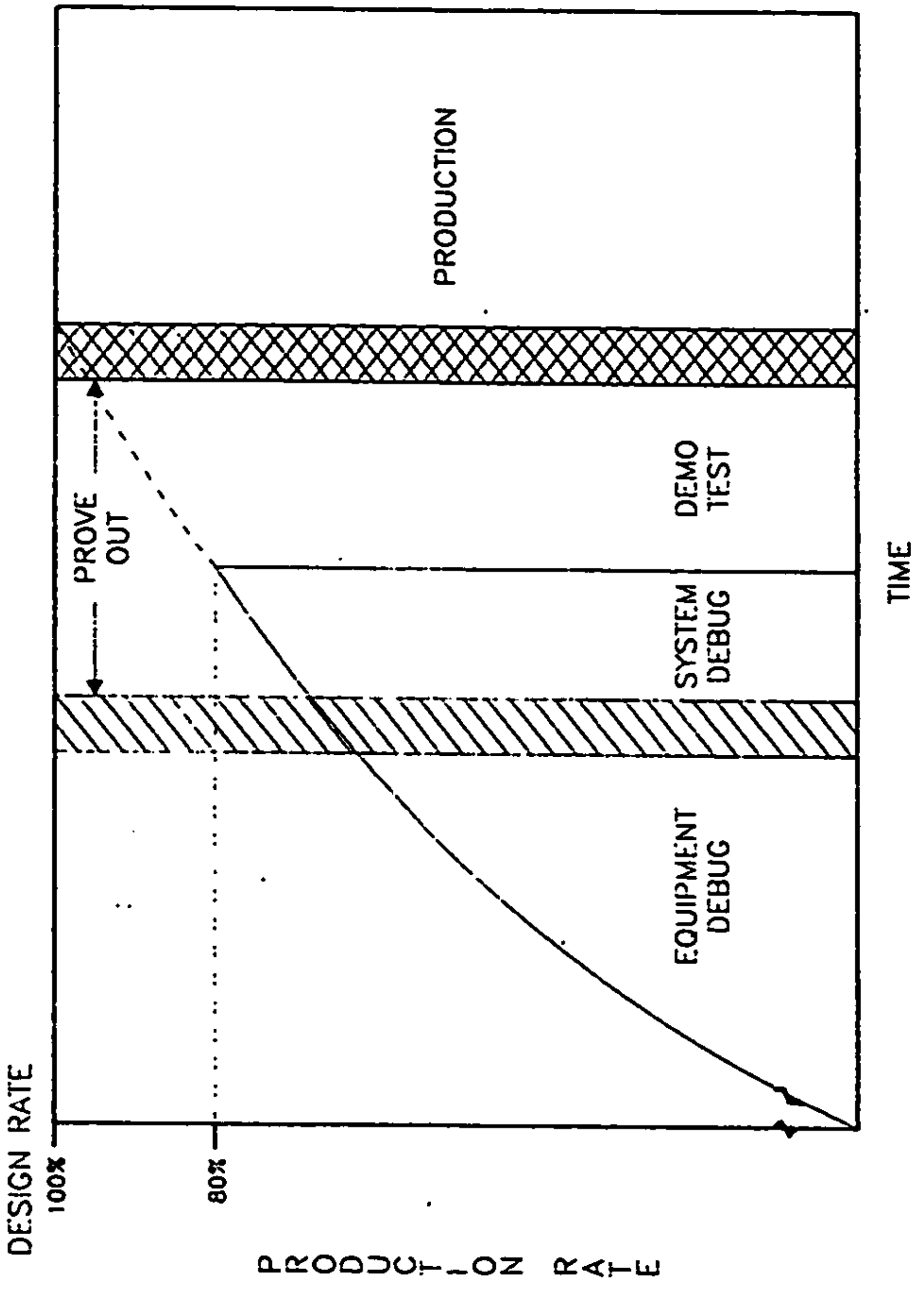


FIGURE 2. PROVE-OUT SEQUENCE

b. Identify system deficiencies and root cause(s) early so that plans for corrective action can be developed and executed in a timely manner.

c. Verify that the facility can produce (at the intended production rate) end items which comply with their technical data package.

d. Document facility/process performance.

4.4 Statistical approach.

Early in the 1970's during the extensive Army effort to modernize and expand its ammunition production base, it was decided that each facilitization program would culminate only after the performance of an acceptance test. The test would be an integral part of the facility prove-out and would be used to establish whether the facility was capable of producing at or above the required level. As the number of programs grew, it became apparent that careful planning for the resources necessary to accomplish the acceptance testing task was required. A sound and consistent statistical approach was needed to determine, on a program by program basis, the extent of testing required and the criteria for acceptance. The approach was to have general application to the wide variety of production facilities under consideration, be practical to implement and yield results which could be used to make valid management decisions regarding production capability. Recognizing that the Government would have already committed the majority of project funds prior to the time the test would be executed, reference to the test as an "acceptance" test was changed to "demonstration" test.

4.4.1 Capability level.

The framework of the adopted approach is a statistical test of the hypothesis that the capability of the production system meets the required capability. The statistical test has the property that, if the system is capable of producing at or above the required level, it will have a high probability of passing (low risk of failing) the test and, if the system is only capable of performing at or below some lower capability level, it will have a high probability of failing (low risk of passing) the test. A graphical illustration of this property is provided in figure 3.

4.4.2 Production capability and net rate.

The parameter of interest, and consequently the one addressed by the hypothesis being tested, is the average number of accepted units produced per hour of scheduled system operating time. This parameter is referred to as the production capability, and the quantity used to estimate it as a result of testing for some specified time is called the net rate. If the observed net rate exceeds the specified critical value, the system passes the test. The test time and critical value are determined from the probability distribution of the net rate. This distribution results from the random processes which contribute to the amount of acceptable product generated by a production process over a given period of time. These random processes include probability distributions of equipment failure time, distributions of times to repair equipment, distributions of reject and/or scrap quantities, and so on. If the net rate is less than the critical value, appropriate corrective action

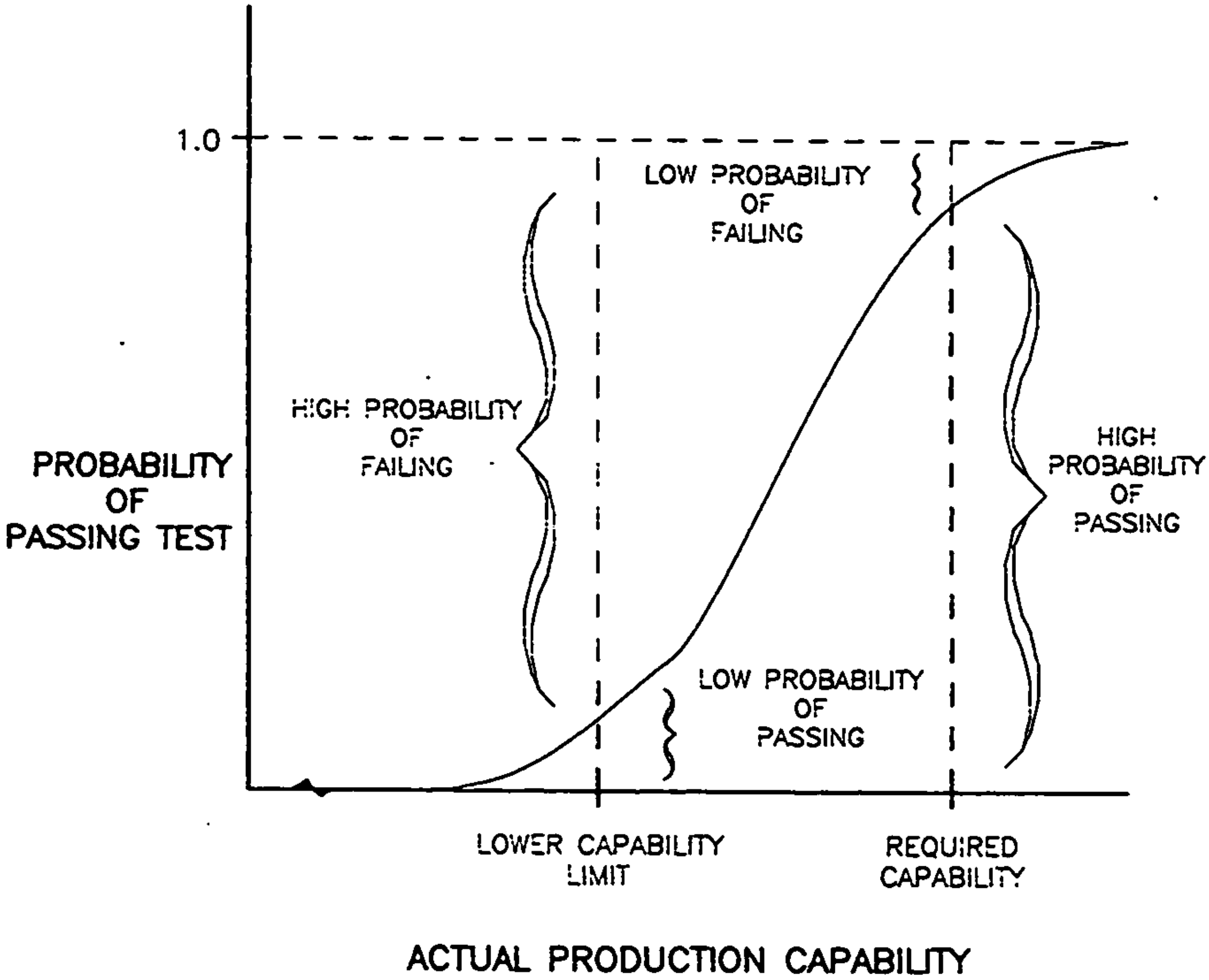


FIGURE 3. DEMONSTRATION TEST CONCEPT

must be recommended. Rationale for the identification of system deficiencies and proposed corrective actions should be based on the analysis of the reliability, availability, and maintainability (RAM) data, quality data, and production output data required to be gathered on the system during the test.

4.4.3 Methodology.

The details of the statistical methodology involved in the approach, including statistical assumptions, concepts, models, and procedures, are provided in Appendix A.

4.5 Acquisition and Implementation

Sample acquisition clauses together with corresponding DD1423, Contract Data Requirements List (CDRL), and Data Item Descriptions (DID) are provided in Appendix C as guidance for implementation of the procedures covered in this handbook. This baseline guidance may be tailored to suit individual project requirements.

5. DETAILED REQUIREMENTS

5.1 Prove-Out Planning and Programming.

5.1.1 Prove-Out Event Sequence.

Principal events associated with prove-out of a production facility are shown in figure 4. Planning and programming activities must commence early and be an integral part of the facility planning, programming, design and execution phases. Time spans will vary in accordance with specific project plans.

5.2 Prove-Out Funding.

5.2.1 Prove-Out Costs.

Prove-out costs will normally include preparation of the DTS, DTP, DTR, and the physical prove-out except hardware costs when run concurrent with production. Acceptance testing and debugging of individual items of equipment will not be considered prove-out costs and will be completed prior to the start of prove-out. Prove-out begins with system debugging and ends with approval of the DTR.

5.2.2 Initial Production Facilities.

For initial production facilities (IPF), preparation of the DTS and DP will be funded as facility project prove-out costs. All other costs will be budgeted as non-recurring costs included in end item low rate initial production or first production program costs. This also applies to IPF turnkey facilities.

5.2.3 Product Manufactured during Prove-Out.

Acceptable products manufactured during prove-out will be delivered against contract requirements, considered as Army industrial stock or become Government furnished material.

5.2.4 Prove-Out of Army Facilities provided for other Services.

The Army will provide funds for prove-out of Army facilities provided for the manufacture of other Services' (Air Force, Navy, etc.) items.

5.2.5 Turnkey Facility Prove-Out.

For turnkey projects prove-out is funded concurrent with the facility effort. If reliable cost estimates cannot be identified when a contract is negotiated, an option with a ceiling price which cannot be exceeded will be included.

5.2.6 Use of Production Hardware.

Every attempt should be made to schedule production to support prove-out efforts. This is crucial to minimizing overall prove-out costs. However, should there be no scheduled production at the appropriate time for use in prove-out, the entire cost will be borne by the facility project.

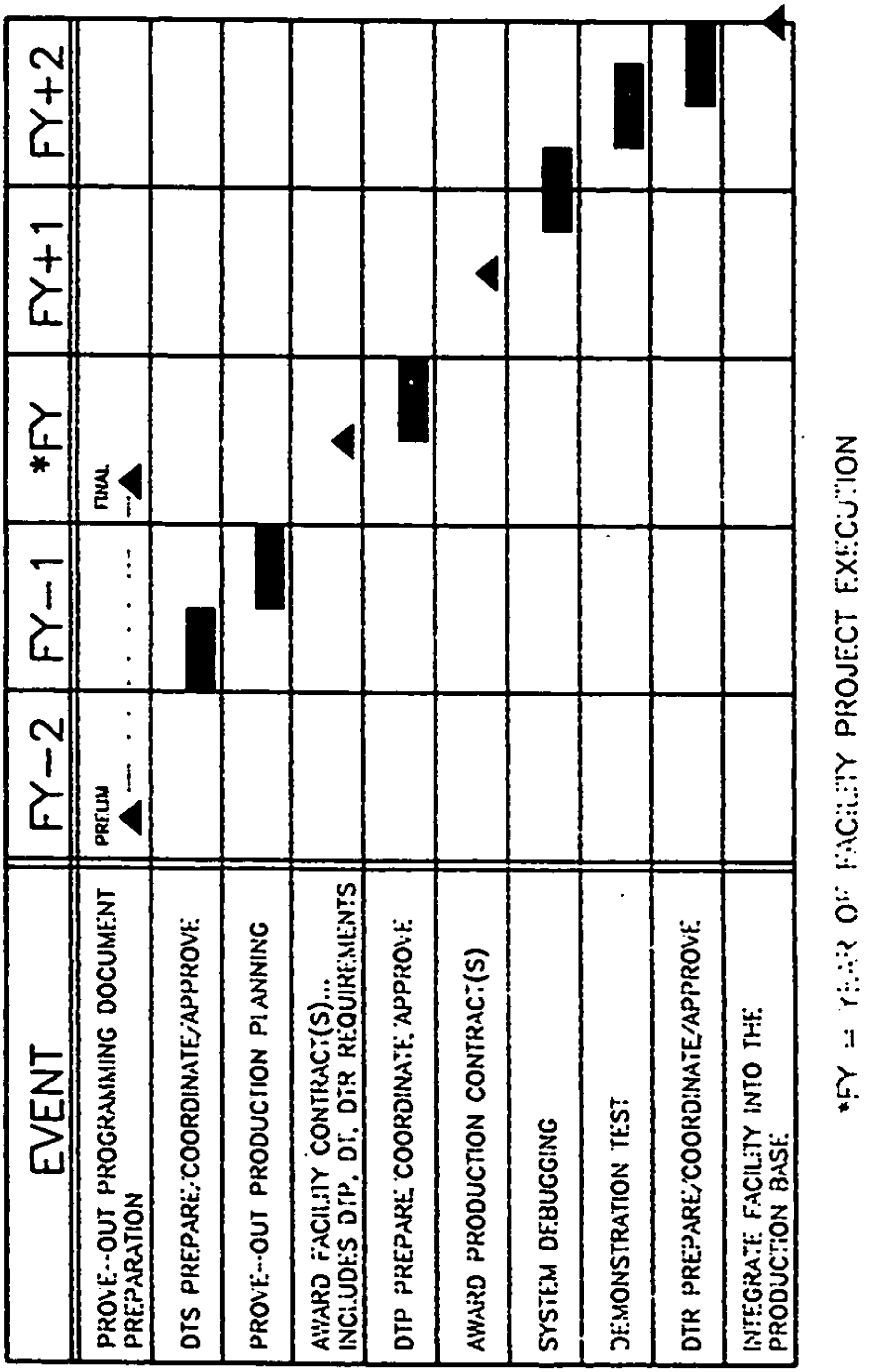


FIGURE 4. PROVE-OUT PLANNING, PROGRAMMING AND EXECUTION

5.2.7 Self - Facilitization

Prove-out costs will be charged in accordance with the approved accounting system.

5.3 Demonstration Test Specification (DTS).

5.3.1 Purpose.

The DTS provides the Governments' demonstration test requirements to be used by the contractor in subsequent preparation of the detailed demonstration test plan.

5.3.2 DTS Preparation, Coordination and Approval.

The cognizant Government engineering center will prepare, coordinate, and approve each DTS. A DTS will be prepared for all facility projects requiring prove-out. DTS format and content guidance provided herein is structured so the preparer (Government) may cite this handbook and need only provide the supplemental project specific data called for therein.

5.3.3 DTS Format and Content.

A basic format for the DTS is given below. Additional information on each area in the DTS is given in subsequent paragraphs. The DTS guidance should be considered a baseline from which a preparer can develop a DTS tailored to a specific facility project.

a. Cover Sheet

b. Foreword

c. Table of Contents

d. List of Abbreviations

e. Project Identification

(1) Project Number

(2) Project Title

(3) Facility

(4) End Item

(5) Item Specification

(6) Design Rate

f. Test Objectives

(1) Product

(2) System

(3) Secondary Objective

g. Applicable Documents

h. Test Requirement

(1) Debugging Phase

(2) Pre-Test Requirements

(3) Test Readiness Meeting

(4) Demonstration Test

(5) Material

(6) Sequencing

(7) Reject Rate

(8) Data Collection

(9) Test Failure

(10) Test Time

i. Demonstration Test

(1) Procedure

(2) Conditions

(3) Participating Government Organization

j. Test Data Evaluation

k. Reports

(1) Progress Report

(2) Test Report

5.3.3.1 Cover Sheet.

The DTS cover sheet identifies the document as a DTS and provides the preparation/approval date, project title, project number, and preparing Government organization. An example is shown at figure 5.

5.3.3.2 Foreword.

The DTS foreword should provide a brief preview of the document highlighting such factors as:

a. Identify preparer.

b. Cite guidance material such as this handbook.

c. Purpose of the DTS.

d. Project number and title.

e. Project objective.

f. Point of contact for information/questions concerning the DTS.

DEMONSTRATION TEST SPECIFICATION

FOR

MOD – 5.56MM (SAWS/CONVENTIONAL)

TRACER CHARGING

EQUIPMENT

AT

LAKE CITY ARMY AMMUNITION PLANT
INDEPENDENCE, MISSOURI

PROJECT 5850086

APPROVED 30 JUNE 1986

Prepared by

PRODUCTION BASE MODERNIZATION ACTIVITY

PBMA

PICATINNY ARSENAL, NJ 07806–5000

FIGURE 5. EXAMPLE DTS COVER SHEET

5.3.3.3 Table of Contents.

The DTS table of contents will usually follow the format shown in 5.3.3.

5.3.3.4 List of Abbreviations.

Each DTS should contain a list of abbreviations to define any acronyms unique to that DTS or otherwise not already defined in this handbook.

5.3.3.5 Project Identifications.

The DTS will provide the following facility project and related item information.

a. Project Number.

b. Project Title.

c. Location of facility: give plant name and address.

d. End Item Identification: state item nomenclature.

e. Specification: cite end item specification to be used as a basis for inspection of product manufactured during the demonstration test.

f. Production Rates and Shift Basis: state overall project objective (e.g., the modernized facility shall be capable of producing 5,400,000 M856 Tracer Cartridges per month on a 3-8-5 shift basis).

5.3.3.6 Test Objective.

a. Product. To determine if the product produced by the system conforms to the latest applicable specifications and drawings.

b. System. To determine system capability to produce at the design production rate.

c. Secondary Objective. The secondary objective of the test is to assess the achieved Reliability, Availability and Maintainability (RAM) characteristics of the production facility.

5.3.3.7 Applicable Documents.

Cite this handbook and any other documents referred to or discussed in the DTS.

5.3.3.8 Test Requirements.

a. Debugging.

Debugging is considered a part of the build-up phase of the program. During the debugging phase, the facility will be in production. The equipment, manufacturing procedures, inspection procedures, and set-up and calibration procedures shall be evaluated by the contractor and modified or corrected as necessary. Any changes to the equipment functional criteria or Technical Data Package (TDP) will be approved through the engineering change process prior to implementation.

During the debugging phase, log books will be maintained for each operation. The log books will contain, as a minimum, the following:

(1) Equipment Identification (nomenclature and drawing number).

(2) A record of all changes and equipment modifications.

(3) Identification of all pertinent documentation, including revision status and ECPs.

(4) Data sheets showing a history of production rate buildup shall be completed for all periods of operation and be incorporated in the log book.

(5) Failure reports will be completed for each corrective maintenance action, including failure identification, failure analysis, corrective actions taken, and problem status.

(6) Verification will be accomplished through record checking and/or visual inspection that no environmental safety, storage, or equipment deficiencies (including utilities) exist which could compromise the validity of the System Demonstration Test results.

b. Pre-Test Requirements.

Prior to the test readiness review, and the start of the demonstration test, the contractor will demonstrate the following:

(1) All required documentation, including operating and maintenance manuals (both preventive and corrective), quality control manuals, inspection plans, and calibration procedures have been proven for accuracy and completeness, approved by the Government and in place and ready for use.

(2) The system has been in production for a sufficient length of time (as indicated by production data, quality data, etc.) to provide confidence that the production equipment has passed through the debugging phase. Production, inspection, and material handling equipment will have passed acceptance requirements per an approved purchase description and completed all first article acceptance requirements. All inspection equipment has been verified for precision and accuracy by the Government.

(3) All acceptance inspection equipment has been approved by the Government and fully and accurately described in the applicable equipment drawings, operating manuals, and calibration procedures are available.

(4) The required number of personnel have been trained and are available to conduct the test.

(5) Sufficient material to conduct the test is available.

(6) All raw material has inspection reports showing compliance with the specification requirements.

(7) The required spare parts to maintain the facility for the duration of the test are available.

(8) The facility conforms to all applicable safety, health, and environmental regulations, and personnel and procedures are in place to assure continued compliance.

(9) Maintenance and repair facilities and trained personnel to adequately maintain the production and inspection equipment are available. All special tools and equipment for calibration, maintenance, and inspection operations are available.

(10) Where applicable, SPC plans per MIL-Q-9858A, capability studies, and available historical SPC data, should be available for review at the test readiness meeting. All planned SPC will be in place during DT data collection.

(11) Software directly associated with production equipment, control systems, material handling equipment, etc., that influences production rates will have passed acceptance requirements per approved specifications and be in place during DT data collection.

c. Test Readiness Meeting.

After approval of the Demonstration Test Plan by the Government and before start of the System Demonstration Test, the contractor convenes a test readiness review meeting at the production facility. The purpose will be to review the prerequisites and to ensure compatibility and understanding of all test requirements set forth in the approved test plan/procedures. The Government will be notified a minimum of 10 days before conduct of the review to enable appropriate representation. The results of the test readiness review will be documented and made available to the Government prior to the start of the test.

d. Demonstration Test.

The Demonstration Test is conducted in accordance with the approved Demonstration Test Plan. The test will commence after production criteria of para 5.3.3.8 b (2) have been met.

e. Material.

All accepted parts and materials will be production items capable of being used as part of the production quantity.

f. Sequencing.

Sequencing of operations, when required, will be as defined in the approved Demonstration Test Plan.

g. Reject Rate.

Reject rate specified in the SOW/contract will be specified in the Demonstration Test Plan as a test parameter.

h. Data Collection.

(1) Personnel. Data collection will be performed by the contractor.

(2) Quality. The results of all tests and inspections performed in accordance with applicable specifications will be tabulated and included in the test report.

(3) Data Collection Plan. The DTP will state that data collection and analysis will be performed in accordance with Appendix B.

i. Test Failure.

In the event of failure to meet the requirements of the DTS a correction plan will be prepared defining the problem areas, proposed corrective actions, and procedures to demonstrate the effectiveness of the corrective actions. Implementation of the plan will be contingent upon approval of the Government.

j. Test Time.

Using the guidance and example contained in Appendix A, test times are determined as follows:

(1) Scheduled operating hours determination.

The demonstration test will be conducted on a 1-8-5 (or as otherwise specified) shift basis.

Scheduled working hours per shift = 8 hours (or as otherwise specified).

Assumed down time (minimum) per shift = 1 hour (or as otherwise specified). Examples of assumed down time include lunch, breaks, start-up/clean up, scheduled preventative maintenance, etc.

Scheduled operating hours are, therefore 7.00 hours per shift (or as otherwise specified).

Assume 21 (or as otherwise specified) working days per month.

Scheduled operating hours per month available for production is

21 X 7.00 X 1 or 147.0 hours per month (or as otherwise specified).

(2) Test Parameters. (See Appendix A, 2, for terminology and notation).

C_0 = Production capability required = (specify)

C_1 = Lower Capability Limit = (specify)

$D = \frac{C_1}{C_0}$ = (calculate)

α = Producer's risk = (specify)

β = Consumer's risk = (specify)

R = Production rate during test = (specify)

$\Pi_0 = \frac{C_0}{R}$ = Capability factor = (calculate)

U = System mean time to repair = (specify based upon experience)

T_0 = Test time factor (from appropriate table)

$T = T_0 \cdot U$ = Scheduled demonstration test time = (calculate)

Π_c = Critical value which specifies criteria for the demonstration test = (from appropriate table)

Acceptable pieces produced during test to be successful = $R \cdot T \cdot \Pi_c$

5.3.3.9 DEMONSTRATION TEST

a. Procedure.

(1) After the Government has determined that the requirements of 5.3.3.8 have been met, the test will be initiated. The facility will be run for the test periods determined in para 5.3.3.8. This test should be conducted during on-going production.

(2) Reject rates are obtained by determining the total number of parts / assemblies / components processed at each work station and dividing this sum into the total number of (repairable and non-repairable) rejected items found. Rates should be calculated for the period of the evaluation. The scrap rate can be extracted by identifying the number of non-repairable parts / assemblies / components and dividing this sum by the total number of untis processed. Work pieces used to set-up an operation/process will not be counted as rejects or scrap. This set-up work piece part quantity shall, however, be minimal and will be reviewed by the Government prior to the demonstration test.

(3) During the Demonstration Test, data will be collected utilizing the data sheets and instructions contained in Appendix B for each operation / process. Data will be collected for each operation/sub-system in the process for the scheduled demonstration test time.

b. Conditions.

(1) Notification of system readiness will have been received by the Government.

(2) Preoperational Test Review by the Government will have been conducted.

(3) Shift Schedule: (specify)

(4) Product produced during the demonstration test must comply with all requirements and quality assurance provisions stated in latest applicable TDP in the contract at the time of the DT. Units produced will be inspected in accordance with approved inspection system requirements (QA/QC) to verify the product is acceptable.

(5) Details will be provided in the DTP of how the separate parts of the line will be operated and scheduled to fulfill the requirements of the Demonstration Test. Details of how the material handling equipment will be tested (operated) will also be described in the DTP.

(6) A DTP will be prepared based upon this document, MIL-HDBK-792 (AR), and the contract SOW as applicable. The plan will include a schedule for testing the various operatins in the process. The demonstration test will be performed in accordance with the approved DTP.

c. Participating Government Organizations

The DTS will identify all participating Government organizations and their role(s) in the prove-out effort.

5.3.3.10 Test Data Evaluation.

See Appendix A for data analysis discussion and requirements.

5.3.3.11 REPORTS

a. Progress Report.

A monthly progress report will be furnished to (specify). Test progress should be included in the monthly report to (specify).

b. Test Report.

A copy of the test report, including backup data, shall be prepared utilizing the format in 5.6 and forwarded to the following Government organizations: (List Organizations).

5.4 Demonstration Test Plan (DTP).

5.4.1 Purpose.

The DTP provides a comprehensive document describing all of the planned activities and related management controls for demonstrating that the facility will perform as required by the DTS.

5.4.2 DTP Preparation, Coordination and Approach.

The DTP will be prepared in accordance with the DTS and requirements set forth in the project statement of work (SOW). The DTP is prepared by the facility contractor who will conduct the DT. The cognizant Government engineering center will coordinate, as appropriate, and approve each DTP. DTP format and content guidance provided herein is structured so that this handbook may be cited and only the supplemental project specific data called for therein need be provided. See Appendix C for sample acquisition clauses and documentation.

5.4.3 DTP Format and Content.

A basic format for the DTP is given below. Additional information on each area in the DTP is given in subsequent paragraphs. This DTP guidance should be considered a baseline from which a DTP tailored to a specific facility project can be developed.

a. Cover Sheet.

b. Preface.

c. Table of Contents.

d. Part I, System Debugging.

   (1) Objective.

   (2) Pre-Test Requirements.

   (3) Management.

   (4) Schedule.

   (5) Data Collection.

   (6) Government Support.

(7) Station Certification.

e. Part II, Demonstration Test.

(1) Objective.

(2) Management.

(3) Inspection.

(4) General Test Description.

(5) Process Description.

(6) Equipment Maintenance Program.

(7) Environmental Considerations.

(8) Schedule and Build-up Curve.

(9) Government Support.

(10) Personnel Requirements.

(11) DT Data Collection.

(12) DT Evaluation.

(13) Training Requirements.

(14) Reports.

5.4.3.1 Cover Sheet.

An example, except for the document title (i.e., use DTP instead of DTS), is shown in figure 5.

5.4.3.2 Preface.

Provide background information about the project as follows: brief description of the facility project, brief description of the test highlighting any significant aspects, point of contact for questions concerning the test plan, picture or illustration of the item being made.

5.4.3.3 Table of Contents.

Provide a table of contents which should follow the basic format (paragraph headings) shown in 5.4.3.

5.4.3.4 Part I, System Debugging.

a. Objective.

Cite the objective, e.g., what will system debugging accomplish; covering those activities required to prepare the facilities, personnel, and equipment for the formal DT. This includes exercising the equipment for the purposes of troubleshooting, checking initial operation, detecting and eliminating early failures, and stabilizing equipment performance.

b. Pre-Test Requirements.

Cite 5.3.3.8b as conditions which must be met before conclusion of the system debugging phase and start of the demonstration test.

c. Management.

Identify by name, organizational titles, and positions the individual having overall responsibility and those individuals responsible for major functions. Define respective responsibilities of each individual (e.g., planning, supervision of specific aspects, issuance of directions).

d. Schedule.

Prepare a time schedule for system debugging activities. Specify interim milestones for any activities requiring in excess of one month duration. One master schedule to include both debug and DT is acceptable. See figure 6.

e. Data Collection.

Cite 5.3.3.8a for data to be recorded in equipment log books during the debug phase.

f. Government Support.

(1) List all Government organizations that will participate in the test and the corresponding functions.

(2) List all GFM/GFE required. Indicate time frames in which GFM/GFE will be required.

(3) List all Government facilities or services that will be required and when they will be required.

g. Station Certification.

Contractor will furnish sufficient evidence to the Government to certify that all inspection operations can reliably detect defects specified in the approved inspection plan.

5.4.3.5 Part II, Demonstration Test.

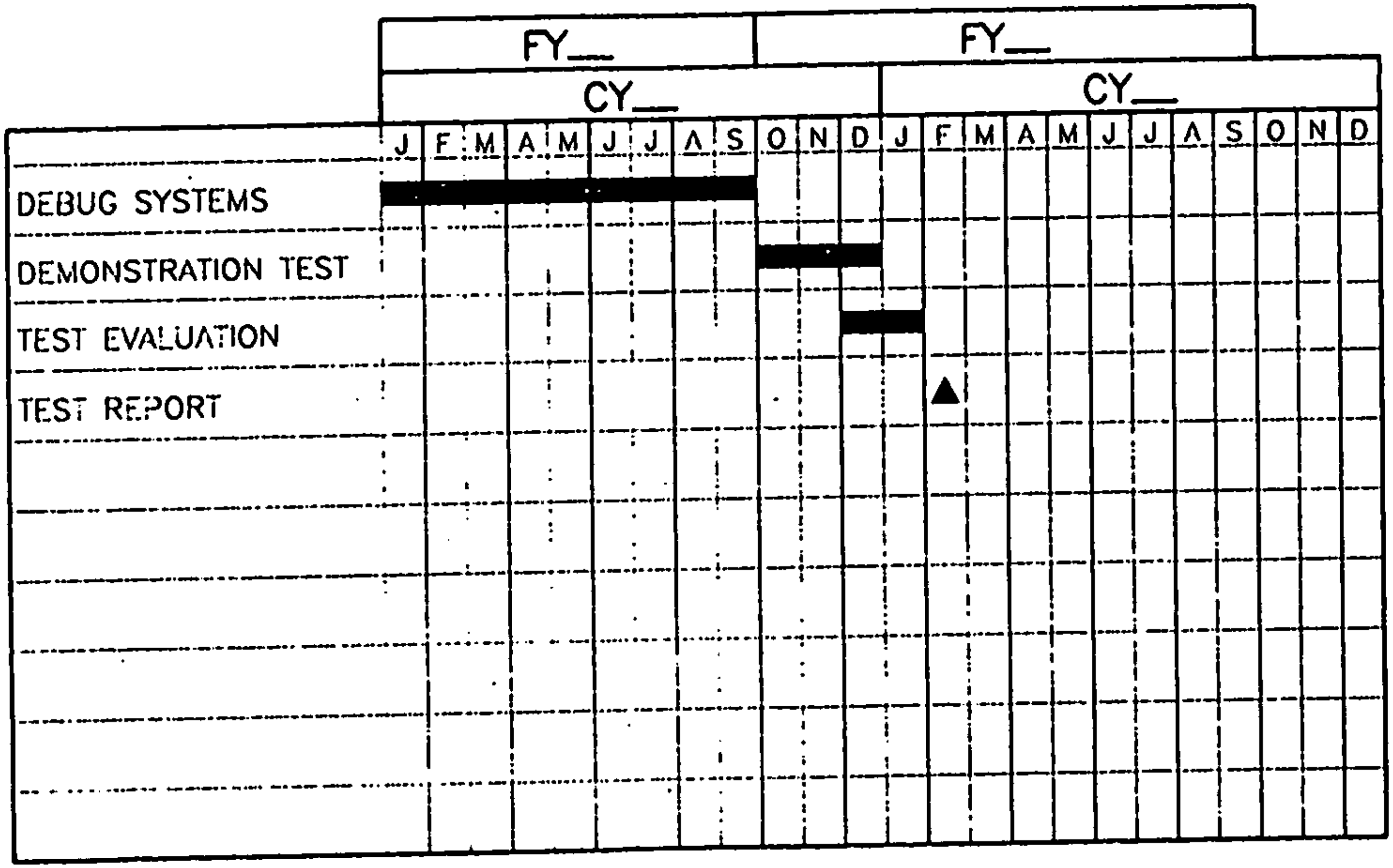
a. Objective.

State the objective of the test to include item(s) to be produced, item specification number (s), and the required production rate. Information should be based on the latest known facility requirements and any differences from corresponding data in the DTS should be fully explained.

b. Management.

(1) Identify by name, organizational title, and position, the individual having overall test responsibility and those individuals responsible for major functions of the test. Define respective responsibilities of each individual (e.g., planning, supervision of specific aspects of the test, issuance of directions, evaluation of data).

***PROVE-OUT SCHEDULE**
PROJECT ________



*NOTE: SIMILAR SUPPORTING SCHEDULES SHOULD BE PREPARED FOR ANY TASKS EXCEEDING 1 MONTH. SUCH SCHEDULES SHOULD BREAK DOWN MAJOR TASKS INTO LOGICAL STEPS, BY OPERATION, BY SUBSYSTEM, ETC., AS APPROPRIATE.

FIGURE 6. EXAMPLE PROVE-OUT SCHEDULE

(2) Specify methods or procedures by which accomplishment of the test will be controlled to insure compliance with the approved test plan.

c. Inspection Requirements.

Cite contractor inspection plan approved by the Government.

d. General Test Description.

Give a general description of the overall DT to include type of test (mechanical functioning, inert production, live), duration of test, number of items to be produced, start-up and close-down operations, overall philosophy, special conditions, constraints, and governing documentation.

e. Process Description.

(1) Provide a simplified flow process diagram indicating by number each step in the production process (including, but not limited to, manufacturing, material handling, inspection, and storage). See figure 7.

(2) For each step in the process, provide a narrative description which addresses the following:

- Contractor operation number (number should be consistent throughout the DTP).
- Operation description (including inspection).
- Equipment description (include manufacturer and model).
- Inspection requirements (include calibration).
- Certification requirements (material, personnel, etc.) where applicable.
- Manpower requirements (manual operations).
- Special safety requirements.
- Special environmental controls (e.g., regulated temperature and humidity).
- Contractor operational procedure (define days/week; hours/shift; shifts/day; scheduled downtime for breaks, cleanup, set-up, lunch, etc.)

(3) A summary matrix spreadsheet should be prepared and included. The format should be as shown in figure 8.

(4) Equipment Maintenance Program.

- Describe the overall maintenance concept to include use of alternate lines or equipment, periodic shutdown, repair in place, etc.

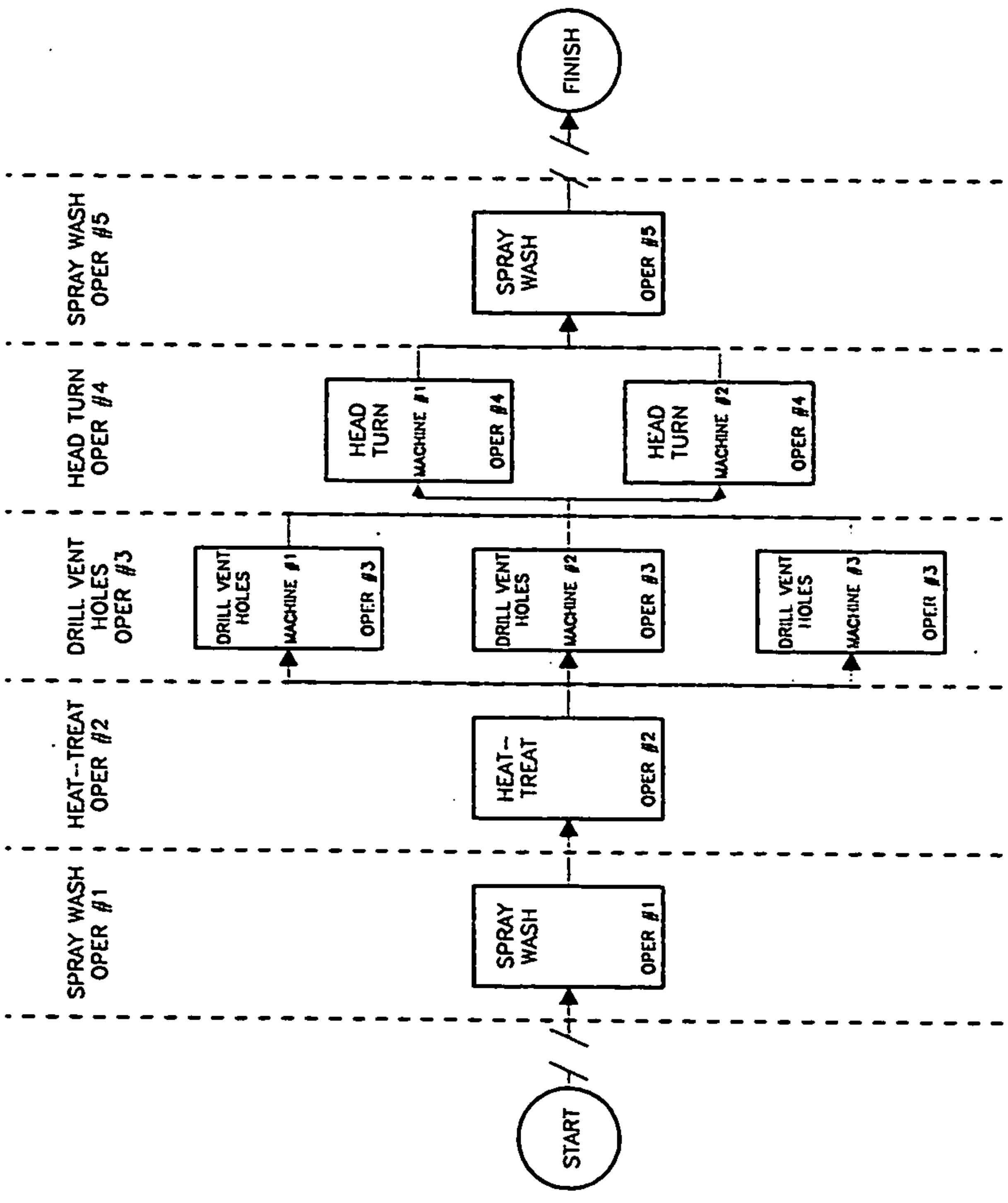


FIGURE 7. EXAMPLE PROCESS FLOW CHART

Oper No.	Operation Description	Equipment Description (Include Manufacturer)	EQUIP QTY On Hand To Meet Design Rate	EQUIP QTY To Be Tested	R Equipment Cycle Rate per Machine (parts per hour)	C_0 Required Pdn Capability per Machine (parts per hour)	C_1 Lower Capability Limit (parts per hour)	MTTR Estimated Mean Time to Repair (hours)
1	Spray Wash	Ransohoff (3) Stage Mesh Belt Conveyor Type Washer	1	1	2,700	2,400*	1,920	< 0.5
2	Heat-Treat	Pacific Scientific Gas Fired Pusher-Type Quench Furnace	1	1	1,350	1,200	960	< 0.5
3	Drill Vent Holes	Special Design Air Driven 6-Spindle Drilling Machine w/Rotary Index Table, Amron	3	2	450	367	294	< 0.5
4	Head Turn	1-5/8-TA 6-Spindle Conomatic Chucking Type Screw Machine	2	2	650	525	420	< 0.5
5	Spray Wash	See Operation No. 1						

*Two spray washes required for process using same piece of equipment. All rates based on required facility production rate of 1,000 parts per hour.

NOTES:

1. Include inspection operations
2. R, C_0, C_1 for individual operations should take into account all production loss factors such as rejects, availability, maintenance, etc., that may require a higher capability than the net capability specified as the facility objective in the DTS.
3. If the capability factor, π_0, or the mean time to repair, MTTR, for any operation differ from the corresponding values specified in the DTS, then new test time(s), T, and critical values, δ^{T}, should be computed for these operations in accordance with the procedures of Appendix A, section 6. Such operations should be highlighted and fully discussed in the DTP because test times different from those specified in the DTS may be required.

FIGURE 8. EXAMPLE PROCESS SPREADSHEET

— Identify by individual operation the maintenance effort to be performed on each item of equipment and associated tooling. Include, as a minimum, the following:

- Preventive maintenance schedule.
- Manuals.
- Records/documentation required.
- List maintenance tasks to be demonstrated during the test.

(5) Environmental Considerations. List all processes, operations and equipment that are affected by and/or impact upon existing environmental policies or regulations (including federal, state, and local). Cite applicable policy/regulation in each instance. This should not contradict or replace any applicable project Environmental Impact Assessment or Statement.

f. Schedule and Build-up Curve.

(1) Schedule. Prepare a time schedule for all major activities (including non-test activities such as facility start-up and close-down, etc.) required to accomplish the demonstration test. Specify interim milestones for any activities requiring in excess of one month duration. See figure 6 for a recommended format. One master schedule to include both debug and DT is acceptable.

(2) Buildup Curve. Prepare a production build-up curve showing production rate acceleration from initial system start-up through full rate and the demonstration test. Identify associated hardware requirements. Figure 2, with hardware requirements added, would represent a buildup curve sufficient for prove-out and production planning purposes.

g. Government Support.

(1) List all Government organizations that will participate in the test and the corresponding functions.

(2) List all GFM/GFE required. Separate GFM/GFE into the required for preparation and that required for performance of the test. Indicate time frames in which GFM/GFE will be required.

(3) List all Government facilities or services that will be required and when they will be required.

h. Personnel Requirements.

(1) List total number of personnel required for performance of the DT. Categorize by function (e.g., data collection, production inspection, maintenance, supervision).

(2) List number of personnel required for full-scale production. Categorize by function (e.g., production, inspection, maintenance, supervision).

i. DT Data Collection.

State that, as a minimum, data collection will be in accordance with Appendix B.

j. DT Evaluation.

(1) Identify company/agency/department performing the evaluation.

(2) State that, as a minimum, DT evaluation will be performed in accordance with Appendix A. Identify and describe any computer simulations, if used, to analyze DT data.

(3) Identify any prior tests or other information that will assist in the evaluation of the equipment/process capability and/or end item acceptance.

k. Training Requirements.

Identify personnel training requirements, if any, directly attributable to DT. Specify operations or functions and type of training required.

l. Reports.

State that a Demonstration Test Report (DTR) will be prepared and submitted to the Government in accordance with 5.6.

5.5 Demonstration Test (DT).

5.5.1 Purpose.

Prove-out objectives are given in 4.3. The DT phase is where data collection takes place on each operation in the manufacturing system or process.

5.5.2 DT Conduct and Coordination.

a. Performance.

The DT is performed by the facility contractor in accordance with the Government approved DTP (see 5.4 and Appendix C).

b. Notification of Test.

Advance notice of test dates and locations will be furnished for Government witnessing of the test as specified in the facility contract.

c. Government Witnessing of Tests.

DT's will be monitored by the cognizant Government engineering organization representatives or such other Government personnel as may be appropriate to the scope of the facility project and contract terms. Monitoring is for the purpose of assuring conformity with the DTP and the accuracy of the recorded test data.

5.5.3 Special DT Considerations.

The following areas of special consideration are highlighted to aid in the recording, interpretation and evaluation of DT data and facility capability.

a. System versus Operations.

During the DT, specific data is collected on each operation in the manufacturing process. It should be emphasized that the operation must be running at its full capability during data collection even if the overall system cannot yet sustain full production. A helpful rule-of-thumb is that data collection on operations within a manufacturing process should not commence until the overall system has achieved stable production of at least 80% of its required rate. At this production level, system debugging is essentially complete and many individual operations should be capable of running at full rate. Raw material or parts may be "banked" at such operations to permit them to run at higher rates than the system may be capable of for the data collection time period. If at any time prior to the DT it becomes evident that initial objectivies cannot be achieved, the contractor should propose revised objectives and DT parameters for Government approval.

b. Trial DT Run.

After the test readiness meeting (see 5.3.3.8c) establishes that the DT phase of prove out may commence, a short trial run would be helpful to give hands on experience to data collectors, managers, etc., with actual DT activities, documentation, etc., prior to start of the formal test period.

c. Provisioning.

Before commencing with data collection on any operation, in addition to assuring that the operation has shown a basic capability to run at rate, the contractor should also assure that sufficient material (e.g., raw material, parts, equipment spares, etc.) necessary to conduct the test are available.

d. Material Handling.

Material handling equipment is normally evaluated based on its ability to support dependent equipment under test. However, material handling equipment also commonly incorporates buffers or banks into the process. The status of such buffers must be monitored during DT of any dependent equipment and included in subsequent analysis of production capability.

e. Plant Support Equipment.

A facilities' production capability depends not only on the manufacturing equipment but may be limited by plant support equipment such as air, water, steam, pollution abatement equipment, etc. The status of such equipment should be monitored during the DT and included in subsequent evaluation of production capability.

f. Software.

Production facilities are incorporating increasing amounts of production equipment, control systems, and information systems which rely on software to perform properly. Software is tested in conjunction with its associated equipment during the DT through its affect on equipment performance.

g. Product Considerations.

(1) Product Evaluation Specifications. Situations can occur where end item specifications may not adequately address product acceptability at interim stages in a production process. This is especially true in the case of continuous chemical processes. In such cases, special product

evaluation specifications (PES) should be prepared to address product acceptability at specified points in the overall product process. This allows the process to be broken down into smaller modules for the DT.

(2) Special Tests. Product acceptability and production rate may depend on the results of laboratory tests or ballistic tests performed during production or afterwards. In such cases, analysis of DT results should take these factors into account.

h. Statistical Process Control (SPC).

SPC is becoming increasingly prevalent in production facilities. If SPC is to be employed on an operation during production, then SPC should be an integral part of system debugging. SPC process capability studies, along with root cause analysis, cause-consequence analysis, etc., will be extremely valuable during system debugging. An SPC plan in accordance with contract requirements stemming from MIL-Q-9858A should have been prepared identifying processes to be controlled, parameters and characteristics to be monitored. Details of capability studies conducted for each of the controlled processes together with any other available SPC history for any processes should be reviewed prior to conduct of the DT. All planned SPC should be in place during DT data collection and SPC data collected during DT will be taken into account when the DT results are evaluated.

5.5.4 Reporting.

After completion of DT, the contractor will analyze the data collected in accordance with Appendix B (as a minimum) and prepare a comprehensive test report in accordance with 5.6.

5.6 Demonstration Test Report (DTR).

5.6.1 Purpose.

The DTR provides a record of DT results, identified deficiencies, conclusions, and recommendations for improvements and corrective actions, as applicable.

5.6.2 DTR Preparation, Coordination and Approval.

The DTR will be prepared in accordance with this handbook and requirements set forth in the project SOW. The DTR is prepared by the facility contractor who conducted the DT. The cognizant Government engineering center will coordinate, as appropriate, and approve each DTR. DTR format and content guidance provided herein is structured so that this handbook may be cited and only the supplemental project specific data called for therein need be provided. See Appendix C for sample acquisition clauses and documentation.

5.6.3 DTR Format and Content.

A basic format for the DTR is given below. Additional information on each area in the DTR is given in subsequent paragraphs. This DTR guidance should be considered a baseline from which a preparer can develop a DTR tailored to a specific facility project.

a. Cover Sheet.

b. Table of Contents.

c. Introduction.

d. Summary.

e. Objective.

f. Requirements.

g. Process Description.

h. Summary of System Debug Testing.

i. Demonstration Test.

j. Conclusions.

k. Recommendations.

l. Appendices (Data and analyses, as applicable).

5.6.3.1 Cover Sheet.

The DTR cover sheet, except for the document title, should contain the same basic information as that of the DTS and DTP (see figure 5).

5.6.3.2 Table of Contents.

Provide a table of contents which follows the format (paragraph headings) shown in 5.6.3.

5.6.3.3 Introduction.

a. Briefly discuss the facility project objective and background to familiarize a reader with the project.

b. Briefly discuss the prove-out period. This should be an overall chronology of the period from debugging through the demonstration test.

c. Briefly describe or identify the manufacturing process.

5.6.3.4 Summary.

Briefly summarize the results of the demonstration test to include production capability, RAM characteristics, and product quality for each operation in the manufacturing process. A suggested format to organize the data for summarizing the results is given in figure 9. This form should be included in the summary.

5.6.3.5 Objective.

State the overall objective of the DT. It should be the same as given in the DTP, but if facility project requirements have changed since the DTP approval, the latest information should be reflected in the DTR.

TEST SUMMARY

			MACHINES				PRODUCTION	
OPERATION NO.	OPERATION DESCRIPTION	EQUIPMENT DESCRIPTION	QTY ON HAND	QTY IN TEST	OBSERVED AVAILABILITY	REJECT RATE 2	REQ'D RATE 1,3	OBSVD RATE 3

NOTES:
1. REQUIRED TO MEET FACILITY DESIGN PRODUCTION RATE
2. PERCENT RATE = [1 − (GOOD PIECES BEFORE REWORK/TOTAL PRODUCED)] x 100
3. PIECES/HOUR or SHIFT, ETC.

FIGURE 9. EXAMPLE TEST SUMMARY

5.6.3.6 Requirements.

Give the test time and quantitative production rates and reject rates to be demonstrated for each operation in the process. Highlight and explain any deviations from the DTP.

5.6.3.7 Process Description.

Cite the process description information included in the DTP. Highlight and explain any changes from the DTP.

5.6.3.8 Summary of System Debugging.

Provide a brief chronology of the system debugging to include any significant problems encountered, corrective actions, equipment modifications, and a summary of rate and quality level buildup attained during debug.

5.6.3.9 Demonstration Test.

Provide the following information on the DT:

a. Provide a brief test description that includes all pertinent assumptions, definitions, and factors which influence the data. Highlight and explain any areas which differ from the DTP.

b. Describe how production, quality and downtime (or failure) data was collected and analyzed. Cite the DTP, where applicable, and fully explain any supplemental data and analyses involved. Downtime (or failure) codes should be summarized as in figure 10.

c. Tabulate statistics used to compute quantitative production rates, RAM, and quality results for each operation. Results for every operation tested should be shown. Figure 11 is representative of how this data should be presented. Additional information concerning data analysis is given in Appendix B.

d. Provide a detailed listing of downtimes and a downtime analysis. See figure 12 for an example of how downtime analysis data should be presented.

e. Computer simulations approved in the DTP may be used to analyze DT data. If so, the simulation should be fully identified/described and the results provided and discussed.

f. Discuss any significant equipment operating or product quality problems occurring during the DT along with corrective actions taken.

5.6.3.10 Conclusions.

Indicate to what degree the system met test objectives.

5.6.3.11 Recommendations.

Indicate if the production system is suitable for ongoing production. If test objectives were not yet met, provide recommendations (actions and costs) for correcting problem areas.

FAILURE CODES – BODY LOADING

CODES	DESCRIPTION	DEFINITIONS
		UNTRAYING MACHINE
100	MISCELLANEOUS PROBLEM	UNTRAYING
101	TRAY POSITION	TRAY IMPROPERLY POSITIONED TO UNLOAD
102	TRAY OVERRUN	TRAY HITS LIMIT SWITCH AND MACHINE
103	INFEED JAM	BODY JAMS DURING UNTRAYING
		CONE SYNTRON
200	MISCELLANEOUS PROBLEM	CONE CONVEYOR
201	FEED RATE	CONE SYNTRON FEED RATE REQUIRES ADJUSTMENT
202	CONE TURNED OVER	CONE OVERTURNED IN SYNTRON
203	CONE JAM	CONE JAMS EXITING SYNTRON
		POWDER FEED SYSTEM
210	HUNG BUCKET	POWDER BUCKET HANGS UP WHILE FEEDING
211	NO POWDER	CONVEYOR BRINGS PALLET W/O POWDER
212	HUNG PALLET	CONVEYOR SYSTEM JAMS WHEN CALLED FOR
215	MISCELLANEOUS PROBLEM	POWDER CONVEYOR SYSTEM
		ASSEMBLY MACHINE
300	MISCELLANEOUS PROBLEM	ASSEMBLY MACHINE
301	REJECT PART	BODY WILL NOT FIT ON NEST
302	OUT JAM	BODY & NEST ASSEMBY JAM ON OUTFEED
303	BODY JAM	BODIES JAM ENTERING ASSEMBLY MACHINE
304	NEST JAM	NEST NOT AVAILABLE FOR ASSEMBLY
305	NO BODY	BODY NOT AVAILABLE FOR ASSEMBLY
306	LIMIT SWITCH	SWITCH REQUIRES ADJUSTMENT OR REPLACEMENT
307		MACHINE OPERATIONAL
308	LEAD CUP	LEAD CUP FALLS OUT OF BODY & CAUSES HANGUP
		PELLET PRESS
400	MISCELLANEOUS PROBLEM	PELLET PRESS
401	PART IN PUNCH	BODY STICKS IN PUNCH AFTER CONSOLIDATING POWDER
402	UPPER CAM JAM	UPPER PUNCH FAILS TO SEAT OVER BODY
403	HIGH PUNCH	PUNCH FAILS TO RETURN TO NORMAL POSITION
404	NO BODY	BODY MISSING FROM NEST
405	NO NEST	NEST MISSING FROM BODY
406	INFEED JAM	BODY ASSEMBLIES JAM ENTERING PRESS

FIGURE 10. EXAMPLE FAILURE CODE SHEET

TEST DATA SUMMARY
BODY LOADING OPERATION

COLUMN NO.	1	2	3	4	5	6	7	8	9	10
MACHINE NO.	SCHED UPTIME	ACTUAL UPTIME	DOWN TIME*	MTBF	MTTR	AVAIL	NO. FAILURES	QTY ACCEPTED	QTY REJECT	NET RATE
1	1691.2	1345.6	345.6	7.75	1.99	.796	174	130857	1084	77.4
2	1751.3	1358.9	392.4	6.90	1.99	.776	197	129024	664	73.7
3	1680.4	1356.4	324.0	7.89	1.88	.807	172	128041	985	76.2
SUMMARY	5122.9	4060.9	1062.0	7.48	1.99	.793	543	387922	2733	75.7

$$\text{COL 4 (MTBF)} = \frac{\text{COL 2}}{\text{COL 7}} = \frac{4060.9}{543} = 7.48 \qquad \text{COL 6 (AVAILABILITY)} = \frac{\text{COL 2}}{\text{COL 1}} = \frac{4060.9}{5122.9} = .793$$

$$\text{COL 5 (MTTR)} = \frac{\text{COL 3}}{\text{COL 7}} = \frac{1062.0}{543} = 1.99 \qquad \text{COL 10 (NET RATE)} = \frac{\text{COL 8}}{\text{COL 1}} = \frac{387922}{5122.9} = 75.7$$

*NOTE: In this example, all downtime was corrective maintenance.

FIGURE 11. EXAMPLE TEST DATA SUMMARY SHEET

DOWNTIME ANALYSIS OF BODY LOADING SYSTEM

STATION/CODE		FREQUENCY	TOTAL TIME	AVERAGE TIME
BODY	LOADING STATION 2	197	392.417	1.992
0	NONCODED FAILURES	1	2.500	2.500
101	TRAY POSITION	1	3.067	3.067
200	CONE CONVEYOR-MISC PROBLE	2	10.983	5.492
210	HUNG BUCKET	6	18.433	3.072
211	NO POWDER	16	65.783	4.111
212	HUNG PALLET	2	5.000	2.500
215	POWDER CONVEYOR	2	5.667	2.833
302	OUT JAM	1	.500	.500
303	BODY JAM	1	.650	.650
304	NEST JAM	3	4.383	1.461
307	LIMIT SWITCH	10	4.767	.477
308	LEAD CUP	2	.717	.358

FIGURE 12. EXAMPLE DOWNTIME ANALYSIS

5.6.3.12 Appendices.

Appendices should be used to present raw data, quality control data, analyses, simulation results, and other supporting data or analyses, as applicable. This supporting data should be cross referenced to associated paragraphs in the DTR.

6. NOTES.

6.1 Intended Use.

This handbook contains requirements and guidance for the application of prove-out to the establishment or modernization of Army Materiel Command production facilities. Because of the wide range in scope and complexity of facility projects, the guidance contained in this handbook is intended to help users develop prove-out programs tailored to specific projects.

6.2 Subject Term (Key Word) Listing.

- Demonstration Test
- Maintainability
- Prove-Out
- Quality Assurance
- Reliability
- Turnkey Facility

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APPENDIX A

STATISTICAL METHODOLOGY

1. General

This appendix provides details of the statistical approach applicable to the planning and carrying out of a demonstration test of the capability of a production facility.

2. Terminology and Notation

a. C = *Production Capability*, defined as the expected number of acceptable units produced per hour of scheduled system operating time.

C_0 = Production capability required.

C_1 = Lower capability limit.

b. A = *System Availability*, defined as the expected proportion of scheduled system operating time that the system *actually* produces.

c. P = *Process Average*, defined as the expected proportion of acceptable units produced during any interval of *actual* system operating time.

d. R = *Production Rate*, defined as the rate (in units / hr, parts / hr, pounds / hr, etc.) at which the system will produce when actually operating *during* the test. R must be greater than or equal to C_0. See App A, 6.a(4).

e. D = C_1 / C_0 = *Discrimination Ratio*, a measure of the degree to which it is desired to discriminate between acceptable and unacceptable systems. The closer D is to 1, the greater the discrimination. Test time increases as the discrimination ratio increases. See App A, 6.f., for a further discussion of this point.

f. α = Probability of rejecting a system when it is capable of producing at or better than the mobilization requirement; i.e., when $C \geq C_0$. This quantity reflects the risk to the contractor of having adequate systems rejected.

g. β = Probability of accepting a system when it is only capable of producing at or below the lower capability limit; i.e., when $C \leq C_1$. This quantity reflects the risk to the government of accepting systems that are considered inadequate.

h. T = *Scheduled System Test Time*, defined as the length of the test, and which excludes administrative downtime, i.e., lunch, breaks, etc., and logistic downtime, i.e. waiting for parts, etc.

T_m = Scheduled system operating time available per month.

T_0 = Test time factor given Π_0, Π_1, α, and β.

T_{min} = Minimum test time = $U \cdot T_0$.

i. Π = *Capability Factor* $= \frac{C}{R}$

Corresponding to C_0 define $\Pi_0 = \frac{C_0}{R}$

Corresponding to C_1 define $\Pi_1 = \frac{C_1}{R}$

j. U = *Upper Bound on System Mean-Time-To-Repair (MTTR)*, determined from experience with the present system or similars systems. See App A, 6.a(3).

k. Π_c = *Critical Capability Value*, specifies the pass / fail criteria for the demonstration test and is selected from the appropriate table or calculated.

3. The Production Process Model

The model considered in the development of the statistical approach for DT is that of a production process (or system) which produces units, both good and bad (i.e., acceptable and unacceptable), at a rate, R, per hour of actual system operating time. P is the expected proportion of units produced by the process which are acceptable or good units. Hence, the rate at which good units are produced is provided by the product P·R. During the course of the operation, equipment comprising the process will experience stoppages because of mechanical failures. Subsequent to repair, the production process resumes operation, manufacturing units at the rate R. The amount of time required to perform repairs is referred to as active maintenance time. If the system mean time to repair is denoted by MTTR, and the mean time between failure by MTBF, then the long run proportion of the time the production system will be operating is the availability, A, and is given by

$$A = \frac{MTBF}{(MTBF \div MTTR)}$$

For the production process total scheduled system operating time is comprised of both actual operating time and active maintenance time spent on repairs. Therefore, for a given amount, T, of scheduled operating time the process is expected to have actual operating time given by $A \cdot T$, during which it is expected to produce $R \cdot A \cdot T$ units, of which $P \cdot R \cdot A \cdot T$ are expected to be acceptable. If the latter expression is divided by T, an expression for C, the expected number of acceptable units produced per hour of scheduled system operating time, results. That is,

$$C = P \cdot A \cdot R$$

or

Production Capability = (Process Average) x (System Availability) x (Production Rate)

The process parameter C, modelled in this way, is the primary parameter of interest for the prove-out DT. However, the hypothesis test procedure discussed later is structured, for convenience, around Π, the capability ratio. Inferences and tests concerning C will be equivalent to those concerning Π.

4. Assumptions

In order to proceed from the model to the development of statistical inference procedures the following assumptions are required.

a. The production rate, R, is constant. For most applications this assumption is an idealization, since there will generally be some variability in the production rate. However, the statistical procedures discussed herein, can be shown to be insensitive (i.e., robust, to use the statistical term) with respect to reasonable departures from this assumption.

b. The process is in sufficient statistical control to assume that P is a constant. It should be noted that this does not mean that the actual proportion of good units in any period remains constant, but only that the process average governing the random process generating good units remains constant. As with the preceding assumption the procedures are again robust with respect to reasonable departures. In both cases, as well as for several of the assumptions which follow, it should be noted that all that is needed is for the assumptions, and the model as a whole, to reasonably apply only during the execution of the demonstration test.

c. The distribution of times between failure is exponential with mean denoted by MTBF. If the variance of the times between failure is denoted by σ_f^2, then because of the exponential assumption,

$$\sigma_f^2 = (\,MTBF\,)^2$$

The exponential distribution has been historically shown to be a reasonable assumption for time between failure distributions of a wide variety of equipment. It is not unreasonable to apply it, therefore, in the modelled process.

d. The distribution of times to repair is exponential with mean denoted by MTTR. If the variance of the time to repair is denoted by σ_r^2, then

$$\sigma_r^2 = (\,MTTR\,)^2$$

In practice the *log-normal* distribution is often assumed for time to repair. For a log-normal distribution with mean given by MTTR it can be shown that

$$\sigma_r^2 = constant \cdot (\,MTTR\,)^2$$

For production processes, especially at the point in time when prove-out procedures are to apply, such a constant will generally not be known. Assuming an exponential distribution on the times to repair is equivalent to assuming the constant is equal to 1. Sensitivity tests conducted during the development of the statistical procedures have shown that the procedures are robust in this respect.

e. The demonstration tests will be sufficiently long so that the random processes governing failure and repair will have resulted in a steady-state availability, A, for the production process. This assumption is only necessary, if the demonstration test procedure requires that all equipment initially be in an operable state and buffers between operations be seeded, rather than having achieved some steady-state level prior to the start of the test through operation of the process.

5. The Hypothesis Test Methodology

The approach is based on a statistical test of the hypothesis that the true capability ratio of the system, Π, is greater than or equal to Π_0, where:

$$\Pi = \frac{C}{R}$$

and $C = P \cdot A \cdot R$, as modelled above. If a test of the system is run for test time, T, and N, the number of acceptable units produced, is observed, then it can be shown that the quantity $\hat{\Pi} = \frac{N}{RT}$, to be used as the test statistic, is approximately normally distributed with mean, Π, and variance σ^2 given by the following expression:

$$\sigma^2 = \frac{1}{R}(1-P)\frac{\Pi}{T} + 2(MTTR)(1-A)\frac{\Pi^2}{T}$$

In fact, it can be shown that as T increases indefinitely, the distribution of the quantity,

$$\left(\frac{\frac{N}{RT} - \Pi}{\sigma}\right)$$

approaches that of a normal distribution with mean 0 and variance equal to 1.

It can be further shown that under reasonable constraints on the relationships between the parameters of the model,

$$\sigma^2 \le \frac{2(MTTR)(1-\Pi)\Pi^2}{T}$$

Therefore, define: $\sigma^2_{max}(\Pi) = 2U(1-\Pi)\Pi^2$ where U is the upper bound on the system MTTR.

The above results provide the framework upon which the hypothesis test procedure can be developed with specified risks, α at Π_0 and β at Π_1 ($\Pi_1 \le \Pi_0$). Consider the following test acceptance procedure:

$$\text{Accept:} \quad \text{if} \left(\frac{N}{RT} - \Pi_0\right) > Z_\alpha \frac{\sigma^2_{max}(\Pi_0)}{T}$$

Reject: if otherwise

where Z_γ for $0 < \gamma < 1$ denotes the 100γ *th* percentile of the standard normal distribution; i.e. the normal distribution with mean equal to 0 and variance equal to 1. (Table VI provides commonly required values of Z_γ). For T sufficiently large, the probability of rejection for $\Pi = \Pi_0$ under the above procedure is less than or equal to α, and the probability of acceptance for $\Pi = \Pi_1$ is less than or equal to β. The minimum required value of T, denoted T_{min}, can be shown to be:

$$T_{min} = \frac{\sigma^2_{max}(\Pi_1)}{(\Pi_0 - \Pi_1)^2}\left\{Z_{1-\beta} + Z_{1-\alpha}\frac{\sigma_{max}(\Pi_0)}{\sigma_{max}(\Pi_1)}\right\}^2$$

and therefore

(1) $$T_{min} = U \cdot T_0$$

(2) $$T_0 = 2\,\frac{(1-\Pi_1)\,\Pi_1^2}{(\Pi_0 - \Pi_1)^2}\left\{ Z_{1-\beta} + Z_{1-\alpha}\,\frac{\sqrt{(1-\Pi_0)\,\Pi_0^2}}{\sqrt{(1-\Pi_1)\,\Pi_1^2}} \right\}^2$$

The above acceptance procedure is equivalent to

$$\text{Accept: if } \hat{\Pi} = \frac{N}{RT} > \Pi_0 - Z_{1-\alpha}\,\frac{\sigma_{max}(\Pi_0)}{T}$$

Let $$\Pi_c = \Pi_0 - Z_{1-\alpha}\frac{\sigma_{max}(\Pi_0)}{\sqrt{T_{min}}} \quad \text{or}$$

(3) $$\Pi_c = \Pi_0 - Z_{1-\alpha}\frac{\sqrt{2U(1-\Pi_0)\Pi_0^2}}{\sqrt{T_{min}}}$$

Then the acceptance procedure becomes:

(4) Accept: if $\hat{\Pi} > \Pi_c$

Reject: if otherwise

Therefore, in order to test the hypothesis that $\Pi = \Pi_0$ versus $\Pi = \Pi_1$ with specified risk levels α and β, determine T_{min} using (1) and (2) above, and use the acceptance procedure (4) with Π_c determined from (3). The required statistical test procedure is then established.

The next section of this Appendix discusses the establishment of a specific demonstration test for a given set of system and test parameters. The overall approach is to establish a test time and acceptance criteria at the system level, but employ the hypothesis test at the operation level provided the test parameters at the operation level do not differ substantially from the system level parameters, as is discussed in the next section. If there is a substantial difference for particular operations, then new minimum test times and/or test criteria are established for just those operations. Rejection of any operation based on the test will indicate that the operation does not have the production capability necessary to support the system level requirement. In such cases corrective action must be addressed by the contractor in the DTR.

6. Establishing the Demonstration Test

a. To establish a demonstration test time for a particular production facility, or portion thereof, values of the test parameters C_0, C_1, α, β, R, and U, defined in the preceding section, must be specified. It is required that a sound and complete rationale be used to establish the values specified for those parameters in the DTS and/or DTP. This rationale should include as a minimum:

(1) A determination of an hourly production capability, C_0, for the system, or portion thereof, corresponding to the overall facility production requirement. The demonstration test will have the property that, if the system has a production capability at least as good as C_0, it will have a high probability ($1 - \alpha$) of passing the test. A proper determination of C_0 for a given production rate requirement entails an accurate specification of scheduled system operating time per month. A facility rate requirement may typically be stated in a manner similar to the following:

"N acceptable units per month on an X/Y/Z basis"

(NOTE: X is the number of shifts per day, Y is the number of hours per shift, and Z is the number of days per week).

The X/Y/Z portion of this requirement provides little information relative to the amount of scheduled system operating time per month. In fact it provides only an upper limit. For instance, if X/Y/Z is 3/8/5, then it can be concluded that scheduled system operating time per month must be less than or equal to 21 x 3 x 8 = 504 hours; i.e., the product of the number of days per month (NOTE: for Z = 5, this is usually taken to be 21; for Z = 7 the value is 30) times the number of shifts per day times the number of hours per shift. The actual amount of scheduled system operating time per month must take into consideration periods of scheduled downtime, such as breaks, lunches, scheduled maintenance, set-up or start-up time, and so on. The best way to illustrate the proper determination of scheduled system operating time per month, to be denoted herein as T_m, is via an example. Suppose for a given ammunition production facility the following requirement is provided:

120,000 acceptable rounds per month on a 3/8/5 basis.

The following additional information is also available.

i. A 30 minute lunch break and two 15 minute breaks are scheduled for each shift.

ii. At the beginning of each shift a 30 minute set-up period is required.

iii. At the beginning of the third shift each day there will be 1 hour of preventive maintenance.

Scheduled system operating time per month, T_m, is then:

T_m = (Maximum shift hours possible per month) - (Total monthly loss due to lunches and breaks) - (Total monthly downtime due to set-ups) - (Total monthly downtime due to scheduled preventive maintenance)

= (21 x 3 x 8) - (21 x 3 x 1) - (21 x 3 x ½) - (21 x 1)

= (504) - (63) - (31.5) - (21)

= 388.5 hours

For this value of T_m , the correct value of C_0 is then determined as:

$$C_0 = \frac{(120{,}000)}{T_m} = \frac{(120{,}000)}{(388.5)}$$

= 308.9 acceptable units per hour of scheduled system operating time.

Note how this compares to the value of 238.1 which would result by incorrectly assigning a value of 504 to T_m . Similar reasoning should be applied when the requirement for production rate is stated in other ways. Of major importance is the fact that the value of scheduled system operating time be an accurate estimate of the anticipated system operating time over the period for which the requirement is stated; i.e., monthly, weekly, daily, etc.

(2) A justification, possibly reflecting economic considerations, regarding selection of the risk levels α and β , as well as the lower capability level, C_1 (or, alternatively, the discrimination ratio, D). The demonstration test will have the property that, if the system has a production capability no better than C_1 , it will have a high probability $(1 - \beta)$ of failing the test.

(3) A justification for the specified value of U, the upper bound on the system MTTR. It is not necessary that this value be close to the true system MTTR, simply greater with a good deal of assurance. Since required test time will be directly proportional to the specified value of U, a reasonable upper bound should be selected to avoid excessive costs associated with over-testing.

(4) As defined above, R is the rate at which the system will produce when actually operating during the test. The key words here are *actually* and *during*. The former refers to the fact that R is the rate at which the system will produce if all operations experience no equipment failures, including rejects and/or scrap. It is equivalent to the "cycle rate" of the system and is directly related to the cycle rates of the equipment which comprise the system. The word *during* refers to the fact that to some degree R may be controllable and hence set at a particular value to be maintained throughout the period of the demonstration test. If R can not be adjusted, it is generally considered to be a known fixed value reflecting the rate at which equipment will be running during the test. In all circumstances R must be greater than or equal to C_0 . In most cases R will be substantially greater than C_0 . In the situations when *system* uptime can be determined, it is possible to obtain an estimate of R by dividing the total number of units processed (both acceptable and unacceptable) by the total system uptime.

b. For the specified values C_0 , C_1 , α , β , R , and U , the tables in section 9 of this appendix can be used to determine the required system demonstration test time, T_{min} , and the test criterion, Π_c . First, however, the values, Π_0 and D must be calculated from:

$$\text{(i)} \qquad \Pi_0 = \frac{C_0}{R}$$

and

$$\text{(ii)} \qquad D = \frac{C_1}{C_0}$$

The tables correspond to different values for α and β. However, in each case, α and β are equal. In developing these tables it was considered that equivalent protection to the "producer" and "consumer", in this case, the facility contractor and the government, respectively, should suffice for the purpose of planning demonstration tests on production facilities. The table for Π_c is only valid for α = β and should not be used for other cases. If the reader wishes to use other values of α and/or β, the formulas for T_{min} and Π_c provided in the preceding section of this appendix can be used. The columns in the tables correspond to different values of Π_0, the desired capability factor. The rows correspond to different values of D, the discrimination ratio. By going to the row corresponding to the value of D computed above (i.e., the smallest tabled value of D greater than the computed D), and then going over to the column headed by the computed value of Π_0 , a value of T_0 , the test time factor, can be found. If there is no column headed by Π_0 , then linear interpolation between columns is acceptable. The appropriate value for the test time, T, can then be determined from:

$$T \geq T_{min} = U \cdot T_0$$

EXAMPLE: Given the following test parameter specification, determine the required demonstration test time, T_{min}, and test criterion, Π_c :

C_0	1000 units / hr
C_1	900 units / hr
α	.10
β	.10
R	1250 units / hr
U	0.5 hr

Calculate:

$$\Pi_0 = \frac{C_0}{R} = \frac{1000}{1250} = 0.80 \; .$$

$$D = \frac{C_1}{C_0} = \frac{900}{1000} = 0.90$$

For α = β = .10, table II is used. By going down to the row with D = .90 and column headed by Π_0 = .80, a test time factor of T_0 = 280.3 is found. The scheduled demonstration test time, T should then be:

$$T \geq T_{min} = U \cdot T_0 = (0.5) \times (280.3) = 140.15 \text{ hrs}$$

Similarly, table V is used to find the value:

$$\Pi_c = .761$$

c. The values T and Π_c completely specify the system level demonstration test that should be conducted for the given test parameters. These values would be provided in the appropriate paragraph of the DTS and/or DTP.

d. The next step is the process of establishing the matrix for each operation in the system as described in section 5.4.3.5 of this handbook. Determination of the operation/machine level inputs to this matrix requires a thorough understanding of how upstream operations must perform in order to compensate for losses downstream. For complex systems this makes necessary the performance of a manufacturing system analysis. Such analyses are often conducted using computer simulation models such as GENMOD, which will verify whether operation level performance parameters are adequate. To illustrate how this information is used, consider a continuation of the above example where the system is comprised of five operations, with Operation #1, #4, and #5 performed by single work stations (machines), Operation #2 performed by three machines, and Operation #3 performed by four machines. To achieve the required C_0 off the entire system, higher capabilities are required for the upstream operations. Based on a manufacturing system analysis the contractor provides the following information in the DTP for each operation:

OPERATION	MACHINES	C_0	R	Π_0	U
1	1	1280	1540	0.831	0.50
2	3	420	480	0.875	0.75
3	4	300	450	0.667	0.25
4	1	1100	1300	0.846	0.20
5	1	1000	1250	0.800	0.30

If , for any operation, the machine Π_0 value is less than the system Π_0 by more than 20% of the difference between Π_0 and Π_c or the machine U is more than 10% greater than the system U, the formulas for T_{min} and Π_c provided in section 5 above should be used to recompute T_{min} and Π_c for that operation. The recomputed values of both should be used if the recomputed T_{min} is larger than the system T_{min}. The recomputed value of Π_c should be used if it is less than the system Π_c, regardless of the recomputed T_{min}. In the above example, for Operation #2, U=0.75 hrs. exceeds the system U= 0.5 hrs. by more than 10% and, for Operation #3, Π_0 = 0.667 is less than the system Π_0= 0.8 by more than 20% of the difference between Π_0=0.8 and Π_c=0.761. Hence, recomputed values of T_{min} and Π_c for these operations (using the same D, α, and β values as in the system computation) are for Operation #2: T_{min}= 145.57 hrs. and Π_c=0.835; and for Operation #3: T_{min}= 108.03 hrs. and Π_c=0.633. Therefore, a slight increase in test time is required for operation #2 machines. And modified Π_c values apply to both operations.

e. After properly assigning values to the various parameters required and determining a value of test time, T ≥ T_{min} , care must be taken to properly interpret and use T. It must be remembered that T, or its operation level equivalent, is the amount of scheduled operating time required to achieve the desired demonstration level for the system, or operation, respectively. Downtime due to scheduled breaks, set-ups, or preventive maintenance is not to be counted against T. On the other hand, downtime for corrective maintenance is counted. As a result, the number of shifts required for demonstration will be typically greater than the number determined by simply dividing T by 8. A sufficient number of shifts must be run to provide the required scheduled operating time totalling T.

f. A point of clarification is required concerning the fact that the tables from which T_0 is determined reflect that T_0 decreases as Π_0 increases for a fixed discrimination ratio, D. This appears to be counterintuitive, since higher values of Π_0 are associated with higher demonstration levels for production capability and, hence, should require longer test times. This is simply not true. Within a given table (i.e., for fixed risk levels) the size of T_0 depends on the size of the difference between Π_0 and Π_1 which is to be detected by the test. For a fixed D this difference increases as Π_0 increases. Clearly, the larger the difference to be detected, the smaller the test time required for detection. For example, suppose D = 0.8; for Π_0 = 0.80 the value for Π_1 is Π_1 = 0.64 and the difference to be detected by the demonstration test is $\Pi_0 - \Pi_1 = 0.16$. If Π_0 is increased to Π_0 = 0.9, the value for Π_1 is Π_1 = 0.72 and the difference to be detected is $\Pi_0 - \Pi_1 = 0.18$. This increase from 0.16 to 0.18 in the difference to be detected corresponds to a consequent decrease in required test time, as is reflected in the tables.

7. Statistical Test Procedure

For each operation in the system, a demonstration test for test time $T \geq T_{min}$ (i.e. the T_{min} value for the operation which may be different than the system value) is conducted. During the test the production rate R for each machine in the operation will be as specified in the approved DTP. Data is collected in accordance with Appendix B of this handbook and processed to yield the information necessary to conduct the operation level tests of hypotheses.

Continuing with the above example, the way in which the hypothesis test is conducted will be illustrated for operation #5 as follows. For that operation a test of 140 hours (140.16 rounded to the nearest integer number of hours) was conducted with production rate R=1250 units/hr. During the test it is found that the total number of units (acceptable + reject) produced is M = 146,856 units, produced in 112 hours of actual uptime. This implies that the true R was actually 1311.2 units/hr as opposed to 1250 units/hr. The number of acceptable units was found to be N = 142,410. Therefore:

$$\hat{\Pi} = \frac{N}{RT} = \frac{142410}{(1311.2)(140)} = .776$$

and $\hat{\Pi} > \Pi_c = .761$ Hence, the operation is not rejected and no deficiency noted. Had the $\hat{\Pi}$ been less than Π_c, the operation would have been rejected and corrective action required.

8. Approximate Confidence Interval Estimates

Prior to the actual running of the demonstration test, it can be claimed that the minimum 100(1-β)% lower confidence limit of production capability, C, will be $C_1 = D \cdot C_0$ for each application of the hypothesis test procedure at whatever level, be it system or operation. After the test is actually run and data collected, a two-sided 100(1-γ)% confidence interval, [C_L , C_U], can be determined for each operation as follows:

$$C_L = \frac{N}{T} - Z_{1-\frac{\gamma}{2}} S$$

and

$$C_U = \frac{N}{T} + Z_{1-\frac{\gamma}{2}} S$$

where

$$S = \left[\frac{2\hat{U}(1-A)(N/T)^2}{T}\right]^{1/2}$$

and

$$A = \frac{M}{RT}$$

$\hat{U}$ is an estimate of MTTR obtained from the collected data or from past history, if data is not considered adequate to estimate MTTR because of limited number of stoppages actually occurring during the test. The estimate should be conservative (over-estimate).

To illustrate again, consider the above example. Suppose that in addition to the already mentioned information, the collected data indicated that the 28 hours of downtime (i.e. 140 − 112) resulted from repair needed to restore operation #5 for a total 35 failures or stoppages. This results in an estimate of MTTR:

$$\hat{U} = \frac{28}{35} = 0.8 \text{ hrs.}$$

From the other information:

$$A = \frac{M}{RT} = \frac{146856}{(1311.2)(140)} = 0.8$$

and

$$S = \left[\frac{(2)(0.8)(1-0.8)(142410/140)^2}{140}\right]^{1/2} = 15.4 \text{ units / hr.}$$

Therefore, the 90% confidence interval for C, the production capability of operation #5 is:

$$C_L = (142410/140) - (1.645)(15.4) = 991.9 \text{ units / hr}$$
$$C_U = (142410/140) \div (1.645)(15.4) = 1042.5 \text{ units / hr}$$

NOTE: $Z_{.95} = 1.645$

On the basis of this demonstration test, it can be stated that with 90% confidence operation #5 is capable of producing between 991.9 and 1042.5 units/hr of scheduled system operating time. Had the confidence interval been below (or even predomimantly below the 1000 units/hr required of operation #5 it would have been cited as a deficient operation in the DTR.

9. Tables for T_0, Π_c, and Z_γ

The remaining pages of this appendix provide the tables necessary to plan and evaluate the DT. Use of these tables is as explained in preceding sections of this appendix and the main body of this report.

TABLE I

TEST TIME FACTORS, T_a

$\alpha = .05$ $\beta = .05$

D	Π_a, CAPABILITY FACTOR DESIRED							
	.60	.65	.70	.75	.80	.85	.90	.95
.40	14.5	13.2	11.8	10.5	9.1	7.6	6.1	4.4
.42	16.0	14.5	13.0	11.6	10.0	8.4	6.7	4.9
.44	17.6	16.0	14.4	12.8	11.1	9.3	7.5	5.4
.46	19.5	17.7	15.9	14.1	12.3	10.3	8.3	6.0
.48	21.5	19.6	17.6	15.6	13.6	11.5	9.2	6.7
.50	23.9	21.8	19.6	17.4	15.1	12.7	10.2	7.4
.52	26.6	24.2	21.8	19.3	16.8	14.1	11.4	8.3
.54	29.6	27.0	24.2	21.5	18.7	15.7	12.7	9.2
.56	33.1	30.1	27.1	24.0	20.8	17.6	14.1	10.3
.58	37.2	33.8	30.4	26.9	23.3	19.6	15.8	11.5
.60	41.9	38.0	34.1	30.2	26.2	22.0	17.7	12.9
.62	47.3	43.0	38.5	34.1	29.5	24.8	19.9	14.5
.64	53.8	48.8	43.7	38.6	33.4	28.0	22.4	16.3
.66	61.4	55.7	49.8	44.0	38.0	31.8	25.4	18.4
.68	70.6	63.9	57.2	50.3	43.4	36.3	28.9	20.9
.70	81.7	73.9	66.0	58.0	50.0	41.7	33.1	23.8
.72	95.3	86.1	76.8	67.4	57.9	48.2	38.1	27.3
.74	112.3	101.3	90.2	79.0	67.7	56.2	44.3	31.5
.76	133.7	120.4	107.1	93.7	80.1	66.2	51.9	36.6
.78	161.4	145.1	128.8	112.4	95.8	78.9	61.6	43.1
.80	197.9	177.7	157.3	136.9	116.3	95.4	74.0	51.3
.82	247.4	221.7	195.9	170.0	143.9	117.5	90.5	62.0
.84	316.7	283.3	249.7	216.1	182.2	147.9	113.0	76.4
.86	418.3	373.3	328.2	283.0	237.6	191.8	145.2	96.6
.88	575.1	512.1	449.0	385.8	322.3	258.3	193.5	126.4
.90	836.0	742.6	649.1	555.5	461.5	367.1	271.7	173.6
.92	1317.6	1167.3	1017.0	866.5	715.6	564.2	411.7	256.0
.94	2360.8	2085.8	1810.6	1535.2	1259.5	983.3	705.6	424.0
.96	5349.3	4712.0	4074.5	3436.8	2798.7	2159.9	1519.6	874.2
.98	21531.3	18905.0	16278.5	13651.8	11024.7	8396.8	5767.1	3130.8

TABLE II

TEST TIME FACTORS, T_0 $\alpha = .10$ $\beta = .10$								
D	Π_0, CAPABILITY FACTOR DESIRED							
	.60	.65	.70	.75	.80	.85	.90	.95
.40	8.8	8.0	7.2	6.4	5.5	4.6	3.7	2.6
.42	9.7	8.8	7.9	7.0	6.1	5.1	4.1	2.9
.44	10.7	9.7	8.8	7.8	6.7	5.7	4.5	3.3
.46	11.8	10.8	9.7	8.6	7.4	6.3	5.0	3.6
.48	13.1	11.9	10.7	9.5	8.3	7.0	5.6	4.1
.50	14.5	13.2	11.9	10.5	9.2	7.7	6.2	4.5
.52	16.1	14.7	13.2	11.7	10.2	8.6	6.9	5.0
.54	18.0	16.4	14.7	13.0	11.3	9.6	7.7	5.6
.56	20.1	18.3	16.5	14.6	12.7	10.7	8.6	6.2
.58	22.6	20.5	18.4	16.3	14.2	11.9	9.6	7.0
.60	25.4	23.1	20.7	18.3	15.9	13.4	10.7	7.8
.62	28.7	26.1	23.4	20.7	17.9	15.1	12.1	8.8
.64	32.7	29.6	26.6	23.4	20.3	17.0	13.6	9.9
.66	37.3	33.8	30.3	26.7	23.1	19.3	15.4	11.2
.68	42.9	38.8	34.7	30.6	26.4	22.1	17.6	12.7
.70	49.6	44.9	40.1	35.3	30.3	25.3	20.1	14.4
.72	57.9	52.3	46.6	41.0	35.2	29.3	23.2	16.6
.74	68.2	61.5	54.8	48.0	41.1	34.1	26.9	19.1
.76	81.2	73.2	65.0	56.9	48.6	40.2	31.5	22.2
.78	98.0	88.1	78.2	68.3	58.2	47.9	37.4	26.2
.80	120.2	107.9	95.6	83.2	70.6	58.0	44.9	31.1
.82	150.2	134.6	119.0	103.2	87.4	71.4	54.9	37.6
.84	192.4	172.1	151.7	131.2	110.6	89.9	68.6	46.4
.86	254.0	226.7	199.4	171.9	144.3	116.5	88.2	58.7
.88	349.3	311.0	272.7	234.3	195.7	156.9	117.5	76.8
.90	507.8	451.0	394.2	337.4	280.3	223.0	165.0	105.4
.92	800.2	709.0	617.7	526.2	434.6	342.7	250.1	155.5
.94	1433.8	1266.8	1099.7	932.4	765.0	597.2	428.6	257.5
.96	3249.0	2861.9	2474.7	2087.3	1699.8	1311.8	922.9	531.0
.98	13077.2	11482.1	9886.9	8291.5	6695.9	5099.9	3502.7	1901.5

TABLE III

TEST TIME FACTORS, T_0

$\alpha = .15$ $\beta = .15$

D	Π_0, CAPABILITY FACTOR DESIRED							
	.60	.65	.70	.75	.80	.85	.90	.95
.40	5.7	5.2	4.7	4.2	3.6	3.0	2.4	1.7
.42	6.3	5.8	5.2	4.6	4.0	3.3	2.7	1.9
.44	7.0	6.4	5.7	5.1	4.4	3.7	3.0	2.1
.46	7.7	7.0	6.3	5.6	4.9	4.1	3.3	2.4
.48	8.5	7.8	7.0	6.2	5.4	4.5	3.6	2.6
.50	9.5	8.6	7.8	6.9	6.0	5.0	4.1	2.9
.52	10.5	9.6	8.6	7.6	6.6	5.6	4.5	3.3
.54	11.8	10.7	9.6	8.5	7.4	6.2	5.0	3.7
.56	13.1	12.0	10.7	9.5	8.3	7.0	5.6	4.1
.58	14.7	13.4	12.0	10.7	9.2	7.8	6.3	4.6
.60	16.6	15.1	13.5	12.0	10.4	8.7	7.0	5.1
.62	18.8	17.0	15.3	13.5	11.7	9.8	7.9	5.7
.64	21.3	19.3	17.3	15.3	13.2	11.1	8.9	6.5
.66	24.4	22.1	19.8	17.4	15.1	12.6	10.1	7.3
.68	28.0	25.3	22.7	20.0	17.2	14.4	11.5	8.3
.70	32.4	29.3	26.2	23.0	19.8	16.5	13.1	9.4
.72	37.8	34.1	30.5	26.7	23.0	19.1	15.1	10.8
.74	44.5	40.2	35.8	31.4	26.9	22.3	17.6	12.5
.76	53.0	47.8	42.5	37.1	31.8	26.3	20.6	14.5
.78	64.0	57.6	51.1	44.6	38.0	31.3	24.4	17.1
.80	78.5	70.5	62.4	54.3	46.1	37.9	29.4	20.3
.82	98.1	87.9	77.7	67.4	57.1	46.6	35.9	24.6
.84	125.6	112.4	99.1	85.7	72.3	58.7	44.8	30.3
.86	165.9	148.1	130.2	112.3	94.2	76.1	57.6	38.3
.88	228.1	203.1	178.1	153.0	127.8	102.5	76.8	50.1
.90	331.6	294.5	257.5	220.3	183.1	145.6	107.8	68.8
.92	522.6	463.0	403.4	343.7	283.8	223.8	163.3	101.5
.94	936.4	827.3	718.1	608.9	499.6	390.0	279.9	168.2
.96	2121.7	1868.9	1616.1	1363.1	1110.0	856.7	602.7	346.8
.98	8540.0	7498.3	6456.6	5414.7	4372.7	3330.4	2287.4	1241.8

TABLE IV

TEST TIME FACTORS, T_a

$\alpha = .20$ $\beta = .20$

D	Π_a, CAPABILITY FACTOR DESIRED							
	.60	.65	.70	.75	.80	.85	.90	.95
.40	3.8	3.4	3.1	2.7	2.4	2.0	1.6	1.1
.42	4.2	3.8	3.4	3.0	2.6	2.2	1.8	1.3
.44	4.6	4.2	3.8	3.3	2.9	2.4	2.0	1.4
.46	5.1	4.6	4.2	3.7	3.2	2.7	2.2	1.6
.48	5.6	5.1	4.6	4.1	3.6	3.0	2.4	1.7
.50	6.2	5.7	5.1	4.5	3.9	3.3	2.7	1.9
.52	6.9	6.3	5.7	5.0	4.4	3.7	3.0	2.2
.54	7.7	7.0	6.3	5.6	4.9	4.1	3.3	2.4
.56	8.7	7.9	7.1	6.3	5.4	4.6	3.7	2.7
.58	9.7	8.8	7.9	7.0	6.1	5.1	4.1	3.0
.60	10.9	9.9	8.9	7.9	6.8	5.8	4.6	3.4
.62	12.4	11.2	10.1	8.9	7.7	6.5	5.2	3.8
.64	14.1	12.7	11.4	10.1	8.7	7.3	5.9	4.3
.66	16.1	14.5	13.0	11.5	9.9	8.3	6.6	4.8
.68	18.4	16.7	14.9	13.2	11.3	9.5	7.6	5.5
.70	21.4	19.3	17.3	15.2	13.1	10.9	8.7	6.2
.72	24.9	22.5	20.1	17.6	15.1	12.6	10.0	7.1
.74	29.3	26.5	23.6	20.7	17.7	14.7	11.6	8.2
.76	35.0	31.5	28.0	24.5	20.9	17.3	13.6	9.6
.78	42.2	37.9	33.7	29.4	25.0	20.6	16.1	11.3
.80	51.7	46.4	41.1	35.8	30.4	24.9	19.3	13.4
.82	64.7	57.9	51.2	44.4	37.6	30.7	23.6	16.2
.84	82.8	74.0	65.3	56.5	47.6	38.7	29.5	20.0
.86	109.3	97.6	85.8	74.0	62.1	50.1	37.9	25.3
.88	150.3	133.9	117.4	100.8	84.2	67.5	50.6	33.0
.90	218.5	194.1	169.7	145.2	120.6	95.9	71.0	45.4
.92	344.4	305.1	265.8	226.5	187.0	147.5	107.6	66.9
.94	617.0	545.2	473.2	401.3	329.2	257.0	184.4	110.8
.96	1398.2	1231.6	1065.0	898.3	731.5	564.5	397.2	228.5
.98	5627.7	4941.2	4254.8	3568.2	2881.6	2194.7	1507.4	818.3

TABLE V

CRITICAL VALUES, Π_c								
D	Π_{cr}, CAPABILITY FACTOR DESIRED							
	.60	.65	.70	.75	.80	.85	.90	.95
.40	.368	.403	.441	.480	.524	.573	.632	.713
.42	.379	.415	.453	.493	.537	.586	.645	.726
.44	.390	.426	.465	.506	.550	.599	.658	.737
.46	.400	.437	.477	.518	.562	.612	.670	.748
.48	.410	.448	.488	.529	.574	.624	.682	.759
.50	.419	.458	.498	.541	.586	.635	.693	.769
.52	.429	.468	.509	.551	.597	.646	.704	.778
.54	.438	.478	.519	.562	.607	.657	.714	.787
.56	.447	.487	.529	.572	.618	.667	.724	.796
.58	.455	.496	.538	.582	.628	.677	.733	.804
.60	.464	.505	.547	.591	.637	.687	.743	.812
.62	.472	.514	.556	.601	.647	.696	.752	.820
.64	.480	.522	.565	.610	.656	.705	.760	.828
.66	.487	.530	.574	.618	.665	.714	.769	.835
.68	.495	.538	.582	.627	.674	.723	.777	.842
.70	.502	.546	.590	.635	.682	.731	.785	.849
.72	.510	.554	.598	.644	.691	.740	.793	.855
.74	.517	.561	.606	.652	.699	.748	.801	.862
.76	.524	.568	.614	.660	.707	.756	.808	.868
.78	.531	.576	.621	.668	.715	.764	.816	.875
.80	.537	.583	.629	.675	.723	.772	.823	.881
.82	.544	.590	.636	.683	.731	.779	.830	.887
.84	.550	.597	.644	.691	.738	.787	.838	.893
.86	.557	.604	.651	.698	.746	.795	.845	.900
.88	.563	.610	.658	.706	.754	.802	.852	.906
.90	.569	.617	.665	.713	.761	.810	.860	.912
.92	.576	.624	.672	.720	.769	.818	.867	.919
.94	.582	.630	.679	.728	.777	.826	.875	.926
.96	.588	.637	.686	.735	.784	.834	.883	.933
.98	.594	.643	.693	.743	.792	.842	.891	.941

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APPENDIX B

DATA RECORDING and AUTOMATED ANALYSIS PROCEDURES

1. General

This appendix provides a description of recommended data collection and recording procedures applicable to the conduct of a prove-out demonstration test of the capability of a production facility.

2. Purpose

The basic intent of the data collection and recording procedures described herein is to adequately account for every minute of operation of every station/machine being monitored during the demonstration test. This data provides a complete and accurate record of every machine's performance, so that a precise assessment of production capability will result from the analysis. Additionally, the recommended data recording format provides a means of establishing convenient data files for input to automated analysis software for processing of the data required to prepare the DTR.

3. Data Collection Sheet

a. The recommended data collection sheet to be utilized during the demonstration test is provided in Figure 13.

b. Instructions for completion of the data collection sheet are as follows:

Block	Instructions
1	Enter name of production facility.
2	Print or type data collector's name, leaving room for signature.
3	Enter function or operation that the production station performs. Only one station/machine per data sheet.
4	Enter page number and total number of pages for the station.
5	Enter assigned station number.
6	Enter "Start of Shift" time, to the nearest minute, using Military (2400 hr) time. If more than one station is being observed, take care to record each station's start time on the appropriate data sheet.

INSTALLATION (1)			DATA COLLECTION OPERATION (3)			NO. OF UNITS PRODUCED (16)		LBS___ PTS___ OTHER___ (17)
PAGE___OF___ (4)	STATION NO. (5)		START TIME OF SHIFT (6)		END TIME OF SHIFT (15)	RATE (14)	ACCEPT (18)	REJECTS (19)

DATE (7)	EVENT TIME (8)	EVENT CODE (9)	DURATION (10)		REMARKS (11)	(12) / MP	FAILURE CODE (13)
			MIN.	SEC.			

EVENT CODES

1. END OF SHIFT
2. BREAK/LUNCH
3. CORRECTIVE MAINTENANCE
4. END OF TEST
5. PREVENTIVE MAINTENANCE
6. ADMINISTRATIVE (STATE REASON)
7. SPECIAL USE (SEE INSTRUCTIONS)
8. OPERATIONAL DOWNTIME (TOOL CHANGE)

MP - MAINTENANCE PERSONNEL

SIGNATURE (20)

TYPED NAME (2)

FIGURE 13 - DATA COLLECTION SHEET

Block	Instructions
	(Blocks 7 through 12 are completed for each stoppage following start time.)
7	Enter test date on each data record line used. Start a new sheet each day. A 6-digit format should be used; e.g. 3 February 1987 would be recorded as 020387.
8	Enter the event stop time to the nearest minute, using Military time. (A timing device, such as a stopwatch, should be used and started immediately to measure precisely the duration of the stoppage).
9	Enter the appropriate 1-digit event code selected from the list of codes provided at the bottom of the form. (A detailed explanation of these codes and their usage is provided below.)
10	After the station is restored to an operating condition, enter the duration of downtime in minutes and seconds.
11	Enter remarks which clearly describe the reason for the station stoppage unless an equipment failure code (see Block 13) is applicable, in which case this block need not be completed. It is essential that stoppages for the same reason result in this block being completed in a consistent manner. The entry in this block is limited to 47 alphanumeric characters including blanks.
12	If the number of maintenance personnel required to restore station to operation exceeds one (1), enter number utilized.
13	If the stoppage is the result of an equipment failure requiring corrective maintenance (Event Code 3) and a previously defined 3-digit failure code describes the mode of failure, the failure code is entered.
14	At least four times a shift the actual production rate should be measured while the station/machine is experiencing uninterrupted operation. All rate measurements will be averaged to compute an average rate for the shift. The average rate is recorded in this block.
15	Enter the "End of Shift" time to the nearest minute in Military time. If the "End of Test" (Event Code 4) occurs during the day data is being gathered, it is that time which is recorded in this block. Under any circumstances the time recorded in this block is the time at which the station was shut down for the day, unless required corrective maintenance on the station caused the shutdown. In this latter case the time of day maintenance personnel cease effort is recorded.
16	Enter the total number of units processed during the shift whether it be in pounds or parts.

Block	Instructions
17	Indicate whether the entry in Block 16 is in pounds or parts. If another term is applicable, enter the term in OTHER.
18	Enter the number of acceptable (conforming or nondefective) units, parts, pounds, etc. processed during the shift.
19	Enter the sum of the number of rejects which occurred during the shift. This includes repairable and non-repairable (scrap) rejects.
20	Sign completed data forms at the end of the shift and turn in to individual assigned primary responsibility for the data collection process.

c. Event Codes - The data reporting system developed for the prove-out demonstration tests hinges upon the identification of all significant activities experienced by each production operation/station/machine during the test. These activities, or events, are mutually exclusive in the sense that every machine is engaging in one of these activities at all times. Each of these events has a specific code number assigned to it. The intent, characteristics, and requirements of each event code are presented below.

(1) Code 0: Start of Shift - It is necessary, for every machine, for every day, to record the time at which production was scheduled to begin, i.e. the nominal start of shift. A decision will have been made beforehand as to whether any so-called warm-up or set-up time is to be included as part of the shift.

(2) Code 1: End of Shift - The scheduled end of production time for each machine each day is also to be recorded. As with start of shift, a decision will have been made as to whether or not tear-down or clean-up time is to be included.

(3) Code 2: Lunch/Breaks - The most common stoppage for a machine is caused quite simply by the operator not being present. There may be several reasons why an operator is not present and all must be accounted for. Those absences due to regularly scheduled lunches or breaks are to be recorded by event code 2. No other machine stoppage, even if operator related, should be recorded with this code. The time that the lunch or break begins shall be recorded in the usual manner. In addition, it is important to know how long the stoppage lasted. Thus, the duration must also be recorded. This, and any other duration, is to be recorded in minutes and seconds. That is, a 30 minute lunch would be recorded as 30:00.

(4) Code 3: Unscheduled Stoppage/Corrective Maintenance (Failure) - One of the primary reasons for running a prove-out demonstration test is to estimate production equipment availability. Hence, it is important to properly identify and calculate downtime, i.e. attribute to the equipment all the stoppages that are due to the equipment itself and not due to some outside influence. Event code 3 is used for all unscheduled stoppages, those lapses in production that can properly be called a failure of the machine. In practice, the use of code 3 should be straightforward, as most failure modes should have been experienced or anticipated prior to the start of the test. In such cases it may be more efficient for recording and processing of the data to assign all failure modes a failure code number prior to the test. Additional codes can be assigned after the test begins to cover

those failures not anticipated. As for code 2, failure events require the start time and duration. Note carefully that the duration for a code 3 should be the time actually spent to correct the failure. If a lunch or break should occur while the repair is being made, care should be used to record the proper duration of these two non-overlapping events. If a repair must be delayed until the arrival of a repairman and if this delay is lengthy, prior agreement may allow for part of the total downtime for that machine to be attributed to administrative downtime (code 6). If failure codes are employed, each code 3 event is appropriately annotated by one of them.

(5) Code 4: End of Test - On the last day of the test, a code 4 shall be used to note the end of shift, rather than a code 1. All details applicable to event code 1 for data collection also apply to code 4.

(6) Code 5: Preventive Maintenance - If a preventive maintenance policy is incorporated into the test, such that a machine is deliberately stopped to preclude failure rather than for repair, then event code 5 shall be employed. Just as with code 3, the information collected is start time and duration.

(7) Code 6: Administrative Downtime - Any unscheduled stoppage that cannot be rightly charged against the machine should be considered of an administrative nature. This category, a code 6, covers many diverse activities, including set-up or tear-down time, safety briefings, power failures, lack of parts or raw material, union meetings, awaiting maintenance personnel or repair parts, etc. The purpose of a code 6 is to account for stoppages which are not of a routine, recurring nature and which should not be counted as part of the downtime for the machine. In general, the activities to be considered as administrative downtime would be discussed before the test begins.

(8) Code 7: Special Use - This code can be used to characterize special events peculiar to a particular system/operation/station/machine not suitably described by other event codes defined herein.

(9) Code 8: Tool Change - Some machines require, as part of their normal operation,replacement of tool heads at at fairly fixed intervals. Such procedures are not preventive maintenance, because in general the machine itself is not serviced. They are not administrative downtime because they represent repetitive anticipated stoppages. They are not failures because the machine itself was still producing parts at the time of the stoppage. Therefore, a distinct event code is required. Use of this code requires discussion prior to the start of the test and care must be taken to distinguish among tool change, tool breakage, and tool adjustment, which represent quite different situations. The latter two are more readily included under code 3 events.

d. Special Considerations - Most events will be straightforward and the recording of them should present no problems, either because the nature of the event is self-evident or sufficient preparations were made beforehand to anticipate those events which are not obvious. Occasionally, however, some situations may arise which could benefit from further discussion herein.

(1) Off-shift Repairs - Now and then a failure may occur which is so severe that it cannot be repaired during the shift in question and repairs must extend into at least the next shift. Such a situation creates two problems, namely how to record the event properly and also how to determine the correct duration for the time to repair. Two general rules apply here. First, only one failure has actually occurred, so that, no matter how many days (or

shifts) it spans, only one code 3 event should be recorded. Second, all repairs must be considered as taking place during a work shift. Thus, if repairmen work overtime on the repair, the end- of-shift time must be adjusted accordingly. Consider the following example: a machine fails at 3 pm; the normal shift ends a 4:30; repairmen stay till 5:30 but cannot finish the repair; the next shift starts at 7:30 am; and the repair is finally finished at 8:15. The proper way to record this event is as follows. Show a code 3 at 1500on the first day with a duration of 195 minutes; a code 6 at 0730 (the next day) for a duration of 45 minutes. Note that all the repair time is shown at once on the code 3 event line and that the 45 minutes of missed production the next day is considered as administrative downtime, since all real downtime attributable to the machine has already been accounted for.

(2) Multiple or Continuous Failures - Certain types of failures can only be repaired by tinkering, that is by making an adjustment, running the machine, making another adjustment, and so on. Typically these adjustments take only 10 or 15 seconds and the run periods are only 1 or 2 minutes. Under these circumstances, it is not correct to consider each stoppage and adjustment as a separate failure, so long as the same problem is being addressed throughout. For one thing, as long as adjustments are necessary, the machine should not really be considered as upand running. Also because event times can only be recorded in whole minutes, these multiple events tend to get recorded as having taken place simultaneously. This causes problems when determining MTTF. As described here, these multiple events should be recorded as a single failure, with duration reflecting the true time the machine was out of service.

4. Data Recording

a. Following completion of data collection as described in the preceding section, it is recommended that data files be established on a data storage device (magnetic tape, hard or floppy disk, etc.) to serve as the permanent record of the test and provide a consistent format for automated processing and analyses. This section provides the recommended format for such data files. This format is used for input files for already existing software available from the Government.

b. Data File Structure - A typical file for a single operation/machine has the following basic format:

Header Record
Code 0 Record for 1st Day Start
Records for All Event Codes 2, 3, 5, 6, 7, or 8 for 1st Day Events
Code 1 Record for 1st Day End
Code 0 Record for 2nd Day Start
Records for All Event Codes 2, 3, 5, 6, 7, or 8 for 2nd Day Events
Code 1 Record for 2nd Day End
Code 0 Record for Last Day Start
Records for All Event Codes 2, 3, 5, 6, 7, or 8 for Last Day Events
Code 4 Record for Last Day End of Test (Not a Code 1 Record)

c. Data Record Formats - Each record in the data file is essentially comprised of 80 character positions, some of which may not be used (left blank) for a particular kind of record. The field definitions and lengths for each kind of record are as follows:

(1) Header Record

Char. 1 - 30	......Preassigned machine or station title.
Char. 31- 62	......Blank
Char. 63- 66	......Preassigned 4-digit Operation Number
Char. 67	......Blank or hyphen
Char. 68- 70	......Preassigned 3-digit Station Number
Char. 71	......Blank
Char. 72- 80	......Facility Name

NOTE: The use of station numbers is optional. It provides a means of identifying machines performing the same production operation. SP 1 (2) Event Code Records

Char. 1 - 6	......6-digit Date (MMDDYY)
Char. 7 - 10	......4-digit Event Time (for Code 0 only)
Char. 11- 14	......4-digit Event Time (for all other codes)
Char. 15	......1-digit Event Code
Char. 16- 21	......6-digit Duration (where applicable) (MMMMSS)
Char. 22- 25	......Operation Number (same as header)
Char. 26- 28	......Station Number or Blank
Char. 29- 33	......Blank
Char. 34- 71	......Descriptive Comments (for Codes 2,3,5,6,7,8)
Char. 72- 80	......Facility Name

NOTES:

i. For event code 0, the time is placed in char. 7 - 10. For all other events, the time is placed in char. 11 - 14. This aids in locating the start of each day's data when visually scanning file listing.

ii. The downtime duration is placed in char. 16 - 21 only for those records requiring it. The number of minutes go in char. 16 - 19 and the number of seconds in char. 20 - 21.

iii. The operation number is placed in char. 22 - 25 for all event records except codes 1 and 4. These event records have specialized formats as explained in note vi below.

iv. If predefined failure codes are being used in event code 3 records, they will be placed in the first three character positions of the comment field, i.e. char. 34 - 36.

v. The facility name shall be placed in char. 72 - 80 in all records.

vi. Event Code 1 and 4 records require the entry of production data as follows: production quantity (right-justified) in char. 30 - 35; rejects (right-justified) in char. 43 - 46; and production rate in parts per minute in char. 52 - 56. When rate timings are not made on any day, the rate field should be omitted.

d. Figure 14 provides an illustration of a sample data file.

```
WIDGET MACHINE                                                      0005-001 ACME AAP
0612870815    0        0005001                                               ACME AAP
061287     08206003412000S001    UPSET PRESS FAILURE                         ACME AAP
061287     09296000604000S001    UPSET PRESS ADJUSTED                        ACME AAP
061287     10402000908000S001    BREAK                                       ACME AAP
061287     12002002500000S001    LUNCH                                       ACME AAP
061287     12423002308000S001    HEATER COOLER DOWN                          ACME AAP
061287     13133000612000S001    POWER RESET                                 ACME AAP
061287     13253000027000S001    BILLET JAM                                  ACME AAP
061287     13283002318000S001    POWER SHUT OFF                              ACME AAP
061287     14326000304000S001    PIERCE PUNCH ADJUSTED                       ACME AAP
061287     15251        0005001  212           0          .95                ACME AAP
0613870730    0        0005001                                               ACME AAP
061387     07423000506000S001    POWER SHUT OFF                              ACME AAP
061387     08196000408000S001    UPSET SWITCH STUCK                          ACME AAP
061387     08246000305000S001    UPSET SWITCH STUCK                          ACME AAP
061387     08406001414000S001    UPSET SWITCH REPAIRED                       ACME AAP
061387     09206000614000S001    IRON - LUBE PROBLEM                         ACME AAP
061387     11106000618000S001    UPSET PUNCH ADJUSTED                        ACME AAP
061387     12002002600000S001    LUNCH                                       ACME AAP
061387     12306000252000S001    ROBOT STUCK                                 ACME AAP
061387     13056004500000S001    IRON - BROKE STUD                           ACME AAP
061387     14021        0005001  152           0          .95                ACME AAP
0614870730    0        0005001                                               ACME AAP
061487     07306045500000S001    PIERCE DOWN                                 ACME AAP
061487     12002002500000S001    LUNCH                                       ACME AAP
061487     15301        0005001  000           0                             ACME AAP
0615870730    0        0005001                                               ACME AAP
061587     08153041000000S001    BELT BROKE                                  ACME AAP
061587     12002002500000S001    LUNCH                                       ACME AAP
061587     15304        0005001  010           0                             ACME AAP
```

FIGURE 14 - SAMPLE DATA FILE

5. Data Reduction

The following process should be followed in reducing the collected data to provide the quantities which would be presented in the "Test Data Summary" for each operation as illustrated in Figure 11 of Section 5.6 of this handbook.

a. Scheduled Uptime = Total Shift Length - (Σ Code 2 + Σ Code 6)

where Total Shift Length = Code 1 - Code 0

b. Total Breaks = Σ Code 2 + Σ Code 6

c. Total Downtime = Σ Code 3 + Σ Code 5 + Σ Code 8

d. Actual Uptime = Scheduled Uptime - Total Downtime

e. Availability = (Actual Uptime) / (Schedule Uptime)

f. Total Failures = Number of Code 3 Events

g. MTBF = (Actual Uptime) / (Total Failures)

h. MTTR = (Σ Code 3) / (Total Failures)

i. Total Rejects = (Chars. 44-46 on Code 1 or 4 Event Record)

j. Total Processed = (Chars. 29-34 On Code 1 or 4 Event Record)

k. Total Accepted = Total Processed - Total Rejects

l. Observed Rate = (Total Processed) / (Actual Uptime)

m. Net Rate = (Total Accepted) / (Scheduled Uptime)

A computer program, RAMASS, has been written in the C programming language to perform this reduction. A compiled version of the program on a 5 1/4" floppy disk is available for IBM PC's and compatibles upon request from: Commander, U.S. Army Production Base Modernization Activity, ATTN: AMSMC-PBT-P(D), Picatinny Arsenal, NJ 07806-5000. Information regarding the program source code is also available upon request from the above address. The next section of this appendix provides a sample of the input and output for the program.

6. RAMASS Program for Automated Analysis

a. Sample Input File - a listing of a short, but illustrative, input file is provided on the following page.

SAMPLE INPUT FILE FOR PROGRAM RAMASS

```
PALLETIZER - 81MM                                                   2007-001 XAAP
1115870800    0       0007001                                                 XAAP
111587      08006003000000007001    OPERATOR ABSENT                           XAAP
111587      09403000015000007001    32 FAILED TO COUNT BOX                    XAAP
111587      10343000103000007001    33 STUCK HYD VALVE                        XAAP
111587      10456000121000007001    WAIT FOR BOXES                            XAAP
111587      10523000016000007001    33 STUCK HYD VALVE                        XAAP
111587      10546000023000007001    OPERATOR ERROR                            XAAP
111587      11026001831000007001    OPERATOR ERROR                            XAAP
111587      11256000148000007001    NO PALLET                                 XAAP
111587      11293000045000007001    33 PALLET FEEDER VALVE STUCK              XAAP
111587      11333001015000007001    34 BROKEN LIMIT SWITCH CAM                XAAP
111587      13056000051000007001    STRAP HUNG                                XAAP
111587      13076000126000007001    STRAP HUNG                                XAAP
111587      13286000158000007001    STRAP HUNG                                XAAP
111587      13316000146000007001    STRAP HUNG                                XAAP
111587      13336000030000007001    OPERATOR ERROR                            XAAP
111587      13376000110000007001    OPERATOR ERROR                            XAAP
111587      13483000035000007001    32 FAILED TO COUNT                        XAAP
111587      13566000027000007001    STRAP HUNG                                XAAP
111587      14173000056000007001    35 MISALIGNMENT LIMIT SWITCH              XAAP
111587      14193000350000007001    35 MISALIGNMENT LIMIT SWITCH              XAAP
111587      14253000021000007001    32 FAILED TO COUNT                        XAAP
111587      14503000026000007001    35 MISALIGNED LIMIT SWITCH                XAAP
111587      15206004000000007001    CLEAN UP                                  XAAP
111587      16001         0007001  10800          0         43                XAAP
1116870800    0       0007001                                                 XAAP
111687      08006000800000007001    OPERATOR NOT PRESENT                      XAAP
111687      08153000030000007001    32 FAILED TO COUNT 1 BOX                  XAAP
111687      08253000048000007001    32 FAILED TO COUNT 1 BOX                  XAAP
111687      08503000035000007001    32 FAILED TO COUNT 1 BOX                  XAAP
111687      09093000030000007001    32 FAILED TO COUNT 1 BOX                  XAAP
111687      09443000012000007001    35 FAILURE TO STACK PROPERLY              XAAP
111687      10446000551000007001    WAIT FOR BOXES                            XAAP
111687      11222002500000007001    LUNCH BREAK                               XAAP
111687      12073000060000007001    32 FAILED TO COUNT 1 BOX                  XAAP
111687      14183000123000007001    32 FAILED TO COUNT BOX                    XAAP
111687      14504         0007001  14580          0         47                XAAP
```

b. Sample Output - a portion of the output provided by RAMASS for the input file listed above is provided on the following pages.

SAMPLE OUTPUT for PROGRAM RAMASS

MODULE 6 = PALLETIZER - 81MM　　　OPERATION 0007 at XAAP　　　12/01/87

Date	Start Time	Event Time	Time to Failure	Repair Length	Module Failure	System Failure	Failure Mode
11/15/87	08:00						
11/15/87		09:40	70.00	0.25	1	20	32 FAILED TO COUNT BOX
11/15/87		10:34	53.75	1.05	2	21	33 STUCK HYD VALVE
11/15/87		10:52	15.60	0.27	3	22	33 STUCK HYD VALVE
11/15/87		11:29	16.03	0.75	4	23	33 PALLET FEEDER VALVE STUCK
11/15/87		11:33	3.25	10.25	5	24	34 BROKEN LIMIT SWITCH CAM
11/15/87		13:48	117.07	0.58	6	25	32 FAILED TO COUNT
11/15/87		14:17	27.97	0.93	7	26	35 MISALIGNMENT LIMIT SWITCH
11/15/87		14:19	1.07	3.83	8	27	35 MISALIGNMENT LIMIT SWITCH
11/15/87		14:25	2.17	0.35	9	28	32 FAILED TO COUNT
11/15/87		14:50	24.65	0.43	10	29	35 MISALIGNED LIMIT SWITCH
11/15/87		End of Shift at 16:00					
11/16/87	08:00						
11/16/87		08:15	36.57	0.50	11	30	32 FAILED TO COUNT 1 BOX
11/16/87		08:25	9.50	0.80	12	31	32 FAILED TO COUNT 1 BOX
11/16/87		08:50	24.20	0.58	13	32	32 FAILED TO COUNT 1 BOX
11/16/87		09:09	18.42	0.50	14	33	32 FAILED TO COUNT 1 BOX
11/16/87		09:44	34.50	0.20	15	34	35 FAILURE TO STACK PROPERLY
11/16/87		12:07	111.95	1.00	16	35	32 FAILED TO COUNT 1 BOX
11/16/87		14:18	130.00	1.38	17	36	32 FAILED TO COUNT BOX
11/16/87		End of Shift at 14:50					

SAMPLE OUTPUT for PROGRAM RAMASS

.ily Stats for PALLETIZER - 81MM OPERATION 0007 at XAAP 12/01/87

Date	Sched. Uptime	Total Breaks	Total Down	Actual Uptime	Avail.	MTBF	MTTR	Tot. Fail	Tot. Rej.	Total Prod.	Prod Rate	Obsv Rate (In PPM)	Net Rate (In PPM)
;/15/87	379.82	100.18	18.70	361.12	0.95077	36.11	1.87	10	0	10800	43	29.91	28.43
1/16/87	371.15	38.85	4.97	366.18	0.98662	52.31	0.71	7	0	14580	47	39.82	39.28
fotals	750.97	139.03	23.67	727.30	0.96849	42.78	1.39	17	0	25380		34.90	33 80

Action	Count	Total	Avg.	Low	High
Preventive	0	0	0.00	0.0	0.0
Admin.	15	114	7.60	0.4	40.0
Tool Chng.	0	0	0.00	0.0	0.0

S	90% Confidence Int. for Net Rate	
0.365	33.195	34.397

SAMPLE OUTPUT for PROGRAM RAMASS

STATION SUMMARY

12/01/87

Module	MTBF	MTTR	Total Module Fail.	Avail.	Total Sched. Uptime	Total Actual Uptime	Net Rate	Rej Rate
EXPLOSIVE INSP + DISP SYS 60MM	131.85	31.38	1	0.80774	163.23	131.85	33.08	0.00
MELT - 60MM	87.29	8.38	3	0.84311	310.62	261.89	16.57	0.00
POUR - 60MM	252.70	1.43	1	0.90987	277.73	252.70	17.73	0.04
HOT PLATES + PALLET CONV-60MM	130.94	2.22	2	0.98335	266.32	261.89	20.28	0.00
CAST FINISHING - 60MM	20.75	3.02	12	0.80434	309.55	248.98	16.34	0.01
PALLETIZER - 81MM	42.78	1.39	17	0.96849	750.97	727.30	33.80	0.00

APPENDIX C

ACQUISITION CLAUSES AND DOCUMENTS

1. General

This appendix provides baseline guidance for implementation of the prove-out procedures covered in this handbook in conjunction with the facility acquisition process. This baseline guidance may be tailored to suit individual project requirements.

2. Acquisition Clauses

a. Demonstration Test Specification (DTS)

Since the DTS is a Government prepared document, acquisition is not normally applicable. However, where the preparing organization desires a contractor review of the DTS prior to finalization, the following requirements clause may be included in the appropriate contract:

"The contractor shall review the Government furnished DTS and provide the results of this review to (specify organization). (DI-MISC-80508)"

b. Demonstration Test Plan (DTP)

"The contractor shall prepare a DTP in accordance with the applicable DTS (cite specific DTS, if possible) and the basic guidance in MIL-HDBK-792(AR), Prove-out of Production Facilities, Section 5.4. (DI-QCIC-80775)."

c. Demonstration Test (DT)

"The contractor shall conduct a system demonstration test to determine the capability of the facility and equipment to produce an acceptable product at the design rate. The demonstration test shall be performed in accordance with the approved DTP (cite specific DTP, if possible). Advance notice of the test will be furnished to the Government prior to testing. (DI-T-1909)"

d. Demonstration Test Report (DTR)

"The contractor shall provide a DTR in accordance with the approved DTP (cite specific DTP, if possible) and basic guidance in MIL-HDBK-792(AR), Prove-out of Production Facilities, Section 5.6. (DI-QCIC-80774)."

3. Contract Data Requirements List (CDRL)

A sample CDRL, DD1423, corresponding to the requirements clauses of Appendix C, section 2, is shown in figure 15.

4. Data Item Descriptions (DID)

Sample DID's corresponding to the requirements clauses and CDRL of Appendix C, sections 2 and 3, respectively, are shown in figures 16, 17, 18, and 19.

CONTRACT DATA REQUIREMENTS LIST

ATCH NR ____ TO EXHIBIT ____ TO CONTRACT/PR ____

CATEGORY ____

SYSTEM/ITEM ____

CONTRACTOR ____

Sequence Number	Title or Description of Data / Subtitle	Authority (Data Item Number)	Contract Reference	Technical Office	Frequency / As of Date	Date of 1st Submission / Date of Subsequent Submission	Distribution and Addressees	
	Technical Report - Study/Services DTS Review Comments	DI - MISC - 80508 *	Insert applicable SOW Para	Approval Organization LT	OTIME	See Blk 16	Approval Org (List others as applicable)	(Specify no. of copies for each)
Remarks: * Contractor format is acceptable. Submit no later than (Specify) days after receipt of DTS.								Total
	Demonstration Test Plan	DI-QCIC-80775	Insert applicable SOW Para	Approval Organization LT	ONE/R	See Blk 16 R/ASR	Approval Org (List others as applicable)	(Specify no. of copies for each)
Remarks: Submission NLT (Specify) days prior to start-up.								Total
	Test Scheduling Report Notification of Test	DI - T - 1909 *	Insert applicable SOW Para	Approval Organization LT	ASREQ	See Blk 16 See Blk 16	Approval Org (List others as applicable)	(Specify no. of copies for each)
Remarks: * Report to be submitted (Specify) days prior to test. Omit para 10.3 through 10.7. Contractor format acceptable.								Total
	Demonstration Test Report	DI-QCIC-80774	Insert applicable SOW Para	Approval Organization LT	ONE/R	See Blk 16	Approval Org (List others as applicable)	(Specify no. of copies for each)
Remarks: Final report is to be forwarded within (Specify) days after completion of the demonstration test.								Total

PREPARED BY ____ DATE ____ APPROVED BY ____ DATE ____

DD FORM 1423 PAGE 1 OF 1 PAGES

FIGURE 15. SAMPLE DD1423, CDRL

DATA ITEM DESCRIPTION				Form Approved OMB No. 0704-0188
2. TITLE Technical Report - Study/Services			1. IDENTIFICATION NUMBER DI-MISC-80508	
3. DESCRIPTION/PURPOSE 3.1 A technical report provides fully documented results of studies or analyses performed.				
4. APPROVAL DATE (YYMMDD) 880115	5. OFFICE OF PRIMARY RESPONSIBILITY (OPR) G/T2137		6a. DTIC APPLICABLE X	6b. GIDEP APPLICABLE
7. APPLICATION/INTERRELATIONSHIP 7.1 This data item description contains the format and content preparation instructions for the data product generated by the specific and discrete task requirement as delineated in the contract. 7.2 This DID supersedes DI-A-5029. 7.3 Defense Technical Information Center (DTIC), Cameron Station, Alexandria, VA 22314.				
8. APPROVAL LIMITATION		9a. APPLICABLE FORMS	9b. AMSC NUMBER G4293	

10. PREPARATION INSTRUCTIONS

10.1 Format.

(a) The report and all attachments shall be typewritten, or otherwise clearly lettered, and shall be duplicated using non-fading ink.

(b) Text shall be prepared on standard letter size paper (8 1/2" X 11").

(c) When attachments are included, they shall be fully identified, referenced in the text, and folded to conform to the size paper used in the report.

(d) Security classification and distribution markings shall conform to the requirements of the contract, purchase description and security requirements checklist, as applicable.

10.2 Content.

(a) Title Page - Identifies the report by providing contract number, project name or purchase description title, task number, and reporting period.

(continued on page 2)

11. DISTRIBUTION STATEMENT

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.

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Page 1 of 2 Pages

FIGURE 16. SAMPLE DID, DTS REVIEW

DATA ITEM DESCRIPTION

IDENTIFICATION NO(S).

AGENCY: Army

NUMBER: DI-T-1909

1. TITLE

Test Scheduling Report

2. APPROVAL DATE

15 Dec 69

3. DESCRIPTION/PURPOSE

The Test Scheduling Report informs the system or equipment technical supervisor of a scheduled major test.

4. OFFICE OF PRIMARY RESPONSIBILITY

USAMC

5. DDC REQUIRED

6. APPROVAL LIMITATION

7. APPLICATION/INTERRELATIONSHIP

This data item is applicable to test programs other than those conducted at National Ranges since test scheduling information is an integral part of:

DI-A-1012, Documents Required by National Ranges
DI-T-1905, Flash Reports
DI-T-1906, Test and Demonstration Reports.

8. REFERENCES (Mandatory as cited in block 10)

AMCR 70-7

MCSL NUMBER(S)

10. PREPARATION INSTRUCTIONS

Within twenty-four (24) hours after a test is definitely scheduled, a Teletype will be sent to the technical supervisor with the following information included:

1. Test nomenclature

2. Scheduled data and hour of test

3. Test objective

4. Test hardware

5. Test description

6. Comparison of test objectives, hardware and description with that of project office test plan, with explanation of deviations

7. Comparison of test objectives, hardware and description with detailed test plan and explanation of all deviations. Intended "quick fixes" improvisions and deviations in either test objectives, hardware or description will be explained in detail.

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FIGURE 17. SAMPLE DID, NOTIFICATION OF TEST

DATA ITEM DESCRIPTION			Form Approved OMB No 0704-0188
1. TITLE DEMONSTRATION TEST PLAN (DTP)			2. IDENTIFICATION NUMBER DI-QCIC-80775
3. DESCRIPTION/PURPOSE 3.1 The DTP provides a comprehensive document which describes all of the planned activities and related management controls for demonstrating that a facility will perform as required by the government furnished Demonstration Test Specification (DTS).			
4. APPROVAL DATE (YYMMDD) 89 02 28	5. OFFICE OF PRIMARY RESPONSIBILITY (OPR) AR/AMSMC-PBT-P(D)	6a. DTIC APPLICABLE	6b. GIDEP APPLICABLE
7. APPLICATION/INTERRELATIONSHIP 7.1 This DID contains the format and content preparation instructions for the DTP generated by the specific and discrete task requirements as delineated in the contract. 7.2 This DID is applicable to prove-out of production or manufacturing facilities. 7.3 This DID replaces DI-T-10362.			
8. APPROVAL LIMITATION	9a. APPLICABLE FORMS		9b. AMSC NUMBER A4641
10. PREPARATION INSTRUCTIONS 10.1 <u>Reference Documents.</u> The applicable issue of the document cited herein, including the approval date and dates of any applicable amendments, notices, and revisions, shall be as specified in the contract. 10.2 <u>Content and Format.</u> The content and format of the DTP shall be as specified in paragraph 5.4 of MIL-HDBK-792(AR).			
11. DISTRIBUTION STATEMENT DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.			

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FIGURE 18. SAMPLE DID, DTP

DATA ITEM DESCRIPTION			Form Approved OMB No 0704-0188
1 TITLE: DEMONSTRATION TEST REPORT (DTR)		2 IDENTIFICATION NUMBER: DI-QCIC-80774	
3 DESCRIPTION/PURPOSE: 3.1 The DTR provides a record of demonstration test results, identified deficiencies, conclusions, and recommendations for improvements and corrective actions, as applicable.			
4 APPROVAL DATE (YYMMDD): 89 02 28	5 OFFICE OF PRIMARY RESPONSIBILITY (OPR): AR/AMSMC-PBT-P(D)	6a DTIC APPLICABLE	6b GIDEP APPLICABLE
7 APPLICATION/INTERRELATIONSHIP: 7.1 This DID contains the format and content preparation instructions for the DTR generated by the specific and discrete task requirements as delineated in the contract. 7.2 This DID is applicable to prove-out of production and manufacturing facilities. 7.3 This DID replaces DI-T-10063.			
8 APPROVAL LIMITATION	9a APPLICABLE FORMS	9b AMSC NUMBER: A4640	
10 PREPARATION INSTRUCTIONS: 10.1 Reference Documents. The applicable issue of the document cited herein, including the approval date and dates of any applicable amendments, notices, and revisions, shall be as specified in the contract. 10.2 Content and Format. The content and format of the DTR shall be as specified in paragraph 5.6 of MIL-HDBK-792(AR).			
11 DISTRIBUTION STATEMENT: DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.			

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FIGURE 19. SAMPLE DID, DTR

Custodian:
Army-AR

Preparing Activity:
Army-AR
(Project QCIC-A096)

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INSTRUCTIONS: In a continuing effort to make our standardization documents better, the DoD provides this form for use in submitting comments and suggestions for improvements. All users of military standardization documents are invited to provide suggestions. This form may be detached, folded along the lines indicated, taped along the loose edge *(DO NOT STAPLE)*, and mailed. In block 5, be as specific as possible about particular problem areas such as wording which required interpretation, was too rigid, restrictive, loose, ambiguous, or was incompatible, and give proposed wording changes which would alleviate the problems. Enter in block 6 any remarks not related to a specific paragraph of the document. If block 7 is filled out, an acknowledgement will be mailed to you within 30 days to let you know that your comments were received and are being considered.

NOTE: This form may not be used to request copies of documents, nor to request waivers, deviations, or clarification of specification requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document*(s)* or to amend contractual requirements.

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STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
	☐ VENDOR ☐ USER ☐ MANUFACTURER ☐ OTHER *(Specify)*: ______
b. ADDRESS *(Street, City, State, ZIP Code)*	

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

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