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RELIABILITY AND MAINTAINABILITY

PART 6: IN-SERVICE R & M

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- Part 1 - Management Responsibilities and Requirements for Programmed and Plans
- Part 2 - General Application Guidance on the use of Part 1 (ARMP-1)
- Part 3 - Application of National R&M Requirements Documents (to be issued later)
- Part 4 - Guidance for Writing R&M Requirements Documents (to be issued later)
- Part 5 - Guidance on R&M Training
- Part 6 - In-Service R&M

RELIABILITY AND MAINTAINABILITY

PART 6: IN-SERVICE R&M

PREFACE

i This Part of the Defence Standard defines those measures which must be considered when there is a requirement for the preparation of an In-Service R&M Assessment Plan and is for Ministry of Defence use. It may be used by other purchasing authorities, Government and Industry.

ii This Standard has been agreed by the authorities concerned with its use and shall be incorporated whenever relevant in all future designs, contracts, orders etc and whenever practicable by amendment to those already in existence. If any difficulty arises which prevents application of the Defence Standard, the Directorate of Standardization shall be informed so that a remedy may be sought.

iii This Part of the Defence Standard was prepared by the Committee for Defence Equipment Reliability and Maintainability (CODERM) and as a result of consultation reflects comments received from various authorities within the MOD and Industry.

iv Any enquiries regarding this Standard in relation to an invitation to tender or a contract in which it is invoked are to be addressed to the responsible technical or supervising authority named in the invitation to tender or contract.

v This Standard has been devised for the use of the Crown and of its contractors in the execution of contracts for the Crown and, subject to the Unfair Contract Terms Act 1977, the Crown will not be liable in any way whatever (including but without limitation negligence on the part of the Crown its servants or agents) where the Standard is used for other purposes.

vi This Part of the Defence Standard includes "ALLIED RELIABILITY AND MAINTAINABILITY PUBLICATION - 6" (ARMP-6).

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RELIABILITY AND MAINTAINABILITY

PART 6: IN-SERVICE R&M

0 Introduction

0.1 To achieve and maintain R&M objectives defined during design, development and production of defence materiel there may be a need to assess and where necessary improve In-Service R&M.

0.2 Assessment and where appropriate improvement of the In-Service R&M, may be carried out by various authorities - the original equipment contractor, the purchaser, the military user, another contractor or any combination of these.

1 Scope

1.1 This Part of the Defence Standard defines those measures which must be considered by the sponsor, the Procurement Executive and the Contractor, when there is a need for the preparation of an In-Service R&M Assessment Plan, within the overall R&M plan for the specified defence materiel.

1.2 It should be regarded as an expansion of Def Stan 00-40 (Part 1)/2 (ARMP-1) and Def Stan 00-40 (Part 2)/1 (ARMP-2) Appendices A paragraph 325.

2 Related Documents

2.1 The following documents and publications are referred to in this Part of the Standard.

STANAG 4174	Allied Reliability and Maintainability Publications
ARMP-1	NATO Requirements for R&M
ARMP-2	General Application Guidance on the Use of ARMP-1
ARMP-3	Application of National R&M Documents.
ARMP-4	Guidance for Writing NATO R&M Requirement Documents
ARMP-5	Guidance on R&M Training.
00-40 (Part 1)/2 (ARMP-1)	Management Responsibilities and Requirements for Programmes and Plans.
00-40 (Part 2)/1 (ARMP-2)	General Application Guidance on the use of Part 1 (ARMP-1)

2.2 Whenever ARMP-6 is revised or amended, CODERM will agree acceptance of the changes following which D Stan will issue copies of the latest issue/amendment of the ARMP, together with any resultant amendments to Def Stan 00-40 (Part 6)/1 (ARMP-6), to all official holders of this Part of the Standard.

2.3 The following publications may be of use when using this document:

- Def Stan 00-41 (All Parts) MOD Practices and Procedures for Reliability and Maintainability.
- Def Stan 00-5 (Parts 1-4) Design Criteria for R&M of Land Service Materiel.
- Def Stan 00-25 (All Parts) Human Factors for Designers of Equipment.

2.4 The documents listed above, clauses **2.1** and **2.3**, may be obtained from the sources shown below:

DOCUMENT	SOURCE
STANAG'S and Allied Reliability and Maintainability Publications (ARMP's)	Directorate of Standardization Stan 2 Kentigern House 65 Brown Street GLASGOW G2 8EX
Defence Standards	Directorate of Standardization Stan 1 Kentigern House 65 Brown Street GLASGOW G2 8EX

2.5 Reference in this Part of the Standard to any related documents means in any invitation to tender or contract the edition and all amendments current at the date of such tender or contract unless a specific edition is indicated.

3 Definitions

For the purpose of this Part of the Standard, the terms and definitions shown in Annex A of Appendix A of Def Stan 00-40 (Part 1)/2 (ARMP-1) apply.

4 Application

This Part of the Standard and in particular the ARMP-6 Appendix A of this Part of the Standard, shall be used for In-Service R&M.

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IN-SERVICE R & M

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MAY 1988

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NORTH ATLANTIC TREATY ORGANIZATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)
NATO LETTER OF PROMULGATION

MAY 1988

1. ARMP-6 "In-Service R & M" is a NATO UNCLASSIFIED publication. The agreement of interested nations to use this publication is recorded in STANAG 4174.
2. ARMP-6 is effective on receipt.
3. It is permissible to distribute copies of this publication to contractors and suppliers and such distribution is encouraged.

A J MELO CORREIA
Major-General, POAF
Chairman MAS

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RECORD OF CHANGES

Change Date	Date Entered	Effective Date	By whom Entered

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CHAPTER 1

INTRODUCTION

101. GENERAL

In addition to the engineering disciplines employed during design, development and production of defence materiel, to achieve and maintain specified R&M objectives, there may be a requirement to assess and, where necessary and cost effective, to improve the in-service R&M achievement. This may arise from latent design or manufacturing defects, or because the effects of the in-service environment cannot be fully predicted during design and development. It may also arise from the need to determine deviation of actual R&M performance from the expected and to recommend appropriate changes to design, manufacture or logistic planning. Assessment and, where appropriate, improvement of the in-service R&M achievement may be carried out by a variety of agencies - the original equipment contractor, the purchaser, the military user, another contractor or any combination of these.

102. SCOPE

This document defines those measures which must be considered by the responsible organizations when there is a requirement for the preparation of an In-Service R&M Assessment Plan, within the overall R&M plan for the specified defence materiel. It should be regarded as an expansion of ARMP-1 and 2, paragraph 325.

103. APPLICABILITY

- (a) This document applies to all materiel when referenced - in part or as a whole - in a contract or purchase order. If any inconsistency exists between the contract requirements and this document, then the contract requirements shall prevail.
- (b) In-Service R&M assessment defined herein shall be conducted in accordance with this document to the extent specified in the contract. The purchaser must ensure that his requirements in the contract are complete and clear.

104. TERMINOLOGY

A glossary of some important terms used in this document is contained in ARMP-1.

105. RELATED DOCUMENTS

ARMP-1	NATO Requirements for R&M
ARMP-2	General Application Guidance on the Use of ARMP-1
ARMP-3	Application of National R&M Documents
ARMP-4	Guidance for Writing NATO R&M Requirement Documents
ARMP-5	Guidance on R&M Training

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CHAPTER 2

GENERAL REQUIREMENTS

201. GENERAL

This Chapter outlines the general requirements for an R&M programme during the in-service phase. The objectives of such a programme are described along with details of the plan necessary to achieve them.

202. OBJECTIVES OF IN-SERVICE R&M ASSESSMENT

The objectives of the in-service R&M assessment will vary with different systems/equipments and different operational roles, but will generally include one or more of the following.

- (a) To quantify the achieved R&M of the system/equipment.
- (b) To assess the requirements and capabilities of technologies which are new to the military services and to provide information for the user and for future generations of systems/equipments.
- (c) To identify the factors inhibiting a system/equipment from achieving the specified R&M levels.
- (d) To initiate action to improve R&M where appropriate, including the establishment of additional R&M goals, and to evaluate the effectiveness of those actions.
- (e) To determine the effectiveness of the R&M engineering disciplines and practices which were applied during development and production.
- (f) To assess the effectiveness and/or necessity of built-in or military users test equipment and related procedures in the identification of failures.
- (g) To assess the effectiveness of maintenance procedures, including the training of personnel engaged in such tasks.
- (h) To recommend appropriate and cost-effective measures for improving the system/equipment R&M.
- (i) To use the observed R&M results to the fullest advantage, such as revising spare parts scaling.
- (j) To identify training needs, where such training will enhance the R&M of the system/equipment.
- (k) To assess the life of the system/equipment.

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203. IN-SERVICE R&M ASSESSMENT PLAN

- (a) Definition. A document showing how the in-service R&M assessment will be carried out. The plan shall describe in detail the tasks necessary to effect the assessment, showing chronologically, and in relation to the overall project timescale, their sequence, phasing and planned duration. Important stages, such as Periodic Reviews, shall be identified.
- (b) Preparation. The responsible organization shall prepare an In-Service R&M Assessment Plan (subsequently referred to as 'the Plan') detailing the agreed activities which are to be carried out for the assessment and, where specified, the improvement of the R&M of defence materiel in service use. The necessary R&M data will usually be obtained by monitoring selected equipments during their normal service use but, in some cases, there may be a need for special trials conducted on a sample of equipments.
- (c) Format. The Plan shall define the tasks to be undertaken and the organizations responsible for them. The Plan shall include, as required:
- (1) A definition of failures and a categorization as to cause, criticality, frequency and chargeability;
 - (2) A description of the data to be collected, the timescale and the method of collection, and the authorities responsible for collection and analysis;
 - (3) A list of the procedures to be employed in carrying out the tasks, including a description of software packages used in the analysis of the raw data;
 - (4) Allocation of resources required to perform each task;
 - (5) Anticipated problem areas in the collection and analysis of data and the possible means by which these problems may be overcome;
 - (6) Establishment of stages for the Plan and their relationship with other activities in hand;
 - (7) The means by which all personnel associated with the in-service R&M assessment are made aware of the requirements of the Plan;
 - (8) The key appointments responsible for managing the Plan and their responsibilities and functions;

- (9) The overall organization, to indicate the integration between reliability, maintainability and related disciplines;
 - (10) The lines of authority and communication;
 - (11) The arrangements for the periodic review and, if necessary, changing of the plan to take account of in-service experience.
- (d) Reports and Recommendations. The Plan shall stipulate the content, distribution and frequency of progress and stage reports to be issued during the agreed timescale and in accordance with any current contract. Additional requirements for items such as design review committees and safety committees shall also be stipulated.
- (e) R&M Improvements. As a result of the collection and analysis of data, action may be proposed to improve R&M. Such action may involve design changes to the system/equipment, design changes to test equipment, or changes to logistic support such as test philosophy or maintenance routine. The Plan shall state the format and information content of such proposals. The purchaser will consider such proposals together with the military staffs, or any other interested party, and decide on the appropriate follow-up action.

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CHAPTER 3

SPECIFIC R&M IN-SERVICE REQUIREMENTS

301. GENERAL

This Chapter highlights the factors to be considered when establishing the requirements for data collection and analysis. The additional factors that should be considered when further service trials or demonstrations are necessary are also described.

302. DATA COLLECTION

(a) Methods of Collection

- (1) The Plan shall detail the manner in which specific data are to be gathered. The military services of the NATO nations already organize the retrieval of R&M data using standardized procedures and reporting formats and these shall normally be adopted. Proposed variations from these procedures should, when appropriate, be agreed with the purchaser.
- (2) The Plan shall identify the organization or personnel responsible for the data collection, and the method of data collection. The responsibility for collection may rest with military users' personnel at the location where the equipment is in use, or the contractor may be given a mandate to collect and evaluate the data. The method used to record the data shall be via existing military documents or computer systems or by special arrangements agreed between the contractor, the purchaser and the relevant military staffs.

- (b) Data Set Requirements. The data required will depend on the objectives of the assessment, which might range from assessing the achieved levels of R&M, to determining what design changes are required to improve these levels. Each project will have its own particular requirements and a data set shall be agreed between all concerned. Wherever possible the data set should be chosen so that the selected data items can be extracted from the data set used by the relevant military service for defect/failure reporting.

(c) Systems/Equipment Data

- (1) The Plan shall stipulate the type and numbers of systems/equipments which are to be considered in the in-service assessment of R&M. This may be the complete production complement or may be restricted to a particular manufacturing batch, build standard or operational group.
- (2) The Plan shall define which in-service applications of the system/equipment are to be analysed. For example, a

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particular system/equipment may be installed in a number of different ships, tanks or aircraft; it may be used in a standby or a fully operational mode.

- (3) The Plan shall identify the equipment parameters or data which are considered relevant. These may include serial numbers, build standards, delivery dates, and relevant history, such as scheduled or unscheduled maintenance actions.

(d) Operating Data

- (1) In order to assess the R&M of a group of systems/equipments it is essential that the operating data for the individual systems/equipments within the group are specified and recorded. This applies to systems/equipments which remain fault-free in addition to those which have failures.
- (2) Where it is necessary and cost-effective to record operating times the method shall be stated in the Plan. This may be by use of elapsed time indicators recording the operation of the system/equipment, or by a variety of other means including manual recording of operating time or, for aircraft, flying time. Care will be taken to assure that, for multi-function systems/equipment, all applicable measurable use, rounds fired, miles travelled, operating times - are considered. Where an overall estimate of reliability and maintainability is to be obtained, formula for converting the measures of use to a common base will be proposed in the Plan and tested for realism during the initial data collection and analysis phases.
- (3) The responsibility for recording and collection of operating data shall be stipulated in the Plan.

(e) Environmental Data

- (1) The localized environment of an equipment will have a major bearing on its ultimate reliability. Methods may need to be devised for determining the environmental conditions which the system/equipment experiences in service use. The method used for determining the environmental conditions shall be specified in the Plan. This may be by reference to previously published data, by calculation, or by direct measurement of the environment. The size of sample should be statistically sound.
- (2) The R&M assessments may not be limited to climatic and mechanical conditions, but may also include the localized environment of the system/equipment, duty cycles, switching, electro-magnetic environment, etc, as well as conditions such as storage, handling,

maintenance and operational standby. The Plan shall state all the conditions to be considered.

- (f) Limits of Performance. The Plan shall define the limits of acceptable performance and the method of measurement.

303. DATA ANALYSIS

- (a) Organization. The Plan shall define the organization responsible for the analysis of the data collected or for the assessment of the system/equipment R&M. The analysis may be undertaken by contractors' or purchasers' staff. In each case the arrangements shall be agreed between the contractor and the purchaser.
- (b) Method. The method of data analysis shall be defined in the Plan this shall include terms of reference and nominated membership of relevant defect/failure investigation committees, the periodicity of R&M assessments and definition of reporting methods.
- (c) Objectives. The objectives of R&M analysis and R&M assessment will vary with different equipments and different operational roles, but will generally include one or more of the items listed in paragraph 202. This list of objectives is not intended to be exhaustive; the particular requirements of the contract shall be specified in the Plan.
- (d) Limitations of In-Service R&M Data. Data collected during development can differ significantly from that collected during the in-service assessment for many reasons. The differences may be due to all or any one of the following:
- (1) Latent design or manufacturing faults.
 - (2) The actual in-service environment differs from that predicted.
 - (3) The actual usage of the equipment, ie the duty cycle, differs from that predicted.
 - (4) The understanding of what constitutes a defect or failure may differ.
 - (5) The use of data collection systems established for reasons other than R&M assessments.

The analysis of in-service R&M data should recognize these differences, and it may be necessary for agreement to be reached between the contractor and the purchaser on whether specific defects/failures are attributable to the contractor or otherwise, and to establish an exclusion list before the analysis is started. Care should be taken to ensure that,

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if in-service R&M test results are to be compared with the original design and development R&M test results, then both sets of tests should use the operating conditions of the equipment used during the development R&M tests.

304. FURTHER SERVICE TRIALS AND DEMONSTRATIONS

Further service trials and demonstrations may be required to gain accurate R&M figures when particular problems are identified or when alternative operational roles require comparison. Where necessary and cost-effective, the Plan shall include proposals for further in-service R&M demonstrations or assessment under defined conditions. As a minimum, the Plan shall define:

- (a) The statistically significant number of systems/equipments to be included in the trial.
- (b) The build standard of the systems/equipments, and serial numbers where relevant.
- (c) The required operational performance of the system/equipment and the method of monitoring and test.
- (d) The environmental conditions of the trial.
- (e) The operational role of the system/equipment during the trial.
- (f) The duration of the trial. This may be in terms of the numbers of missions required, system/equipment operation time, duty cycles, calendar time, the number of defects/failures or any other relevant parameter.
- (g) The defect/failure data reporting, analysis and categorization procedures.
- (h) The specified R&M values (including confidence levels) or accept/reject criteria.
- (i) The method of measurement and statistical test plan where appropriate.
- (j) Consequence of failure to reach a system/equipment acceptance R&M value, where such a decision is appropriate.
- (k) The reporting procedures to be adopted.

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