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00-40 (PART 5) / Issue 1 (ARMP-5)

RELIABILITY AND MAINTAINABILITY

PART 5: GUIDANCE ON R & M TRAINING

AMENDMENTS ISSUED SINCE PUBLICATION

AMD NO	DATE OF ISSUE	TEXT AFFECTED	SIGNATURE & DATE

Revision Note

Historical Record

NATO ARMP-5 - May 1988.

Arrangement of Defence Standard 00-40

Part 1 - Management Responsibilities and Requirements for Programmes 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 5: GUIDANCE ON RELIABILITY AND MAINTAINABILITY TRAINING

PREFACE

i This Part of the Defence Standard is a guide on Reliability and Maintainability (R&M) Training, and should be adopted by MOD sponsors of contracts, and by contractors, to ensure that the standard of R&M throughout the MOD and Industry is maintained at a high level.

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 - 5" (ARMP-5).

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CONTENTS IV

RELIABILITY AND MAINTAINABILITY

PART 5: GUIDANCE ON RELIABILITY AND MAINTAINABILITY TRAINING

0 Introduction

0.1 This Part of the Defence Standard promulgates the Allied Reliability and Maintainability Publication - 5 (ARMP-5). It has been endorsed by the Committee for Defence Equipment Reliability and Maintainability (CODERM).

0.2 The UK as a participating nation of NATO has ratified the use of ARMP-5 in STANAG 4174. To ensure continuity with DEF STAN 00-40 (PART 1)/2 (ARMP-1) the ARMP-5 is published as Appendix A to this Standard.

1 Scope

This Part of the Defence Standard describes those training aspects of R&M to which the MOD is committed for Ministry staff involved with the procurement of Defence equipment and for Contractors who may wish to avail themselves of the training.

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-6	In-Service R&M
Def Stan 00-40 (Part 1)/2 (ARMP-1)	Management Responsibilities and Requirements for Programmes and Plans
Def Stan 00-40 (Part 2)/1 (ARMP-2)	General Application Guidance on the Use of Part 1 (ARMP-1)

2.2 Whenever ARMP-5 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 5)/1 (ARMP-5) 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 Material.
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 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 Standard and in particular the ARMP-5 Appendix A of this Part of the Standard, shall be used for Guidance on Reliability and Maintainability Training.

GUIDANCE ON RELIABILITY AND MAINTAINABILITY TRAINING

ARMP-5

MAY 1988

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N A T O U N C L A S S I F I E D

II

ARMP-5

NORTH ATLANTIC TREATY ORGANIZATION

MILITARY AGENCY FOR STANDARDIZATION (MAS)

NATO LETTER OF PROMULGATION

MAY 1988

1. ARMP-5 “Guidance on Reliability and Maintainability Training” is a NATO UNCLASSIFIED publication. The agreement of interested nations to use this publication is recorded in STANAG 4174.

2. ARMP-5 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

RECORD OF CHANGES

Change Date	Date entered	Effective Date	By whom Entered

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CHAPTER 1

INTRODUCTION

101. GENERAL

ARMP-1 (NATO Requirements for Reliability and Maintainability) is the baseline document for the achievement of the required levels of availability and mission success during the in-service life of military materiel. It emphasizes the need for properly conducted Reliability and Maintainability (R&M) work during the design and development stage.

The timely provision of military materiel with acceptable levels of R&M is essential to the achievement of the required operational effectiveness, coupled with acceptable life cycle costs. R&M requirements must be realistic and an agreed management strategy followed. This should include a continuous and evolutionary approach, with R&M as an integral part of any project, from inception to final acceptance into service. Special attention must be paid as to how R&M characteristics affect logistic expenditure - maintenance equipment installations, manpower and spares provisioning.

In order to raise the standards of R&M throughout NATO it is essential that the subject is properly understood and applied at all levels and during all phases of the procurement process. To this end, the need for adequate training is self-evident and this ARMP is intended to give guidance on this aspect.

102. SCOPE AND APPLICABILITY OF NATO R&M TRAINING

In the most simple terms, people who require training in the theory and practice of R&M are:

a. those who are full-time and specialized R&M practitioners, advisers or consultants

b. those whose work involves them in decisions or management processes concerned with R&M or brings them into contact with specialized R&M practitioners.

By its very nature, specialized R&M knowledge is normally only acquired by attendance at a second degree course or equivalent; such training will normally be conducted only by Universities or comparable Institutions. The definition of such training is not an appropriate subject for this publication and will not be considered further. It remains only to be said that, in the procurement of modern military equipment, the availability of specialized R&M advice at this level is regarded as essential. Suitably trained and qualified specialists must therefore be available and their advice sought at the earliest possible date.

This publication is addressed to the second category and it is emphasized that training at this level should cover the broadest possible field: purchasing and procurement staff concerned with the procurement of NATO materiel, contractors involved in design, development and production and also those responsible for NATO material in-service.

103. RELATED DOCUMENTS

ARMP-1 NATO Requirements for Reliability and Maintainability

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-6 In-Service R&M

CHAPTER 2

R&M TRAINING COURSES

201. GENERAL

For obvious and practical reasons, it is not possible to cover all the areas and levels, below that of the full-time specialist, for which R&M training is appropriate. Practical experience has shown that there are, in fact, two levels for which training is both extremely important and feasible.

202. TRAINING FOR SENIOR MANAGERS AND ENGINEERS

Senior staff, both in government procurement agencies and industry, should be aware of the need for comprehensive R&M programmes during development but require only a broad over-view of the subject. Any project management training course should include appropriate coverage of R&M. This may not in itself be sufficient and it is recommended that one-day seminars on R&M are organized in order to guarantee the widespread dissemination of the fundamentals of R&M at this level.

An example seminar syllabus is at Annex A. It should be noted that seminars of such short duration need not be confined to a centralized training location but can be taken to the recipients, thus making it easier for senior staff to attend.

203. TRAINING FOR MIDDLE LEVEL MANAGERS AND ENGINEERS

At the middle levels of management and engineering, staff are in more immediate and regular contact with R&M programmes and require a more detailed knowlegdge of the subject. At this level, a one week course is suggested. A possible outline syllabus is at Annex B. Such courses are best conducted at residential training centres where maximum use can be made of the available time and opportunities exist for practical work and syndicate discussion. The list of topics should not be regarded as exhaustive; variations may well have to be made to suit the broad classes of equipment being covered or the available instructional talent. The value and importance of including selected real-life examples in such training is emphasized.

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ANNEX A to
ARMP-5

SYLLABUS FOR A SENIOR STAFF SEMINAR
ON THE ACHIEVEMENT OF NATO R&M REQUIREMENTS

	SESSION	TOPICS	APPROX TIME (Mins)
1.	INTRODUCTION	Aims of the Seminar - organization of sessions - structure and role of NATO ARMPs	15
2.	TERMINOLOGY AND MAIN CONCEPTS	Definition of R&M terms - organization of resources - maintenance concept - tailoring concept. Importance of R&M to enhanced operational effectiveness and reduced through-life costs.	30
3.	SPECIFICATION	Specification of R&M Requirements	40
4.	GENERAL REQUIREMENTS	R&M programme - engineering requirements - traceability - interfaces and co-ordination - quantitative requirements - documentation	60
5.	TASKS	Scope of tasks - management of tasks - importance of design - trade-off studies - testing - reliability growth - monitoring sub-contractors and suppliers - feedback during production cycle - influence of software	80
6.	IN-SERVICE R&M	Data collection - monitoring achievement - corrective action	30
7.	SIMPLE CASE STUDIES	Examples of typical R&M successes and failures	60
8.	CONCLUSION	Summary and general discussion	45
		Total time	360

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ANNEX B to
ARMP-5

SYLLABUS FOR A 5-DAY COURSE FOR MIDDLE MANAGEMENT ON THE ACHIEVEMENT OF NATO R&M REQUIREMENTS

LECTURE NO	TOPICS	APPROX TIME (Mins)
Day 1		
1.	INTRODUCTION - Self introduction by Course staff and Course members - Course administration - purpose and structure of Course - organization of sessions	15
2.	OVERALL REQUIREMENTS - Importance of R&M - need for common policy within NATO - development of ARMPs - contractual status of ARMPs - use in collaborative projects - tailoring concept	20
3.	TERMINOLOGY - Basic definitions of availability, reliability and maintainability - meaning of purchaser and contractor - failure and repair definitions - failure rates and repair time distributions - critical and life-limited items - discrepancies - life and mission profiles	20
4.	FAILURE CAUSES - Failures due to design stresses, due to manufacturing defects, due to maintenance and mal-operation - early life, random and wear-out failures - modes of operation and levels of failure	20
5.	ORGANIZATION FOR R&M - Need for effective organization for R&M - role of purchaser and contractor - R&M in the procurement cycle - organization of resources - the maintenance concept - trade-off with cost and performance - in-Service R&M organization	40
6.	SPECIFICATION FOR R&M - Staff targets and requirements - methods of specifying R&M requirements (Quantitative and Qualitative) - relationship to maintenance concept - translation of requirements into contractual specifications - incentive clauses and warranties	40
7.	R&M PROGRAMME - Establishment of R&M programme - role of purchaser and contractor - R&M programme plans - programme implementation and monitoring - influence of reliability and maintainability on the design phase - R&M in development and production - interfaces and co-ordination - programme documentation - need for traceability	60

8.	CASE STUDY - For a typical defence project examine and discuss the specifications, contracts and programme plan to meet the R&M requirements	60
9.	SYNDICATE EXERCISE - Briefing on exercise to be undertaken by the students in syndicates during the course - suggested topic: to write or review a R&M programme plan for a typical Defence project	20
	Total Time	295

Day 2

10.	ENVIRONMENTAL CONDITIONS - Determining duty cycles - environmental conditions experienced - other factors, eg manufacturing, storage	20
11.	ALLOCATIONS - Allocation and apportionment of R&M requirements	15
12.	RELIABILITY PREDICTION - Similar equipment, similar function, parts count, parts stress analysis - MIL Handbook 217D and relevant computer programs - manual exercise and demonstration of computer analysis (if possible) - example of prediction - reliability apportionment	90
13.	MAINTAINABILITY PREDICTION - Application, downtime, skill levels, logistics policy, MIL Handbook 472 - reliability centred maintenance - maintenance engineering analysis - integration of maintainability data with logistic support	40
14.	R&M MODELLING - Reliability models - system dependencies - reliability block diagrams - analytical and simulation models - Markov analysis - Monte Carlo simulation - maintainability models - evaluation of intended level of repair - requirements for updating models	60
15.	FAILURE MODES EFFECTS AND CRITICALITY ANALYSIS - Purpose of failure modes effects analysis (FMEA) - application - procedure - functional and hardware approaches - criticality analysis - relationship to FMECA - MIL Standard 1629A - examples	60

16.	FAULT TREE ANALYSIS - Application - symbols - construction - top/event fault - common mode failures - minimum cut sets - examples	60
	Total Time	345

Day 3

17.	R&M DESIGN CRITERIA - Importance of R&M in design - contractors' role - reliability design criteria - reliability design guidelines - maintainability design criteria - diagnostic strategy - maintainability design guidelines - design criteria for human functions - updating requirements - sneak circuit analysis	60
18.	SOFTWARE R&M - Contribution of software to system R&M - software development strategies - test programs - verification and validation - support technology and tools - software problems	60
19.	DESIGN REVIEWS - Need for formal design reviews - frequency - attendance - content - check lists - presentation - case studies	40
20.	ENVIRONMENTAL STRESS SCREENING - Purpose of environmental stress screening (ESS) - ESS application - methods and techniques - ESS test plan - analysis of results and corrective actions	30
21.	RELIABILITY GROWTH - Test, analyse and fix principle - growth planning - monitoring - theoretical models - contractual aspects - reliability development/growth test (RDGT) plan - case studies	90
22.	R&M QUALIFICATION TEST PROGRAMME - Purpose of programme - reliability qualification test (RQT) - RQT plan - maintainability qualification test (MQT) - MQT plan - criteria of compliance - cost factors - integration with overall qualification testing plan	60
23.	PRODUCTION RELIABILITY ACCEPTANCE TEST (PRAT) PROGRAMME - purpose - criteria of compliance - cash limits - PRAT plan	20
	Total Time	360

Day 4

24.	TRADE-OFF STUDIES - Purpose of trade-off studies - frequency - parameters considered	15
25.	CRITICAL AND LIFE-LIMITED ITEMS - Importance of critical items - identification and listing - control and special handling - life-limited items - avoidance of use - factors limiting item lives - determination of item lives - monitoring of critical life-limited items - input to maintenance requirements	90
26.	INTEGRATION OF PURCHASER-SUPPLIED EQUIPMENT - R&M characteristics of purchaser-supplied equipment (PSE) - provision of information by purchaser - need for evaluation and validation of R&M information for PSE - co-operation between purchaser and contractor	20
27.	MONITOR/CONTROL OF SUB-CONTRACTORS AND SUPPLIERS - Monitoring/control of sub-contractors and suppliers R&M programmes	15
28.	FAILURE DATA REPORTING ANALYSIS AND CORRECTIVE ACTION SYSTEM - Closed loop data reporting during development and testing - early corrective action, failure definition, failure causes, failure mechanisms - relationship to design reviews - need for data accuracy	30
29.	IN-SERVICE R&M - R&M assessment plans - data collection on early in-service systems/equipment - relation with Purchaser's maintenance organization - corrective actions based on failure causes - maintenance data centres - use of in-service data in specifications	30
30.	CASE STUDY - Based on a typical defence project and requiring trade-off studies and the management of critical and life-limited items	60
31.	SYNDICATE EXERCISE - Continuation of syndicate work	90
	Total Time	350

Day 5

32.	SYNDICATE EXERCISE PRESENTATIONS - Presentations and discussion by syndicates of results of course exercise	180

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33.	COURSE SUMMARY - Review of topics covered and questions raised by students	30
34.	COURSE APPRAISAL	20
	Total Time	230

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Published by and obtainable from:
Ministry of Defence
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Tel No: 041-248 7890

The following Defence Standard file reference relates to the work on this Standard - D/D Stan/350/02/08.

Contract Requirements

When Defence Standards are incorporated into contracts users are responsible for their correct application and for complying with contract requirements.

Revision of Defence Standards

Defence Standards are revised when necessary by the issue either of amendments or of revised editions. It is important that users of Defence Standards should ascertain that they are in possession of the latest amendments or editions. Information on all Defence Standards is contained in Def Stan 00-00 (Part 3) Section 4, Index of Standards for Defence Procurement - Deferice Standards Index published annually and supplemented periodically by Standards in Defence News. Any person who, when making use of a Defence Standard encounters an inaccuracy or ambiguity is requested to notify the Directorate of Standardization without delay in order that the matter may be investigated and appropriate action taken.

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Our Reference : D/DStan/11/2

Date : 9 November 1998

Removal of Product Qualification Approval

IMPORTANT ANNOUNCEMENT

1. This Standard contains a Product Qualification Approval (PQA) scheme. [i]MOD policy requires that all PQA schemes are removed from Defence Standards called up in contracts placed after 1st January 1998.

2. Users of this Standard are to contact the Project Manager (PM), Equipment Support Manager (ESM) or Technical Service Authority (TSA) named in the contract or order, to identify whether there is a continuing need for an approvals scheme.

3. [ii]Product Conformity Certification (PCC) is a risk based process that replaces PQA. Once a risk has been identified PCC can be included as a contract clause. In exceptional circumstances agreement can be sought from AD/Stan for PCC to be included in a Defence Standard.

4. At the next revision of this Standard the PQA scheme will be removed.

T R Leaver
Head of Standards Programme Management
Tel: 0141 224 2595 FAX: 0141 224 2503

[i] Defence Council Instruction (General) 197/97; Quality Temporary Memorandum 5/98; Chief of Defence Procurement Instruction CDPI/TECH/250 (draft)

[ii] PCC is certification that a product meets its specification. When PC is required by the contract, the contractor is responsible for obtaining the necessary PCC. Certification shall be provided from a NAMAS accredited laboratory when appropriate. PCC shall apply where a Risk Assessment has been identified by the PM; ESM or TSA.