DEF STAN 00-970 NOTICE OF PROPOSED AMENDMENT (Def Stan 00-970-NPA)

TITLE OF PROPOSAL: Def Stan 00-970 Part 11 Annex A – Amendment to Guidance	

Stage of Amendment:	Consultation

Def Stan 00-970 NPA Serial No:	*NPA/2013-003*		
Unsatisfactory Report Serial No:	*N/A*		
MAA Originator:	Flt Lt	Darren Smith	MAA-Cert-MPS1a

Affected Part: (including paragraphs)	Section 1 - General, para 1.5 (Definitions) Section 3 - General Requirements for Aircraft Engines, para 3.E515 (Engine Critical Parts) Annex A - Lifing Procedure for Critical Parts, all paras affected.
Cross-reference to other relevant amendment proposals or documents:	N/A

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Part 1 (for issue to User Community)

INTRODUCTION ***(Not more than 250 words)***

The current version of Def Stan 00-970 Part 11 is largely based on the EASA certification specification, CS-E. Feedback from both industry and the user community however, has revealed that there are some inconsistencies between both CS-E and Def Stan 00-970 Part 11, specifically at Annex A of the Def Stan 00-970 Part 11. The current wording at Annex A is far more prescriptive in its terminology than CS-E, i.e. it mandates the use of 4 specific lifing methodologies and does not allow for the application of more recently developed, and potentially more accurate, Lifing Methodolgies.

Therefore, both Para 3.E515 and Annex A have been reviewed and amended to clarify the intent and guidance in respect of Engine Critical Parts, in keeping with the requirements of CS-E. It is recognised that, for engines to be operated in the miltary domain, there are additional military considerations to be taken into account when determining critical part lives. For this reason, Annex A in its proposed form is still deemed necessary.

SUMMARY OF PROPOSED AMENDMENT

Change:

The changes to Def Stan 00-970 Part 11 include:

1. Rationalisation and movement of definitions from Annex A to Section 1 General para 1.5 - Definitions. Where definitions are already captured within CS-E, definition removed.
2. Restructuring of existing content within para 3.E515 and Annex A, and deletion of unnecessary and prescriptive lifing methodology content, such that the intent of the airworthiness requirements is clarified. No additional requirements introduced.

Proposed amendments attached. The conventions used in this NPA are as follows: *New Regulation - No change marks.* Existing regulation - All new or changed text is indicated in ►red font◄. Struck through text indicates text that has been removed

Impact Assessment:

Objective:

The proposed changes clarify existing intent and guidance in respect of Engine Critical Part lifing procedures, and amend Def Stan 00-970 Part 11 definitions as required.

Risk Assessment: The impact of not incorporating the recommended changes is that Def Stan 00-970 Part 11 Annex A will remain rigid and inflexible in its approach, and will not take into account recent developments in Lifing Methodologies.

Furthermore, the potential conflict between CS-E and Def Stan 00-970 Part 11 definitions will remain unaddressed, which could lead to confusion.

Courses of Action.

1. **Do nothing** – Undesirable for the reasons stated above.

2. **Partial Amendment** – There is potential that the Def Stan 00-970 Part 11 definitions alone could be reviewed and updated to reduce the conflict with CS-E. However, this would not address the differences that exist between CS-E 515 and para 3.E515 Def Stan 00-970 Part 11. Partial amendment of Def Stan 00-970 Part 11 would therefore be limited in its impact.

3. **Proposed Def Stan 00-970 Part 11 Amendment** – Clarifies existing intent of and guidance in respect of Engine Critical Part lifing procedures, in keeping with CS-E, but cognisant of military specific aspects. Additionally, acceptance of the proposed amendment would address any potential conflict between CS-E and Def Stan 00-970 Part 11 definitions.

Preferred Course of Action: Proposed Def Stan 00-970 Part 11 Amendment

Costs and Benefits:

1. **Cost** – Negligible. No additional personnel or infrastructure required. The changes proposed here represent current practice and would have no or little economic impact. Cost to personnel may reduce owing to reduced nugatory effort.

2. **Benefit** – Full amendment will improve clarity of Def Stan 00-970 Part 11 Annex A and will remove the requirement to only apply the Lifing Methodologies currently published in the Part 11 Annex A. This change would likely result in the application of more developed and appropriate Lifing Methodologies to meet the intent of the Airworthiness Requirement for Engine Critical Parts. It may also result in improved overall compliance with the document.

Consultation period ends: 30/Nov/2013

The consultation period for this proposed amendment ends on the stated date. Please send your feedback via email to MAA-Cert-ADSGroup@mod.uk.

Part 2 (for MAA internal use)

Log of Comments (to be completed once the consultation period has ended).

Comment reference	Date	From (name)	Post	Précis or Topic of Comment	MAA Response

Recap of Proposal: *A short summary of the proposal amendment including what changes were incorporated following the consultation period.*

Recommendation. *This section will be completed once all the comments have been received. The recommendation is for the relevant Head of Division to approve the proposal.*

Approval. *This section will detail exactly what has been approved and by whom, and confirm the date for the amendment to be incorporated as well as the date the NPA should be reviewed to determine what the effects of the amendment were in terms of meeting the objective of the change, if there were any unintended consequences and establishing whether the estimated costs were correct.*

Accepted changes will be authorised at the following levels:

- Changes requiring retrospective mandating: 2 *
- Changes not requiring retrospective mandating but having a significant engineering impact: 1* Head of Cert
- Changes not requiring retrospective mandating but having a Minor engineering impact: Deputy Head of Cert.
- Changes deemed as administrational only: Head of ADS.

Approved by:

Signature:	
Name:	
Rank/Grade:	
Post:	
Date signed:	
Date for amendment to be incorporated:	

Part 3 - NOTIFICATION OF AUTHORIZED AMENDMENT (Def Stan 00-970 NAA)

Document Part:		Sub-Part:	

Unsatisfactory Report Reference:		NPA Reference:	

Originator:		Date:	

Amendment to be Incorporated on	**XX/XXX/XX**

APPROVAL

This Def Stan 00-970 NPA has been approved by the xxxx on behalf of DG MAA

INCORPORATION

The amendment will be incorporated in….

Signed (IAW with part 2).

for DG MAA

GENERAL

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1.5 Definitions

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1.5.8 Terms associated with Engine Critical Part Lifing

1.5.8.1 Area Safe Cyclic Life (Ar). The safe life predicted for a critical area in reference cycles.

1.5.8.2 Anomaly. The term 'Anomaly' as used in this document is taken to include surface damage or material process discontinuity.

1.5.8.3 Critical Area. An identified, stressed region of a Critical Part that has a significant possibility of failure from low cycle fatigue.

1.5.8.4 Critical Crack Size. Crack size at which rapid unstable crack growth commences. The critical crack size is associated with exceedance of the material fracture toughness or of the remaining ligament tensile strength, in the absence of vibration. When vibration is present the critical crack size is associated with the onset of vibration crack growth, and is referred to as the 'HCF threshold crack size'. The 'HCF Threshold Crack Size' is the crack size at which the alternating stress intensity factor, due to vibration, is equal to the threshold stress intensity factor for the fatigue crack growth at the stress ratio (minimum stress/maximum stress) appropriate to the combined steady and vibratory stresses in the part.

1.5.8.5 Critical Part. A critical part as defined in this document is an engine rotating or non-rotating component, which from failure analysis shows that the component must achieve and maintain a particularly high level of integrity if hazardous effects are not to occur at a rate in excess of Extremely Remote (CS-E).

1.5.8.6 Crack Size (engineering). The transition from initiation to propagation is defined as being a crack of 0.38 mm radius.

1.5.8.7 Dysfunction. Dysfunction occurs when a part contains a crack that has grown to the critical crack size.

1.5.8.8 Exchange Rate (ER). A damage or usage factor defining the number of reference units used per hour (or flight as appropriate). There will usually be a different value for each critical area. For specification purposes, the ER shall be determined from predicted mission profiles, and shall be modified in the light of development flight experience and data from service usage monitoring. For cyclic lives beyond engineering crack size (0.38 mm radius) separate initiation and propagation factors shall be calculated, or an appropriate compound factor calculated.

1.5.8.9 Expected Predicted Safe Cyclic Life (EPSCL). The life in reference cycles, which is derived using calculated engine stresses in conjunction with S-N curves appropriate to a part having minimum predicted fatigue strength.

1.5.8.10 Factored Test Life (Fr). The safe cyclic life of a critical area in reference cycles derived from rig test results, taking into account any stress and temperature factors and number of tests.

1.5.8.11 Hazardous**.** For a multi-engine application, an aircraft is considered to be at hazard if its ability to continue safe flight is impaired either by damage to the structure or controls or by injury to the crew. For single engine applications, an aircraft is considered to be at hazard if its ability to execute a controlled descent, or the ability of the occupants to abandon the aircraft safely, is impaired either by damage to the structure or controls, or by injury to the crew.

1.5.8.12 Life Factor (γ). The factor applied to convert test cycles to reference cycles for a critical area.

1.5.8.13 Life Management. Life management is the activity or activities necessary to maintain structural integrity throughout the life of the critical parts or assembly in service.

1.5.8.14 Material Process Discontinuity. The term material process discontinuity is taken to include all metallurgical discontinuities, such as High Interstitial Defects (HIDs) in Titanium and soft ceramic inclusions in Nickels that arise out of the normal process controlled manufacturing route and would apply to all similar materials.

1.5.8.15 Minimum Strength Part. A part which exhibits a life at the lower limit of the life distribution as defined in A.2.1.3, caused by the adverse combination of material properties and physical dimensions.

1.5.8.16 Predicted Safe Cyclic Damage Tolerance Life (PSCDTL). The predicted crack growth life in reference cycles to propagate from a pre-existing anomaly to the critical crack size defined in 1.5.8.3 to the probabilities defined in A.2.1.2 and A.2.1.3.

1.5.8.17 Predicted Safe Cyclic Life (PSCL). The life at which it is predicted that a minimum property component of a population would have an acceptably small probability of exhibiting cracking or hazardous events using the safe life method.

1.5.8.18 Predicted Safe Inspection Interval (PSII). The maximum interval that a part, lifed using either the damage tolerance (AMC-E 515(3)(v)) or retirement for cause approach (A.2.3) is allowed to accumulate between inspections. Inspection intervals must be set to ensure that at the end of successive intervals, the peak instantaneous risk of failure remains below an agreed level.

1.5.8.19 Reference Cycles**.** A reference cycle is a cycle consistent with the minimum to maximum stress conditions for the component feature under consideration in normal operation, with due account being taken of temperature, used as a life calculation datum.

1.5.8.20 Service Cyclic Life (Sr). The maximum value in reference cycles to which the operator is authorised to run a part in service.

1.5.8.21 Scatter factor (y). Material scatter factor used to relate resulting critical area equivalent engine cycles from test to safe cyclic lives, i.e. y is the estimated ratio from $N^{+95\%}$ to $N^{-3\sigma}$.

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REQUIREMENT	COMPLIANCE	GUIDANCE
3.E515 ENGINE CRITICAL PARTS	(See AMC E 515) ~~Annex A details a lifing procedure for rotating and non rotating critical parts which is considered to be an acceptable means of compliance. It describes the following four approaches to lifing:~~ ~~Traditional safe life.~~ ~~Databank.~~ ~~Damage tolerance.~~ ~~Retirement for cause.~~ ~~The lifing procedure to be used should be agreed with the Authority and referenced in the Engine Model Specification.~~ When selecting an appropriate lifing methodology additional GM at Annex A should be considered. Owing to the changing nature of military operations a periodic review of the service environment and investigation of service arisings to confirm the predictions concerning duty and capability should be carried out and documented within the Engineering Plan, as per AMC E-515. (AMC E-515 (3) (g)) The analytical techniques employed to predict the critical area, the service environment and accumulation of damage should be of sufficient accuracy such that they result in a realistic and/or safe prediction of the component life as specified at Annex A under A.2.1.3. The contractor should produce a Life Management Plan in support of Critical Part Lifing.	The appropriateness of the methodology used to determine the life of engine critical parts should be demonstrated and agreed with the Type Airworthiness Authority. Where a lifing methodology has previously been deemed acceptable by a recognised Aviation Authority, it may be appropriate to present this approval as evidence of compliance/partial compliance with this requirement. Airworthiness is underpinned by effective usage monitoring. As such, usage data is to be collected in support of usage monitoring (as per Annex A). Service usage data is to be collected and aircraft usage monitored over a representative range of missions for the purpose of re-qualifying the confidence in the exchange rates. See Annex A para 3.5 Service Usage Data. See Annex A para A.3 Life Management Plan (LMP).

Annex A

Lifing Procedure for Critical Parts (see 3.E515) – Additional Military Considerations

A.1 Introduction

A.1.1 ~~The lifing procedure given in this annex applies to rotating and non-rotating critical parts (as identified in the FMEA) which are subject to significant fatigue and therefore require lifing. A critical part is defined as a part whose failure could constitute a hazard to an aircraft or its occupants and therefore requires special controls~~ As per CS-E, the integrity of the Engine Critical Parts must be established by an Engineering Plan, a Manufacturing Plan and a Service Plan. Part of this process is the establishment of approved life for Engine Critical Parts. This Annex offers enhanced guidance material to be considered when determining approved life for rotating and non-rotating Engine Critical Parts. This additional material complements CS-E 515 and is applicable for compliance with all Safe Life determination methods.

A.1.2 ~~The structural integrity of the part will be determined such that the probability of individual failure of any critical part in service is at an acceptably low level. This will be achieved by establishing the service duty of the part, determining its capability to meet that duty and ensuring consistent product quality by manufacturing control. Periodic reviews of the service environment and investigation of service arisings to confirm the predictions concerning duty and capability will also be made~~. Owing to the changing nature of military operations a periodic review of the service environment and investigation of service arisings to confirm the predictions concerning duty and capability is required and should be documented within the Engineering Plan, as per AMC E-515. (AMC E-515 (3) (g))

A.1.3 The analytical techniques employed to predict the critical area, the service environment and accumulation of damage shall be of sufficient accuracy such that they result in a realistic and/or safe prediction of the component life as specified at Annex A under A.2.1.3.

~~A.2 Definitions~~

~~**A.2.1 Area Safe Cyclic Life (Ar).** The safe life predicted for a critical area in reference cycles.~~

~~**A.2.2 Critical Area.** An identified, stressed region of a Critical Part that has a significant possibility of failure from low cycle fatigue.~~

~~**A.2.3 Critical Part.** A critical part as defined in this Annex is an engine rotating or non-rotating component, which from failure analysis shows that the component must achieve and maintain a particularly high level of integrity if hazardous effects are not to occur at a rate in excess of Extremely Remote.~~

~~**A.2.4 Critical Crack Size.** Crack size at which rapid unstable crack growth commences. The critical crack size is associated with exceedance of the material fracture toughness or of the remaining ligament tensile strength, in the absence of vibration. When vibration is present the critical crack size is associated with the onset of vibration crack growth, and is referred to as the "HCF threshold crack size".~~

~~**A.2.5 Crack Size (engineering)**. The transition from initiation to propagation is defined as being a crack of 0,38mm radius.~~

~~**A.2.6 Dysfunction.** Dysfunction occurs when a part contains a crack that has grown to the critical crack size.~~

~~**A.2.7 Expected PSCL (EPSCL).** The safe cyclic life in reference cycles calculated for a part using calculated engine operating stresses and material properties appropriate to a Minimum Strength Part. The life will take into account all relevant factors such as physical features, temperature distributions and mission profile(s).~~

A.2.8 Factored Test Life (Fr). The safe cyclic life of a critical area in reference cycles derived from rig test results, taking into account any stress and temperature factors and number of tests.

A.2.9 Flaws. The term flaw as used in this annex is taken to include surface damage or material process discontinuity.

A.2.10 Hazardous. For a multi-engine application, an aircraft is considered to be at hazard if its ability to continue safe flight is impaired either by damage to the structure or controls or by injury to the crew. For single engine applications, an aircraft is considered to be at hazard if its ability to execute a controlled descent, or the ability of the occupants to abandon the aircraft safely, is impaired either by damage to the structure or controls, or by injury to the crew.

A.2.11 Life Factor (γ). The factor applied to convert test cycles to reference cycles for a critical area.

A.2.12 Life Management. Life management is the activity or activities necessary to maintain structural integrity throughout the life of the critical parts or assembly in service.

A.2.13 Material Process Discontinuity. The term Material process discontinuity as used in this Annex is taken to include all metallurgical discontinuities, such as High Interstitial Defects (HIDs) in Titanium and soft ceramic inclusions in Nickels that arise out of the normal process controlled manufacturing route and would apply to all similar materials.

A.2.14 Minimum Strength Part. A part which exhibits a life at the lower limit of the life distribution as defined in A.3.1.3, caused by the adverse combination of material properties and physical dimensions.

A.2.15 Mission Exchange Rate (β). A damage or usage factor defining the number of reference cycles used per hour (or flight as appropriate). There will usually be a different value for each critical area. For specification purposes (β) shall be determined from predicted mission profiles, and shall be modified in the light of development flight experience and data from service usage monitoring. For cyclic lives beyond engineering crack size (0.38mm radius) separate initiation and propagation factors **(** β_i and β_p**)** shall be calculated, or an appropriate compound factor calculated.

A.2.16 Predicted Safe Cyclic Damage Tolerance Life (PSCDTL). The predicted crack growth life in reference cycles to propagate from a pre-existing flaw to the critical crack size defined in A.2.4 to the probabilities defined in A.3.1.2 and A.3.1.3.

A.2.17 Predicted Safe Cyclic Growth Life (PSCGL). The predicted life in reference cycles from engineering crack to 2/3 dysfunction to the probabilities defined in A.3.1.3.

A.2.18 Predicted Safe Cyclic Life (PSCL). The number of reference cycles that a part of minimum fatigue strength is predicted to be able to withstand with an acceptably remote probability of reaching 2/3 dysfunction in the life limiting critical area. The PSCL is derived using calculated engine stresses, temperatures and material properties appropriate to a minimum strength part.

A.2.19 Predicted Safe Inspection Interval (PSII). The maximum interval that a part, lifed using either the damage tolerance or retirement for cause approach is allowed to accumulate between inspections. Inspection intervals must be set to ensure that at the end of successive intervals, the peak instantaneous risk of failure remains below an agreed level.

~~**A.2.20 Reference Cycles.** A reference cycle is a cycle consistent with the minimum to maximum stress conditions for the component feature under consideration in normal operation, with due account being taken of temperature, used as a life calculation datum.~~

~~**A.2.21 Residual Strength**. The cyclic strength of a critical part available at any time during in-service loading.~~

~~**A.2.22 Service Cyclic Life (Sr).** The maximum value in reference cycles to which the operator is authorised to run a part in service.~~

~~**A.2.23 Service Interval.** The intervals at which the engine would normally be stripped to a level at which the critical parts can be inspected.~~

~~**A.2.24 Scatter factor (y).** Material scatter factor used to relate resulting critical area equivalent engine cycles from test to safe cyclic lives, i.e. y is the estimated ratio from~~
~~$N_{+95\%}$ to $N_{-3\sigma}$~~

~~**A.2.25 Test Overstress Factor (α).** The ratio of critical area effective rig stress divided by the effective engine reference stress.~~

~~**A.2.26 Technical Life Review**. A technical life review underwrites or revises the lives of critical parts based on current data and understanding.~~

~~**A.2.27 HCF Threshold Crack Size.** The crack size at which the alternating stress intensity factor due to vibration is equal to the threshold stress intensity factor for the fatigue crack growth, at the stress ratio (minimum stress/maximum stress) appropriate to the combined steady and vibratory stresses in the part.~~

~~A.3~~ A.2 Life Determination

~~A3.1 Procedural requirements~~ A.2.1 Additional considerations

~~This section of the annex defines the procedural requirements that shall be achieved for compliance and apply to all methods of Safe Life determination. Section A.4.0 describes acceptable methods by which these procedural requirements can be met.~~

~~**A3.1.1**~~ **A.2.1.1** The determination of a critical part life is based on demonstrating an understanding of the component's operational environment and validation of the component life when operating in that environment. Life validation is based on cyclic testing of representative component features, the life of which is factored to account for material scatter and to provide a safety margin.

~~**A3.1.2**~~ **A.2.1.2** A margin of safety in addition to the allowance for material scatter is required to achieve acceptable failure rates in service. This is normally provided by a period of stable crack propagation between crack formation and component dysfunction.

~~**A.3.1.3**~~ **A.2.1.3** The margin of safety required by ~~A3.1.1~~ A.2.1.1 and ~~A3.1.2~~ A.2.1.2 shall be such that the probability of a component exceeding 2/3 life to dysfunction in service at its PSCL, or PSCDTL is less than or equivalent to 1 in 750 with 95% confidence.

~~**A.3.1.4** All factors contributing to the demonstration of a safe life must be considered, including, but not limited to:~~

- ~~Fatigue~~
- ~~Vibration~~
- ~~Creep and rupture~~
- ~~Thermal buckling~~
- ~~Corrosion~~

~~**A.3.1.5**~~ **A.2.1.4** Each critical area shall be considered separately i.e. the OEM is required to demonstrate that they have declared a life based on the feature that will be limiting in operation of the engine.

~~**A.3.1.6** Residual stresses due to the manufacturing process, assembly or welding shall be considered and the approach justified to the Authority~~

~~**A.3.1.7** To determine the critical area's operating environment two-dimensional and/or three-dimensional local thermomechanical stress/strain predictions shall be conducted. Predictions shall include steady state and transient stress or strain and temperature histories throughout the mission, or missions and mission mix specified to determine;~~

~~(a) Reference cycle.~~

~~(b) Mission exchange rate (β) (including separate initiation and propagation βs if propagation life is being utilised).~~

~~(c) Expected Predicted Safe Cyclic Life.~~

~~**A.3.1.8** The analytical techniques employed to predict the critical area, the service environment and accumulation of damage shall be of sufficient accuracy such that they result in a realistic and/or safe prediction of the component life as specified under A.3.1.3. These techniques, assumptions and data shall be available to the Authority on request.~~

~~**A.3.1.9** In order to maintain the 2/3 dysfunction margin **(A.3.1.3)** special consideration is required where vibration or other environmental effects or high working stresses are likely to result in short propagation lives. Where 2/3 dysfunction is larger than engineering crack, the propagation β factor must be re-evaluated on a crack propagation basis. If the propagation β factor (βp) is more than 3 times the initiation β (βI) then the proportion of total life released shall be justified but the risk of dysfunction must not exceed Extremely Remote.~~

~~**A.3.1.10** Predicted metal temperatures shall be validated with measured engine temperatures, or shown to generate conservative life predictions, and in all cases take account of one-half of the effect of a fully deteriorated engine.~~

~~**A.3.1.11** The EPSCL shall be determined for the relevant critical areas, based on the interpolation of available lifing data. This shall be representative of minimum component material strength.~~

~~**A.3.1.12** Critical areas with an EPSCL equal to or greater than 105 reference cycles need not be considered further.~~

~~**A.3.1.13** For critical areas with an EPSCL of less than 105 reference cycles it is required that the PSCL shall be derived and validated by representative cyclic tests, or demonstrated not to be life limiting (this will usually apply only to components with multiple similar features of sufficiently differing stresses that the higher stressed feature can be shown always to fail first)~~

A.3.1.14 The test should be arranged such that the calculated maximum and ranges of stress in line with A.3.1.7 are consistent with those that occur in the engine for each relevant critical area, due account being taken of all static and transient temperatures. Where this is not practical an understanding of the material fatigue behaviour shall be used to correct the test life to the engine condition.

A.3.1.15 **A.2.1.5** No validation test resulting in cracking or failure of a representative part or specimen shall be disregarded in any subsequent calculation of the life of the part unless agreed by the Authority without appropriate review and justification.

A.3.1.16 **A.2.1.6** Test parts shall be kept on completion of testing as they may provide additional information on future lifing issues. The storage of test parts shall be agreed with the customer. Parts shall be retained as long as parts lifed using the result are in service.

A.3.1.17 **A.2.1.7** In addition to the safe life approach In satisfying AMC-E 515, it is expected that the contractor shall conduct

(a) a risk assessment to demonstrate an acceptably low probability of hazardous component failures from material process discontinuities. Acceptable failure levels due to process discontinuities will be in accordance with the Authority's requirements agreed requirements. Where it can be shown by the risk assessment that the risk of failure from discontinuities that are large compared to the material microstructure is at or below Extremely Remote, then the cyclic life can be derived using Safe Life methods and further assessment of the effect of such discontinuities is not required. (AMC E 515 (3)(d)(v))

(b) For critical parts that are potentially sensitive to surface damage the damage tolerance requirements also apply (**A.3.2.3**).

A.3.1.18 **A.2.1.8** The contractor shall make the life declaration figures available to the Authority/Customer, The preferred format is given to include but not be limited to, the content listed in Table A-A. to be These figures should be accompanied by a sketch indicating the position of the critical areas. The procedure for determining service life is detailed at Table A-B of this annex.

A.3.1.19 **A.2.1.9** To allow the full lives to be cleared at entry into service requires the implementation of a Life Management Plan (LMP), as described at A.4 A.3 In the absence of an LMP only half (1/2) of the PSCL shall be cleared.

A.3.2 Approved Safe Life Methodology

Four basic Safe life methods are detailed below. These methods of compliance with the standardisation requirements detailed above, are for guidance purposes and as such are not mandatory. However, alternative methods to, or modifications of, the methods defined below require agreement by the Authority.

A.3.2.1 The Traditional Safe Life Approach

A.3.2.1.1 The traditional approach is based on establishing a PSCL following cyclic testing of representative parts.

~~**A.3.2.1.2** Testing shall be carried out on a random sample of parts representative of the production standard. A component feature test is considered representative if:~~

~~(a) The material is identical or equivalent to a production standard part.~~

~~(b) The component feature configuration and local geometry of a critical area, are identical or equivalent to the engine, and the combination of stress, stress gradient and temperature is at least as severe as in the engine condition.~~

~~(c) The surface condition in the feature tested is identical or equivalent to a production standard part.~~

~~**A.3.2.1.3**~~ **A.2.1.10** To allow multiple critical areas to be tested on a test part and to reduce testing time, tests may be performed at a limited amount of critical area overstress ~~(∝).~~ (Table A-B). The degree of critical area overstress shall not result in unrepresentative overall and local stress or strain conditions when corrected for temperature. (AMC E 515(3)(d)(iv)) ~~Overstress factors greater than 1.14 for nickel and 1.3 for steel and titanium or less than 1.00 for all materials should be avoided where practical. Where overstress factors beyond the limitations detailed in Table A-D are used the life factors calculated in accordance with Table A-E shall be justified based on the interpolation of material behaviour data and subject to approval by the Authority.~~

~~**A.3.2.1.4** The end point of a finite test may be determined in one of two ways:~~

~~**A.3.2.1.5.a** The preferred method is based on the number of test cycles to dysfunction or to a long crack, which is generally assumed as dysfunction (finite result). The number of test cycles (N) used in life calculations is obtained by multiplying this figure by a factor of 2/3 to ensure a definite margin of safety.~~

~~**A.3.2.1.5.b** Results for a critical area, which, after inspection, is found to be crack free (non-finite), can be included in the life calculations based on either:~~

~~(1) Assuming the onset of cracking at a size based on the inspection capability with 50% probability and 90% confidence at the next stress cycle. Where this crack size is greater than engineering crack size, the cyclic life used as part of the life declaration will require to be reduced appropriately.~~

~~(2) A statistical approach to define the most likely finite test life, which is consistent with the probabilities of failure and confidence levels defined in A.3.1.3. This approach shall be justified to and approved by the Authority. The Factored Test Life (Fr) based on methods **A.3.2.1.5.b** can only be claimed where it can be shown that the Fr is less than or equal to two thirds of the cyclic life to dysfunction.~~

~~**A.3.2.1.6** If no inspection is carried out then the area shall be assumed to reach dysfunction on the next cycle, and hence multiplied by 2/3rds in line with 3.2.1.5 above and treated as non-finite in accordance with 3.2.1.5.b.2.~~

~~**A.3.2.1.7**~~ **A.2.1.11** Test results shall be analysed in accordance with practically established material scatter factors ~~(See Table A-C)~~. For critical areas where the life is based on one or more test results, the test scatter factors employed may, in general, be based on either the geometric mean or a statistical approach to define the most likely finite test life, which is consistent with the probabilities of failure and confidence levels defined in A.3.1.3 A.2.1.3. (AMC E 515(3)(d)(iv)). The previous Def Stan approach using the minimum may be used only where it can be shown to be conservative.

For calculating life factors, the overstress may be raised to the power 5.28 or –1/true slope whichever is lower. For under-stress use true life factor where true life factor is defined as ratio of mean first crack lives at test and engine stresses and temperatures. The true life factor must be derived from an SN curve for the appropriate material and feature, based on specimen and component tests.

A.3.2.1.8 **A.2.1.12** The contractor shall demonstrate that available test results do not cast doubt on validity of the scatter factors employed. (AMC E 515(3)(d)(iv))

A.3.2.1.9 **A.2.1.13** Where it is not possible to carry out tests on a particular critical area, Ar shall be based on half the EPSCL, provided that the EPSCL is based on the interpolation of minimum strength and life component related data.

A.3.2.1.10 The Critical Area Safe Life (Ar) for each critical area shall be calculated for each declared mission profile. The critical area that has the lowest life shall determine the Predicted Safe Cyclic Life (PSCL) for the part. Any variation in mission profiles will need to be referred to the engine designer for calculation of a new PSCL. β factors should be confirmed in accordance with paragraph A.4.5.

A.3.2.2 Databank Approach

A.3.2.2.1 For this approach flight cycle critical area stresses and temperatures are read into a material databank to calculate safe lives directly, rather than performing a specific cyclic test for the critical area. The databank will have been compiled in advance from a correlation of laboratory specimen data with previous results of cyclic tests on a variety of component critical features in a given material, safe lives for minimum property parts being defined using statistical techniques.

A.3.2.2.2 A materials databank may be used in place of a specific cyclic test, for the demonstration of critical area safe lives, provided that evidence of its applicability is presented and approved by the Authority.

A.3.2.2.3 In the production of a material databank the following requirements shall be considered:

(a) A statistically significant number of specimens/component tests.

(b) Testing of material possessing the correct specification, microstructure and surface condition.

(c) Adequate testing of the surface condition of the relevant engine component critical area must be included such that it can be shown that all features included in the materials databank exhibit a common cyclic behaviour.

(d) Component testing carried out with representative stress fields and operating conditions (e.g. temperature, surface contact, and residual stress).

(e) All features appropriate to the relevant engine component.

(f) Testing of an adequate total volume of relevant material.

(g) Previous service experience.

A.3.2.2.4 The procedure for submitting and recording Authority approval of a material databank shall be in a manner acceptable to both the Authority and the Contractor.

A.3.2.2.5 Where a databank is not suitable for all critical areas of a component, the contractor may life the feature using rig test results from specific cyclic tests.

A.3.2.2.6 The Critical Area Safe Life (Ar) for each critical area shall be calculated for each declared mission profile. The critical area that has the lowest in-service life shall determine the Predicted Safe Cyclic Life (PSCL) for the part. β factors should be confirmed in accordance with paragraph A.4.5.

A.3.2.2.7 Where it is not possible to fully establish Ar for any feature, Ar shall be based on a half of the EPSCL from the databank.

A.2.2 Analytical Modelling Methods (AMC E 515 (3)(e)(iii))

A.2.2.1 One such example is the 'Correlation approach' where flight cycle critical area stresses and temperatures are read into a material correlation to calculate safe lives directly, rather than performing a specific cyclic test for the critical area. The correlation will have been compiled in advance from a combination of laboratory specimen data with previous results of cyclic tests on a variety of component critical features in a given material, safe lives for minimum property parts being defined using statistical techniques.

A.2.2.2 Where a material's correlation approach is used for the demonstration of critical area safe lives, in place of a specific cyclic test, evidence of its applicability must be provided.

A.3.2.3 Damage Tolerance Approach

A.3.2.3.1 The aim of the damage tolerance approach is to demonstrate that by the appropriate material selection, design, use of reliable inspection methods, control of assembly, overhaul and repair, and with the application of appropriate safety factors, that damage will not propagate to failure within the cyclic life of the component, such that the failure rate does not exceed extremely remote. The margin of safety required by A.3.1.2 shall be achieved either by a 2/3rd factor as in A.3.1.3 or by assuming conservative damage levels.

A.3.2.3.2 This approach applies to critical parts that are potentially sensitive to failure from surface damage. This approach is not an alternative to the previous two methods but is intended to be additional. Exemption from damage tolerance can only be achieved, with agreement from the Authority, where previous experience demonstrates it to be unnecessary, or where the damage tolerance can be demonstrated using a generic materials databank.

A.3.2.3.3 To achieve damage tolerance requires the growth period from an initial flaw to unstable crack growth be demonstrated by analysis or test assuming the initial flaw exists in the critical areas of the component. It is required that the PSCL does not exceed the PSCDTL of the component.

A.3.2.3.4 For the assessment of surface damage tolerance each critical area shall be considered separately.

A.3.2.3.5 In assessing damage tolerance the Predicted Safe Cyclic Damage Tolerance

~~Lives (PSCDTL) shall be determined, by analysis or test for realistic operating conditions, considering the growth of an initial crack of a specified size (ao) to the critical crack size (ac). The life to grow an initial flaw to the critical size shall be substantiated by relevant specimen or component tests.~~

~~**A.3.2.3.6** The initial flaw sizes (ao) assumed shall be based on an understanding of the flaw distributions due to manufacture or surface damage and considering process control and NDI techniques.~~

~~**A.3.2.3.7** For initial flaw sizes based on NDI techniques the flaw size applied shall be based on the flaw that can be detected with demonstrated probability and confidence.~~

~~**A.3.2.3.8** For those components assumed to contain an initial defect population whose upper bounds are considerably lower than the non-destructive Inspection (NDI) limit the initial defect size shall be determined based on the product of the process and the process controls.~~

~~**A.3.2.3.9** A probabilistic approach may be adopted to include the initial flaw size distribution and the crack growth rate distribution when determining a PSCDTL which shall be to 1/750 and 95% confidence the analysis shall be justified by the contractor. A 2/3rds factor is not required.~~

~~**A.3.2.3.10** The assessment may incorporate a crack initiation life within the analysis where sufficient validation testing has been conducted to demonstrate the initiation behaviour and scatter.~~

~~**A.3.2.3.11** The contractor shall further demonstrate that the effects of the assembly techniques will not introduce defects larger than those assumed at new manufacture.~~

~~**A.3.2.3.12** Residual stresses shall be taken into account in determining the PSCDTL, as shall the effects of vibratory stress on the onset of unstable crack growth. The consequences of surface treatments on the ability to inspect the component shall also be considered. Any beneficial effects of induced residual compressive stresses introduced by the manufacturing process, such as shot peening etc, may be taken into account and the procedures used justified. The effect of the service environment on residual stresses shall also be considered.~~

~~**A.3.2.3.13** The residual strength of each critical part with the maximum damage present shall be enough to sustain the highest stress occurring during the operation without catastrophic failure. Consideration shall be given to normal overspeed due to control system tolerances and engine deterioration.~~

~~A.3.2.4~~ A.2.3 Retirement for Cause

~~**A.3.2.4.1**~~ **A.2.3.1** A ‘retirement for cause’ approach to critical part lifing is only to be considered in exceptional cases as dictated by operational requirements and **only** with the prior approval of the **MAA**. This approach attempts to utilise ~~some of the life that may remain in parts that have reached their PSCL and would otherwise be retired from service with some life remaining~~ the remaining life that is extant in parts that have reached their PSCL and would otherwise be retired from service. No part that is known to contain cracks that could result in a critical failure shall be returned to service. Only those parts that pass a rigorous inspection will be returned to service for a period of PSII as defined in ~~A2.19~~ Section 1, para 1.5.8.18 while the remainder are retired.

A.3.2.4.2 No part that is known to contain a crack that could result in a critical failure in the service life of the part shall be returned to service.

A.3.2.4.3 Use of the Retirement for cause approach is not considered as a routine procedure and as such requires approval by the Authority.

A.4 A.3 Life Management Plan (LMP)

A.4.1 A.3.1 For all methods of life declaration a LMP shall be produced by the Contractor and shall cover all critical parts. It shall be agreed with the Authority as well as all subsequent changes and revisions. The LMP, and any subsequent changes/revisions to it, should be approved by the relevant Type Airworthiness Authority (TAA).

A.4.2 A.3.2 With the implementation of a LMP the full PSCL may be released into service. An alternative to the release of the full PSCL for the Service Cyclic Life is to release the component with an initial Service Cyclic Life equal to half of the PSCL and to progress to the full PSCL release via an intermediate, three-quarter PSCL Service Cyclic Life release. This approach follows the same procedures described in the tables at the end of this annex. If the recommendations defined in the LMP are not implemented then the engine designer may revert to fractional life release.

A.4.3 A.3.3 The Life Management Plan shall define the actions to be undertaken after an engine has entered service that will ensure the continued safe operation of the critical parts and This should include:

(a) A definition of the requirements for service sample inspections, or rig testing of service samples, to confirm initial assumptions regarding the service environment. (see para A.3.4)

(b) Requirements for data to confirm or update service usage assumptions, including a definition of the usage monitoring system which details the process for tracking life usage in service. (see para A.3.5)

(c) Technical Life Reviews at specific life intervals to consider all aspects that impact on the Life in order to underwrite or revise the critical part life and define any actions necessary for continued safe operation. The Technical Life Reviews and sampling shall confirm or adjust the assumptions in the damage tolerance assessment. (see para A.3.6)

A.4.4 A.3.4 Sample Inspections

A.4.4.1 The contractor or an approved NDI facility shall carry out detailed inspections of service-run parts. The primary requirement is to find any deterioration in the component caused by, for example, surface damage such as fretting, corrosion, mechanical damage, incipient fatigue, etc. Particular attention shall be paid to the critical areas. To achieve this the LMP shall:

(a) Specify the number of in-service samples that shall be required for each critical part. Provided the samples are satisfactory they will be returned to service.

(b) Specify the timings of such inspections, including the maximum and minimum lives at which samples should be supplied to ensure that the inspection data is available for the Technical Life Review. The life bands shall be such that samples may be taken at natural arisings, and to include as many critical parts as possible within the life band. Should the lead component reach the maximum life without any similar in-service component having been visually inspected at a natural arising, the life management plan shall include the need for a lead engine inspection.

~~(c) Detail the areas and inspection techniques and procedures that shall be employed during the inspections.~~

~~(d) Consider, whether rig testing of the service run components would be advantageous, based on the results of inspections, experience of the material in similar applications, and existing service or development experience. Where additional rig testing of the service run components is sanctioned this shall be carried out as described in A.3.2.1.~~

~~(e) Where samples withdrawn from service are to be used in a cyclic test programme, the Contractor will need to be given the appropriate usage information to allow an estimation of equivalent service cycles. This value should be an estimate of the mean usage. The lives will be combined using a linear damage relationship (e.g. Miner's Law). If the ex-service test result or metallurgical and surface examination indicates inconsistent behaviour with the test evidence previously assembled, steps will be taken to investigate the cause and the PSCL and the sampling programme will be adjusted accordingly.~~

~~(f) The Contractor shall produce procedural documentation covering the assessment of NDI and process control capability. In the case of NDI this shall specify the checks to be performed on equipment being used to assess parts during manufacture and in service, to ensure that inspection sensitivity and reliability is being maintained. In the case of process control capability, sampling plans and/or arisings inspection requirements shall also be defined.~~

~~(g) Identify the potential for increasing the PSCL of the component through increasing the number of samples used in the life derivation.~~

~~(h) Specify the percentage, or number, of time expired parts that are required to be returned to the contractor for examination. This is normally limited to NDI but may be extended to cut-up or rig testing as considered necessary by the Technical Life Review based on service experience.~~

A.3.4.1 In order to identify any deterioration in the component, caused by, for example, surface damage such as fretting, corrosion, mechanical damage, incipient fatigue, etc, detailed inspections of service-run parts are to be carried out at specified intervals. Particular attention shall be paid to critical areas.

A.3.4.2 The contractor shall specify the number and timings of in-service and time expired in-service MOD samples that shall be required for each critical part from each operator. Provided the samples are satisfactory they will be returned to service unless the sample is beyond repair due to the requirements of the inspection on the components.

A.3.4.3 Within the specified timings, the maximum and minimum lives at which samples should be supplied are to be included, to ensure that the inspection data is available for the Technical Life Review. The life bands shall be such that the samples may be taken at natural arisings. As many critical parts as possible should be included within the life band. Should the lead component reach maximum life without any similar in-service component having been visually inspected at a natural arising, then the life management plan should include the need for a lead engine inspection.

A.3.4.4 Where samples withdrawn from service are to be used in a cyclic test programme, the contractor will need to be given appropriate usage information to allow an estimation of equivalent service cycles. (see para A3.5)

A.3.4.5 If the ex-service test result or metallurgical and surface examination indicates inconsistent behaviour with the test evidence previously assembled, steps will be taken to investigate the cause. Consequently, the PSCL and the sampling programme will be adjusted accordingly

A.3.4.6 The Contractor shall produce procedural documentation covering the assessment of NDI and process control capability. In the case of NDI this shall specify the checks to be performed on equipment being used to assess parts during manufacture and in service, to ensure that inspection sensitivity and reliability is being maintained. In the case of process control capability, sampling plans and/or arisings inspection requirements shall also be defined.

~~**A.4.4.2** In addition to the detailed Contractor inspections defined above, critical parts, which are stripped due to natural arising, must be inspected (at least visually) by the Operator. These Operator inspections can also provide useful information on environmental factors that could impact the life. This data should be made available to and monitored by the Contractor.~~

A.3.4.7 In addition to the detailed Contractor inspections defined above, critical parts, which are stripped due to natural arising, should be inspected. These inspections can also provide useful information on environmental factors that could impact the life. This data should be made available when requested from the contractor/OEM.

~~A.4.5~~ A.3.5 Service Usage data

~~**A.4.5.1**~~ **A.3.5.1** ~~The Operator is responsible for data collection and the monitoring of aircraft usage over a representative range of missions for the purpose of re-establishing exchange rates.~~ Data is to be collected and aircraft usage monitored over a representative range of missions for the purpose of re-qualifying the confidence in the exchange rates. ~~An acceptable method is described in Table A-F~~

~~**A.4.5.2**~~ **A.3.5.2** ~~Via the LMP~~ The engine contractor shall:

(a) Identify the method to be used for flight profile monitoring and cycle counting, ~~to be carried out by the operator~~ which shall be in line with para A.1.3 and define actions to be carried out by the customer.

(b) Specify the maximum life that each part may be allowed to accumulate in service before results shall be available.

(c) Undertake analysis of this data or supply information necessary for the work to be carried out by an outside body.

(d) Update cleared life accordingly.

~~A.4.6~~ A.3.6 Technical Life Reviews (TLR)

~~**A.4.6.1**~~ **A.3.6.1** ~~A Technical Life Review is a systematic examination of all engineering and operational aspects that could impact on the safety and integrity of the part in service.~~ A TLR underwrites or revises the lives of critical parts based on current data and understanding and is an integral part of maintaining integrity. (AMC E 515 (3)(g))

A.3.6.2 A TLR should be undertaken by the OEM at an agreed periodicity but not normally longer than 5 years. This is a systematic examination of all engineering and operational aspects that could impact on the safety and integrity of the part in service. Typically the review shall include, but is not limited to, service sampling, flight profile monitoring, development experience, improved understanding of engine and component behaviours, and component material and design alterations after certification. Where there is no directly relevant experience these life reviews shall be completed by 50% and 85% of the PSCL. The TLR will be formally reported and any further requirements included in the LMP.

A.4.6.2 **A.3.6.3** The TLR process continues for the service lifetime of the component. The contractor shall agree the maximum time between TLRs, which should normally be no longer than 5 years.

Table A – A

Life Declaration for Major Rotating Parts ~~(Ref A.3.1.18)~~

The following information shall be included in the life declaration documentation:

- Version control of document.
- Previous life statement number if applicable.
- Reason for change if applicable.
- Engine and marks.
- Engine operational limitations reference.
- Assembly and/or component.
- Part numbers.
- Diagram of potential critical areas.
- Material – common name, and spec code.
- SN curve ref.
- Engine reference stresses (before and after correction to equivalent 0 – max cycle and kt if appropriate) and temperatures and time-points in cycle.
- Reference cycle documentation reference.
- Exponent used.
- Temperature normalisation parameter used.
- Test references and whether results were cracked or not.
- Failure Investigation References.
- Over-stresses.
- List of critical areas and calculated critical area safe lives.
- PSCL.
- Approval signatures.

Table A-B

Procedure for Life Declaration (ref: A.3.1.18)

Determination of Service Life for a part, for a specific mission.

Stage 1

Using relevant engine stresses, temperatures and material properties, customer accepted databank or by test on a new part:

Step (a) Determine the Area Safe Cyclic Lives (Ar) for each identified critical area.

Step (b) Apply appropriate Mission Exchange Rate β and determine the lowest Critical Area Safe Cyclic Life from the identified critical areas.

Step (c) Apply relevant stress and life factors (α and γ) as appropriate to arrive at the PSCL. See Table A-C.

Step (d) Declare Service Cyclic Life Sr = PSCL with a life management plan or a proportion of the PSCL.

Step (e) Declare Service Life = Sr β

Stage 2

From all knowledge accumulated, confirm the PSCL value or re-evaluate it if the experience warrants it. Declare new Service Cyclic Life or confirm current values.

Stage 3

Repeat Stage 2 as service experience accumulates.

Table A-C

Derivation of Test scatter factors for safe life and crack growth assessment

General Relationship

Basic Assumptions

- The distribution curve for the lives or stress (strength) is log-normally distributed.
- The standard deviation, σ, of the associated normal distribution is restricted to certain fixed values, outlines below.
- Nmin/ Nmax and Fmin/Fmax correspond to the $\pm 3\sigma$ from the mean of the distributions of log life and log stress respectively to generate a defined crack size (0.38mm depth) and/or not exceeding 2/3 the burst life.
- GM(Ni) = geometric mean of the sample
- n = sample size
- j = variable.

Safe life assessment for Forgings (initiation)

Nmax/Nmin = 6 Where N is life to failure at a given stress

Fmax/Fmin = 1.4 Where F is stress to failure in a given life

For a single test carried out at engine stress ($\propto$ = 1.0), Scatter Factor (y) = 4.00

Hence

Where p = the lower of 5.28 or –1/slope of the log stress Vs log life

Assessment of spread in sample

Before the calculation of the component scatter factors can be conducted, it is necessary to establish the value of Nmax/Nmin that should be used. For component test samples which contain only finite results, the value

etc …..

~~Table A – D~~ Table A – B

Limitations Applicable to the Value of Overstress

Overstress should not lead to unrepresentative loading of the tested local feature because of gross yielding of the component or local feature.

Forgings

Material	**Limitations on Overstress**
Steels	0.9 – 1.3
Titanium Alloys	0.9 – 1.3
Nickel Alloys	0.9 – 1.14

Overstress factors greater than 1.14 for nickel and 1.3 for steel and titanium or less than 1.00 for all materials should be avoided where practical. Where overstress factors beyond the limitations detailed above are used the life factors calculated shall be justified based on the interpolation of material behaviour data and subject to approval by the Authority.

~~Table A-E~~

~~Calculation of Safe Life from Rig Test Results~~

~~1. During rig testing each Critical Area will be subjected to one or more rig tests, intended to demonstrate the Critical Area Safe Life (Ar).~~

~~2. Assuming a log-normal distribution of life and strength, Ar will be given by:~~
~~Where: n is the number of samples in the test programme.~~

~~3. The Factored Test Life (Fr) for a single test is given by:~~

etc…

~~Table A-F~~

~~Calculation of service usage rates~~

~~Where cyclic usage rates are to be based on a sample of recorded flight tapes, the following method is approved.~~

~~The recorded flight data is used to develop a database of cyclic exchange rates against various parameters such as sortie pattern code, base, flight date using algorithms and constants supplied and validated by the engine manufacturer. These exchange rates are analysed in families of (e.g.) sortie pattern code. The analysis may use Weibull, Log Normal or any other distribution shown to accurately characterise the data. Where there is a reasonable number of data points a good description line is obtained, and this in turn gives rise to narrow confidence bands. In cases where there are few data points the confidence limits are wide, reflecting the uncertainty of the distribution. Having obtained the distribution, it is then necessary to select an exchange rate which is considered to be representative of the fleet operation. The approach adopted is to use whichever of the following gives the higher exchange rate:~~

1. ~~80% probability with 50% confidence~~

2. ~~Arithmetic mean with 95% confidence (the arithmetic mean can be at a range of probabilities dependent on the form of the distribution, but is generally of the order of 50 to 70%).~~

~~The 80% probability case is usually invoked when there is a large amount of data, so the confidence limits are narrow. If the slope is relatively low then the 80% probability is likely to be higher than the arithmetic mean with 95% confidence. Use of this value takes some account of the known scatter in the data.~~

~~The arithmetic mean with 95% confidence is usually invoked on smaller samples where the confidence limits are wide. This accounts for the unknowns in the distribution, especially if the slope is high, when use of the 80% probability number could be risky. Having obtained a representative exchange rate, the overall fleet exchange rate is calculated by appropriately combining the exchange rates (e.g. by sortie pattern code weighted by its use in a representative mission mix.)~~

~~This total procedure will provide a representative exchange rate for each critical area of each component for each Mark of engine, to use in lifing critical parts.~~

Table A-G

Approved Nomenclature for use in lifing statements

An approved nomenclature is described below. This is not mandatory, but alternative abbreviations shall be explained before use.

1) To define the superscript as the designator, for example of the associated crack growth interval to which the value refers.

2) To define the subscript as the designator of the units and probability point to which the value refers.

3) To use both of these sub and superscripts, in all cases where doing so adds information and hence adds clarity.

4) Optionally, braces could be placed around the inspection interval to indicate cases where the inspection method introduces significant error.

Head symbols

N life in cycles
F factored cyclic life (that is, the estimated 1/750 quantile to 95% confidence)
A value of 'F' for life limiting area of component
S fraction of A released for service
H S converted into hours
n sample size
sf estimated scatter, that is, for the ratio of the $+3\sigma$ and -3σ lives on the respective population distribution
y(n) scatter factor (for disc test sample size 'n') to get from the geometric mean life to the life at which not more than 1/750 components have a exceeded the specified failure criterion (e.g. a crack) to 95% confidence. For example y(1)=4.003.
β exchange rate

Subscripts
t test
r reference
gm geometric mean of sample (that is, expected log-mean life of the population) in units of reference cycles
$+3\sigma$ expected plus 3 sigma point on population distribution
-3σ expected minus 3 sigma point on population distribution
av average (exchange rate)
f factored (safe exchange rate), that the greater of the 80% probability and 95% confidence values.

Superscripts

etc..