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NORTH ATLANTIC TREATY ORGANIZATION

RESEARCH AND TECHNOLOGY ORGANIZATION

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RTO MEETING PROCEEDINGS 18

Fatigue in the Presence of Corrosion

(Fatigue sous corrosion)

Papers presented at the Workshop of the RTO Applied Vehicle Technology (AVT) Panel (organised by the former AGARD Structures and Materials Panel) held in Corfu, Greece, 7-9 October 1998.

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- AVT Applied Vehicle Technology
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Fatigue in the Presence of Corrosion

(RTO MP-18)

Executive Summary

The NATO Applied Vehicle Technology Panel organized a workshop with the title "Fatigue in the Presence of Corrosion" held 7-8 of October in Corfu, Greece. There were 18 papers given on this subject followed by a round table discussion and conclusions. The papers selected represented eight countries. Canada contributed two, Germany one, Greece two, Italy two, Netherlands one, United Kingdom two and the United States seven papers.

The papers were primarily oriented towards the airplane corrosion problem although the content of many of the papers could well apply to land or sea vehicles. The attendance at the workshop, which exceeded seventy, consisted of specialists in the fields of aircraft design, airline operation, and aircraft maintenance. This mix of interests contributed to considerable discussion of the individual papers.

The stated objectives of the workshop were

- to promote general discussion on the viability of the current approaches to addressing corrosion-fatigue interactions,
- to exchange technical and life cycle management experiences related to cost effective and safe approaches to fleet management and repair of corrosion, and,
- to identify potential areas for coordinated and prioritized collaborative activities amongst the NATO nations.

The workshop met these objectives. The scope of the papers given provided the attendees with a remarkably good insight on the issues associated with the corrosion problem.

Some of the workshop papers discussed the significance of corrosion-fatigue as a safety issue or an economic issue. There is ample data to support the contention that it is definitely an economic issue. There is also ample data to support the contention that it has not been a significant safety problem. However, the problem is certainly a potential safety concern if maintenance does not perform their task diligently. The economic issue alone is sufficient to motivate the support of research and development that can reduce the maintenance burden. This research will also reduce the threat of catastrophic failure from the corrosion damage.

The workshop identified many questions about corrosion that must be resolved in order to implement effective life cycle management practices. One question is the ability of nondestructive inspections to detect corrosion adequately. The word adequately refers to (1) the detection of what is today referred to hidden corrosion and (2) the quantification of corrosion pitting and thinning such that corrosion management becomes viable. It would be supportive for maintenance to have the capabilities of nondestructive inspections quantified by means of probability of detection for corrosion in the same manner that one is able to quantify the ability of nondestructive inspection for crack detection.

A second question is on the need for institutionalizing the corrosion management process. Currently, there are no strong linkages between the structural engineer and the corrosion engineer. The structural engineer sizes the components of the aircraft based on strength, durability, damage tolerance, and stiffness requirements. There is no formal approach for combining the effects of corrosion with fatigue in a maintenance program. This type of program should start with the designer working for the original equipment manufacturer and be a part of the policy of the systems (or program) manager. It should be passed down to the depots performing the major maintenance and finally to the base and squadron level

for the implementation in the field. One virtue of this approach is that all elements of the maintenance chain are completely aware of criticality of corrosion found in operational aircraft. Another virtue is that this effort should reduce the cost burden through prevention at the design level.

Another question is on the return on investment from the use of corrosion prediction methods. Considerable effort has been expended on tool development for the prediction of corrosion damage in the future from the observance of the current state of corrosion. The return on investment of this effort should be examined carefully. Most structural components are designed to zero static margins. This has been the accepted policy for both military and commercial aircraft for many years. Consequently, they are unable to withstand any thinning without causing the static margins to become negative. When the nondestructive inspection process indicates that corrosion is present, it may be that at that time the margins have become negative indicating that remedial actions are required. In such a case, the use of predictive capability would not be justified.

Another question is whether the testing that is being performed today provides the proper data for the corrosion-fatigue problem. There is a need to establish the corrosion fatigue data for the commonly used materials in aircraft. The paper by B. Schmidt-Brandecker highlighted the need for a test approach involving corrosion fatigue for material selection.

A final question is on the current capability of corrosion prevention compounds and their potential uses in the future. Questions such as (1) should they be an integral part of airworthiness, (2) should there be increased process control on parts that are non-inspectable, and (3) is there a need for process qualification? Item number (3) refers to issues such as long-term breakdown of the compounds, technician training, and performance standards for durability, assurance of sufficient coverage through nondestructive inspection.

It is recommended that the questions above be the subject of a focussed workshop or working group.

Fatigue sous corrosion
(RTO MP-18)

Synthèse

La Commission des technologies appliquées aux véhicules a organisé un atelier sur « La fatigue sous corrosion » du 7 au 8 octobre à Corfou en Grèce. En tout, 18 communications ont été présentées, suivie d'une table ronde et de conclusions. Huit pays étaient représentés. Deux communications ont été présentées par le Canada, une par l'Allemagne, deux par la Grèce, deux par l'Italie, une par les Pays-Bas, deux par le Royaume-Uni et sept par les Etats-Unis.

Les communications ont traité essentiellement du problème de la corrosion des aéronefs, mais les technologies citées auraient pu, dans beaucoup de cas, s'appliquer aux véhicules terrestres ou maritimes. Plus de soixante-dix personnes ont participé à l'atelier, dont la plupart étaient des spécialistes dans le domaine de la conception aéronautique, de l'exploitation des lignes aériennes et de la maintenance des aéronefs. Cette rencontre a été à l'origine de discussions soutenues.

L'atelier avait pour objectifs :

- faciliter une discussion générale sur la viabilité des approches actuelles du problème des interactions corrosion-fatigue,
- permettre de confronter les expériences sur la gestion technique et sur le cycle de vie, en vue de l'élaboration d'approches sûres et rentables de la gestion des flottes d'avions et de la réparation de la corrosion,
- identifier les domaines possibles d'activités coordonnées, hiérarchisées et conjointes entre les pays membres de l'OTAN.

L'atelier a atteint ces objectifs. Le champ d'activités couvert a donné aux participants un très bon aperçu des problèmes de la corrosion.

Certaines présentations ont abordé la corrosion sur le plan économique, ainsi que sur celui de la sécurité. Beaucoup d'éléments permettent d'affirmer qu'il s'agit bien d'une question économique. En même temps, suffisamment de données existent pour soutenir l'affirmation que la corrosion n'a jamais posé de problèmes de sécurité. Cependant, la sécurité pourrait être mise en cause en cas de défaillance du personnel de maintenance. Cet aspect économique est suffisamment important pour justifier, à lui seul, une aide en matière de Recherche et Développement pour diminuer la maintenance. Ces recherches permettront de réduire le risque d'une défaillance catastrophique occasionnée par la corrosion.

L'atelier a fait ressortir le besoin de définir des procédures efficaces de gestion du cycle de vie. L'une des questions posées concerne l'efficacité de la détection de la corrosion par le biais des inspections non-destructives. Le terme définit de façon acceptable (1) la détection du phénomène communément appelé « la corrosion cachée » et (2) la quantification des piqûres de corrosion et de l'amincissement de façon à permettre la gestion de la corrosion. Il serait souhaitable pour le personnel de maintenance que les performances des inspections non-destructives soient quantifiées en ce qui concerne la probabilité de détection de la corrosion, de la même façon que pour la détection des fissures par les méthodes non-destructives.

Une deuxième question concerne l'intérêt de l'homologation du processus de gestion de la corrosion. A l'heure actuelle, il n'existe aucun lien formel entre l'ingénieur des structures et le spécialiste en

corrosion. L'ingénieur responsable de la conception des structures décide des dimensions des éléments structuraux en fonction de la résistance demandée, de la solidité, de la tolérance à l'endommagement, et des normes de rigidité. Il n'existe aucune procédure normalisée permettant de tenir compte à la fois des effets de la corrosion et de ceux de la fatigue dans un programme de maintenance. Ce type de programme doit faire partie de la politique du gestionnaire systèmes (ou programmes) dans une situation où le concepteur travaille pour l'équipementier. Il doit être transmis au dépôts qui réalisent les grands travaux de maintenance et enfin aux bases aériennes au niveau des escadrons pour application opérationnelle. L'un des avantages de cette approche est que tous les éléments de la chaîne de maintenance sont pleinement conscients du niveau de risque représenté par l'éventuelle corrosion des avions en service. La diminution des coûts par l'intervention au stade de la conception représente un avantage supplémentaire.

Une troisième question concerne la rentabilité des investissements liés aux méthodes de prévision de la corrosion. Des efforts considérables ont été consacrés au développement d'outils de prévision des dégâts de corrosion, basé sur l'observation de l'état actuel de la pièce en question. La rentabilité de cette opération doit être suivie de près. Les marges statiques de conception de la plupart des composants structuraux sont de zéro. Ces marges font partie de la politique préconisée pour les avions civils et militaires depuis de nombreuses années. Par conséquent, tout amincissement de ces composants aurait pour effet de placer les marges statiques en négatif. Lorsque les résultats des inspections non destructives indiquent une trace de corrosion, les marges peuvent être négatives et entraîner des mesures correctives. L'emploi de moyens de prévision ne serait pas justifié dans un tel cas.

Une quatrième question concerne l'adéquation des résultats des essais actuellement en cours vis à vis du problème de corrosion sous fatigue. Il faut recueillir des données sur le phénomène de corrosion-fatigue pour les matériaux les plus communément utilisés dans l'industrie aéronautique. Au cours de sa communication, M. B. Schmidt-Brandecker a insisté sur une approche des procédures d'essais qui comprenne la fatigue sous corrosion, aux fins du choix des matériaux.

Une dernière question concerne les possibilités actuelles des composés utilisés pour la prévention de la corrosion, et leurs applications potentielles. En fait, un certain nombre de questions restent posées à cet égard, comme par exemple: (1) est-ce qu'ils devraient faire partie intégrante du domaine de l'aptitude au vol ? (2) est-ce qu'il faut augmenter le nombre de contrôles en cours de fabrication pour les pièces qui ne sont pas contrôlables autrement ? (3) faut-il instaurer des processus de qualification ? Le point (3) concerne des questions comme la décomposition à terme des composés, la formation des techniciens, les normes de performance en matière de longévité, et l'assurance d'une couverture suffisante lors des inspections non destructives.

Il serait souhaitable que ces questions fassent l'objet d'un atelier spécifique ou d'études d'un groupe de travail.

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Preface

Corrosion and fatigue are two factors that affect the life cycle costs and the airworthiness of the NATO aircraft fleets, particularly those in the "aging" category. Corrosion and fatigue have independently been the subject of substantial research and developmental work. More recently, because of the increased concern related to the extended use of airframes, there is an increased requirement to more fully understand the synergistic interactions between corrosion and fatigue. High costs and decreased availability because of expensive repairs and increased down time are characteristic of the situation.

The NATO fleet is aging in both real time and in accrued fatigue damage. Corrosion and fatigue, independently, are high cost maintenance items and both can affect airworthiness. There is also a synergistic relationship between these two phenomena that must be understood before cost effective and airworthy approaches to design and corrosion prevention can be defined. In addition, there is substantial work in progress in NATO countries that could be accelerated by a sharing of experience. There is a strong potential for coordinated and prioritized collaborative activities amongst the NATO nations.

Previous NATO-AGARD activities have provided significant advances in understanding the corrosion and fatigue phenomena independently. To address their synergistic interaction, this workshop on corrosion-fatigue interactions was formed. The workshop had the general objective of promoting discussion on the viability of the current approaches to addressing the corrosion-fatigue interaction. Other major objectives included the focussing of the corrosion-fatigue research of member nations on priority issues and the identification of technology areas where NATO-RTO activity could accelerate the development of improved technology to address corrosion-fatigue.

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Crack propagation
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Airworthiness
Airframes
NATO forces

14. Abstract

The NATO fleets are aging in both real time and in accrued fatigue damage. Corrosion and fatigue, independently, are high cost maintenance items and both can affect airworthiness. There is a synergistic relationship between these two phenomena. Cost effective and airworthy approaches to design and corrosion prevention must be defined. Work in NATO countries could be accelerated by a sharing of experience.

During the Workshop 22 papers were grouped in four sessions:
Session I: In-service Experience with Corrosion Fatigue
Session II: Simulation/Test Evaluation Programs
Session III: Fatigue Prediction Methodologies in Corrosive Environments
Session IV: Structural Integrity – Corrosion and Fatigue Interactions

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