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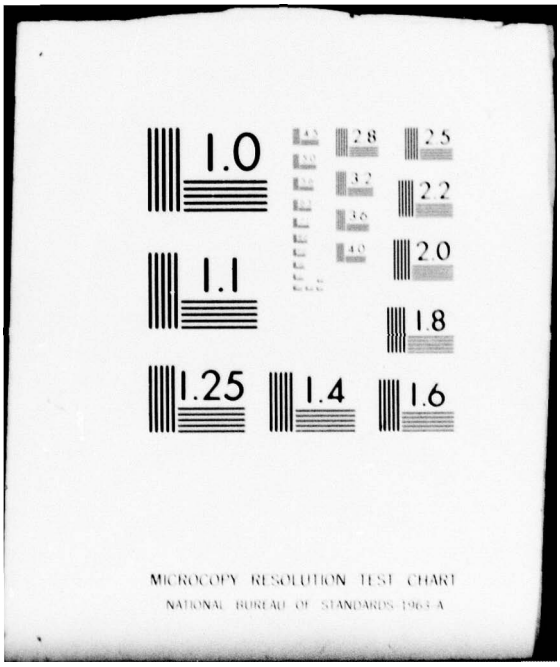
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(9) AGARD Advisory Report No. 141

(6) # CORROSION INFORMATION IN NATO NATIONS

by

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THE MISSION OF AGARD

The mission of AGARD is to bring together the leading personalities of the NATO nations in the fields of science and technology relating to aerospace for the following purposes:

- Exchanging of scientific and technical information;
- Continuously stimulating advances in the aerospace sciences relevant to strengthening the common defence posture;
- Improving the co-operation among member nations in aerospace research and development;
- Providing scientific and technical advice and assistance to the North Atlantic Military Committee in the field of aerospace research and development;
- Rendering scientific and technical assistance, as requested, to other NATO bodies and to member nations in connection with research and development problems in the aerospace field;
- Providing assistance to member nations for the purpose of increasing their scientific and technical potential;
- Recommending effective ways for the member nations to use their research and development capabilities for the common benefit of the NATO community.

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FOREWORD

The Structures and Materials Panel reflects the attitude of the military aircraft community and others in its recognition of corrosion as a topic of continuing importance in view of its aircraft availability, cost and maintenance manpower implications. Its current activity was prompted by views expressed during a Lecture Series on corrosion recently sponsored by AGARD indicating that improvement in the area of corrosion information transfer should be helpful in corrosion control. Before deciding what, if anything, should be done to improve the current situation the Panel decided to determine more precisely what the current situation is, i.e. what information is needed, by what groups, and what sources of information now exist in NATO nations relevant to their aerospace corrosion needs. AGARD arranged to have Mr. N. E. Promisel, U.S., make a survey to answer these questions. This report presents the results of that survey. The Sub-Committee on Corrosion which is charged with the responsibility for guidance of Panel activity in the corrosion area will use this report in connection with its planning of future Panel activity. The report is being published in the belief that the information it contains will be helpful to others in the NATO community interested in the subject.

T. F. KEARNS
Chairman, Sub-Committee
on Corrosion AGARD/SMP

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ACKNOWLEDGEMENT

A study of this type necessarily involves the cooperation and inputs of many people; were I to list all who made important contributions, the list would be very lengthy indeed. To all of these, I am extremely grateful. I do want to identify, however, those who were given and very competently implemented the added burden of organizing national and international interview-conferences and who provided special assistance: T. F. Kearns, U.S. Navy Dept., and the Sub-Committee on Corrosion of which he was Chairman; W. Wallace, National Aeronautical Establishment, Canada; M. Brunin, Aerospatiale, France; H. Zocher, Industrieanlagen Betriebsgesellschaft, and K. O. Sipple, Messerschmitt-Boelkow-Blohm, Germany; S. Signoretti, Aeronautica Militare, Italy; H. van Leeuwen, National Aerospace Laboratory, The Netherlands; L. Søvold, Norwegian Defence Research Establishment, Norway; D. Lewis, Ministry of Defence, United Kingdom; and in the United States: Jerome Kruger, National Bureau of Standards, W. Boyd, Battelle-Columbus; B. Cohen and T. Lynch, Air Force; T. Hull, National Association of Corrosion Engineers; H. Mindlin, Metals and Ceramics Information Center; J. P. Reese, Aerospace Industries Association of America; R. W. Staehle, Ohio State University; M. Steinberg, Lockheed Aircraft Corp. I want to thank, also, Ms. Sharon Dorsey, of the U.S. Navy Dept., for her invaluable secretarial assistance.

N. E. PROMISEL

A number of abbreviations and acronyms are necessarily used in this report. A Glossary of these terms is given in Appendix C.

CORROSION INFORMATION IN NATO NATIONS

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1. ORIGIN, BACKGROUND AND SCOPE OF STUDY

In 1976, under the sponsorship of AGARD, a series of lectures (AGARD Lecture Series 84, compiled in AGARD Report LS-84) was given in Dayton, Ohio, U.S.A.; Delft, The Netherlands; and Lisbon, Portugal, on "The Theory, Significance and Prevention of Corrosion in Aircraft". The audiences consisted of attendees from many countries representing aircraft builders, military and civilian aircraft users, airline operators, research and technology, academia, maintenance and repair, equipment suppliers, materials producers, anti-corrosion surface treaters and other groups from government and industry. Such a melange in the audiences provided excellent opportunities for discussion, for which ample time had been provided.

A theme that recurred often in the discussions was the inadequacy of corrosion information transfer as it currently exists. Particularly in view of the tremendous amount of information that does exist, it is most regrettable that corrosion in aircraft still results in a cost running into the hundreds of millions of dollars annually (as discussed in Section 2), a cost that could be sharply reduced if: (1), problems and hazards were properly defined and recognized at timely stages in the life-cycle of an aircraft; and (2), existing experience and knowledge were transferred to the proper sources (i.e. those who could use this information effectively) in a convenient, timely manner and in proper form. It was clear from audience comments that information such as practical reports and remedies, case histories of service problems and solutions, new technological approaches, and general precautions for application at various stages (from design to service repair) were not adequately reaching those who could use such information to advantage. In fact, the existence and location of such information were often not known, so that it could not even be sought or requested. Thus, there arose, during the discussions, the subjects of corrosion information centers, focal sources for consultation and for dissemination of information, the need for handbooks and guidebooks, workshops and symposia, education and training, and other technology transfer mechanisms. It was fully recognized that a number of these sources already existed but their identities, capabilities, charters and even locations were known only to a very limited degree.

The Lecture Team, therefore, recommended to the Director of AGARD and more specifically to the AGARD Structures and Materials Panel a number of approaches to ameliorate the above situation. The Panel promptly undertook to implement some of these, as a start, and through a newly formed Sub-Committee on Corrosion initiated, inter alia, this study.

Basically, the purpose of this study is (1) to determine the needs of the NATO aerospace industry and related Government establishments for technical data relevant to corrosion principles, material behavior in hostile environments, corrosion prevention, etc.; (2) to determine what national and international resources exist that could be responsive to these needs and what were the facilities for collecting, analyzing, coding, storing and retrieving the desired information; and (3) to suggest approaches to filling identified gaps and unsatisfied needs.

It should be noted that the study was limited to the generic types of information needed and the mechanics of transferring this information. Excluded were the study of specific and detailed technical corrosion problems and remedies and, for example, the identification and description of extant research projects, except in special cases.

2. SIGNIFICANCE OF THE CORROSION PROBLEM

It is unfortunate, but inevitable, that aerospace vehicles and equipment must operate in an aggressive environment thermodynamically hostile to the materials of construction, with resultant deterioration of these materials; that is, corrosion. Aerospace, of course, is not unique in this respect and, in fact, much may be learned from non-aerospace experience. It may further be said, without fear of serious challenge, that: (1), corrosion in aircraft and related flight equipment is still a very serious problem (in one case, 40% of aircraft were reported failing due to corrosion), with much of the corrosion due to basically the same causes as existed years ago; (2), this corrosion is extremely costly to government, industry and, of course, ultimately to the public; and (3), a significant portion of the corrosion and its cost is avoidable, with potential annual savings of many millions of dollars. It should also be noted that this situation is of increasing importance and likely to be aggravated if adequate preventive measures are not taken, because of trends to larger aircraft, longer life requirements, more intricate and miniaturized equipment especially in

electronics, conservation and changes due to scarcity of materials, material and process changes due to health environment control, etc. Let us consider the three basic statements above, which are interrelated and overlapping, in some further detail.

The causes of corrosion may be interpreted from the types listed in Table I, Section 4. Obviously, not all of these are of equal importance and frequency; for example, stress corrosion cracking is a most serious and all too-frequent occurence, and pitting corrosion and dissimilar metal contact corrosion are still very common. None of the listed phenomena are new; they have been operating, unfortunately, since the beginnings of metal aircraft. Changes in materials and methods of construction over the years have created variations and different manifestations, but the fundamentals are the same. In fact, they are better understood now and better protective measures have been developed, but we still find extensive corrosion in aircraft and equipment, some of the reasons for which are discussed below.

The best ultimate measure for the degree of continuing corrosion is its monetary cost. Admittedly, focussing on monetary costs neglects such vital but non-quantifiable factors as reliability, safety in flight and successful completion of mission and such other major considerations as inefficient consumption of materials, manpower and energy, all of which are increasingly critical resources. Even on a quantitative, monetary basis, there are various ways of expressing cost. For example, in an as-yet unpublished report, the IATA indicates, based on a preliminary analysis of several airlines, costs of scheduled maintenance, modification and replacement, that direct cost of corrosion per flight hour could be between $5 and $12; that costs could be 6 to 8% of direct maintenance costs; and that total annual direct costs could be in the order of $100 million. These figures are somewhat different from other estimates, but all estimates are very impressive.

There have been a number of studies of total national corrosion costs in several nations, but none that deal comprehensively with aerospace, so that adequate data in this field are lacking as, indeed, they are lacking in most other fields. Also, there is wide divergence of opinions as to what should be included under both the cost of preventing corrosion as well as the cost if corrosion is not prevented. There is a complex array of interacting factors that must be considered in the life-cycle of a product, e.g. an airplane; for example, special design and construction features, specially selected materials, the preventive measures (coatings, insulation, etc.) inspection procedures, maintenance and repair measures, replacements; loss of availability of aircraft, capital investment in redundant equipment, and other related items. The optimum answer involves trade-offs among all these factors. However, in spite of this complexity in cost estimates, by extrapolation and estimation rough costs may be surmised that are appalling even if they are in error by a large factor.

To provide some feeling for the magnitude of corrosion costs, total annual costs may amount to about $10 billion (roughly 2% of Gross National Product (GNP)) in the U.S.S.R.; about $10 billion (roughly 3% GNP) in West Germany; about $4 billion (roughly 2% GNP) in Japan; and about $70 billion (roughly 4% GNP) in the U.S. Unfortunately, some of these figures are not recent and it is not always clear what has been included in these costs among all the factors mentioned above. Nevertheless, it is not unreasonable to conclude that corrosion costs in an industrialized country may well be roughly a few percent of GNP!

The most recent and comprehensive study of corrosion costs identified by the author has been one under the aegis of the U.S. National Bureau of Standards. (Economic Effects of Metallic Corrosion in U.S., NBS Special Publication 511-1, SD Stock No. SN-003-003-01926-7, available from U.S. Government Printing Office, Superintendent of Documents, Washington, D.C. 20402). The above estimates are rough extrapolations of data included in that report. The elements of corrosion costs considered in that report are: capital costs (replacements, excess capacity, redundant equipment), control costs (including maintenance and repair), design costs (including special processing), and associated costs (for example, loss of product, inventory, technical support). For aircraft owned and operated by the U.S. Air Force, Navy and Coast Guard, annual corrosion maintenance costs were estimated at almost $1 billion, within a calculated uncertainty of ~36%. It was also estimated that, due to corrosion-caused down-time, there was a redundant excess of aircraft of 5 to 8%.

Now our increase in knowledge and our progress in the field of corrosion, specifically aircraft corrosion, have been excellent in the past one or two decades. Science and technology have been very active in enhancing both our understanding of phenomena and our approaches to corrosion prevention. It is striking, therefore, that in spite of this, corrosion to the degree indicated above is still encountered. One concludes that much of this is avoidable. It was estimated in the Bureau of Standards report that approximately 15% may be avoidable (some estimates are much higher); that is, savings of hundreds of millions of dollars annually. This leads one to question what should be done to achieve these savings, which, in turn, brings us again to the subject of this report. Given, then, that a considerable reservoir of knowledge and technology exists to permit substantially reducing corrosion, the problem is one of transferring this information to the potential user in the proper form and language, and in a timely manner. The potential user must recognize that he has a reducible problem and that the needed information, in general, exists and is beneficially

available to him. Thus, an incentive is provided at least to attempt to take the precautionary steps to minimize the incidence of intolerable, avoidable corrosion. This is not to say that currently nothing of this sort takes place or that all the answers are available. As stated above, impressive progress has been achieved, particularly in military aircraft, but evidently there remain many opportunities for substantial improvement and, as will be seen in Section 4, real needs for more effective information and technology transfer addressed to selected phases of the life-cycle of the product, beginning with its design. Obviously, the transfer of information in itself does not insure success in corrosion prevention; the will and skill to implement good practise are essential. However, the converse is also true: the necessary data, knowledge and recommended practise must first be available. This combination, together with a broad base of education beginning in the university but definitely extending into industry, should achieve gratifying and very worthwile results.

3. STUDY METHOD AND APPROACH

Since there were constraints on both time and budget for this study, a significant portion of the data input was obtained by reference to publications and by correspondence, the latter occasionally including a questionnaire. However, the major portion, reported in Section 4, was obtained through personal visits and interviews by the author. The conclusions and recommendations in Section 5 are based on an evaluation of input from all these sources. Since opinions and suggestions received were often conflicting, necessarily the evaluation is subjective to some degree.

The study process was initiated by the Chairman of the above Sub-Committee, Mr. T. F. Kearns of the U.S., alerting contacts in all the NATO countries that they would be approached for specific input and soliciting from them a brief over-view of relevant corrosion information activities in their respective countries. Based on the replies, personal visits were arranged by the author in the U.S. and, for practical reasons, only to single centralized "interviewing" conferences in Germany, England, France, The Netherlands, Norway and Italy. Wherever possible, representatives from adjacent countries participated in these conferences. The attendees represented a wide variety of interests in government, industry and academia, similar in scope to those indicated in Section 1 for the Lecture Series and as further categorized in Section 4. Not all of these were present at all conferences, but enough to permit, in toto, developing quite comprehensive viewpoints. Furthermore, the conference organizers and expected attendees were given questionnaires and other information for preliminary study, for detailed discussion later at the conferences.

In the U.S., the author's country, it was practical to make more detailed and specific visits; namely, to the military, to a representative of the aerospace industry (Lockheed Aircraft Corp.), to a major information center (Metals and Ceramics Information Center), to a major university corrosion center (Ohio State University), to the leading corrosion technical society (National Association of Corrosion Engineers), and to a major government corrosion center (National Bureau of Standards). In addition, through the courtesy and cooperation of the Aerospace Industries Association, a questionnaire was extensively circulated throughout the U.S. Aerospace industry, with excellent and detailed response.

After digesting the considerable inputs from these many sources, the author met twice with the above AGARD Sub-Committee on Corrosion to present and discuss his general observations and specific conclusions and recommendations.

Finally, each country was asked to submit specific information on its own major corrosion institutional information sources and published guidebooks and major references. Compilations based on these inputs (and a few other sources) will be found in Appendices A and B. It was by no means practical to even attempt to make these "directories" complete; under the existing circumstances, they could be only a modest beginning. A separate and special effort to compile much more comprehensive directories would have been necessary, and undoubtedly would be very worthwhile.

As a final precaution, because of the abundancy of views and details received, a draft of this report was reviewed by a representative of each country visited, to insure maximum accuracy of details.

4. THE NATURE OF CORROSION INFORMATION SERVICES FOR AEROSPACE

4.1 General Remarks on the Information Explosion and Information Transfer

Section 2 emphasized the tremendous significance and cost of corrosion in aerospace vehicles and equipment and the potential for reducing the over-all cost of corrosion by about 15% (or more), and simultaneously reducing maintenance man-power requirements, if: (1) full advantage is taken of existing knowledge now spread broadly

across many technical and geographical fronts and (2) there is a conscientious and continuing dedication to this effort throughout the design, construction and usage of the vehicle or equipment. The latter is a management responsibility; the former requires an effective, readily available, economical information transfer mechanism. The specific aerospace needs in this context are the subject of this section.

A glance at the general topic of information transfer provides an intuitive feeling for the nature and magnitude of the problem, even when reduced in scope to the sub-topic of corrosion. The general subject has been studied by many groups from many different viewpoints. The common and growing deep concern is that the pace of technical publication, already overwhelming and beyond the capability of an individual to cope with even in his specialty, continues to grow at a prodigious rate. Indicative of the rate is one estimate that 75% of all information available to mankind has been developed in the past 2 or 3 decades and is expected to double in the next 10 years. Millions of bits of information are generated daily. Unfortunately, a significant portion of this, from a technical point of view, is of dubious quality and reliability and often not of the type directly applicable to specific problems; indeed, much of it may require access to other documents to really make it useful, thus introducing cost increases and time delays. In some cases, also, the referenced documents are obtainable only with difficulty, if at all.

The potential user of engineering information - and this is certainly true in the case of corrosion - is thus confronted with problems of quantity, quality and applicability. The engineer confronted with an immediate problem (as opposed to a research worker, for example) tends, in despair and hope, to seek a familiar specific source (usually a human reference) for advice, regardless less of the wealth of information that exists elsewhere, but seemingly beyond his immediate reach. In the case of corrosion, the problem may well be aggravated by wide scatter in data and by the fact that environmental exposure details are inadequately provided, leading possibly to inappropriate decisions by the naive user.

On a more optimistic note, there is growing recognition and indeed an evolution of new and improved techniques for information transfer, stemming from a number of technologies, which should increase the efficiency, effectiveness and utilization of the whole information cycle: generation, acquisition, organization, storage, retrieval and dissemination. Simultaneously, the cost of acquiring information, using advanced technologies for so doing, is tending lower. On-line computer searching in corrosion, for example, can be very nominal indeed, and far more costeffective, as well as faster and more comprehensive, than manual searching. However, much remains to be done in modernizing our approach to optimal information transfer and more extensive preparation and planning for the future should have begun long ago.

These more general observations are, of course, definitely applicable to the field of corrosion. Turning more specifically to this field, in the current survey a number of types of potential users of information were queried concerning the nature of the services deemed necessary or at least very desirable. Not surprisingly, the replies differed significantly not only with respect to the type of user but also from country to country, depending on the nature and magnitude of its aerospace activity.

For current purposes, it is convenient to categorize information users as follows:

Workers in research, testing, evaluation
Technical people, in addition to research workers, concerned with new technologies and with keeping up to date; specialists; educators
Vehicle and engine designers and constructors
Equipment designers and constructors
Users of aircraft (military and civilian)
Maintenance and repair personnel
Those concerned with manned aircraft as distinguished from unmanned vehicles (e.g. missiles) and spacecraft

The types of services that conceivably could be provided to effect adequate information transfer may be categorized as follows:

Publications

- **Preparation of engineering reference handbooks and manuals**
- **Preparation of state-of-art reports, comprehensive critical reviews of selected topics, and technology assessments**
- **Preparation of periodic "current awareness" publications (e.g. newsletters, short reviews, abstracts)**
- **Critiques and evaluation of published articles and data**
- **Preparation of bibliographies, including assists in searching and provision of copies of referenced documents**
- **Preparation of glossaries of terms for mutual understanding in the exchange of information and dictionaries for new users**

Consulting

- Response to specific technical inquiries, including data compilation
- Provision of expert consultants

Laboratory Work

- Limited laboratory work to support above evaluations or to resolve simple conflicts in data

Educational Sessions

- Arrangement, initiation or stimulation of educational meetings on selected topics, to be sponsored by AGARD, technical societies or other groups

Two other topics served as additional background in discussing the above services. One related to the types of corrosion and related phenomena, as tabulated in Table I. The other related to categories of corrosion subjects as listed in Table II. Of the items in Table I, stress corrosion cracking was probably most frequently a point of reference, although all items were of concern. With respect to Table II, the "key words" most frequently heard in discussions were: design considerations, preventive treatments, testing and evaluation, case histories and feed-back systems, problems of new materials, life-cycle costs and trade-offs, and importance of specificity in manuals and handbooks. Their significance will become apparent in the discussion that follows.

In the interviews, meetings and questionnaires described in Section 3, the above types of services were explored with the variety of users mentioned above, with the results presented below.

4.2 Information Transfer by Means of Publications

This topic was by far of greatest interest, and also the most controversial.

With only a few exceptions, there is a wide-spread desire for publications covering selected aspects of the corrosion problem. Within this broad consensus, however, there are differing opinions on what should be contained in the publications. In some cases, these are simply personal differences of opinion; in other cases, the differences are due to differences in the specific interests of the potential users. Thus, the users of aircraft and engines (such as the airlines and even some elements in government) tend to show only limited interest, if any, in an international handbook that would catalog failures and provide detailed remedial measures. The reason is that the manufacturers (of aircraft and engines) furnish them with the recommended and presumably thoroughly investigated remedies and, in some cases, hold annual meetings to discuss corrosion problems. In general, the aircraft users follow these recommendations religiously. However, since the smaller equipment companies lack the facilities and resources, feed-back mechanisms, communication channels, etc. available to the larger aircraft companies, they, as well as the equipment users, welcome handbooks such as the above. Also, interestingly, the aircraft companies themselves (as discussed below), in spite of their resources, favor this type of information, notably case histories of failures and accounts of service experience, remedies, and their effectiveness.

The above illustrates the diversity of opinion and reasons therefor (in this particular case). It is clear that no "handbook" on a single theme -such as case histories - as was proposed in earlier discussion sessions under different circumstances, will provide the desired degree of usefulness throughout the aerospace community or satisfy important needs. It is therefore appropriate to focus on defining the various information needs and to consider thereafter the optimum approach for producing and disseminating this information. To this end, the discussion that follows deals with the expressed prevalent information interests. It should be kept in mind that although at least some of this information already exists, the problem under consideration is how to have this information recognized by and distributed in proper form to those who need it. It must also be emphasized that all manuals, handbooks, guidebooks, etc. must be used intelligently and cautiously.

Guidance for designers.

This theme was probably the most recurrent of all. There exists a strong feeling that too often designers (especially new designers), as decision makers, do not recognize their creation of potential problems or the importance of designing to minimize corrosion; that even when they do they may not be equipped (knowledge- and experience-wise) to do the most effective job; and that even with the best intentions, they are often hampered by cost restrictions and lack of data on cost trade-offs (for example, prevention of corrosion versus maintenance after corrosion). For various reasons, past design mistakes are too often repeated. Tight scheduling could also affect the quality of protection and ultimate costs. One suggestion,

therefore, was for a Systems Guidance Manual or Handbook for Designers, with one part categorized by types of structures and another part by types of corrosion, with specific preventive measures and even material substitutes if appropriate. Included, also, could be effects of different manufacturing and production processes such as heat-treatment, joining of dissimilar metals and use of insulators. Other suggestions dealt with providing a basic or standard teaching course for designers (that could be later expanded); and having AGARD convene a work shop to develop a plan of education, again particularly for new designers.

Records and reports of service corrosion problems and performance of remedial measures

In spite of the above, there are, of course, many -both designers and others- who fully recognize the threat of corrosion and are anxious to minimize it. These plead for better feed-back of service experience with specific details of cause, nature of corrosion, original preventive measures, why and how the protection broke down, corrective measures and their effectiveness, details of equipment, deployment area and environmental and exposure conditions, materials data, repair costs and any other details relevant to the corrosion problem. Accuracy and reliability in reporting must be emphasized and may, in some cases, require training of reporting personnel. Such a collection of case histories, periodically brought up to date as in a loose-leaf handbook, is desired by the manufacturers to enable them to improve their techniques and to develop better instructions to the users, and by the research workers to point out where further research and development are needed. Specificity is emphasized. Also desired are frequency statistics to enable all concerned (perhaps especially the user) to judge the importance of a corrosion event and to resolve often conflicting reports of trouble. A comprehensive, broad exchange publication of this type - that is, not limited to individual manufacturer-is needed to supplement each manufacturer's own limited publication of several additional reasons. There is little distribution of special data on the less common, though important, service problems. There are many data banks on materials and corrosion behavior but little focussing on service performance and analysis of experience. A manufacturer now benefits from the experience of other manufacturers only incidentally and sometimes not at all, since there may be good communication between the manufacturer and his users but poor communication outside that tight circle, especially internationally. It is interesting to note that there is a current effort by EMAC to set up, on an international basis, an experience data bank for each type of aircraft at its manufacturer. The possibility also exists of recording and exchanging service experience on microfilm, supported by macrographs, sophisticated micrographs, and other data.

The willingness of a manufacturer, airline operator or other user to report problems or proprietary-type information is, obviously, a question. However, discussion indicates general agreement that there would be no major problem and good cooperation if the reports were properly "sanitized", i.e. the specific identity of the source and aircraft or equipment were deleted or concealed.

Although the users are committed for the most part to following the manufacturers' instructions for corrosion prevention or correction, there is a strong feeling that the more that useful information is fed to manufacturers, the more useful would be his publications, instructions, meetings, etc.; that, indeed, manufacturers' publications too often lacked necessary specificity and completeness with respect to previous similar incidents. In fact, one possibility for developing a publication such as discussed above would be to start with a composite of manufacturers handbooks and enlarge or modify them progressively.

One important service that AGARD could provide would be the development of a standard reporting format or, as a minimum, a check-off list of details to report. Omission of even one significant detail in a report could nullify its usefulness.

Testing and inspection.

This subject also recurred very frequently. One major concern related to the interpretation of laboratory results and correlation with service performance. To serve this purpose, a better information exchange system on laboratory and service results is needed. The service results portion would be satisfied in part by the feed-back discussed in the previous paragraphs. However, since this would provide only failure data, an additional mechanism would be needed to obtain data on how well minimum performance requirements were being met. Also, a publication on tests and service correlation could include, for maximum utility, information on where the tests were performed, details of procedures, comparison of results from different sources, status of international standardization and other details.

There continues to be a definite need for the standardization of testing methods and formats for collecting and presenting data. It is recognized that many types of test are needed. In Europe, AECMA is involved, concentrating more on development of methods than on analysis of results. In the U.S., ASTM is the leading test standardization agency and although there is a tendency to adopt their procedures in Europe there remains a great diversity in test method details. It would be beneficial to arrange for more formal or intimate coordination between AECMA and ASTM, as has been done by SAE with AECMA with respect to aerospace materials specifications.

ISO, because its corrosion group is quite broad and general, was not considered to be serving the specific aerospace needs. AGARD could conceivably expand its Sub Committee on Corrosion to provide, on a continuing basis, a specialty service analogous to its activity in the field of fatigue. There appears to be much to be done in the testing field because of the complex spectrum of exposure and operating conditions which, it is claimed, were at least partially neglected in developing existing data. Much past data, therefore, are suspect, particularly, it was said, with respect to accelerated tests on aluminum alloys.

A publication on testing could conceivably also cover inspection, which was emphasized in aspects similar to the above. Such a publication should include details of how to inspect, what to look for, how to distinguish between different types of corrosion (e.g. intercrystalline versus stress corrosion). Inspection techniques should be described in detail and be specific to the corrosion phenomenon.

Data Compilations

In spite of the plethora of corrosion data that continually appear, there is a widespread demand for more, indicative of either questionable quality of existing data, excessive scatter, poor information transfer, or lack of coverage for pertinent materials and environmental conditions. The desire for specific data appears to be almost endless. Although much emphasis is placed on new materials or new conditions of usage, there still appear to be major gaps in data for previous material and environmental systems. A partial and random listing of expressed desires for specific data, by alloy or material, is as follows (recognizing that some of these data already exist): effects of temperature, oxygen concentration, hot gases, developed emf, corrodent velocity (if a fluid), galvanic coupling under a variety of conditions, crevices, variations in corrodent composition, seawater, soft water, tap water, distilled water, demineralized water, salt fog, various humidities; stress corrosion behavior, threshold stress levels, crack propagation; chemistry of corrosion reactions under various conditions; hydrogen embrittlement hazards; behavior of various steels unplated and plated with aluminum and chrome; fastener corrosion and its prevention; effects of long time storage, especially of missiles; detailed protection schemes and their applicability and performance; joint sealants and protection for dissimilar metals under static and dynamic exposure conditions; NATO deployment environments and their effects on equipment (air, sea, land); NATO qualification test data on new hardware; etc., etc.

The engine manufacturers particularly desire data on a wide range of materials and exposure conditions and suggest a "computer-type handbook" (data bank) since most of them have computers and could access a central source. Similarly, the equipment manufacturers have a wide range of requirements, with special emphasis on electronic equipment.

All information should be quantitative and specific as possible. Illustrative of this emphasis was a suggestion that a series of data sheets be published, each giving details of a particular application, protection scheme, service experience with it, remedial measures and their success and other relevant details.

4.3 Information Transfer by Means other than Publications

Concerning referral to individual experts or groups for a specific response.

Almost without exception, this approach, if available, was considered the best for an earliest answer to a practical problem. As an aid to this approach, there is a desire for a directory of corrosion experts - a "Who's Who" of corrosion, so to speak - that would include each individual's specialties. Obviously, this would be a difficult and time-consuming task. It would also be a sensitive one, in the sense that unless an extensive and intensive questionnaire survey were made, there would be a good probability of overlooking eligible experts (to their evident and justifiable displeasure and resentment) and a possibility of including marginally qualified consultants, both situations being to the detriment of the usefulness of the directory.

Concerning state-of-art reports & critical reviews and assessments.

Reactions were mixed; their value appears to be marginal.

International or other groups of experts would be needed for this purpose.

AGARD serves this need primarily through sponsoring symposia.

Concerning publications for "current awareness".

There was interest in this, if a good mechanism could be established.

Reference was made to the manner in which ICAF performs this function for fatigue.

"Awareness" should include new theory and current investigations, in addition to "alerts" on new corrosion data and developments.

Concerning critique and evaluation of published articles, data, etc.

Interest was expressed but implementation was considered doubtful.

Concerning a source for limited laboratory work.

Those who commented on this favored such an arrangement, as a method to resolve issues quickly. In some cases, it was considered that resolution of conflicts was the responsibility of government or other official sources.

Concerning bibliographies and searches.

Although there was some feeling that assistance was not necessary here, the predominant sense was a desire for them in one form or another, e.g. in abstracts, newsletters, computer print-outs on request. The latter was the most favored, particularly with the help of a knowledgeable librarian. A more elaborate system would enable one to specify the environment and operating parameters and receive a response regarding the material to be used, applicable test data, and a related bibliography. One disadvantage is the difficulty in obtaining cited references especially when an existing problem does not allow adequate time. In that case, expert consultants may be the only practical approach. For research, bibliographies and search assists are very useful, of course.

Concerning special educational meetings.

Such specialized educational meetings are considered desirable but should be carefully planned, with orientation toward specific and detailed discussion of identified "real world" problems, an objective too often lacking in the past. Such carefully designed meetings should be broadly advertised and an effort made to have a proper discussion audience or working group. A workshop to familiarize researchers with major, practical corrosion problems would be useful.

Concerning dictionaries, glossaries, etc.

There appears to be a need for mutual understanding of corrosion terms, which will increase as exchange of information increases. Terms sometimes vary from country to country. Nevertheless, it is not clear that additional dictionaries or glossaries are needed beyond those currently in preparation or already available. The AGARD multi-lingual dictionary is helpful and a corrosion dictionary is being prepared in Norway. In addition, ISO and AECMA partially cover corrosion terms in their publications.

Concerning a central information source per se.

A massive, monolithic international Corrosion Information Center was not considered logical. However, national centers, some of which do exist, (see Appendix A), and possibly certain multi-national centers (e.g. EEC), should be very useful, particularly if their functions could be expanded to cover more or all of the needs discussed above, and have an adequate technical staff to provide the necessary services. Although a very broad international center per se is not in order, there is a wide spread desire for some type of international central coordinating group to serve as a clearing house and a focal point for various inputs, special discussions, planning (especially looking into future needs), continuity of effort, cumulative acquisition of data, development of distribution lists and mechanisms, organizing of specific work shops and meetings, development of standard reporting formats, collection and collation of particular pertinent data (e.g. data on military equipment, costs and trade-offs for optimal preventive or corrective action), providing credibility and objectivity, and other functions requiring a broad, stable, specific aerospace corrosion group. An international coordinating group of this description does not now exist, except embryonically in the form of the SMP Corrosion Sub-Committee.

AGARD could well serve these functions. However, recognizing the limited resources of AGARD and the fact that some of these continuing, operating functions are not normally considered to be within the scope of AGARD, the possibility exists of building on a current group, or forming a joint working relation between AGARD and an external group. For the latter, several possibilities were suggested, the most prominent being the European Federation of Corrosion, the German group DECHEMA, and the U.S. National Association of Corrosion Engineers. Further investigation of these sources and their interest was recommended.

Table I

TYPES OF CORROSION AND RELATED PHENOMENA

1. Pitting
2. Stress Corrosion
3. Fracture mechanics, crack initiation, crack propagation
4. Intergranular attack
5. Cavitation
6. Erosion, wear and fretting
7. Corrosion fatigue
8. Bacterial corrosion
9. Galvanic corrosion; dissimilar metal contact
10. Crevice Corrosion; concentration cells
11. Exfoliation corrosion
12. Filarform corrosion
13. Hydrogen embrittlement

Table II

TOPICS OF INFORMATION

1. Theory and related phenomena
2. Economics
3. Prevention (coatings, inhibitors, electro-chemical control, heat treatment, effect of surface treatments and other preventive treatments on fatigue and fracture, etc.)
4. Inspection and detection
5. Overhaul maintenance and repair
6. Standards, specifications, tests, instrumentation
7. Design considerations
8. Failure analysis; case histories
9. Material behavior (as related to corrosion), structure effects
10. Educational resources (e.g. how to use corrosion information)
11. Effects of current situations such as environment control, criticality of materials supply, energy and materials conservation, substitution

5. CONCLUSIONS AND RECOMMENDATIONS

Based on extensive discussions in a number of countries with a variety of technical groups concerned with corrosion, a consensus of conclusions and recommendations has been developed.

5.1 Significance of corrosion

Continuing problems in aerospace corrosion and its tremendous annual cost justify and require a major continuing effort on the part of AGARD.

By way of illustration, the annual cost of maintenance due to corrosion of aircraft in the U.S. Navy, Air Force and Coast Guard is in the order of $1000M. While specific data on how much of this is avoidable are not available, it has been estimated that avoidance of over-all corrosion might be, very roughly, 15% (U.S. figure) and 22% (U.K. figure). Regardless of the uncertainty of these figures, clearly the potential annual savings in cost of corrosion in NATO aerospace vehicles runs into the hundreds of millions of dollars. Other obvious incentives for reducing corrosion relate to safety of equipment & personnel, achievement of mission during flight, availability of vehicles, maintenance man-power requirements, conservation of critical materials and energy, capital investment in more vehicles and spare parts, etc. Finally, it must be emphasized that much of the technical knowledge exists to achieve notable improvements, but to utilize this knowledge most effectively requires major efforts in education and information transfer.

5.2 Concerning publications; general

No single topical handbook, manual or other publication will serve the interests and needs of the various sectors of the aerospace community.

These sectors may be categorized as follows:

Workers in research, testing and evaluation
Other technical groups concerned with new technologies; specialists; educators
Vehicle and engine designers and constructors
Equipment designers and constructors
Users of aircraft (military and civilian)
Overhaul, maintenance and repair personnel
Those concerned with manned aircraft as distinguised from unmanned vehicles (missiles, spacecraft, etc.)

Each sector naturally had its special concerns and therefore is primarily interested in those publications that serve its particular needs.

Recommendation: AGARD sponsor a series of publications on corrosion control addressing the special nees of the various sectors.

5.3 Concerning publications; specific

5.3.1 Guidance for designers. A corrosion guide or manual for designers (especially new designers) is needed since many designers do not recognize the importance of corrosion control, or are constrained in treating it properly by reason of cost, inexperience, or unfamiliarity with previous corrosion problems and other factors.

This subject was probably the most recurrent theme in all discussions. One well-received suggestion was to have the guide manual in two sections: one, dealing with categories of structures; the other, dealing with types of corrosion.

Recommendations: (1) AGARD sponsor a designers' guide to corrosion control.
(2) AGARD convene a workshop to develop a plan of education for designers, especially new designers; also keeping in mind designers' new needs resulting from anticipated longer-life aircraft.

5.3.2 Testing and inspection. A better mechanism is needed for comparing anti-corrosion performance in service with latoratory tests and evaluation, and to establish correlation between the two. In addition, and related to this, there is a need for an inspection manual to give details of what to look for, how to do it, how to interprete the results, how to categorize the type of corrosion, etc.

This topic was also very recurrent. There was a strong expression for a better feedback mechanism from field operations and service, to include all necessary details, much previous data being of dubious value because important details were missing. Concern was also expressed about the inadequacy of test standardization, but with recognition of the need for a variety of tests.

Recommendations: (1) AGARD consider sponsoring a publication responsive to the above needs.
(2) AGARD stimulate more specific cooperation between groups such as ASTM and AECMA on testing methods.

5.3.3 Compilation of service corrosion problems and remedies. The majority of the sectors listed above desire a publication progressively effecting such a compilation, preferably using a standard reporting form or at least a check-off list.

Although company manuals cover specific vehicles and engines, the advantages of more comprehensive, mutual information exchange, especially internationally, are lacking, and company manuals in some cases are inadequate. Even the companies (constructors) themselves want more reports from more sources with more details of the problem: cause, nature and degree of corrosion, prevention used, why and how it broke down, exposure conditons, frequency data, etc.

Recommendations: (1) AGARD arrange for a compilation of major, frequent or complex case histories, perhaps starting with an integrated composite of existing manuals.
(2) AGARD prepare a "standard" failure reporting form or a check-off list of details to report.

Note: The above compilation would also be useful for the previous item on test and service correlation.

5.3.4 Data compilations. There is a wide-spread desire for computerized data banks covering many, many parameters and exposure conditions.

The above interest is especially evident for new or modified materials. The engine and equipment engineers are particularly interested and, in the category of equipment, electronic equipment warrants special attention.

Recommendation: See below under "Central Information Sources".

5.3.5 State-of-art reports, critical reviews, assesaments, evaluation of published articles, and similar publications are not deemed to be of major interest.

5.3.6 Current Awarenesa: Newsletters, short articles and other publications intended to alert the reader to new and promising developments are of

interest if capably prepared, but are considered difficult to achieve satisfactorily.

Recommendation: Since ICAF performs an analogous function for fatigue, the Structures and Material Panel should review ICAF activity and then decide if further useful action relative to corrosion should be initiated.

5.3.7 Dictionaries, glossaries, etc. There is a need for standardization of terms for reliable international exchange of information.

In general, it was considered that enough publications are available to serve this purpose, including the AGARD multi-lingual dictionary and ISO and AECMA documents. Also, it is understood that a corrosion dictionary is being prepared in Norway.

5.4 Information services other than publications

5.4.1 Consultants. There is full agreement that referral of a problem to a specialist group or person, when available, is the quickest and probably most effective way to solve an urgent problem.

A "Who's Who in Corrosion" directory of specialists was considered to be useful but potentially misleading in some respects and, therefore, aroused no great enthusiasm.

5.4.2 Bibliographies and Searches. There is a fairly strong interest in obtaining assistance for these, particularly in the form of computer print-outs.

Research workers especially are interested in this topic. A long-range goal could be to work toward a system that would enable one to specify operating environment and material and structure parameters and receive a computer response providing recommendations for specific protection procedures, with accompanying test data, bibliography, etc.

Recommendations: (1) Investigate the Euronet mini-computer system now in development.
(2) Solicit advice and assistance from the AGARD Technical Information Panel.

5.4.3 Educational Meetings. Symposia such as those already sponsored by the Structures and Material Panel have been very useful and should be encouraged. More emphasis should be placed on orienting these symposia toward "real world" problems, with a proper mix in the audience -or as a workshop- to produce useful, pragmatic discussion.

5.5 Central Information Sources. No single, massive, all-embracing, international corrosion center was deemed either practical or desirable, but national or regional (such as EEC) centers should be encouraged, with adequate staffing to provide services of the type discussed above; e.g. searches, newsletters, data compilations, possibly some major publications such as manuals.

Although no international monolithic corrosion center was desired, there is a strong desire for an international coordinating body, specifically for aerospace corrosion, to serve as a focal point for national and regional centers, for international discussion and long range planning, etc. No group in this sense exists currently.

Recommendation: The present SMP Committee serve this coordinating function temporarily and explore the possibility of some other extant group expanding to assume the responsibility.

Groups mentioned as possibilities include the European Federation of Corrosion, the German DECHEMA group, and the U.S. National Association of Corrosion Engineers.

5.6 Other recommendations

5.6.1 The Structures & Materials Panel should consider organizing a workshop on technical problems in corrosion as an input and guide for research and development laboratories.

Some of these laboratories stated that they have difficulty in identifying the most important problems to investigate. They seek better contact with users and other information sources.

5.6.2 The Structures and Materials Panel should prepare a specific list or index of its reports on corrosion and give it very wide distribution.

Several brief checks indicated that many interested and concerned aerospace activities are not aware of and do not receive these reports. For this special purpose, the standard national distribution system is not adequate.

APPENDIX A

INSTITUTIONAL SOURCES OF CORROSION INFORMATION

It is beyond the scope of this report to even attempt to list all institutional and organizational corrosion information sources in the NATO countries. This would be a major task in itself as reflected in those few national directories that do exist, listed in appendix B. For example, most universities have been ommitted, since their work is mainly research and so extensive as to be impractical to include in this brief report. The following listing is based primarily on the selection made by representatives of each country, with the attendant details furnished by them, in some cases amplified by other sources. Accordingly, there are variations in the degree of coverage within a country and in the nature of the descriptive details. Any major omission is greatly regretted. Under the heading "Description", generally only those functions related to corrosion are indicated. The countries are listed alphabetically; there is no significance to the order in which the sources are listed.

BELGIUM

CEBELCOR

Centre Belge d'Etude de la Corrosion
Avenue Paul Heger, Grille 2
B-1050 Bruxelles

Phone 02/649.63.96 Telex 23069 UNILIB-B
Director: Prof, Dr, M, Pourbaix
Description: CEBELCOR is an international non-profit research center devoted to corrosion research (both fundamental and applied), technical studies to resolve practical problems, consultation to industry and others, organization of educational courses and meetings, and publication of scientific and technical documents and periodicals. Among its publications and documents of which it is either editor or contributor are the following: Corrosion Science, Corrosion Week, and Atlas d'Equilibres Electrochimiques. It also maintains CEFA (Commision des Etudes Fondamentales et Applications) which is open to annual membership, and currently serves as Headquarters for the European Federation of Corrosion described below.

EUROPEAN FEDERATION OF CORROSION

Current Headquarters are at CEBELCOR, above.
Other offices are in France and Germany, which see.

Description: The Federation is a voluntary association of European countries to promote cooperation between non-profit-making scientific and technical societies, for the general advancement of research in the fields of corrosion and material protection. Much of its orientation is toward the chemical industry. It operates under a rotating chairmanship and Executive Committee and, to achieve its objectives, establishes other committees, working parties, etc. to survey and report on specific problems or areas within the corrosion and material protection fields. Among others, three such groups are the Science Advisory Committee, the Working Party on Corrosion

Education, and the Committee on Information and Documentation. "Secretariats" and the focal points for these groups may exist in various countries. General Assemblies are held triennially in different countries around the world.

The Federation sponsors international congresses that include countries outside Europe. It also issues a number of special publications, prepared under the aegis of the above and other groups. These include:

- A "Corrosion Education Manual", for the use of both teachers and students containing, among other educational aids, an extensive inventory of sources of information and advisory services.
- An "Introduction to Corrosion Prevention and Control for Engineers", corresponding to an extensive lecture course by Prof. Dr. Gellings at Twente Technical University in the Netherlands.
- A "Manual of Corrosion Experiments" (in preparation) to supplement knowledge of corrosion processes and protection.
- A film on "Corrosion Prevention by Design" in five parts, covering: Introduction, Design, Materials, Coatings, Environment & Conditions (available in an English version).
- A guide on "Retrieval of Corrosion Information" (in preparation) covering terminology and techniques, information sources and services and recommendations to users.

CANADA

NATIONAL RESEARCH COUNCIL OF CANADA

Montreal Road
Ottawa, Ontario, K1A OR6

a. Canada Institute for Scientific and Technical Information

Contact: Mr. P. Wolters Phone: (613) 993-9128
Description: Bibliographic services employing computer retrieval, such as Canadian Selective Dissemination of Information Service (CAN/SDI) and Canadian On-Line Enquiry System (CAN/OLE).

b. Chemistry Division, Metallic Corrosion Section
Contact: Dr. M. J. Graham Phone: (613) 993-2518
Description: Research on corrosion phenomena and consultation services.

c. National Aeronautical Establishment, Structures and Materials Laboratory
Contact: Mr. J. M. Trenouth Phone: (613) 993-9204
Description: Research in turbine materials corrosion and coatings. Consultation and testing services.

d. Technical Information Services
Contact: Mr. J. Chander Phone (613) 993-1753
Description: Industry-government liaison and technical information on corrosion and related problems.

CANADA CENTRE FOR MINERALS AND ENERGY TECHNOLOGY (CANMET)

a. Physical Metallurgy Research Laboratories
568 Booth Street,
Ottawa, Ontario

Contact: Dr. G. J. Biefer Phone (613) 593-7087
Description: Research on corrosion in metals and environmental cracking and hydrogen damage in steel. Advice and assistance to industry and government.

b. Mineral Sciences Laboratory
552 Booth Street
Ottawa, Ontario

Contact: Dr. G. H. Hoey Phone: (613) 996-4368
Description: Studies and assistance in erosion and corrosion in the metallurgical industries and evaluation of control techniques.

DEPARTMENT OF NATIONAL DEFENCE

a. Defence Research Establishment Pacific
Victoria, British Columbia
Contact: Mr. R. D. Barer Phone (604) 388-2295

Defence Research Establishment Atlantic
Halifax, Nova Scotia
Contact: Dr. R. Brown Phone (902) 426-5365

Description: Provides support and consulting to the Canadian Forces and performs corrosion research on materials, protection, detection, analysis of failures and related corrosion phenomena.

b. Naval Engineering Test Establishment
161 Rue Wanklyn
Lasalle, Quebec

Contact: Commanding Officer Phone (514) 366-4310
Description: Mechanical inspection, chemical analysis, corrosion testing of materials and military equipment components.

NATIONAL ASSOCIATION OF CORROSION ENGINEERS, CANADIAN REGION

Corrosion Service Co, Ltd.
10 Price Street
Toranto, Ontario M4W1Z6

Contact: Director D. C. Downing (416) 964-2230
Description: See under United States, National Association of Corrosion Engineers

FRANCE

C.E.A.T.

Centre d'Essais Aeronautique de Toulouse
23, Avenue Andre-Guillaumet
31056 Toulouse Cedex

Phone: (61)-48-80-40
Head, Materials Laboratory: M. Deviller
Description: Government laboratory responsible for ground tests of aircraft equipment and materials. Provides expertise and studies on related corrosion.

C.E.Pr

Centre d'Essais des Propulseurs
Saclay
91406 Orsay

Phone: 941-81-50
Head, Materials Laboratory: M. Dore
Description: Government laboratory responsible for ground tests of propulsion equipment and materials. Provides expertise and studies on related corrosion.

O.N.E.R.A.

Office National d'Etudes et de Recherches Aerospatiales
29, Avenue de la Division Leclerc
92320 Chatillon S/Bagneux

Phone: 657-11-60
Director of Materials: M. El Gammal
Description: Performs basic and applied research on aerospace materials and anti-corrosion treatments and coatings. Provides expertise and advice on corrosion.

S.N.I.A.S.

Societe Nationale Industrielle Aerospatiale
Laboratoire Central
12, Rue Pasteur
92153 Suresnes

Phone: 772-11-22
Chief of Laboratory: M. Hilaire
Description: Conducts studies on airframe materials, particularly corrosion studies in the laboratory and in hostile outdoor exposure.

SNECMA

Societe Nationale d'Etude et de Construction de Moteurs d' Aviation
Division Metallurgie-Resistance
Route Nationale 7 (B.P. no. 81)
91003 Evry Cedex

Phone: 078-92-60
Chief of Division: M. Brunetaud
Description: Studies on propulsion materials, particularly studies and advice on corrosion at elevated temperatures.

CEFRACOR

Centre Francais d'Etude de la Corrosion
28, Rue Saint-Dominique
75007 Paris

Phone: 705-10-73
Director: M. Cabrillac
Description: Documentation, information and studies on corrosion (not limited to aerospace) and distribution of related "documentary leaflets". Organizes specialist meetings on corrosion and issues a publication called "Corrosion".

C.R.E.O.

Centre de Recherches et d'Etudes Oceanographiques
73-77 rue de Sevres
92100 Boulogne-sur-Seine

Phone: 604-91-51
Director: M. Romanovsky
Description: Studies and consultation on corrosion in a marine environment.

SPECIAL INFORMATION SOURCES

- Centre d' Information du Chrome Dur, 28 rue Saint-Dominique, Paris
- Centre d' Information du Cuivre, Laitons, Alliages, 67, Blvd. Berthier, Paris
- Centre d' Information du Plomb, 1 Blvd. de Vaugirard, Paris
- Centre Technique de l' Aluminium, 87, Blvd. de Grenelle, Paris
- Centre Technique du Zinc, 34 rue Collange, 92-Levallois
- International Nickel France, 49 bis, Av. Hoche, Paris
- Service de Documentation du Centre National de Recherches Scientifiques, 13, Quai Anatole France, Paris

EUROPEAN FEDERATION OF CORROSION

Federation Europeenne de la Corrosion
Scretariat General - Bureau de Paris
Societe de Chimie Industrielle
80, Route de St. - Cloud
92 - Rueil - Malmaison

For description, see under "Belgium". Headquarters are currently at CEBELCOR, Belgium.

GERMANY

DECHEMA

Deutsche Gesellschaft fur chemisches Apparatewesen
Postfach 970146
D-6 Frankfurt (Main) 97

Phone: 0611/75641 Telex: 412 490 dchmad
Contact: Prof. E. Heitz or Prof. A. Rahmel
Description: Provides information and consultation on materials mainly outside the aerospace field, oriented primarily toward the chemical industry, steel producers and other non-aerospace industries. Publishes a convenient loose-leaf collection (now in 10 volumes) of data on the behavior of metallic materials in different environments, entitled "DECHEMA-Werkstoff-Tabelle".

EUROPAISCHE FÖDERATION KORROSION

Generalsekretariat Frankfurt
D-6 Frankfurt (Main) 97
Dechemahaus, Theodor-Heuss-Allee 25

For description, see under "Belgium". Headquarters are currently at CEBELCOR, Belgium.

SPECIAL INFORMATION SOURCES

- Aluminium - Zentrale e.V., D-4 Dusseldorf, Jagerhofstr, 29
- Bleiberatung e.V., D-4 Dusseldorf, Postfach 8706
- Bundesanstalt fur Material prufung, D-1 Berlin 45, Unter den Eichen 87
- Deutches Kupfer-Institut, D-1 Berlin 12, Knesebeckstr, 96
- International Nickel Deutschland GmbH, D-4 Dusseldorf 1, Kreutzstr.34
- Verein Deutscher Eisenhuttenleute VDEh, D-4 Dusseldorf 1, Breite Str. 27
- Zentrale fur Gusserwendung, D-4 Dusseldorf, Grunerstr. 31
- Max Planck Institut fur Eisenforschung, 4 Dusseldorf, Max Planck Str. 1
- Max Planck Institut fur Metallforschung, 7 Stuttgart 1, Seestr. 75
- Technischer Ueberwachungsverein Bayern e.V., 8 Munchen 23, Kaiserstr. 14
- Technischer Ueberwachungsverein Essen, e.V., 43 Essen, Steubenstr, 53

GREECE

NATIONAL TECHNICAL UNIVERSITY OF ATHENS

Laboratory of Physical Chemistry and Applied Electrochemistry
Patision Street
Athens

Contact: Prof. Theodore Skoulikides

ITALY

ISTITUTO RICERCHE BREDA

- Direction and Milan laboratories:
  viale Sarca, 336
  20126 Milano, Italy

- Bari laboratories:
  via F. De Blasio
  70123 Bari/Zona Industriale, Italy

Phone: Milano: (02) 6430541/5 Telex: 330895 IRB I
Bari: (080) 371068 - 372087 Telex: 810012

General Director: Prof.Dr. Carlo Tribuno
Description: Research, failure analysis, consultation, selection and testing of materials and corrosion protection systems. Preparation of state-of-art reports. Educational and training courses on special topics.

ISTITUTO RICERCHE "G. DONEGANI"

Via Fauser, 4
28100 - NOVARA - Italy

Phone 0321 - 24701 Telex: 31679 per Istituto Donegani
Head of Corrosion and Electrochemistry Department: Prof. Giuseppe FAITA.
Description: Provides consultation on broad range of corrosion problems with services in nondestructive testing and failure analysis. Performs research on several aspects of corrosion and corrosion control. On request can organize corrosion courses. Is setting up a data bank from several thousands of internal reports.

CENTRO SPERIMENTALE METALLURGICO S.p.A.

Via di Castel Romano
00129 Roma
P.O. Box 19747

Phone: (06) 64951 Telex: 62173 CSM Roma
Chief of Corrosion Dept: Dr. Roberto Bruno
Description: CSM is an independent company dealing with research & development for the steel industry. It focuses on new electrolytic processes, metallic coatings and other problems related to steel structures for marine, chemical and nuclear applications. Tests include exposure at land and marine stations for exposure to salt-water attack and in high-pressure and high temperature equipment.

ISTITUTO SPERIMENTALE dei METALLI LEGGERI (I.S.M.L.)

Via G. Fauser, 4
C.P. 129
I-28100-Novara

Phone: 0321-24 701
Director: Prof. Franco Gatto
Description: Provides research, technical assistance and testing, and serves both aluminum producers and users. Provides consultation and special services such as training. In particular provides consultation and performs research on corrosion problems and special services such as training.

CENTRO di STUDI CORROSIONE "A. DACCO"

Universita degli Studi di Ferrara
Via L. Borsari, 46
I-44100 Ferrara

Phone: (0532) 25034; (0532) 33522
Director: Prof. Giordano Trabanelli
Description: Members teach graduate and postgraduate courses on physical metallurgy, corrosion and prevention. The Center performs research mainly on corrosion prevention by inhibitors. Other fields of interest are some aspects of localized corrosion and corrosion in industrial plants.

UNIVERSITA di MILANO

Istituto di Elettrochimica e Metallurgia
Laboratorio di Corrosione e Protezione dei Metalli
Via G. Venezian, 21
20133 Milano, Italy

Phone: (02) 2360148
(02) 296863

General Director: Prof. Francesco Mazza

Description: Performs research on localized corrosion of various metals, hydrogen damage of boiler tubes, and surface oxide films. Performs on-line surveillance against corrosion. Provides consultant work for industry and public or private technical organizations and offers educational training in the university.

THE NETHERLANDS

FOUNDATION NETHERLANDS CORROSION CENTRE (NCC)

Secretariat: Schoemakerstraat 97
Postbus 203,
Delft

Description: The Foundation NCC, on which 20 institutions are represented, has as its objective corrosion prevention in general and particularly of metals. It coordinates related activities of societies, committees and other organizations; stimulates collaboration among them; promotes (but does not conduct) basic and applied corrosion research; disseminates information; and maintains contact with foreign institutions. It currently has four semi-permanent working groups covering stress corrosion, marine materials research, electrochemical methods of measurement, and corrosion

NATIONAL AEROSPACE LABORATORY (NLR)

Anthony Fokkerweg 2,
Amsterdam

Phone: (020) 5113113 Telex: 11118
Contact: Dr. Henri F. van Leeuwen
Description: Provides advice and conducts basic and applied research on major aerospace aspects of corrosion.

OTHER ADVISORY INSTITUTIONS

- Industrial Organization TNO, Schoemakerstraat 97, Postbus 215, Delft
- Netherlands Society of Consulting Engineers, Javastraat 44, The Hague
- Society of Consulting Chemists, Ruysdaellaan 5, Huis ter Heide
- Society for Surface Treatment of Metals, Soestdijkse Weg 2462, Bilthoven
- Foundation Netherlands Steel Centre, Johannes Vermeerstraat 9, Amsterdam
- Netherlands Stainless Steel Foundation, Koninginnegracht 32, The Hague
- Institution for Anodizing, Soestdijkse Weg 246A, Bilthoven
- Institution for Efficient Zinc Plating, Weissenbruchstraat 115, The Hague

NORWAY (including, in part, other Scandiavian activities)

THE CORROSION CENTRE (SINTEF)

7034 Trondheim - NTH

Phone: (075) 94000
Contact: Dr. Eng. E. Bardal
Description: The Centre represents all the corrosion groups at the Norwegian Institute of Technology. The scope of the work is long time studies and industrial projects on corrosion and surface treatment, covering many alloys of interest to the arecspace industry. Major current emphasis is on offshore problems such as cathodic protection, galvanic corrosion, stress corrosion cracking and corrosion fatigue.

CENTRAL INSTITUTE FOR INDUSTRIAL RESEARCH

Forskningsveien 1
Oslo 3

Phone: (02) 695 880
Contact: Dr. I. Kvernes or Siv.Eng.E. Risberg
Description: The Institute performs research on industrial projects. In the corrosion field, major activity is on "hot" corrosion and higher temperature oxidation in powerplants.

DET NORSKE VERITAS

P.O. Box 300
1322 Høvik

Phone: (02) 129900
Contact: O. Eng. D. Steensland or Cand. Real. N.E. Askheim
Description: This company performs research in marine corrosion and failure analysis for aircraft, ships, and ship equipment, in connection with its function in classification and licensing for industrial plants, power plants, etc.

NORWEGIAN AIR FORCE MATERIALS COMMAND

2007 Kjeller

Phone: (02) 712700
Contact: Oblt. H. Jaquet

Description: This is the main inspection, maintenance and repair workshop for the Norwegian Air Force and since most of the aircraft are from the U.S., major reliance is on U.S. Air Force practise.

THE NORWEGIAN DEFENCE RESEARCH ESTABLISHMENT

P.O. Box 25
2007 Kjeller

Phone: (02) 712660
Contact: Res. Chemist J. F. Henriksen and Res. Chemist T. Valand
Description: Performs corrosion research in connection with military applications, mainly on aluminum alloys in a marine environment.

THE SHIP RESEARCH INSTITUTE OF NORWAY

Main Office: N-7034 Trondheim-NTH
Branch Office (includes corrosion work): Grenseveien 99, Oslo 6

Phone: (02) 689280 Telex: 18086 sfio n
Contact: Cand. Real. S. Bog

Corrosion Laboratory: Boks 149-Asnes, N3201 Sandefjord

Phone: (033) 67171
Contact: SiV. Eng. A. H. Hansen
Description: Performs research on all types of marine corrosion, materials protection and paint systems, primarily for ships and offshore structures. Has extensive facilities for research workers, teachers and students. A major publication, a joint venture by the Scandinavian ship research institutes and the Netherlands Maritime Institute, is "Ship Abstracts". This publication issued ten times a year, uses computer-processed abstracts from approximately 350 periodicals and reports from all over the world. Of potential interest in aerospace, it includes, as regular categories, materials, corrosion and surface treatments.

SWEDISH CORROSION INSTITUTE

Editiorial Office: Box 43037
10072 Stockholm 43

Description: Among other activities, this Institute publishes "Corrosion Abstracts" monthly, in conjunction with the Scandinavian Group for the Study of Corrosion and the European Federation of Corrosion, and with the cooperation of DECHEMA (Germany) and the Chemical Central Association (Finland).

NORDFORSK

NORDFORSK Box 5103 S-10243 Stockholm, Sweden
NORDFORSK, the Scandinavian Council for Applied Research, is an inter-Nordic organization maintained by national technical research councils and engineering academies in Denmark, Finland, Iceland, Norway and Sweden. Its main task is to plan and organize joint cooperative projects using nationally supported R&D activities. The current specialist fields of concentration are: technological information and documentation, materials technology, environmental protection technology, social

engineering and sciences, data control and component technology, and interscience study and contact activities.

PORTUGAL

NATIONAL LABORATORY OF ENGINEERING AND INDUSTRIAL TECHNOLOGY

Laboratory of Electrochemistry and Corrosion
Rua Buenos Aires, 10
Lisbon - 2

Contact: Engineer Joao Faustino

TURKEY

MIDDLE EAST TECHNICAL UNIVERSITY

Metallurgical Engineering Dept.
O.D.T.U. Ankara

Phone: 23 71 00/2562
Contact: Prof. Dr. Mustafa Doruk
Description: Provides advice and performs research on mechanisms of corrosion, polarization, stress corrosion cracking and iron alloys.

UNITED KINGDOM

ROYAL AIRCRAFT ESTABLISHMENT (RAE)

Royal Aircraft Establishment - Materials Dept
Procurement Executive, Ministry of Defence
Farnborough
Hants GU14 6TD

Phone: 0252 24461 Ext 2029
Head of Materials Dept: Dr. R. J. E. Glenny
Description: Government advisory and research centre for all aspects of aerospace vehicle structural materials and related corrosion aspects.

NATIONAL GAS TURBINE ESTABLISHMENT (NGTE)

National Gas Turbine Establishment - Materials Dept
Procurement Executive, Ministry of Defence
Pyestock
Hants

Phone: 0252 44411 Ext 6122
Head of Materials Dept: Dr. M. G. Cockroft
Description: Government advisory and research centre for all aspects of aerospace vehicle propulsion unit materials and related corrosion aspects.

NAVAL AIRCRAFT MATERIALS LABORATORY (NAML)

Naval Aircraft Materials Laboratory
Royal Naval Aircraft Yard
Fleetlands
Gosport
Hants PO13 OAW

Phone: 0705 22351 Ext 44879
Officer in Charge: Dr. K. Kent
Description: Royal Navy advisory and research centre for all aspects of naval aircraft materials and related corrosion aspects.

NATIONAL CORROSION SERVICE

National Corrosion Service

National Physical Laboratory
Teddington
Middlesex TW11 OLW

Phone: 01-977-3222
Director: Dr. G. P. Rothwell
Description: Government advisory and consultation service for all aspects of corrosion, to industry and government. Conducts tests and plans and monitors longer-term investigations.

CORROSION AND PROTECTION CENTRE INDUSTRIAL SERVICES (CAPCIS)

Corrosion and Protection Centre
University of Manchester Institute of Science and Technology
Sackville Street
Manchester M60 1QD

Phone: 061-236-3311 Ext 2014
Director: Dr. D. Geary
Description: Semi-autonomous advisory and consultation service with research facilities for all aspects of corrosion and prevention, with emphasis on industrial aspects.

HARWELL CORROSION SERVICE

Harwell Corrosion Service
Building 393
Materials Development Division
AERE Harwell
Didcot
Oxon OX11 ORA

Phone: 0235 24141 Ext 4454
Director: Dr. J. E. Antill
Description: Government corrosion consultation service; contract research and testing facilities covering aqueous and gaseous corrosion over a range of temperatures.

PAINT RESEARCH ASSOCIATION

Paint Research Association
Waldegrave Road
Teddington
Middlesex TW11 8LD

Phone: 01-277C4427
Information Contact: Mr. D. Dasgupta
Description: Autonomous advisory and consulting service on all aspects of organic protection coatings and inorganic paints.

FULMER TECHNICAL SERVICES

Fulmer Research Institute
Stoke Poges
Slough
Bucks SL2 4QD

Phone: 028 162181 Ext 275
Information Contact: Mr. G. Sanderson or Dr. W. E. Duckworth
Description: Contract research and consultancy in corrosion prevention; testing facilities.

GROUP FOR AERONAUTICAL RESEARCH AND TECHNOLOGY IN EUROPE (GARTEur)

For corrosion: Dr. Glenny
Head of Materials Dept.
Royal Aircraft Establishment
Farnborough, Hants

Description: GARTEur was organized to provide a research and technology base for the European aeronautical industry through joint planning and execution of work and information exchange. It operates under rotating national chairmen through a Council, Council Committee, Groups of Responsables and Action Groups - all of

international make-up. One of the Groups of Responsables deals with structures and materials (formerly stress corrosion cracking) and currently is headed by Dr. Glenny (above).

INTERNATIONAL RESEARCH AND DEVELOPMENT CO LTD

International Research and Development Co Ltd
Fossway
Newcastle upon Tyne
NE6 2YD

Phone: 0632 650451
Director: Dr. G. Arthur
Description: Autonomous advisory service on high temperature oxidation, and stress corrosion cracking. Facilities include corrosion fatigue testing and protective coating evaluation.

BNF METALS TECHNOLOGY CENTRE

Grove Laboratories
Denchworth Rd.
Wantage, Oxfordshire OX12 9BJ

Contact: Mr. H. S. Campbell
Description: The Centre is an international organization serving the non-ferrous metals industry, through brosdly based research and various services including consulting to industry. It is involved with all aspects of corrosion relating to non-ferrous metals and non-ferrous coatings on ferrous metals. It stores approximately 15,000 corrosion related documents. There is a "Metal Users Consultancy Service" within the Center.

THE METALS SOCIETY

1 Carlton House Terrace
London SW1Y 5DB

Description: While the primary objective of this Society is to promote all aspects of the science and technology of metals and related materials, it covers all aspects of corrosion in its abstracting service and library. It publishes the quarterly "British Corrosion Journal" concerning theory and practise in corrosion and its prevention.

OTHER SOURCES, COORDINATORS AND FOCAL POINTS

1. British Aerospace (BAC)
   British Aerospace (aircraft Group)
   Kingston Division
   Richmond Division
   Kingston-on-Thames
   Surrey KT2 5QS

   Phone: 01-546-7741
   Contact: Mr. J. Fielding
   Description: Coordinates all general fixed wing aircraft corrosion inquiries.

2. Westland Helicopters Ltd.

   Yeovil
   Somerset BA20 2YB

   Phone: 0935 5222 Ext. 111
   Contact: Mr. J. Lee
   Description: Coordinates all general rotorcraft corrosion inquiries.

3. Royal Air Force (RAF)

   Air Eng. 30 (RAF)
   Room 375, Old War Office Bldg.
   Whitehall, London SW1 2EU

   Phone: 01-218-4262
   Commanding Officer: Wing Cdr. B. Robson
   Description: Policy making and coordinating office for RAF corrosion matters, major UK corrosion information sources.

4. Royal Navy (RN)

Naval Aircraft Materials Laboratory (NAML)
Royal Naval Aircraft Yard
Fleetlands
Gosport, Hants PO13 OAW

Phone: 0705 22351 Ext. 44879
Officer in Charge: Dr. K. Kent
Description: In addition to its advisory function (see above), coordinates all naval aviation corrosion matters.

5. British Airways (BA)

Structures Dept.
British Airways (Overseas Division)
Heathrow Airport
London

Phone: 01-759-5511 Ext. 2511
Contact: Mr. R. Mitchell
Description: A civil aviation organization that has accrued much theoretical and practical corrosion expertise related to transport aircraft.

6. European Federation of Corrosion, London Office

Society of Chemical Industries
14 Belgrove Sq.
London SW1

For description see under "Belgium". Headquarters are currently at CEBELCOR, Belgium.

SPECIAL INFORMATION SOURCES

- Aluminium Federation, 60 Calthorpe Road, Edgbaston, Birmingham 15
- Copper Development Association (CDA), 55 South Audley Street, London W 1
- Corrosion Advice Bureau, BISRA, 140 Battersea Park Road, London S W 1
- Institute of Metal Finishing, Electrodepositors Techn Society, 178 Goswell Road, London E C 1
- International Nickel Limited, Thames House, Millbank, London S W 1
- Stainless Steel Development Association (SSDA), 65 Vincent Square, London S W 1
- Tin Research Institute (TRI), Fraser Road, Perivale, Greenford, Middlesex
- Zinc Development Association (ZDA), 34 Berkely Square, London W 1

UNITED STATES

METALS AND CERAMIC INFORMATION CENTER (MCIC)
Battelle-Columbus Laboratories
505 King Ave.
Columbus, Ohio 43201

Phone: (614) 424-6424 Ext. 3471
Director: Mr. Harold Mindlin
Description: MCIC is a Defense Dept. sponsored center covering practically all metals, ceramic-based materials, structural composites, processes, quality control and related topics. Mechanical and design characteristics and corrosion and compatibility are emphasized. Data from many sources are collected and evaluated and incorporated in a computerized storage-retrieval-display system. The Center provides advisory services; performs special assignments; prepares bibliographies, literature searches, state-of-art reports, databooks and handbooks; publishes current awareness periodicals (including one on corrosion compatibility) and a monthly newsletter (widely distributed gratis).

NATIONAL TECHNICAL INFORMATION SERVICE (NTIS)
U.S. Dept. of Commerce
5285 Port Royal Rd.
Springfield, VA 22151

Phone: (703) 321-8500
Director: Mr. W. T. Knox
Description: The Service is a government sponsored, self-sustaining organization

providing a central source for the public sale of Government-sponsored research reports and other analyses. Almost a million titles covering an extremely wide array of subjects are on file. It provides computer search service, and summaries and whole reports in newsletters, microforms, magnetic tapes and cumulative volumes and indexes.

NATIONAL ASSOCIATION OF CORROSION ENGINEERS (NACE)
1440 South Creek
Houston, Texas 77084

Phone: (713) 622-8980
Executive Director: Mr. T. J. Hull
Description: NACE is an engineering society, of international scope, devoted to promoting the science and technology of corrosion control. Its coverage is extremely broad, encompassing all forms of corrosion, in all materials, for all industries, in a variety of environments (the common ones such as marine and atmospheric as well as special unique ones). Theories, measurement techniques, economics and other aspects are included. Its data bank exceeds 100,000 pages of printed information in the form of journals, books, reports, proceedings of congresses, etc. and it now has for its own sources of information a computerized storage and retrieval system. The Association provides advisory services and sponsors technical meetings, congresses and symposia. It publishes extensively including "Corrosion" (monthly), "Corrosion Abstracts" (bimonthly), "Corrosion Abstracts Yearbook", "Materials Performance" (monthly), a Reference Book Series and various books and reports on test methods, recommended practises, data survey, electrochemical equilibria, inhibitors, and other topics. Committee T-9 deals with Corrosion of Military Equipment.

AMERICAN SOCIETY FOR METALS (ASM)
Metals Information
Metals Park, Ohio 44073

Phone: (216) 338-5151
Director for Information: Mr. H. D. Chafe
Description: ASM is an international technical society covering the entire spectrum of metals and engineering non-metallic materials, materials treatment and processing, theory and application, and materials-related phenomena such as corrosion. In the latter field, it deals with all forms of corrosion and environmental compatibility. It sponsors meetings, congresses, symposia and expositions, both generalized and specific; conducts extensive education and training courses; publishes reports, handbooks, periodicals, reference books, newsletters, etc.; and maintains a major information gathering, storage and retrieval (including on-line computer) service. Its information service includes, either through regular publication or on request, abstracts, digests, tapes, indexes, bibliographies, translation service, searching and other related activities.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)
Information Center
1916 Race St.
Philadelphia, PA 19103

Phone: (215) 569-4200
Administrator for Information: Ms. Dolores G. Collyer
Description: ASTM is a technical organization for the very extensive development of standards on characteristics and performance of materials, products, systems and services and the promotion of related knowledge. It covers all types of materials and test methods. It operates through more than 115 technical committees such as Committee G-1 on Corrosion of Metals and F-7 on Aerospace Industry Methods (Subcommittee 4 is on Hydrogen Embrittlement). All aspects of corrosion are included in its standards and test methods. Its output and services are primarily through its publications; for corrosion these are mainly the "Annual Book of ASTM Standards", (Part 10), "Corrosion in Natural Environments" (STP558), "Metal Corrosion in the Atmosphere" (STP435), "Localized Corrosion-Cause of Metal Failure" (STP516), "Stress Corrosion Cracking of Metals" (STP518), and others.

THE ELECTROCHEMICAL SOCIETY (ECS)
P.O. Box 2071
Princeton, New Jersey 08540

Phone: (609) 924-1902
Executive Secretary: Mr. V. H. Branneky
Description: ECS is a technical society serving the fields of electrochemistry and corrosion science. It covers all types of corrosion, with major emphasis on theory, and all types of metals. It sponsors symposia and publishes, in addition to its periodic Journal, a Corrosion Monograph Series including a handbook, a testing handbook, and books on individual metals and on stress corrosion.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS (AIChE)
345 East 47th St.
New York, N.Y. 10017

Phone: (212) 752-6800
Director: Mr. F. J. Van Antwerpen
Description: AIChE is a technical society for the advancement of chemical engineering in theory and practise. It covers a wide variety of industrial materials and the entire spectrum of corrosion. Its main output is through its periodicals that include a Symposia Series, Chemical Engineering Progress, AIChE Journal and an international Translation Periodical.

OTHER GENERAL ABSTRACTING SERVICES THAT INCLUDE CORROSION TOPICS

1. Chemical Abstracts Service (CAS)
The Ohio State University
Columbus, Ohio 43201

Phone: (614) 421-6940
Description: CAS is a division of the American Chemical Society and provides comprehensive coverage of chemical literature from 13000 journals plus patents from 26 countries. "Chemical Abstracts" is published weekly and annually references about 400,000 documents. Abstracts are also available on microfilm and from computer-readable files.

2. Engineering Index, Inc. (Ei)
United Engineering Center
345 East 47th St.
New York, N.Y. 10017

Phone: (212) 752-6800
Executive Director: Mr. J. E. Creps, Jr.
Description: Ei is a not-for-profit informational service providing a data base for abstracts and an index to the world's major engineering literature and conferences. The data are produced in a monthly periodical, on magnetic tape, in microfilm and in a weekly current awareness service on library-sized cards.

SPECIAL CORROSION INFORMATION SOURCES

- Alcoa Laboratories, Alcoa Center, Pennsylvania 15069
- Copper Data Center, Battelle-Columbus Labs., 505 King Ave., Columbus, Ohio 43201
- Magnesium Data Center, Battelle-Columbus Labs., 505 King Ave., Columbus, Ohio 43201
- The International Nickel Co. Inc., 1 New York Plaza, New York, N.Y. 10004
- The International Lead and Zinc Research Organization, Inc. 292 Madison Ave., New York, N.Y. 10017
- Tin Research Institute, Inc., 483 West Sixth Ave., Columbus, Ohio 43201
- Titanium Metals Corp. of America, 400 Rouser Rd., P.O. Box 2824 Pittsburgh, PA 15230
- American Iron and Steel Institute, 1000 16th St. N.W., Washington, D.C. 20036
- National Referral Center (for referral to knowledgeable sources), Libarary of Congress, Science & Technology Division, Washington, D.C. 20540

APPENDIX B

PUBLISHED SOURCES OF CORROSION INFORMATION

As in Appendix A, no attempt has been made to establish a comprehensive, evaluated listing of handbooks, reference books and other major compilations of technical data, knowledge and references on corrosion; such a task, although desirable, was completely impractical within the scope of this report activity. Also, as in Appendix A, the listing below is based mainly on information furnished by representatives of various NATO countries, expanded occasionally by reference to other sources. Even so, some details in some cases were not available. In general, textbooks and journal articles have been omitted to keep the listing within allowable length. This compilation should be regarded, therefore, primarily as an abbreviated, selected list of corrosion information references of probable interest to the aerospace field. The order of listing has no major significance.

1. "CORROSION PREVENTION DIRECTORY", published by the Dept. of Industry, available from Her Majesty's Stationery Office, Atlantic House, Holborn Viaduct, London EC1P 1BN, England. Covers advisory services, consultants, suppliers, standards, institutions, publications, educations and research sources. 136 pages.

2. "CORROSION MANUAL", Ref. AP119A-0200-1, sponsored by Ministry of Defence, available from Air Publications and Forms Store, Bldg 10, Royal Arsenal West, London SE18 6SY. Covers nature, detection, prevention, control and treatment of corrosion, especially for maintenance personnel. A condensed version as a handbook is also available (Ref. AP-119A-0201-1).

3. "CORROSION IN NAVAL AIRCRAFT", Ref. AP 119A-0202-1, a handbook similar to the condensed handbook in Item 2 but with emphasis on Navy operations.

4. "GENERAL REPAIRS TO AIRFRAMES", Ref. AP 101-A-0600-6, sponsored by and available from same sources as in Item 2. Provides a general repair manual with information on repairs to protective treatments, Ref. AP 119A-0601-1, "Aircraft Painting", provides information on paint schemes, surface preparation, application, etc.

5. "PRECAUTIONS AGAINST CORROSION AND DETERIORATION", Ref. AvP 970, Available from the Secretary (RDT2), Procurement Executive, Ministry of Defense, St. Giles Court, London WC2H 8LD, England. Chapter 801 covers contractual requirements for military aircraft and Chapter 400 covers magnesium alloys, exfoliation corrosion of aluminium alloys, and stress corrosion cracking.

6. "GENERAL DESIGN REQUIREMENTS FOR AIRCRAFT EQUIPMENT FOR SERVICE AIRCRAFT", Ref. AvP 24, available as in Item 5. Covers contractual requirements: Part I, Environmental Conditions; Part 2, Engineering Requirements; Part 3, Materials, Corrosion and Finishes; Part 4, Marking and Notices; Part 5, Servicing and Maintenance.

7. "TREATMENTS FOR PROTECTION OF METAL PARTS OF SERVICE STORES AND EQUIPMENTS AGAINST CORROSION", Ref. Defence Guide DG-8, available from source in Item 2. Covers non-proprietary treatments as listed in British specifications.

8. "CONTROLLING CORROSION", sponsored by Dept. of Industry, available from The Secretary, Comm. on Corrosion, Dept. of Industry, Rm 548, Ashdawn House, 123 Victoria St., London SW; England. A series of booklets, mainly to industry, covering methods, advisory services, economics, standards, case histories and monitoring.

9. "CRITICAL SURVEY OF DATA SOURCES: CORROSION OF METALS", by R. B. Diegle and W. K. Boyd. Issued by the U.S. National Bureau of Standards and available from U.S. Government Printing Office, Superintendent of Documents, Wash., D.C. 20402, USA 28 pages. Describes a variety of sources of corrosion information.

10. "CORROSION DATA SURVEY", published by National Association of Corrosion Engineers, 1440 Sough Creek, Houston Texas 77084, USA. 283 pages of charts, tables and graphs summarizing corrosion data for specific materials in particular environments, in two volumes.

11. "HANDBOOK ON CORROSION TESTING AND EVALUATION", edited by W. H. Ailor, John Wiley and Sons, Inc. New York, N.Y., U.S.A. A comprehensive treatment of testing based on a symposium sponsored by The Electrochemical Society. 900 pages.

12. "METALS HANDBOOK", published by American Society for Metals, Metals Park, Ohio, 44073, USA. The 8th edition is in 11 volumes, with Volume 1 being most important for corrosion data and other corrosion information. The 9th edition (only volume 1 available) includes corrosion of irons and steels.

13. "STRESS CORROSION CRACKING CONTROL MEASURES", by B. F. Brown. NBS Monograph 156. 71 pages. Issued by and available from same sources as Item 9 above. Covers test methods and control measures for copper alloys, aluminium alloys, titanium alloys, high strength steels, stainless steels and nickel alloys.

14. "THE CORROSION OF LIGHT METALS", by H. P. Godard, W. B. Jepson, M. R. Bothwell and R. L. Kane, John Wiley and Sons, Inc. New York, N.Y., USA. A monograph sponsored by The Electrochemical Society covering aluminum, beryllium, magnesium, titanium and their alloys. 360 pages. 400 references to worldwide literature on aluminum corrosion.

15. U.S. GOVERNMENT-INDUSTRY DATA EXCHANGE PROGRAM (GIDEP)
Failure Experience Data Bank Summary - Inquiries should be addressed to GIDEP Operations Center, Corona, California 91720 Phone: (714) 736-4677

16A. U.S. AIR FORCE PUBLICATIONS sponsored or prepared by the Air Force Materials Laboratory (AFSC), Wright-Patterson Air Force Base, Ohio 45433, USA. Inquiries about the availability of publications should be addressed to the above laboratory. Selected documents are:

- Technical Manuals for Corrosion Control, one for each major aircraft system, Series T-29-23
- Technical Manual T.O. 1-1-689 on Prevention and Control of Corrosion and Fungus in Communication, Electronic, Meteorological and Avionic Equipment
- Technical Manual T.O. 1-1-2 Corrosion Prevention and Control for Aerospace Equipment

16B. US NAVY PUBLICATIONS published by direction of the Commander, Naval Air Systems Command and available from the Navy Publications and Forms Center, 5801 Tabor Ave, Philadelphia, PA. 19120.

- Technical Manual NAVAIR 01-1A-509, Aircraft Weapons Systems Cleaning and Corrosion Control, Stock No 0801-LP-000-6040
- Technical Manual NAVAIR 16-1-540, Avionic Cleaning and Corrosion Prevention/ Control, Stock No 0816-LP-312-6000

16C. US ARMY PUBLICATIONS Inquiries about the availability of these publications should be addressed to the Commander, U.S.A. A.G. Publication Center, 1655 Woodson Rd. St. Louis, MO 63114

- Technical Manual TM55-1500-333-24, Maintenance Manual for Cleaning Procedures for Army Aircraft
- Technical Manual TM43-00105 Corrosion Control
- Technical Manual TM55-1500-204-25/1 General Aircraft Maintenance Manual
- Technical Bulletin TB746-93-2 Aircraft Painting Manual

17. "GUIDANCE MATERIAL FOR DESIGN AND MAINTENANCE AGAINST CORROSION", being prepared for publication in 1979 by IATA, P.O. Box 550, Succursale, Place de l'Aviation International, 1000 Sherbrooke St. West, Montreal, Quebec H3A 2R4, Canada. The purpose of this publication is to emphasize the the seriousness and significance of corrosion and to promote adequate protection against the environment. The generalized text is supported by basic guidelines for corrosion prevention somewhat in the form of specification requirements and objectives.

18. "CORROSION ABSTRACTS", published six times a year by National Association of Corrosion Engineers (NACE), 1440 South Creek, Houston, Texas 77084, USA. Covers abstracts of the world's corrosion control literature. See also Appendix A, NACE, for other publications.

19. "ATLAS OF ELECTROCHEMICAL EQUILIBRIA IN AQUEOUS SOLUTIONS", published by NACE (for address, see Item 18) to cover the well-known Pourbaix diagrams

20. "CORROSION CAUSES AND ITS PREVENTION", first in a series of handbooks being sponsored by National Association of Corrosion Engineers. In preparation.

21. "CORROSION ABSTRACTS", published twelve times a year by Swedish Corrosion Institute. Available from Almqvist & Wiksell, 26, Gamla Brogatan, Box 62, 10120 Stockholm 1, Sweden. Covers indexed information on corrosion phenomena, their effects and prevention

22. AGARD PUBLICATIONS, available from national distribution centers.

- Directory of Organizations, Investigators and Programs in High Temperature Corrosion Research, AGARD Report No. 585. Although mainly devoted to high temperature corrosion, many references are included on other aspects of corrosion.
- Corrosion Fatigue of Aircraft Materials, AGARD Report 659

- Specialists Meeting on Stress Corrosion Testing Methods, AGARD Conference Proceedings No. 98
- Chapter 6, Fretting - Corrosion Damage in Aluminium Alloys, Manual on Fatigue of Structures, AGARD MAN-9
- The Theory, Significance and Prevention of Corrosion in Aircraft, AGARD Lecture Series No. 84
- Engineering Practice to Avoid Stress Corrosion Cracking, AGARD Conference Proceedings No. 53

23. "INSTRUCTION ON THE PROTECTION AGAINST CORROSION OF AIRCRAFT AND OTHER AERONAUTICAL MATERIEL", Norme AIR 7251, issued by Service Technique Aeronautique, 4 Ave. de la Porte d'Issy, 75753 Paris Cedex 15, France.

24. INTRODUCTION TO CORROSION PREVENTION AND CONTROL FOR ENGINEERS", by P.J. Gellings, published by the Delft University Press, Delft, The Netherlands, and sponsored by the European Federation of Corrosion. It covers both theory and practise, with appendices containing a variety of useful data.

25. "CORROSION EDUCATION MANUAL", sponsored by the European Federation of Corrosion (EFC). Available from Secretariat of the EFC Working Party on Corrosion Education, Swedish Corrosion Institute, Box 43037, S-100 72 Stockholm 43, Sweden. It is essentially an inventory of corrosion information sources.

26. DECHEMA - MATERIALS TABLES, published by DECHEMA, Postfach 970146, D-6 Frankfurt (Main)97, Germany. This publication is a loose-leaf binder of information on the behavior of metallic materials in different environments, arranged alphabetically by environment. Now in 10 volumes.

27. "STRESS CORROSION OF LIGHT ALLOYS: EXPERIMENTAL METHODS", published by Istituto Superimentale dei Metalli Leggeri (ISML), Novarra, Italy

28. "THEORY OF STRESS CORROSION AND HYDROGEN EMBRITTLEMENT" by G. Bollani, issued by Fiat (LRCAA), Turino, Italy.

29. "CORROSION AND PROTECTION OF METALS", by G. Bianchi and F. Mazza, published by Masson Italia, Milano, Italy

30. "PROCEEDINGS OF THE EUROPEAN SYMPOSIA ON CORROSION INHIBITORS", published every five years (next due in 1980) by the University of Ferrara and available from Ufficio Economato, Univ. of Ferrara, Via Savonarola 9, 44100 Ferrara, Italy.

31. "SHIP ABSTRACTS", published ten times a year by the Ship Research Institute of Norway, Information Dept., N-7034 Trondheim-NTH, Norway. Includes a category on Corrosion, Surface Treatment and Painting.

32. "ELECTROCHEMICAL MECHANISMS OF CORROSION", by M. Doruk, Publication No. 42 from Dept. of Metallurgical Engineering, Middle East Technical University, Ankara, Turkey.

33. "CORROSION OF METALS IN MARINE ENVIRONMENTS", by F. W. Fink and W. K. Boyd, edited by D.J. Maykuth, Defense Metals Information Center Report 245, published by Bayer and Company, Columbus, Ohio, USA.

34. "MATERIALS & CORROSION", edited by H. J. Engell and D. Behrens, published by Verlag Chemie Gmbh, Pappelallee 3, Weinheim/Bergstrasse, West Germany.

APPENDIX C

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

AECMA	Association Europeenne des Constructeurs de Materiel Aerospatial
ASTM	American Society for Testing and Materials
DECHEMA	Deutsche Gesellschaft fur Chemisches Apparatewesen
EEC	European Economic Community
EMAC	Engineering & Maintenance Advisory Committee of IATA
Euronet	European Information Network (Frankfurt/M, London, Paris, Rome, with special section (SDIM) on metallurgy)
GNP	Gross National Product
IATA	International Air Transport Association
ICAF	International Committee on Aircraft Fatigue
ISO	International Standards Organization
NBS	National Bureau of Standards (US)
SAE	Society of Automotive Engineers
SMP	Structures and Materials Panel, AGARD

REPORT DOCUMENTATION PAGE

1. Recipient's Reference	2. Originator's Reference	3. Further Reference	4. Security Classification of Document
	AGARD-AR-141	ISBN 92-835-1327-4	UNCLASSIFIED

5. Originator Advisory Group for Aerospace Research and Development
North Atlantic Treaty Organization
7 rue Ancelle, 92200 Neuilly sur Seine, France

6. Title
CORROSION INFORMATION IN NATO NATIONS

7. Presented at

8. Author(s)
N.E. Promisel

9. Date
July 1979

10. Author's Address
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14. Abstract

The Structures and Materials Panel of AGARD reflects the attitude of the military aircraft community and others in its recognition of corrosion as a topic of continuing importance in view of its implications in aircraft availability, cost and maintenance manpower. Improvement in the area of corrosion information transfer should be helpful in corrosion control but, before determining precisely what should be done to improve the current situation, the Panel decided to sponsor a survey of what information is needed, by what groups, and what sources of relevant information now exist in NATO nations.

This report presents the results of that survey which is being published in the belief that the information it contains will be helpful to others in the NATO community.

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