World of Composites

News articles and announcements of interest to the composites technical community

Seventh Volume in Composite Series Now Available from ASTM

The seventh volume in the ASTM series on Composite Materials Testing and Design is now available.

Special Technical Publication 893, *Composite Materials Testing and Design: Seventh Conference*, contains 23 papers selected and reviewed by experts in the field. It was sponsored by ASTM Committee D-30 on High Modulus Fibers and Their Composites. This new volume emphasizes toughness as related to damage tolerance of advanced composites. Also emphasized are the problems researchers face with characterizing and analyzing the complex failure mechanisms associated with stress concentrations and delaminations.

The papers in STP 893 are divided into five areas: structures; failure mechanisms; strength; delamination; and analysis and characterization. Researchers and designers in the fields of composite materials and aerospace, automobile manufacturers, appliance makers, and users of lightweight, high-strength materials will want to add this book to their collections.

To order STP 893, contact ASTM Customer Service Department, 1916 Race Street, Philadelphia, PA 19103, 215/299-5585. ISBN 0-8031-0447-2. Publication Code Number: 04-893000-33.

Second Symposium on Test Methods and Design Allowables for Fiber Composites

ASTM Committee D-30 on High Modulus Fibers and Their Composites is sponsoring the Second Symposium on Test Methods and Design Allowables for Fiber Composites. The symposium is to be presented at Phoenix Az, on 3-4 Nov. 1986. C. C. Chamis, NASA Lewis Research Center, is the symposium chairperson. The program for the symposium follows.

Monday, 3 November

8:00 a.m.: Registration
8:20 a.m.: Introductory Remarks

Session 1: Extreme/Hostile Environment Testing

CHAIRPERSON: G. P. Sendeckyj
AFWAL
Wright-Patterson Air Force Base, Ohio

8:30 a.m.: High Temperature Testing of Glass/Ceramic Matrix Composites—J. F. Mandell and D. H. Grande, Massachusetts Institute of Technology, Cambridge, MA

9:00 a.m.: Environmental Effects on High Strain Rate Properties of Graphite/Epoxy Composites—G. Yaniv, G. Piemanidis and I. M. Daniel, Illinois Institute of Technology, Chicago, IL

9:30 a.m.: Mechanical Properties Characterization of Composite Sandwich Materials Intended for Space Antenna Applications—K. J. Bowles and R. D. Vannuci, NASA Lewis Research Center, Cleveland, OH

10:00 a.m.: Refreshments and break

10:30 a.m.: Effects of Low Temperature on Short Fiber Reinforced Thermoplastics—S. S. Yau and T. W. Chou, University of Delaware, Newark, DE

11:00 a.m.: Sand Erosion of Fiber Composites: Testing and Evaluation—T. H. Tsiang, Rohr Industries, Inc., Chula Vista, CA

11:30 a.m.: Abrasive Wear Behavior of Advanced Thermoplastic Materials: Woven Graphite/Peek Composites—P. M. Mody and T. W. Chou, University of Delaware, Newark, DE, and K. Friedrich, Technical University of Hamburg-Harburg, West Germany

Lunch

Session II: Establishing Design Allowables

CHAIRPERSON: R. Zabora
Boeing Aeroplane Company
Seattle, Washington

1:30 p.m.: Test Methods for Determining Design Allowables for Fiber Reinforced Composites—A. K. Munjal, Aerojet Strategic Propulsion Co., Sacramento, CA

2:00 p.m.: The Role of Statistical Data Reduction in the Development of Design Allowables for Composites—P. Shyprykevich, Grumman Corporation, Bethpage, NY

2:30 p.m.: Statistical Methods for Calculating Design Allowables in MIL-HDBK-17—S. W. Rust, F. R. Todt, B. Harris, D. Neal, and M. Vangel, Battelle Columbus Division, Columbus, OH

3:00 p.m.: Refreshments and break

3:30 p.m.: Effect of Impacts by a Blunt Object on Strength of a Thick Graphite/Epoxy Rocket Motor Case—C. C. Poe, Jr. and W. Illg, NASA Langley Research Center, Hampton, VA

4:00 p.m.: A Test Method to Measure the Response of Composite Materials under Reversed Cyclic Loads—C. E. Bakis, R. A. Simonds, and W. W. Stinchcomb, Virginia Tech, Blacksburg, VA

4:30 p.m.: Parametric Studies of Crack Arrestment in Composite Panels—R. C. Madan and C. Y. Kam, McDonnell Douglas Corporation, Long Beach, CA

5:00 p.m.: Adjourn

Tuesday, 4 November

Session III: Property Behavior Specific Testing

CHAIRPERSON: J. F. Mandell
Massachusetts Institute of Technology
Cambridge, MA

8:30 a.m.: A Through-the-Thickness Strength Specimen for Composites—P. A. Lagace and D. B. Weems, Massachusetts Institute of Technology, Cambridge, MA

9:00 a.m.: Use of Torsional Tube to Measure In-plane Shear Properties of Filament-Wound Composites—G. E. Foley, M. E. Roylance, and W. W. Houghton, U.S. Army Materials Technology Laboratory, Watertown, MA

9:30 a.m.: An In-Plane Shear Test Method for Composite Materials—J. M. Kennedy, G. L. Farley, NASA Langley Research Center, Hampton, VA, S. S. Gross, Clemson University, Clemson, SC

10:00 a.m.: Refreshments and break

10:30 a.m.: The Torsional Failure and Fracture Energy in Shear of a Pultruded Rod—J. O. Outwater, University of Vermont, Burlington, VT

11:00 a.m.: The Influence of Test Fixture Design in the Iosipescu Shear Test for Fiber Composite Material—M. G. Abdallah, Hercules, Inc. Aerospace Division, Magna, UT, and H. E. Gascoigna, California Polytechnic State University, San Luis Obispo, CA

11:30 a.m.: Elastic-Plastic Stress Concentrations around Notches in Continuous Fiber-Reinforced Metal-Matric Composites—W. S. Johnson and C. A. Bigelow, NASA Langley Research Center, Hampton, VA

12:00 noon: Adjourn, Conclusion of Symposium

U.S. Army Materials Technology Laboratory Composites Technology Standardization Area

The U.S. Army Materials Technology Laboratory in Watertown, MA, has been assigned the Department of Defense (DOD) Lead Service Activity responsibility for the new Composites Technology Standardization Area (CMPS) in accordance with DOD Directive 4120.3. The new standardization area for Composites Technology (CMPS) is intended to provide technical engineering documentation including specifications, standards and handbooks, in support of advanced composites design, development, manufacturing, procurement, materials processing and quality assurance, which are vital to the DOD/composites engineering community.

As part of its responsibility, MTL is required to prepare a DOD Program Plan for Composites Technology to achieve the "highest practicable degree of standardization of procedures, practices and techniques" in composites technology. The DOD program plan is currently being coordinated by MTL with DOD/NASA activities and nongovernment standards bodies (that is, ASTM D-30 and Society of Automotive Engineers, [SAE] composites committees). The CMPS program plan includes the composites standardization projects of the Army, Navy, Air Force, NASA, ASTM, SAE, and other associated groups. The program plan will provide an organized, coordinated approach to integrate all related on-going projects together with their objectives, purpose, schedule and resources, outlining specified courses of action for resolution of composites standardization issues.

Additional information is available from the DOD Composites Technology (CMPS) Program Plan coordinator, Mr. Frank T. Traceski, U.S. Army Materials Technology Laboratory, ATTN: SLCMT-MSR-ES, Watertown, MA 02172-0001, 617-923-5566 or AV955-5566.

Conference Reports

Future Testing Needs for Metal Matrix Composites

Jerome Persh presented the following keynote speech at the First Symposium on Testing Technology of Metal Matrix Composites sponsored by ASTM Committee D-30 on High Modulus Fibers and their Composites. The symposium was held on 19 Nov. 1985 in Nashville, TN.

In this presentation, rather than dealing with testing technology in a technical sense, I plan to interpret the expression in a more broad sense. The technical presentations that will be given during this meeting provide a true snapshot of where the United States stands technologically in this essential area, and there is little that I can contribute to the information the fine speakers are presenting here at this symposium. Therefore, rather than risking the danger of technical involvement, my intuition tells me to stay clear.

But before getting into the subject of this symposium, let me tell you briefly how the Department of Defense (DOD) is structured and where this area of technology fits into the overall scheme of things. Figure 1 displays an overall organization of the DOD with the group that I work in highlighted. This highlighted box is further expanded on Figs. 2 and 3.

The responsibilities of the military systems technology office are shown on Fig. 4. The overall mission of the research and advanced technology office is displayed on Fig. 5, and its in-house laboratory coverage is displayed on Fig. 6. The proposed 1986 fiscal year budget for the R&AT organization is shown on Fig. 7. For those not familiar with the DOD funding categories, I have included Fig. 8, which shows the breakdown of DOD budget categories.

Of the total R&AT science and technology program I showed on Fig. 7, that located to the materials and structures area is displayed on Fig. 9. With these fundings, our responsibilities cover

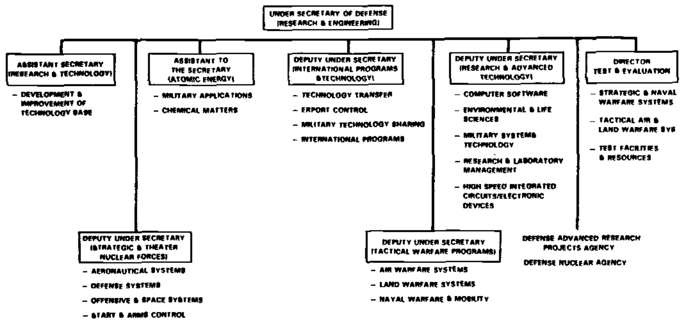

FIG. 2—*Under Secretary of Defence (Research and Engineering).*

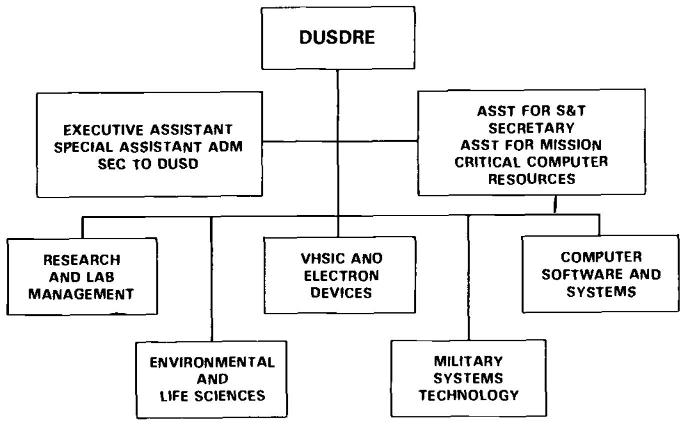

FIG. 3—*R&AT Organization.*

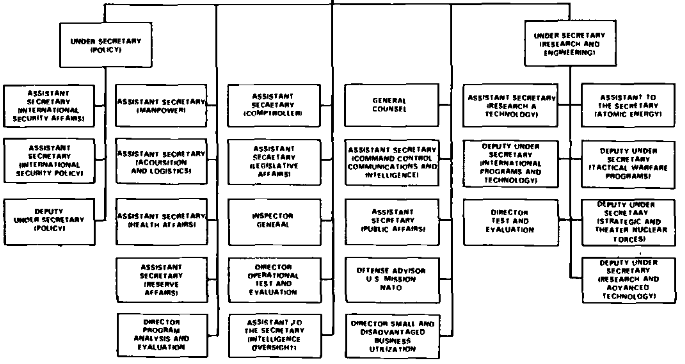

FIG. 1—*Office of the Secretary of Defence.*

- ELECTRONIC SYSTEMS
  – SEARCH, SURVEILLANCE, FIRE CONTROL, C^3 AND EW
- COMBAT VEHICLES
  – AIRCRAFT, SHIPS, SUBMARINES, TANKS, TRUCKS
- PROPULSION AND FUELS
  – GAS TURBINES, DIESELS, RAMJETS, ROCKETS, TRANSMISSIONS
- CONVENTIONAL WEAPONS
  – GUIDED WEAPONS, GUNS, PROJECTILES, BOMBS, FUZES, EXPLOSIVES
- MATERIALS AND STRUCTURES
  – COMPOSITES, ARMOR, RAPID SOLIDIFICATION ALLOYS, E/M WINDOWS

FIG. 4—*Military Systems Technology areas of responsibility.*

THE DoD SCIENCE AND TECHNOLOGY PROGRAM INCLUDES RESEARCH (6.1), EXPLORATORY DEVELOPMENT (6.2), AND ADVANCE TECHNOLOGY DEVELOPMENTS (6.3A)

RESPONSIBILITIES	ROLES	FUNCTIONS
• POLICY	• SCIENTIFIC ADVISOR FOR USDRE	• STRUCTURE S&T PROGRAM ACROSS SERVICES
• GUIDANCE	DoD POINT OF CONTACT FOR SCIENTIFIC COMMUNITY	• RESOLVE TECHNICAL DIFFERENCES
• OVERSIGHT		• ENHANCE RETURN ON INVESTMENT

FIG. 5—*Deputy Under Secretary for Research and Advanced Technology.*

LABORATORIES	74
PEOPLE	60,000
PROFESSIONALS	27,000
PROPERTY & EQUIPMENT	$4 BILLION

FIG. 6—*In-house laboratories.*

	FY 1985	FY 1986 REQUEST
RESEARCH	861	971
EXPLORATORY DEVELOPMENT	2,261	2,555
ADVANCED TECHNOLOGY DEV.	1,377	1,748
TOTAL SCIENCE AND TECHNOLOGY	4,499	5,274
STRATEGIC DEFENSE INITIATIVE	1,389	3,713

FIG. 7—*Science and Technology Program, fiscal year 1986 budget submission (dollars in millions).*

TO FACILITATE MANAGEABILITY, THE RDT&E PROGRAM IS DIVIDED INTO THE FOLLOWING SIX CATEGORIES OF EFFORT:

R&AT RESPONSIBILITY
- RESEARCH (6.1)
- EXPLORATORY DEVELOPMENT (6.2)
- ADVANCED TECHNOLOGY DEVELOPMENT (6.3A)

- ADVANCED DEVELOPMENT (6.3)
- ENGINEERING DEVELOPMENT (6.4)
- OPERATIONAL SYSTEMS DEVELOPMENT

MANAGEMENT AND SUPPORT (6.5)

FIG. 8—*Structure of the RDT&E Program.*

practically every mission area of the DOD as shown on Fig. 10. It is to be noted that the subject of this symposium impacts all of the mission areas in which we do work. As such, it is distributed throughout the overall program. Of the total materials and structure budget shown on Fig. 9, it would be extremely difficult to isolate those dollars allocated to testing and testing methods, although it is known that work is continually on-going in these areas. It should also be noted that work on metal-matrix composites is underway in practically all of the mission areas. And because the needs of each mission area are somewhat different in certain aspects, test data needs will be different. Achieving a common set of test methods across all of the mission areas is probably an impossible task except for a few basic properties. This subject will be addressed later. To complete the overall picture, let me outline in very broad terms where I see the Department of Defense Materials and Structures Science and Technology Program is going (Fig. 11), certainly the overall philosophical direction is towards more and more SOPHISTICATION. The "handwriting was on the wall" when we started our rapid solidification technology (RST) program in 1980. We were dealing with micron size powder particles; now we are headed towards sub-micron particles. We are involved in the exciting areas of SOL-GEL processing and organometallic synthesis.

Processing science is another important area of research, that is, the understanding of the effect of processing variables on the generation and development of property-controlling microstructures of constituent materials. This can only lead to the development of unique structures, and properties precisely tailored the needs.

The materials development direction is clearly towards composites. Not only are the fiber-reinforced organic, metal, ceramic, and carbonaceous matrix composites being developed, but also those in which the reinforcement is produced simultaneously with the matrix. Key research areas include the fiber interface regions and mechanisms and concepts to achieve precisely the structural properties desired.

The final general direction in which we are headed is toward demonstration. We have found that it is unsatisfactory to stop our work with a new materials development. It has to be demonstrated on a structural or functional component that closely simulates the final use to which it is intended to be put. I am sure you have noticed that over the past number of years more and more sub- and full-scale components are being subjected to real environmental testing and followed up with detailed analysis leading to understanding of the results. Before we consider we have finished our job, these things must be done. This is a fundamental change in the overall character of our programs that has taken place over the past 10 or 15 years.

Along with each of these directions, we have found that it is insufficient to carry any new materials and structures development through demonstration without the establishment of a knowlegeable government, industry, and academia "team." This is why you see so many of our "thrust" programs in discrete technological areas. If new developments are to be used for advanced military hardware, we have to show that it does what we say it will do, and have the "team" in place to provide the expertise to do the explaining. This is definitely a consequence of the ever increasing sophistication. Whether this is "good" or "bad" is another question. It is just the way it is now.

Now that I have placed in perspective just where this technological area fits in the overall DOD scheme of things, I would like to discuss some of the issues and challenges that your community has

WHO, WHAT, AND HOW MUCH	$ MILLIONS					
	FY 1980	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
MATERIALS TECHNOLOGY	108.0	118.8	136.4	145.6	155.3	186.4
STRUCTURES TECHNOLOGY	65.4	109.1	121.8	127.0	96.4	75.3
RESEARCH	54.2	70.9	81.1	83.8	77.7	82.7
EXPLORATORY DEVELOPMENT	94.4	115.7	128.3	120.0	132.4	141.0
ADVANCED TECHNOLOGY DEVELOPMENT	27.8	36.5	45.1	63.4	63.7	46.7
MANUFACTURING SCIENCE	—	4.8	3.7	5.4	9.6	9.1
ARMY	33.3	39.9	49.2	48.6	69.2	73.6
NAVY	56.7	72.1	76.6	83.4	73.1	80.2
AIR FORCE	66.0	94.3	105.3	111.3	109.4	107.9
DARPA	17.4	21.6	27.1	29.3	35.0	38.3
TOTAL	173.4	227.9	258.2	272.6	286.7	300.0

FIG. 9—*DOD Materials and Structures Technology Program scope.*

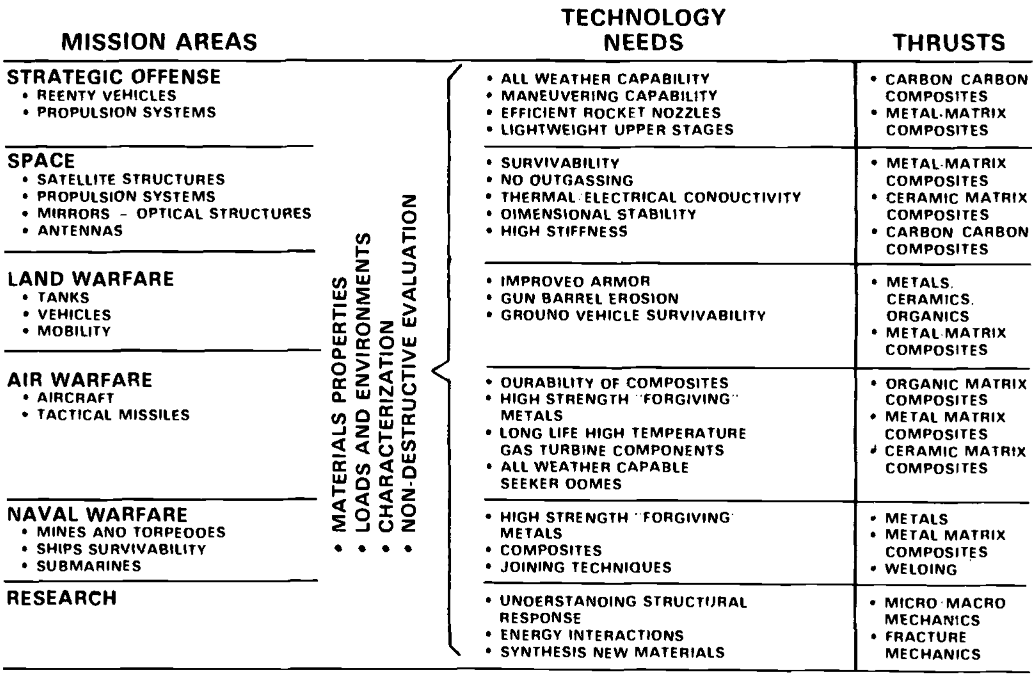

FIG. 10—*DOD Materials and Structures Science and Technology Program.*

to face in the future. As I said at the outset, I do not plan on getting into the technical aspects because you are much more qualified to discuss these matters and will have ample opportunity during the course of this symposium.

It is difficult to know just where to enter the arena of testing methods and standards and specifications for Metal-Matrix Composites (MMC). One is tempted to go past the overall voluntary consensus situation and go directly to MMCs, but to do that would lose an important element of the story.

My first real indoctrination into this arena came, when I was appointed chairman of the materials panel of the Defense Material Specifications and Standards Board (DMSSB). I discovered quickly the overall area of specifications and standards, including test methods, is extremely complex with many forces working both with and against achievement of rationale results. It did not take very long to find out that we needed some help to sort out the players, so the National Academy of Sciences (NAS)/National Materials Advisory Board (NMAB) was chartered early in 1975 to "delineate an optimum plan (for DOD) for the generation, implementation, and improvement of DOD materials and process specifications and standards that would utilize, if possible, the resources and organizations in existence and with due consideration of other aspects of national standardization programs." This was a tall order. Under the strong chairmanship of Nate Promisel, with the support of Bob Shane who was on the NMAB staff at that time, the NMAB produced a truly monumental report (NMAB-330) late

PHILOSOPHICAL DIRECTION → SOPHISTICATION

- SOL – GEL PROCESSING
- ORGANOMETALLIC SYNTHESIS
- SUB-MICRON PARTICLE SYNTHESIS
- PROCESSING SCIENCE-MICROSTRUCTURE CONTROL
- COMPOSITES INTERFACE PHENOMENA
- UNDERSTANDING RESPONSE TO ENVIRONMENT
- TAILORING TO NEEDS

MATERIAL DIRECTION → COMPOSITES

- ORGANIC MATRIX
- METAL MATRIX
- CERAMIC MATRIX
- CARBON/CARBON
- HYBRIDS

→ PARTICLE REINFORCEMENT
→ CONTINUOUS FIBER REINFORECEMENT

PROGRAMMATIC DIRECTION → DEMONSTRATION

- SUB AND FULL SCALE COMPONENTS
- REAL ENVIRONMENT TESTING
- UNDERSTANDING OF RESULTS
- ESTABLISHMENT OF "TEAMS"

FIG. 11—*Basic character and trends in Materials and Structures, Science and Technology in the DOD.*

in 1977, which summarized the entire situation as it existed then. Unfortunately the committee yielded to very the strong forces I mentioned before and produced the "stock" answer. One of the primary recommendations was that the DOD should use to the greatest extent possible, the national voluntary specifications and standards system.

Unfortunately, because of the pace of the development of DOD equipment we must move much more quickly. We generally cannot wait for the voluntary consensus procedure to function to produce an agreed-to specification, standard, or test method. Furthermore, as I said before, the hallmark of our materials and structures research and development programs is sophistication. This means that there are new developments coming along at a rapid rate which are being factored into designs. Additionally, we have gained a great respect of the effect of processing on the physical property data that is used to design a component of military equipment. We have also gained a greater appreciation for the influence of the test method on the actual data generated including its accuracy and reliability.

So here we are confronted with the need for accurate, reliable physical property data, particularized to a specific mission area, without a common, agreed-to basis for acquiring this data. Moreover, the mechanism for making this data available to the design community was not in place. Addressing the second item first, in 1980 we established the DOD Metal-Matrix Composite Information Analysis Center (MMCIAC), which had as one of its primary responsibilities the publication of "real time" data books on the various classes of MMCs. By "real time" I mean that because of the rapid pace of this technological area, the data books would be issued in loose leaf format and would contain pertinent processing and test method information along with estimates of the reliability of the data contained. The information assembled in these books is obtained from industry and government reports along with personal interviews by the MMCIAC people and their consultants. Several have already been issued with more to come. Those so far published are the *Continuous Boron Reinforced Aluminum Metal-Matrix Composite Data Book* and *Discontinuous Silicon Carbide Reinforced Aluminum Metal-Matrix Composite Data Review.* Next fiscal year data reviews on graphite fiber reinforced aluminum and copper will be issued. As I will discuss later, the graphite fiber reinforced aluminum is of particular interest for the spacecraft community and requires special attention. In essence what I am saying here is that in absence of an existing mechanism for acquiring, analyzing, and disseminating the latest property data on the fast developing MMCs, the DOD has created one.

Now to address the initial point regarding test methods to acquire this data. These test methods must keep pace with the development of these new materials. There are probably a few established and accepted test methods available and acceptable for the more-or-less homogeneous silicon carbide particle reinforced metals; but the information needed to judge the utility of the data obtained using these test methods is far and beyond what has been the case with standard alloys. As I said before the date the material was produced is as important as the processing history used because the technology has been, and still is, moving along at a rapid rate. Furthermore, the accuracy requirements and temperature ranges over which the data are required has become more demanding. Because this is a dynamic process our data books will have to be continually updated. An analogous, but even more stringent situation, exists for the continuous fiber MMCs because the data accuracy demands are difficult to meet with existing equipment.

Very closely interwoven is the need to understand the failure mechanisms for MMCs. Our understanding of these mechanisms is far from satisfactory as are our nondestructive inspection, analyses, and evaluation methods. The area of nondestructive testing and evaluation will be the subject of an in-depth conference to be held at the U. S. Air Force Academy in Colorado Springs this coming summer. This conference will be cohosted by three DOD Information Analysis Centers (IACs), namely, Nondestructive Testing (NDTIAC), Metals and Ceramics (MCIC), and Metal-Matrix Composites (MMCIAC). A large fraction of the coverage at this conference will be on MMCs.

The message I am conveying here is that because the technology is moving along at a rapid rate and new combinations of reinforcing fibers and matrices are being produced continually, the conference (or workshop) mechanism for displaying latest development and discussing new techniques in test methods and associated technologies applicable to MMCs is a necessity. This is why I felt so strongly that this symposium is essential for our needs in this arena. It is, after all, the way we do our best work in the United States.

Because it is probably one of the most stringent, I would like now to illustrate our property data demands with the specific example of MMCs for spacecraft applications. To do this I again must go back in time about two years when the Navy and Air Force decided to jointly fund a program to establish a baseline or standard MMC system for spacecraft structures. To implement this program, 500 lb (227 kg) of 100 million modulus pitch based graphite fiber was purchased from the Union Carbide Corporation. These fibers are being processed into MMCs, using a standard aluminum as the matrix material. These MMCs will be provided as government furnished material to the U.S. Spacecraft Industry for mechanical/physical property measurements as well as structural testing. A flow diagram of how this program is working is shown on Fig. 12. The 13 spacecraft contractors participating in this program, together with an illustration of the testing they will perform on these materials is shown on Fig. 13. To give you a broad idea of the diver-

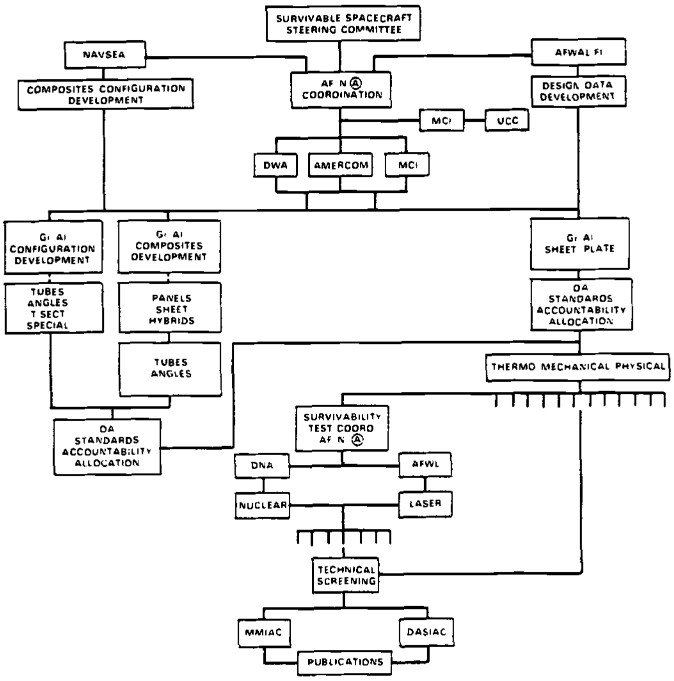

FIG. 12—*Graphite fiber reinforced metals for survivable spacecraft structures.*

CONTRACTOR \ PROPERTY REQUIREMENTS	PHYSICAL PROPERTIES	MECHANICAL PROPERTIES	THERMAL/ELECTRICAL PROPERTIES	SURVIVABILITY TESTS	MISCELLANEOUS TESTS	ESTIMATED WEIGHT OF WIRE REQUIRED FOR TESTS (LBS)
BOEING	X	X	X			37.2
GENERAL ELECTRIC SPACE DIVISION	X	X	X	X	X	21.6
GRUMMAN AEROSPACE CORP.	X	X	X	X	X	72.0
HARRIS CORPORATION	X	X	X			7.9
H.R. TEXTRON	X	X	X			2.3
HUGHES AIRCRAFT	X	X	X			20.4
LOCKHEED MISSILE & SPACE COMPANY		X	X	X		8.4
MARTIN MARIETTA DENVER	X	X	X	X		8.3
McDONNEL DOUGLAS CORPORATION	X	X	X	X	X	7.0
TRW, INC.	X	X	X		X	5.6
UNITED TECHNOLOGIES RESEARCH CENTER	X	X	X			1.5
VOUGHT CORPORATION		X				5.6

FIG. 13—*Graphite fiber reinforced aluminum data collection.*

sity of information needed for spacecraft design with these materials, Fig. 14 lists the property information required. As I said before, very few of the standard tests are appropriate for these materials for this application, and in many cases test methods are still evolving. Referring back to Fig. 12, you can see that the MMCIAC will play the data dissemination role for this program.

PHYSICAL PROPERTIES
- DIMENSIONAL STABILITY
- DENSITY
- SOLAR ABSORPTIVITY
- INFRARED EMITTANCE
- VOLUME FRACTION
- DAMPING CHARACTERISTICS

MECHANICAL PROPERTIES
- INTERFACE STRENGTH
- SHEAR STRENGTH AND MODULUS (ASTM-D-4255 (METHOD A))
- COMPRESSIVE STRENGTH AND MODULUS (ASTM D-3410)
- TENSILE STRENGTH AND MODULUS (ASTM D-3552)
- MINIMUM STRUCTURAL DISTORTION
- FLEXURAL STIFFNESS
- EXTENSIONAL STIFFNESS
- S-N
- IMPACT RESISTANCE
- PIN BEARING
- BEND RADIUS

THERMAL/ELECTRICAL PROPERTIES
- THERMOSTRUCTURAL RESPONSE
- THERMAL EXPANSION
- THERMAL-VACUUM CYCLING
- DIFFUSIVITY
- SPECIFIC HEAT
- THERMAL CONDUCTIVITY
- ELECTRICAL CONDUCTIVITY
- ELECTRICAL RESISTIVITY

FIG. 14—*Data requirements for graphite fiber reinforced aluminum spacecraft structures.*

Once the data are accumulated and coalesced into reasonable form, MMCIAC will issue data books similar to the ones I mentioned before.

This mechanism that we have established recognizes that each organization will use its own favorite test method for obtaining the data it needs for its use. Unquestionably, except for a very few, these test methods and equipment will be different. That is why on Fig. 12, many steps along the way to technically screen the information we are accumulating are apparent. This will include evaluations of the test methods as well as other accountability factors. Finally, before any information is disseminated, the MMCIAC will conduct a workshop involving the participating contractors, to undertake an attempt to get some consensus on the validity of each set of data and the caveats that go with it.

Although I have not emphasized it, you probably noted on Figs. 12 and 13 that we have an important need for survivability testing and analysis. This need implies test data at very high strain and temperature rates. Additionally, because we are dealing with spacecraft in this instance, some property data must be obtained in vacuum as well as in air. To further complicate the situation, because these materials are anistropic, the need to obtain test data in two and sometimes three orientations. Needless to say, a vast amount of information on these materials must be obtained before the designer can confidently consider them for use (Fig. 15). The spacecraft area is unquestionably one of the most complicated, but using it as an illustration gives you an idea of what we are faced with as far as introducing new materials into systems. Accurate, reliable, and reproducible test methods are an essential ingredient in this step-wise process.

Before closing I would like to share with you my thoughts regarding the outcome of a workshop conducted for the DOD by the Institute for Defense Analyses (IDA) in February of this year on the subject of test methods for organic matrix composites. On the surface it appears that the test methods developed for these materials would be applicable to MMCs. This may not be true in all instances, however. In any case, the excellent document that emerged from this workshop (IDA Memorandum Report M-81—

• MICROPLASTIC PROPERTIES	• MICRO YIELD STRESS (MYS) • PRECISION ELASTIC LIMIT (PEL) • MICROCREEP
• ANELASTIC PROPERTIES	• VISCOELASTICITY • SURFACE ELASTICITY • RECOVERY
• THERMAL EXPANSION	• THERMAL CYCLING • THERMAL FATIGUE
• STRESS RELAXATION	• WARPAGE • FABRICATION INTERNAL STRESSES • ETCHING FOR SURFACE YIELD • STRESS CYCLING • VIBRATIONAL STRESS RELIEF
• ELASTIC MODULUS	• THERMOELASTIC COEFFICIENT • SHEAR MODULUS
• STRUCTURAL FACTORS	• ANISOTROPY • PHASE CHANGES, TRANSFORMATIONS • AGING, MICROSTRUCTURAL CHANGES • DELAMINATION • CRACK GROWTH • POISSON'S RATIO
• THERMAL CONDUCTIVITY	• THERMAL DIFFUSIVITY
• CHEMICAL EFFECTS	• MOISTURE ABSORPTION • OUTGASSING • DECOMPOSITION OF ORGANICS • STRESS CORROSION • COMPOSITION OF GLASSES • ALLOY CONTROL

FIG. 15—*Materials properties related to dimensional stability.*

available to all requestors) concluded that some 13 500 specimens were needed to achieve standardization of test methods for only shear, compression, and specimen preparation. The workshop conferees arrived at a cost of some two to two and one half million dollars to accomplish this task which would take roughly two and one half years. Now considering that this information is only a fraction of what is really needed, the overall problem appears enormous. To further complicate the situation, as I pointed out before, the DOD needs for property data span a wide range of mission areas that have specific needs. Moreover, because to my knowledge none of the funding agencies (DOD, Department of Energy [DOE], and the National Aeronautics and Space Administration [NASA]) have specific funding lines for this work, it is difficult for me to visualize how we are to take on this task as a special program. It is encouraging that the Suppliers of the Advanced Composite Materials Association (SACMA) have taken this on as a challenge, but I think that we in government have to take it one step further. That is, escalate the overall issue to the Office of Science and Technology Policy (OSTP)/Committee on Materials (COMAT) Forum, because it is obviously a national problem, which impacts many federal agencies. It is therefore my suggestion, that ASTM Committee D-30 on High Modulus Fibers and Their Composites organize itself to bring this overall matter to the attention of OSTP/COMAT for consideration through the mechanism of "white papers" and briefings. There are also receptors in the legislative branch of the government to whom this matter should be addressed. In essence, it appears too simplistic to request funding from the DOD, DOE, or NASA to do this job without getting some sort of national consensus from both the Executive and Legislative Branches of the Government.

In closing, I have tried to give a broad picture of the challenges facing this community and the directions I see the Department of Defense Materials and Structures Program going in. I am confident that we will do what we have to do in the years to come. This symposium is one of the essential steps to getting us there.

Jerome Persh
Staff Specialist for Materials and Structures
Pentagon, Washington, DC 20301.

D-30 Structures Composites Standards at Upcoming Meeting

Mirriam-Webster defines composite as "Something that is made up of diverse elements" (Third New International Dictionary). This rather general definition allows the possibilities of the "revolution in structures" noted by Du Pont executive vice-president R. C. Forney at the Fifth International Conference on Composite Materials. Forney said that "The success of the revolution in structure for which advanced composites are the technological linchpin depends, first, on improvement in materials, and on better understanding of the properties of materials and materials in combination." He said that changes are underway in design and manufacturing of composite materials.

Airplanes and other aerospace products have been the primary driving force for advances in composite materials technology and the most common applications of composite materials to date. In the very familiar shape of a plane, however, new ideas are being translated into actuality, as with the forward swept wing now being tested. Other conventional products take on new and improved performance characteristics as composite materials replace those previously used. Medical prostheses, engine and automotive body parts, and sporting goods such as tennis rackets and golf clubs, are some examples.

"In the most basic terms, a composite combines two dissimilar materials into a new material better suited for a particular application than either original material alone" [*1*]. Generally, high stiffness fibers hardly the diameter of human hair reinforce another material to make a composite structure. These structural materials are generally metals, plastics, or ceramics, reinforced with different fibers or particles. The result is an engineered material with specially designed and tailored properties such as density, stiffness, strength, and thermal conductivity. Further, manufacturing often becomes easier and more efficient with composites since one structure can be made instead of several composites joined by bolts or rivets. The fewer connections, parts, and joints lead to lower costs as well as greater load carrying efficiency.

A group writing standards is Committee D-30 on High Modulus Fibers and Their Composites. D-30 concentrates on both fibers and the composite materials in which the fibers are contained. A great deal of activity addressing important technology requirements is underway in Subcommittee D30.02 on Research and Mechanics, where the work in D-30 begins (see listing that follows this report). After projects move further along, they become the responsibility of either D30.03 on Automotive/Industrial Composites or D30.04 on High-Performance Fibers and Composites.

Participation in D-30's standards development work is requested and encouraged. The committee will meet 3–6 Nov. 1986 in Phoenix, AZ. The meeting will include the technical committee meetings, special task group meetings, and will feature a one-and-one-half-day symposium on Test Methods and Design Allowables for Composite Materials. The symposium program appears in this issue on pp. 117 and 118. For more information, contact D-30 Chairman Wayne Stinchcomb, Virginia Polytechnic Institute and State University, Norris Hall, Engineering Science and Mechanics Dept., Blacksburg, VA 24061 (703/961-5316).

Reference

[1] Mark Hodges, "Changing the Structure of Our World," *Georgia Tech Research Horizons*, Vol. 1, No. 1, (Spring 1986), p. 4.

Cicely Enright
Senior Assistant Editor/Reporter of ASTM Standardization News

General Activities of D-30

Compression Testing

TASK GROUP CHAIRMAN: Ray Adsit, Rohr Industries, (619) 691-6453

- Study test methods for compressive strength of unidirectional composites:

  round-robin testing for D3410 and Modified D695
  evaluate $(0/90)_{ns}$ coupon to determine unidirectional compressive strength from laminate compressive strength data

- Evaluate laminate compression test methods:

  round-robin testing, using seven test methods, completed
  good agreement between six test methods, low data scatter
  propose a standard compression test method for laminates

- Research open-hole compression and compression after impact test methods (NASA RP 1142)

Shear Testing

TASK GROUP CHAIRMAN: Dale Wilson, University of Delaware, (302) 451-8960

- Evaluate torsion, rail shear, and Iosipescu shear test methods

- Round-robin testing for Iosipescu method (Wyoming and Asymmetric Four-Point Bend Versions):

  zero degree continuous and 90° continuous fiber graphite-epoxy composites
  discontinuous fiber composite

Specimen Preparation

TASK GROUP CHAIRMAN: Richard Hall, Hercules, (801) 251-3137

- Investigate specimen preparation parameters and determine their influence on test results:

  laminate lay-up, laminate bagging, laminate cure, rough cutting, tabbing, final specimen machining, surface finishing, instrumentation, conditioning, and dimensional examination

Interlaminar Fracture Toughness

TASK GROUP CHAIRMAN: Kevin O'Brien, NASA Langley, (804) 865-2093

- Thirty-two participants conducting round-robin tests to evaluate four test methods and three graphite fiber composites:

  Double cantilever beam, end notch flexure, edge delamination specimen, cracked lap shear
  AS4/3501-2, AS4/BP907, AS4/PEEK (APC2)

Long-Term Behavior

TASK GROUP CHAIRMAN: Ken Reifsnider, Virginia Tech, (703) 961-5316

- Planning Workshop on "Critical Issues Related to the Long Term Behavior of Composite Materials and Structures" (1/2-day session, Nov. 5, Phoenix, AZ)

National Materials Properties Data Network

TASK GROUP CHAIRMAN: Paul Lagace, MIT, (617) 253-3628)

- Focal point for communications on data needs for composites
- Coordinate D-30 activity with the NMPDN to determine requirements for incorporating composite materials properties in the data base

Guidelines for Selection and Use of Standard Test Methods for Composite Materials

TASK GROUP CHAIRMAN: Wayne Stinchcomb, Virginia Tech, (703) 961-5316

- Assist in the identification and evaluation of appropriate test methods
- Promote uniformity in the development of material qualification and design allowable data

Test Methods for Metal Matrix Composites

Tension Testing

TASK GROUP CHAIRMAN: Peter DiGiovanni, Raytheon, (617) 663-7442 ext. 2207

- Continued evaluation of D3552, especially specimen geometry (dog-bone versus tapered versus straight sided)
- Evaluate test methods and specimen geometries for MMC laminates
- Study procedures for elevated temperature testing, including grips, tabs, and strain measurement

Compression Testing

TASK GROUP CHAIRMAN: Golam Newaz, Battelle Columbus, (614) 424-4670

- Evaluate candidate compression test methods
  IITRI Method (D3410) modified for MMC's
  Direct Compression Method proposed by AMTL
- Prepare written test procedures for each test method
- Propose round-robin testing using the two candidate test methods

Fracture Toughness Testing

TASK GROUP CHAIRMAN: Golam Newaz, Battelle Columbus, (614) 424-4670

- Evaluate validity of fracture test methods for particulate reinforced, discontinuous reinforced, and continuous unidirectionally reinforced MMC's
- Propose use of ASTM Standard E 399 (J-integral) for fracture toughness testing of particulate reinforced and discontinuous reinforced MMC's
- Prepare written test procedures

Fatigue Testing

TASK GROUP CHAIRMAN: Steven Johnson, NASA Langley, (804) 865-2715

- Study and compare damage and failure mechanisms in different fiber metal matrix systems:
  boron/aluminum
  Si-C/aluminum
  FP/aluminum
  Si-C/titanium
  particulate and whisker/aluminum
- Evaluate fatigue sensitivity of different fibers and matrix materials
- Identify possible damage sensitive parameters (for example, stiffness, crack growth) to measure fatigue response
- Develop definitions of residual strength and life for fatigue testing

Shear Testing

TASK GROUP CHAIRMAN: John Kennedy, Clemson University, (803) 656-5632

- Identify sources of continuous and discontinuous fiber reinforced MMC cylindrical tubes
- Develop baseline data on shear strength and modulus using torsion tests on tubes
- Study and evaluate lamina shear test methods, including ±45° tension test and 10° off-axis test
- Study and evaluate laminate shear test methods. including Iosipescu, rail shear, slotted tension, and picture frame methods
- Propose round-robin testing on selected shear test methods
- Compare round-robin data to baseline strength and modulus data
- Propose shear test methods for metal matrix composites

Calendar on Composites

7-9 Oct. 1986
First Conference on Composite Materials—American Society for Composites
Dayton, OH
Contact: Dr. Charles Browning,
Materials Laboratory, Wright-Patterson
Air Force Base, OH 45433

7-9 Oct. 1986
18th International SAMPE Technical Conference
Seattle, WA
Contact: Marge Smith, SAMPE, P.O. Box 2459,
Covina, CA 91722
Telephone: 818-331-0616

8-10 Oct. 1986
12th Polish Symposium on Experimental Research in Mechanics of Solids
Jadwisin near Warsaw, Poland
Contact: Prof. Jacek Stupnicki, Warsaw
Technical University, Nowowiejska 24,
00-665 Warsaw, Poland
Telephone: 215463

2-5 Nov. 1986
SEM Fall Conference and Exhibit: Optical Methods in Composites
Keystone, CO
Society of Experimental Mechanics, 14 Fairfield Dr.,
Brookfield Center, CT 06805;
Telephone: 201-775-7373

2-7 Nov. 1986
2nd Symposium on Test Methods and Design Allowables for Fiber Composites
Phoenix, AZ
Contact: M. E. Lieff, ASTM, 1916 Race St.,
Philadelphia, PA 19103
Telephone: 215-299-5516

7-12 Dec. 1986
ASME Winter Annual Meeting
Anaheim, CA
Contact: ASME, United Engineering Center,
345 E. 45th St., New York, NY 10017

5-10 Jan. 1987
2nd International Conference on Constitutive Laws for Engineering Materials
Tucson, AZ
Contact: C. S. Desai, University of Arizona,
Department of Civil Engineering and Engineering Mechanics,
Tucson, AZ 85721;
Telephone: 602-621-6569

27-30 April 1987
Composite Materials—Fatigue and Fracture (9th Symposium)
Cincinnati, OH
Contact: Matt Lieff, ASTM
Telephone: 215-299-5516

20-25 July 1987
ICCM-VI, 6th International Conference on Composite Materials
London, England
Contact: Mr. F. L. Matthews, Director, Centre
for Composite Materials, Imperial College,
Prince Consort Rd., London SW7, 2BY, England
Telephone: 441-589-511 X4003

27-30 July 1987
ECCM 2, Second European Conference on Composite Materials
London, England
Contact: European Association for Composite Materials, 2,
Place De La Bourse, 33076 Bordeaux,
Cedex, France
Telephone: 33 56 52 65 47

27-30 July 1987
4th International Conference on Composite Structures
Paisley, Scotland
Contact: Dr. I. H. Marshall, Dept. of Mechanical
and Production Technology, Paisley College of Technology,
Paisley, Renfrewshire, Scotland
Telephone: 441-887-1241

Sept. 1987
Second Conference on Composite Materials—American Society for Composites
Newark, DE
Contact: Dr. Charles Browning, Materials Laboratory,
Wright-Patterson Air Force Base, OH 45433

13-15 Oct. 1987
19th International SAMPE Technical Conference
Washington, DC
Contact: Marge Smith, SAMPE, P.O. Box 2459,
Covina, CA 91722
Telephone: 818-331-0616

15-20 Nov. 1987
ASME Winter Annual Meeting
New York, NY
Contact: ASME, United Engineering Center, 345 E. 45th St.,
New York, NY 10017

24-29 April 1988
Composite Materials—Testing and Design (9th Symposium)
Las Vegas, NV
Contact: Matt Lieff, ASTM
Telephone: 215-299-5516

21-27 Aug. 1988
17th International Congress of Theoretical and Applied Mechanics
Grenoble, France
Contact: Prof. Germaine, Ecole Polytechnic, Paris, France

27-30 Sept. 1988
20th International SAMPE Technical Conference
Minneapolis, MN
Contact: Marge Smith, SAMPE, P.O. Box 2459, Covina, CA 91722
Telephone: 818-331-0616

Calendar prepared by Prof. Michael W. Hyer, Department of Mechanical Engineering, The University of Maryland, College Park, MD 20732.