ORNL/FTR--3542

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ORNL

FOREIGN TRIP REPORT

ORNL/FTR-3542

DATE: March 1, 1990

SUBJECT: Report of Foreign Travel of J. W. Davis, McDonnell Douglas Astronautics Company, to FRG and France

TO: Alvin W. Trivelpiece

FROM: John W. Davis

PURPOSE: The purpose of this travel was to participate in the International Thermonuclear Experimental Reactor (ITER) Workshop on Plasma Facing Components and Blanket/First Wall Engineering and the Specialists' Meeting on ITER Materials Data Base. The development and manufacture of carbon-carbon composites were discussed with staff at Societe Europeenne de Propulsion (SEP).

SITES VISITED:

1/27-2/10/90	Max Planck Institute for Plasma Physics, Garching, FRG	G. Vieider
2/11-13/90	Societe Europeenne de Propulsion, Bordeaux, France	F. Delnest F. Christin

ABSTRACT: This report summarizes the results of the Plasma Facing Components Workshop, the Blanket/First Wall Workshop, and the Specialists' Meeting on ITER Materials Data Base which were held at the ITER Winter Session in Garching, FRG. In addition to the ITER meetings a visit was made to SEP, which produces a carbon-carbon called SEPCARB N1. This material is currently being evaluated for use in the bumper limiter of the CIT. This report describes the company, the products they produce, and their testing capability.

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COMPREHENSIVE TRIP REPORT

Introduction

In addition to the scheduled Workshops on the Plasma Facing Components and Blanket/First Wall Engineering, a specialists' meeting was scheduled to review the reference materials data base. This materials meeting was a follow-up to the specialists' meeting held in August 1988. At that time it was recommended that a design data base be developed for use in the ITER program. This meeting was scheduled to review that data base, make recommendations regarding the interpretation of the data, and where appropriate, provide additional information. Following the ITER activities a visit was made to the SEP facilities in Bordeaux, France. The bumper limiter of the CIT experiment requires the use of a carbon material with a high thermal conductivity, if the temperature limit of 1700°C is to be maintained. A review of the thermal conductivities of various carbon materials revealed that only the SEPCARB N1 produced by SEP possessed a conductivity adequate to meet the CIT needs. As a result the CIT project has placed a purchase order for SEPCARB N1 for evaluation. As part of the technology exchange between the CIT program and the ITER program, the results of the data requirements and properties of this material were provided to the ITER project. Based on the results of the CIT study the ITER project plans to evaluate the use of high conductivity composites for use in the divertor in place of the pyrolytic graphite.

Appendix A contains the itinerary for the trip.

Workshop on Plasma Facing Components, January 29-30, 1990, Garching, FRG

U.S. Attendees:
T. D. Burchell (ORNL)
J. W. Davis (McDonnell Douglas)
P. L. Goranson (FEDC/ORNL)
R. E. Nygren (SNLA)
D. L. Smith (ANL)

In addition to the United States attendees there were two representatives from Japan, nine from the European Communities (EC), and nine from the USSR. The meeting consisted of presentations of the designs for both the divertor and the first wall tiles by the various design teams as well as results of the research and development programs supporting the designs. In general, the designs consist of water-cooled copper of refractory metal tubing with pyrolytic graphite brazed to the tubes. To improve the cooling capability of a copper tube containing twisted tape, the Soviets have developed a process where copper particles are embedded in the tube wall. The particle size is roughly 30 mm in diameter and appears to increase the film coefficient, thus allowing higher heat flux capability than one would have with finned tubing or twisted tape alone.

Thermal heat flux peaking factors on the divertor are becoming more important, particularly with regard to the alignment of the tiles. The Soviets are proposing the use of washers behind the panel supports for use in aligning the tile assembly, prior to start-up. They have also looked at the peaking factors and feel that they can range from 1.3 to 2; they recommend the project assume an average of 1.5. Considerable concern was expressed with regard to the use of pyrolytic graphite. In tests which simulate disruptions, performed both by Japan and the European Communities (EC), the tiles either broke apart or cracked. The project is recommending the development of an alternate material, specifically a carbon composite, similar to the one being considered for compact ignition tokamak (CIT).

This meeting provided an opportunity for a technology exchange between the divertor and first wall design of ITER and CIT, particularly in the area of peaking factors, maximum temperature limits imposed on graphite and in the area of carbon materials. It is in the interest of both programs that this path of communication continue.

Workshop on Blanket and First Wall Engineering, January 31-February 6, 1990, Garching, FRG

U.S. Attendees: M. C. Billone (ANL)
J. W. Davis (McDonnell Douglas)
Y. Gohar (ANL)
P. L. Goranson (FEDC/ORNL)
D. L. Smith (ANL)
I. N. Sviatoslavsky (University of Wisconsin)

In addition to the United States attendees there were two representatives from Japan, eight from the EC, and seven from the USSR. The meeting consisted of presentations of the designs by the various design teams. The EC, Japan, and United States design teams looked at solid breeder blanket designs, while the Soviet design team looked at a lithium-lead coolant design. A key concern raised by the Japanese is the potential for irradiation assisted stress corrosion cracking (IASCC), created during the bakeout of the graphite first wall tiles. They are recommending a procedure which calls for the draining of the water from the blanket, followed by a helium purge to remove traces of water prior to the 350°C bakeout. While the objective of the meeting was to develop a consensus on a reference design, each team tended to favor their approach over the others and as a result no agreement was reached.

An interesting comment by the EC with regard to the next phase of the ITER study was that 80% of the funding would go to European industry to develop the concept and the fabrication capability. This should not only help the EC to increase their competitive edge for winning that portion of the ITER structure in construction, but should also increase the ITER political support within the EC.

ITER Specialists' Meeting on Materials Data Base, February 7-9, 1990, Garching, FRG

U.S. Attendees: M. C. Billone (ANL)
T. D. Burchell (ORNL)
J. W. Davis (McDonnell Douglas)
T. C. Reuther (DOE)
D. L. Smith (ANL)

In addition to the United States attendees there were 3 representatives from Japan, 12 from the EC, and 4 from the USSR. Following an overview of the objectives of the meeting and the design issues for the plasma facing structures and the blanket and first wall structure the meeting was divided into the following three groups: (1) structural materials, (2) plasma facing materials, and (3) breeding materials. Each of these groups was chartered with the task of developing a consensus on the data base to be used by the designers for the remainder of the current ITER design phase along with responding to specific questions developed by the project designers regarding the use of materials. A detailed report on the conclusions and recommendations regarding the use of the data base is being written for the ITER project and will be available as an ITER report.

Since I was chairman of the structural materials group and was unable to attend the other two group meetings the comments on the Specialists' meeting contained in this trip report only reflect the activities that occurred in the structural materials task group. For information on the other two groups the reader is directed to the trip report of T. D. Burchell for the plasma facing materials and to M. C. Billone for the meeting on breeding materials.

Participating in the structural materials working group were the traveler and T. C. Reuther for the United States, J. L. Boutard and E. Zolti for the EC, A. Hishinuma and N. Sekimura for Japan, and S. A. Fabritsieff and V. V. Rybin for the USSR.

Significant amounts of information were presented on type 316 stainless steel, copper alloys, molybdenum alloys, and niobium alloys. Appendix B contains a list of the presentation materials obtained along with additional material not presented but distributed. The traveler was impressed by the amount of new information brought by both the EC and the USSR, particularly in the area of radiation effects. In general, the thrust of the research within the EC and in Japan is on the properties of stainless steels, while the interest of the USSR is in the area of copper alloys, molybdenum alloys, and tungsten alloys. They are currently pursuing the development of a 4Mo-10Re alloy, which appears to be superior in performance with regard to radiation resistance than the conventional Mo-50Re alloy.

In previous presentations by the Soviets it was difficult to separate data generated from their research activities from data already available in the open literature. In the presentations at this meeting they were careful to identify the data obtained from the literature and the data developed in their research programs. They also identified what experiments were currently in reactor and when the data would be available. It appears that they plan to bring more data on the refractory metals and copper alloys at the summer meeting in Garching. Invitations to participate in the Leningrad meeting were extended to the traveler, T. C. Reuther, and D. L. Smith.

The Need for Materials Support in the ITER Design

The ITER group is in need of the assistance of a materials group on an interactive basis. There are questions regarding the use of materials or requests for data that need a rapid response. If the designers are to meet a schedule, they cannot wait until a meeting is held but need support from a group which has the responsibility of obtaining the needed answers.

Meeting at SEP Solid Propulsion and Composites Division, February 13, 1990, Bordeaux, France

Attendees: Claude Bonnet, Sales and Marketing Manager
Lucien Delneste, Composites Operations Programs Manager
Jean-Claude Clebant, Manager Project Design Composite Structures
Robert Colmet, Research and Development of Matrix Composites
John W. Davis, ORNL

A meeting was held at the SEP manufacturing facility to review the status of the purchase order for SEPCARB N1 carbon-carbon which is currently a candidate for use in the limiter of the CIT and to determine the feasibility of developing a higher thermal conductivity composite for possible use in the divertor of ITER or CIT. SEP has four manufacturing facilities, all in France, and 4000 employees of which 1000 are engineers and managers. To augment their technical capability, they collaborate with the University of Bordeaux on developing new materials. The Bordeaux plant produces missile propulsion systems as well as composites for use in military, space, and industrial applications. They currently produce a low-cost carbon-carbon based on Movoltex technology, of which the SEPCARB N1 is a derivative; a SiC-carbon composite also based on Movoltex; a SiC-SiC composite; and a basket-weave carbon-carbon composite which is identical to the FMI-4D composite technology.

In addition to their manufacturing capability they have a large laboratory facility capable of measuring both thermophysical and mechanical properties of their composites, as well as microstructural characterization. The mechanical properties laboratory includes both static capability up to 2000°C in air and 2800°C in inert atmosphere and dynamic capability (fatigue) up to 1800°C in vacuum or inert gas. The fatigue tests can either be load or strain controlled.

Within France they have a reputation for high quality products and technical capability and my impression of their capabilities appears to support this. They are interested in supporting both the CIT and ITER activities, which includes collaborating in the development of new materials.

APPENDIX A

ITINERARY

<u>1990</u>

1/27-28	Travel from St. Louis, MO, to Garching, FRG
1/29-2/2	Participate in ITER Workshops on Plasma Facing Components and Blanket/First Wall Engineering
2/3-4	Weekend
2/5-9	Participate in Workshop on Blanket/First Wall Engineering and Specialists' Meeting on Materials Data Base
2/10	Travel to Paris, France
2/10-11	Weekend
2/12	Travel to Bordeaux, France
2/13	Participate in meetings at SEP-Division of Propulsion and Composites
2/14	Travel from Bordeaux, France, to St. Louis, MO

APPENDIX B

PRESENTATION MATERIAL ACQUIRED

Stainless Steel Data

1. "ITER Design Databook" (data pages developed on information presented at the 1988 ITER Specialists' Meeting), J. W. Davis
2. "Properties of Irradiated Austenitic Stainless Steels," M. L. Grossbeck
3. "Summary of Weld Simulations on Irradiated Materials and Irradiated Weldments of Austenitic Steels" (data developed by Hua Tay Lin and M. L. Grossbeck, et al.), J. W. Davis
4. "Results of US/Japan Collaboration Studies on Austenitic Stainless Steels," A. Hishinuma
5. "Characteristics of SCC in Water under Irradiation," N. Sekimura
6. "Fatigue Strength of EC316L Before and After Irradiation at 430°C and 10 dpa," W. Vandermeulen
7. "Tensile Properties of EC316L, US316, US-PCA, and JAP-PCA after Irradiation to 250°C and 10 dpa," W. Vandermeulen
8. "Characterization of Irradiated 316LN Welded Joints, SOUDIX 1 Experiment (Tensile, Density, and Metrology)," A. A. Travassoli
9. "Irradiated Properties of Austenitic Stainless Steels," J. L. Boutard

Copper Alloys

1. "ITER Design Data Book Data Pages on GLIDCOP and Cu-Be-Ni," J. W. Davis
2. "Strength and Fatigue of Dispersion Strengthened Copper," T. J. Miller, S. J. Zinkle, and B. A. Chin
3. "Effects of Neutron Irradiation to $10^{25} n/m^2$ on the Properties of Various Commercial Copper Alloys," S. A. Fabritsieff et al.
4. "Development of Dispersion Strengthened Copper Alloy MAGT-02 (Cu-Al-Ti-Hf)," V. R. Barabash et al.

Molybdenum, Tungsten, and Niobium Alloys

1. "Unirradiated Fatigue Strength of Molybdenum Alloys," J. W. Davis
2. "Use of Mo and Mo Alloys for the ITER Divertor," R. F. Mattas
3. "Mo-Re Alloys for the Divertor of ITER," S. A. Fabritsieff et al.
4. "Refractory Metals for Divertor (Molybdenum and Tungsten Alloys)," S. A. Fabritsieff et al.
5. "Properties of Nb-1Zr," R. M. Mattas

Graphites from the Plasma Facing Components Workshop

1. "Test of Divertor Samples and Mock-Ups," J. Linke
2. "Specification of the JET Testbed," K. Dietz
3. "Laser Heat Flux Experiments on Carbon Materials," J. G. van der Laan
4. "Material Test by JEBIS," M. Seki
5. "Emissivity Data for Graphites and CFCs," M. I. Budd

APPENDIX C

DISTRIBUTION

1. John J. Easton, Jr., Assistant Secretary for International Affairs and Energy Emergencies (IE-1), DOE, Washington, DC 20585
2. N. Anne Davies, Acting Associate Director for Fusion Energy, Office of Energy Research, DOE, Washington, DC 20545
3. James Decker, Acting Director, Office of Energy Research, DOE, Washington, DC 20585
4. Richard L. Egli, Assistant Manager, Energy Research and Development, DOE/ORO
5. D. J. Cook, Deputy Director, Safeguards and Security Division, DOE/ORO

6-7. Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831

8. J. W. Davis, McDonnell Douglas Astronautics Company, P.O. Box 516, Fusion Power, St. Louis, MO 63166
9. D. G. Doran, Pacific Northwest Laboratory, P.O. Box 999, Richland, WA 99352
10. R. J. Dowling, Office of Fusion Energy, DOE, Washington, DC 20545
11. R. E. Price, Office of Fusion Energy, DOE, Washington, DC 20545
12. M. Roberts, Office of Fusion Energy, DOE, Washington, DC 20545
13. F. W. Wiffen, Office of Fusion Energy, DOE, Washington, DC 20545
14. D. L. Smith, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439
15. B. R. Appleton
16. C. C. Baker
17. E. E. Bloom
18. T. D. Burchell
19. W. Fulkerson
20. M. L. Grossbeck
21. R. L. Klueh
22. L. K. Mansur
23. P. J. Maziasz
24. A. F. Rowcliffe
25. J. Sheffield
26. J. O. Stiegler
27. R. E. Stoller
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