March 24, 1972

To: J. R. Weir
From: H. E. McCoy

Subject: Reply to Comments by Visiting Committee on Hastelloy N Cracking

Many pieces of material removed from various parts of the MSRE have been examined. Metallographic examination has shown that grain boundary cracks from 1.5 to 12.5 mils were visible after straining. The shallowest cracks formed in parts exposed to gases and a static pool of fuel salt and the deepest cracks formed in parts from the pump bowl. Various types of chemical analyses have offered circumstantial evidence that Te and maybe S could be responsible for the cracking. However, the possibilities of other fission products being important or an interrelation between corrosion and fission product intrusion could not be eliminated. These findings suggested numerous laboratory experiments, most of which are currently in progress.

a) Small melts of Hastelloy N containing additions of Se, Sr, Tc, Ru, Cd, Sn, Sb, Cs, S, As, Ce, and Rh have been made and their mechanical behavior evaluated.

b) Samples of Hastelloy N, type 304 stainless steel, and Ni are being exposed to vapors of Se, S, Te, I₂, As, Cd, and Sb. They are being annealed for long periods of time, strained, and examined for cracks.

c) Tellurium is being electroplated on about 40 alloys. They are being annealed, strained, and examined for cracks.

d) Radioactive Te has been deposited on Ni, type 304 stainless steel, and Hastelloy N. The samples are being annealed and will be sectioned to obtain diffusion data and viewed by autoradiography to determine whether the diffusion is selective along grain boundaries.

e) Creep tests of Ni, type 304 stainless steel, and Hastelloy N are being run in an atmosphere of Te vapor plus Ar to determine how stress influences the cracking.

f) Tube burst tests of the same materials are being run in various salt environments to investigate the effects on the mechanical properties.

g) Equipment is being built to strain cycle Hastelloy N in various environments. This will allow a study of the progression of cracks with straining.
INTRA-LABORATORY CORRESPONDENCE  
OAK RIDGE NATIONAL LABORATORY  
March 15, 1972

To: Section Heads  
J. H. Frye, Jr.

Subject: ANNUAL INFORMATION MEETING AND VISITING COMMITTEE

There are three items of business associated with the subject topic to be discussed at our Staff Meeting on March 17, 1972:

1. Division information meetings are not subject to the recent request from AEC-Hq. to cut down on the number of technical meetings sponsored by AEC contractors; hence, the annual meeting of divisions will proceed as normal, while GCR, MSR, and Nuclear Safety meetings will be scheduled on a biennial basis. Letters inviting outside guests to any O4 functional meetings in the future must go to the appropriate management level at the outside installation rather than to an individual.

2. Attached is the report of the Metals and Ceramics Division Advisory Committee covering our meeting last fall. The report is extremely complimentary in nature and the findings of the Advisory Committee should be orally passed on to staff members in a commendable manner. In addition, each Section Head should critically review the report and forward appropriate comments to be incorporated into a reply.

3. Two new members need to be added to our Advisory Committee, replacing Leo Brewer and Mel Adams, whose terms have expired after serving the 1968-1971 period. Remaining members are Sid Siegel (1970-73) and Walter Kohn (1971-74). I would like to have several nominees for each opening to discuss with John Frye and Don Trauger before forwarding to Alvin Weinberg. Keep in mind that we must have a balanced committee representing the overall interests of the Division and the fact the scope of the Division is being broadened in character to cover non-nuclear as well as nuclear activities.

J. E. Cunningham

Gave branch to JHF in Nov-Dec
Dr. Alvin M. Weinberg, Director
Oak Ridge National Laboratory
P. O. Box X
Oak Ridge, Tennessee 37830

Dear Alvin,

The Annual Information Meetings for the Metals and Ceramics Division have been improved in organization and presentation each year and it is difficult to suggest any additional improvements. Reducing the number of papers presented each morning to six or seven might be helpful. The meeting with the division staff before the formal presentation was very useful in giving us a broad perspective of the division's program. The chairman of each session gave excellent introductions to explain the reasons for the work to be described and the relation to the overall goals. The speakers did a uniformly good job of reviewing the objectives of their work; outlining the achievements to date; and summarizing the remaining problems. The material sent prior to the meeting was very helpful for the committee and the limitation of formal presentations to the mornings was very important to allow the committee to meet individually with members of the staff.

Within the budgetary limitations that have been placed on the Division, the committee feels that generally the program of the Division is well organized with proper emphasis on the most urgent problems.

The development of an economic breeder reactor is a very important national goal. The highest priority has been given to the Liquid Metal Fast Breeder Reactor (LMFBR), but there are many serious obstacles to be overcome. There is no question that the difficulties can be overcome, but a major development program on the demonstration plant and on the total fuel cycle technology remains to be carried out.

The plastic, creep, and fatigue behavior of stainless steels above 800°F needs additional investigation, to provide the basis for improved types of structural analyses required by new ASME codes. The Division should seek an expanded program in this area.

The high thermal conductivity and other advantageous properties of the carbide, and carbo-nitride, fuels point to the need for continued work on advanced fuels that may play an important role in future reactors with higher power density and higher temperatures.

Until a highly reliable commercial FBR is fully demonstrated, it is important that the High Temperature Gas-Cooled Reactor (HTGR) and the Molten Salt Breeder Reactor (MSBR) be carried along in their developments, so that potentially attractive options are not abandoned prematurely.
Inasmuch as the MSBR is the primary responsibility of ORNL, it is important to make an extra effort to quickly resolve any problems that might arise. So far, the MSBR has worked remarkably well with few problems. As the economics of the total fuel cycle may be the decisive factor in determining the breeder reactor of the future, the self-contained and rapid processing cycle of the MSBR gives it a potentially important advantage. The development of procedures for fabrication of molybdenum components has worked out very well and all aspects of the fuel processing are very promising. The research aimed at understanding of the factors that control the properties of graphite has been quite successful and the graphite produced at ORNL now seems well advanced over commercial graphite, and the problem of dimensionally stable graphite seems in hand. The sealing problem has not been solved, but it is not a critical problem. Sealing with fluoride salt may be effective or He bubbling may take care of the problem. The problem of hydrogen containment is important not only for MSBR but also for the fusion reactor. It is hoped that control of reducing conditions of the fused salt will eliminate the problem of fissures in the MSRE steel that seems to be due to fission product tellurium. The resolution of this problem should be strongly pushed.

Although ORNL does not have primary responsibility for the HTGR, the Metals and Ceramics Division has research capabilities that can make important contributions to the HTGR program. The improved coating for fuel particles and the improved bonding materials for the fuel sticks have been significant contributions. Reprocessing of spent HTGR fuel, with proper attention to control of gaseous effluents, remains a substantial problem which should continue to receive important contributions from the M and C Division.

The fundamental research activities of the division provide a very important backup to the work directly related to reactor problems. Both during the formal presentations during the morning session of October 28, and as a result of visits with members of fundamental research units, the committee received a favorable impression of the vitality and relevance of the fundamental research program. The committee had some opportunity to learn about work on surfaces in the group headed by Drs. Cathcart and Clausing. Important progress on properties of oxide layers is being made there. The theoretical group under the direction of Dr. Faulkner is providing valuable general backing for the division and also doing successful quantitative work on the electronic structure of alloys. Theoretical work on the migration of vacancies and interstitials by Coghlan and Yoo of the defect theory group represents a significant contribution to the critical problem of void growth. Finally, the committee was very well impressed with the recent results on electron radiation damage produced by the electrons of the 850-kV electron microscope and observed by the same instrument. The relevance of these results for prediction of radiation damage by neutrons requires considerably more study.

The committee wishes to make a suggestion concerning theoretical work in the division. It would seem to us that a consolidation of the "theoretical research" group and the "defect theory" group, both of which are quite small at the present time, would enhance the effectiveness of all individuals concerned since the interest and areas of expertise in these two groups are very nicely complementary.
We believe also that such a consolidated theoretical group might satisfy the theoretical needs of the rest of the division in an even more effective manner than at the present time.

In the context of new programs where M and C capabilities may make important contributions, two of us examined the problems of the Kansas Salt Mine Waste Repository in detail, and we spent some time reviewing the status of the controlled fusion program. The question of long term storage of radioactive wastes from nuclear reactors should have the highest priority and a commitment made soon to some reasonable procedure. It is difficult to imagine a more practical solution with a minimum of hazard than the proposed salt mine storage if it turns out that drill holes can be located and plugged and if hydraulic mining in the vicinity can be stopped. It appears important to examine more carefully the question of the materials used for the containers. More durable containers should be used to make retrieval easier if it should turn out after many decades that the waste could be useful, or that alternate storage or disposal methods become preferable. Also, more durable containers should allay fears of dispersal of the activity.

It is difficult to predict when controlled fusion reactors might become practical, but it is already apparent that severe materials problems exist and it is timely to initiate long range studies of the materials problems.

Returning to the problems of the M and C Division, it seems to us that budgetary problems of recent years have been handled well and that the general morale of the division is higher than in past years.

In summary, we recommend special attention to the following areas:

1. Mechanical properties investigations to support structural design methods.
3. Fissuring in the Hastelloy under MSR conditions.
5. Problems of H₂ containments in MSR, and in future CTR systems.

We hope the increasing diversification of the ORNL activities will open up new opportunities to use the talent of the M and C Division.

Sincerely yours,

Leo Brewer
Walter Kohn
Sidney Siegel