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Energy Research Advisory Board
to the
United States Department of Energy
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Washington, D.C. 20585
(202) 586-5444

July 12, 1989

To: Cold Fusion Panel

Enclosed is the Draft Interim Report. Please submit your comments by COB July 21 to John Huizenga (FAX No. (716) 473-6889) with a copy to Dave Goodwin (FAX No. (301) 353-5079).

A hard copy of the draft will follow in the regular mail.

John Huizenga will send you in several days a schedule of future Panel activities. Among these are two meetings, one at Chicago O'Hare Airport on October 13 and a final meeting on October 30-31. Please note these dates on your calendars.

William Woodard

Enclosure

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DRAFT

INTERIM REPORT OF THE COLD FUSION PANEL TO THE ENERGY RESEARCH ADVISORY BOARD

THIS IS A PRELIMINARY DRAFT THAT HAS NOT YET BEEN SEEN BY ALL PANEL MEMBERS. IT WILL BE SENT TO ALL PANEL MEMBERS FOR THEIR COMMENTS. AFTER THEIR COMMENTS ARE INCORPORATED, THE PANEL'S REPORT WILL BE SUBMITTED TO THE FULL ERAB. THE FULL ERAB WILL REVIEW THE PANEL'S REPORT FOR POSSIBLE MODIFICATION OR REVISION AND APPROVAL PRIOR TO SUBMISSION TO THE SECRETARY.

INTRODUCTION

As a result of the startling announcements in March 1989 by Utah scientists claiming the attainment of cold fusion, the Secretary of Energy requested (see Appendix A) that the Energy Research Advisory Board (ERAB) convene a panel (see Appendix B) to assess the possibility of cold fusion. The panel meetings and schedule of laboratory visits are summarized in Appendix C.

Since the above announcement, many laboratories worldwide have initiated research in cold fusion. In the United States, a major effort has been undertaken to search for cold fusion by a large number of research groups at industry, university, and national laboratories. Unfortunately, at the present time, the reports from different laboratories are quite divergent. Some laboratories claim excess power production attributed to cold fusion, usually for intermittent periods and for various periods of time but with no supporting evidence for the production of commensurate quantities of fusion products. Other laboratories find no measurable excess power production and no measurable high levels of fusion products. Some laboratories attribute the discrepancies to inaccuracies in measurements, others to non-reproducibility of a new and not understood process. Tritium levels above normal have been reported in some cells following electrolysis but not in others. Neutrons near background have been reported in some D_2O electrolysis and pressurized D_2 gas experiments, but at levels 10^{12} below the amounts required to explain the experiments claiming excess power.

In the past 8 weeks the Panel or subgroups thereof have participated in the Workshop on Cold Fusion in Santa Fe, have visited the laboratories listed in Appendix C, have studied the open literature and numerous privately distributed reports, and have participated in many discussions.

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GENERAL CONCLUSIONS

Although the Panel's task is not yet completed, the Panel finds that the experiments reported to date do not present convincing evidence that useful sources of energy will result from the phenomena attributed to cold fusion. Indeed, evidence for the discovery of a new nuclear process termed cold fusion is not persuasive. Hence, no special programs to establish cold fusion research centers or to support new efforts to find cold fusion are justified at the present time.

However, there remain unresolved issues and scientifically interesting questions stemming from reported cold fusion efforts. Some of these are relevant to the mission of DOE and should be handled by carefully focused and cooperative efforts within current programs by normal mechanisms for project selection.

The reports of excess heat and fusion products are assessed in separate sections. Preliminary recommendations are summarized in the final section.

CALORIMETRY AND EXCESS HEAT

The claim for electrochemically charged palladium cells as prospective energy sources rests on reports of "excess heat" (or, more precisely, excess power) that cannot be accounted for in the thermal balance normally applied to water electrolysis. Among the issues the Panel addressed in site visits were whether the power levels themselves are being accurately measured and whether the reactions being considered in these cells are, in fact, satisfying the chemical assumptions made. These heat measurements have been done with calorimetry varied as to technique and to levels of precision and accuracy. In most cases, calorimetric effects attributable to excess heat are very small and the calorimetric measurements are difficult and subject to subtle errors arising from various experimental problems.

For the purposes of this report, the calorimetry is usefully differentiated as to whether the D_2 and O_2 gases are allowed to exit the cell completely unreacted or are intentionally catalytically recombined to regenerate D_2O and to recover the corresponding heat. In the case of open cells, where the gases are assumed to be vented without reaction, any output power (as heat) greater than the electrical input power minus the power equivalent of the D_2O formation enthalpy [1.527 V x I (cell current)] is considered excess, a result reported by several groups. In closed cells with total recombination (and with a deuterium-charged Pd electrode), the total electrical power in and total heat power out would normally balance (as for Pt and Pd electrodes in light water). At present no experimenters who have performed calorimetry with closed cells under strict recombination conditions have reported any excess heat. Another important point is that most of the reported measurements with open cells are actually power measurements, and the data have not conclusively demonstrated that the total amount of energy produced (as heat and chemical energy) exceeds the total electrical energy input.

Since the claimed excess heats have, in most cases, been of a magnitude significantly less than the 1.527 V x I factor itself, issues of calibration,

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reliability, and support of the assumptions of zero recombination are especially critical. The Panel's site visits have identified experimental uncertainties, e.g., nonlinearities of the calibration in power output vs. temperature, time dependence of calibration, and doubtful accuracy of data acquisition relative to the magnitude of the effects asserted. Even in laboratories that report excess heat, this effect, under apparently identical conditions, is often not reproducible. In none of our visits to the different sites did we see an operating cell that was actually producing excess heat. So far, we have seen no experimental results that are sufficiently free of ambiguities and calibration problems to make us confident that the steady production of excess heat has been observed. However, there are reports of sporadic temperature "excursions" or "bursts" that apparently represent power outputs significantly larger than the input power. These events cannot be attributed to problems with accuracy or calibration alone and are presently not understood. In general, the calorimetry to date does not persuasively demonstrate the production of excess heat, but the bursts will require evaluation in the Panel's final report.

FUSION PRODUCTS

Since deuterium fusion necessarily yields fusion products (neutrons, protons, tritium, ^{3}He, ^{4}He, gamma rays), it is essential to establish the presence of such products in any claim of fusion. Each watt of power must be accompanied qualitatively by 10^{12} particles per second. This makes product detection by far the most sensitive method to search for fusion. Results to date on fusion products are summarized in the following paragraphs.

Neutrons are an established signature of the well studied d+d fusion reaction. Although many experimenters report no neutrons, some report as many as 1 neutron per second. If confirmed, this rate would be of some scientific interest (even if not indicative of cold fusion). This rate is so far below the 10^{12} neutrons per second required for 1 watt that it is of no interest as a practical energy source.

Numerous experimenters have sought tritium production in electrochemical cells and have found no excess tritium. One group reports finding up to 10^{14} tritium atoms (neglecting losses to the gas phase) in each of several cells with Pd cathodes and Ni anodes. Some of these experimenters report neutrons produced from similar electrochemical cells, but at a rate of about one neutron per second. If the tritium were a result of deuterium fusion, the rate of neutron production should be comparable and thus some 10^{10} times greater than reported.

Another important fusion signature is ^{3}He which should be detectable within a cathode after operated at fusion power levels of watts. It has been postulated that the cold fusion reaction might conceivably proceed predominately by the production of ^{4}He and thermal energy. None of the researchers to date, including those reporting the production of heat, have reported ^{3}He or ^{4}He above the detectable level of 10^9 atoms. One watt-hour of energy corresponds to more than 10^{15} atoms.

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Low level cold fusion in geologic processes has been proposed to cause high $^3He/^4He$ ratios and tritium abundances associated with volcanoes. Several laboratories are currently attempting to detect volcanic tritium.

INTERIM RECOMMENDATIONS

1. The Panel recommends that the cold fusion research efforts in the area of heat production focus primarily on confirming or disproving reports of excess heat. Emphasis should be placed on calorimetry with closed systems and total gas recombination, use of alternative calorimetric methods, reasonably well characterized materials, exchange of "promising" electrodes between groups, and careful estimation of systematic and random errors. Cooperative experiments are encouraged to resolve some of the claims and counterclaims in calorimetry. Such experiments should be pursued at a limited number of laboratories and supported at a modest level on the basis of competitive proposals. At the present time, the panel recommends against any significant expenditures to establish cold fusion research centers or to support new efforts to find cold fusion.

2. A shortcoming of most experiments reporting excess heat is that they are not accompanied in the same cell by simultaneous monitoring for equivalent fusion products. If the excess heat is to be attributed to fusion, such a claim should be supported by measurements of fusion products at commensurate levels.

3. Experiments designed to check the reported production of excess tritium in electrolytic cells are desirable.

4. Experiments reporting fusion products (e.g., neutrons) at a very low level, if confirmed, are of scientific interest but have no apparent applications to the production of useful energy. Continued support of such experiments at modest levels is justified, provided the proposals for such research are evaluated in comparison with other DOE research proposals. In view of the difficulty of these experiments, collaborative efforts are encouraged to maximize the detection efficiencies and to minimize the background.