THE INITIATION OF EXCESS POWER AND POSSIBLE PRODUCTS OF NUCLEAR INTERACTIONS DURING THE ELECTROLYSIS OF HEAVY WATER

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ABSTRACT

The electrolysis of heavy water is being investigated with an insulated flow calorimetric system. In each of a series of tests, the electrolyte was 0.1 to 1.0 N LiOD in D_2O and cylindrical palladium cathodes surrounded by wire-wound platinum anodes were used at cathode current densities of 100 to 800 mA/cm^2. The most recent test was made with a "closed system" without off-gas in which the electrolysis gases were internally recombined. Fast neutrons and gamma rays were measured continuously during each test. It was shown that certain system perturbations could initiate and extend the generation of excess power. In one test, an apparent increase in the neutron count rate was also coincident with system perturbations.

INTRODUCTION

The generation of excess energy and possible products of nuclear interactions, as proposed by Fleishmann and Pons [1] and Jones et al., [2] has been the rationale for the continued experimental investigation of the electrolysis of heavy water with a LiOD electrolyte solution and palladium cathodes. Our experimental approach has been to utilize an electrolysis system with positive heat removal by circulating cooling water and the continuous monitoring of fast neutrons and gamma rays. The most recent test also incorporates an internal recombination of the gases generated by electrolysis so that the system is totally closed without off-gas. The goal of this research is to carry out careful experiments with a complete energy balance while simultaneously measuring the products of possible nuclear interactions. Excess power and apparent increases in the neutron and gamma-ray count rates have been observed.

MATERIALS AND METHODS

Experimental System

A complete description of the experimental system has been reported previously [3,4]. To summarize, the approach is to use an insulated electrolysis cell, typically 4-cm-diam, made from Pyrex glass that is enclosed in a water cooling jacket. The electrolyte volume is 100 to 125 mL contained in 10- to 12-cm of height with an internal gas space of 4 to 9 cm enclosed with a Teflon top flange. Most of the tests have been made in an "open system" mode with the electrolysis gases exiting, but one extended run (1900 h) was made with an internal catalytic recombiner that resulted in a "closed system" without off-gas.

The total system also included constant-current DC power supplies for the cell current; an internal calibration heater; the catalytic recombiner; a heating/cooling system coupled to a cooling water pump; a syringe attached to a plastic tube for sampling or replenishment of the electrolyte; thermocouples for measuring inlet and outlet cooling water temperatures and the electrolyte temperature; NE-213 and NaI scintillation systems for measuring fast neutrons and gamma rays; and a strip-chart recorder and microcomputers for data acquisition and processing (Fig. 1).

Materials

The heavy water was deuterium oxide obtained from Aldrich Chemical Company, Inc., and designated as 99.9% atom % D with a tritium content of 2000 Bq/L. The electrolyte was prepared by dissolving reagent-grade, natural lithium in the D_2O at a concentration of 0.1 to 1 N.

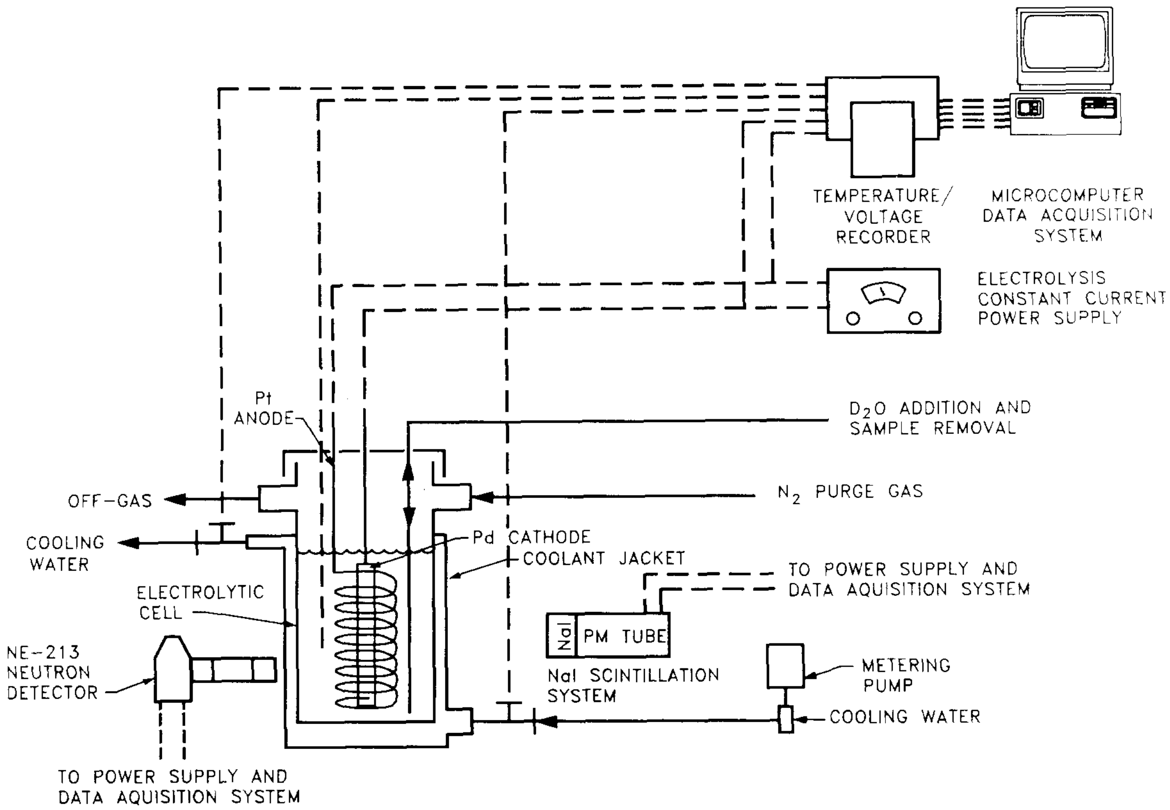

Fig. 1. Electrochemical system for the study of electrolysis of heavy water.

All of the cathodes were cylindrical rods of 99.9% palladium, obtained from Materials Research Corporation, that were cast in argon and swaged to the desired diameter (0.28 or 0.58 cm diam x 8.5 cm). A platinum connecting wire was then attached, and the rods were annealed at 900°C for 2 to 4 h in vacuum. All of the anodes and the recombiner were coils of wire fabricated from 99.9% platinum wire in the size range of 24 to 32 gauge (Englehard Corporation) [3,4].

Energy Balance

The energy balance for each test was determined by assuming that (1) the electric current was 100% efficient for electrolysis, (2) there was no accumulation of D_2, (3) the electrolysis gases were not recombined except in the closed-system test, and (4) there was no heat loss to the ambient. For the open and closed systems, the rate of energy input is [volts x amps]. The rate of energy removal in the open system was a combination of forced cooling [cooling water temperature increase x flow rate], electrolysis [negative heat of formation of the electrolysis products], and the increase of latent heat of the off-gases. For the closed system, the rate of energy removal was simply that of forced cooling.

RESULTS AND DISCUSSION

Several long-term (hundreds of hours) electrolysis tests have been made. Periods of excess power were observed in almost all cases; in a few tests, apparent increases in the neutron and gamma-ray count rates were also evident.

Excess Power

Apparent excess power has been observed in both open and closed electrolysis systems. There were periods of several hours when apparently spontaneous (no obvious initiation) excess power was measured at levels as high as 50% excess (Fig. 2). It was also shown that excess power could be initiated and extended for many hours by varying system parameters such as cathode current density, electrolyte concentration,

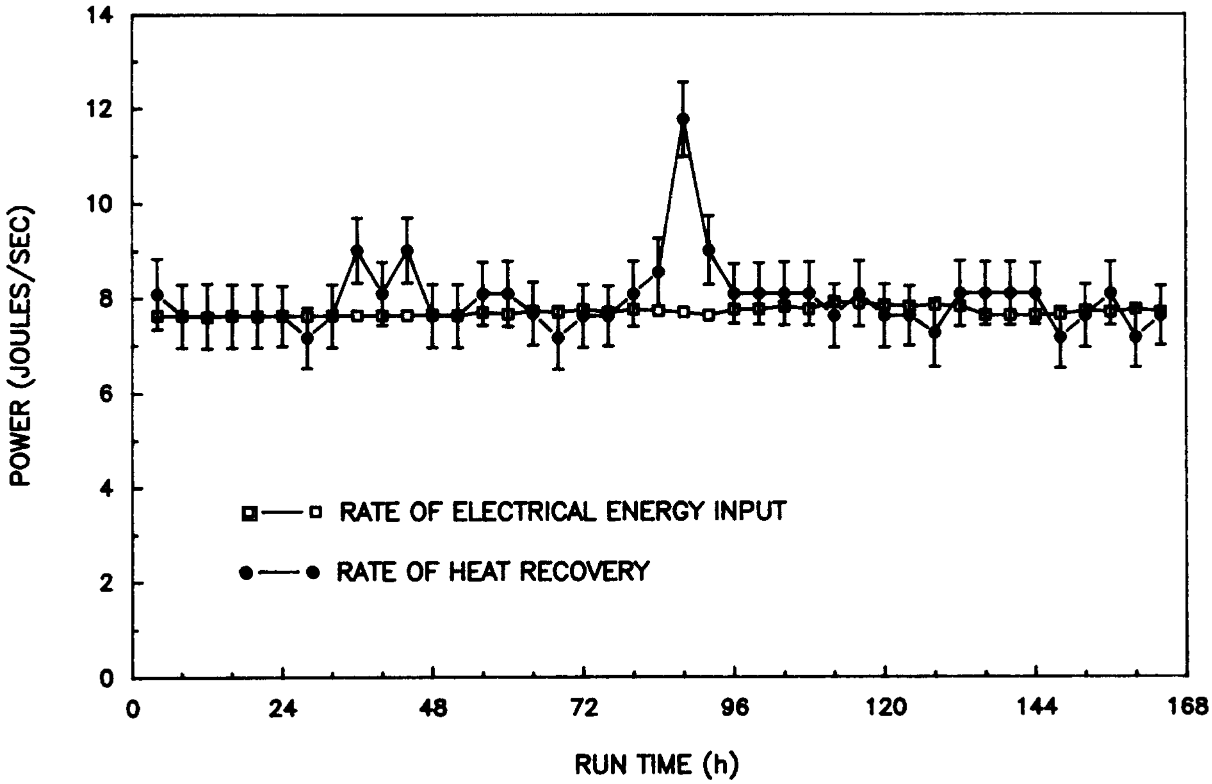

Fig. 2. Power balance for an open-system test in which a 0.56-cm-diam x 8.5-cm palladium cathode was used in 0.2 N LiOD at a cathode current density of 100 mA/cm^2. The error bar represents calculated uncertainty in the experimental value.

and electrolyte temperature (Fig. 3). The latter parameter seemed to be the most effective means for producing system perturbations that initiated excess power. This approach was of particular utility in the closed system where excess power was initiated and extended for hundreds of hours by reducing the electrolyte temperature (Fig. 4).

Increased Neutrons and Gamma Rays

In various tests, the neutron count rate spontaneously exceeded the background by over three standard deviations on several occasions. Typical of these was an open-system test where, during the first few hours, the neutron count rate exceeded the background by about three and one-half standard deviations (Fig. 5).

Perhaps the most interesting neutron result was obtained in a closed system where an apparent coincidence of increased neutron count rate was observed during the period of induced excess power (Fig. 6).

CONCLUSIONS

On several occasions, excess power was observed during the electrolysis of heavy water in the presence of a palladium cathode. In some cases, the excess power was apparently spontaneous; however, it could also be induced for many hours by system perturbations caused by varying certain operating parameters. Apparent increases in the neutron count rate were also observed in several instances, including one period that was coincident with induced excess power.

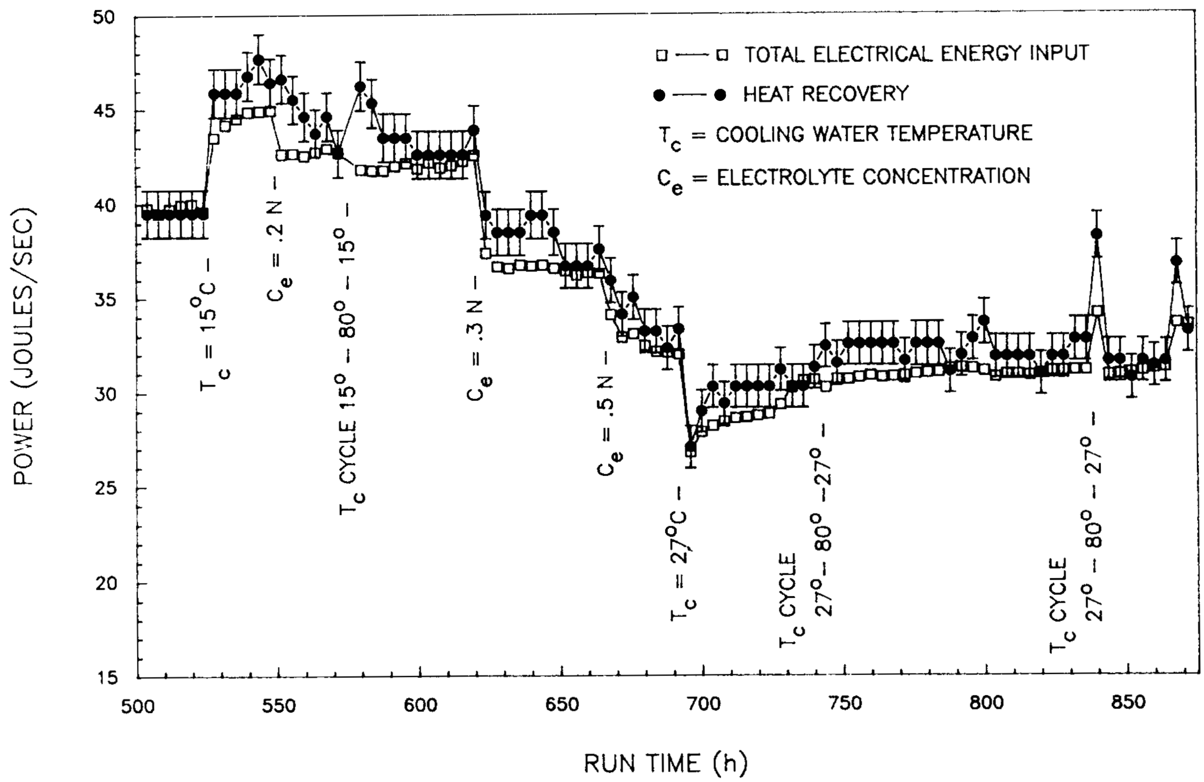

Fig. 3. Power balance for an open-system test in which a 0.28-cm-diam x 8.5-cm palladium cathode was used at a cathode current density of 600 mA/cm². Excess power was initiated and extended by varying certain system parameters.

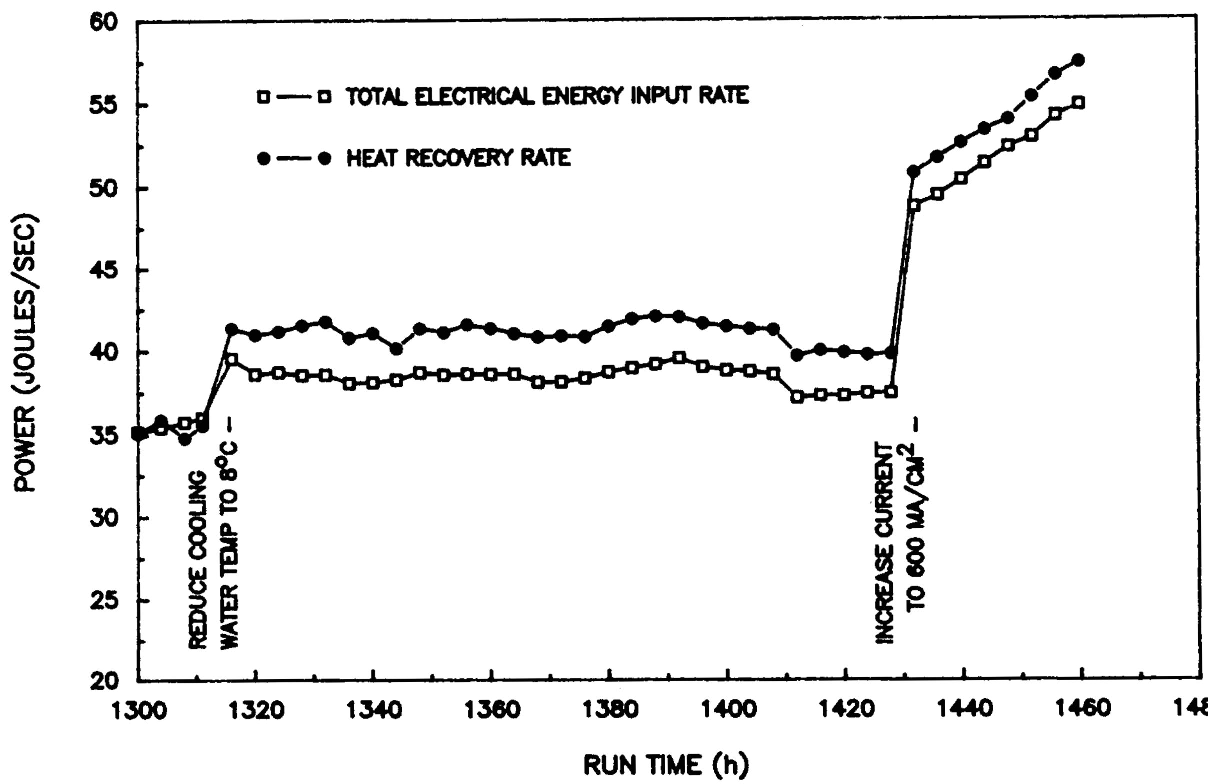

Fig. 4. Power balance of a closed-system test in which a 0.28-cm-diam x 8.5-cm palladium cathode was used in 0.1 N LiOD at a cathode current density varying from 500 to 600 mA/cm². The experimental uncertainty is approximately 0.4 joules/sec.

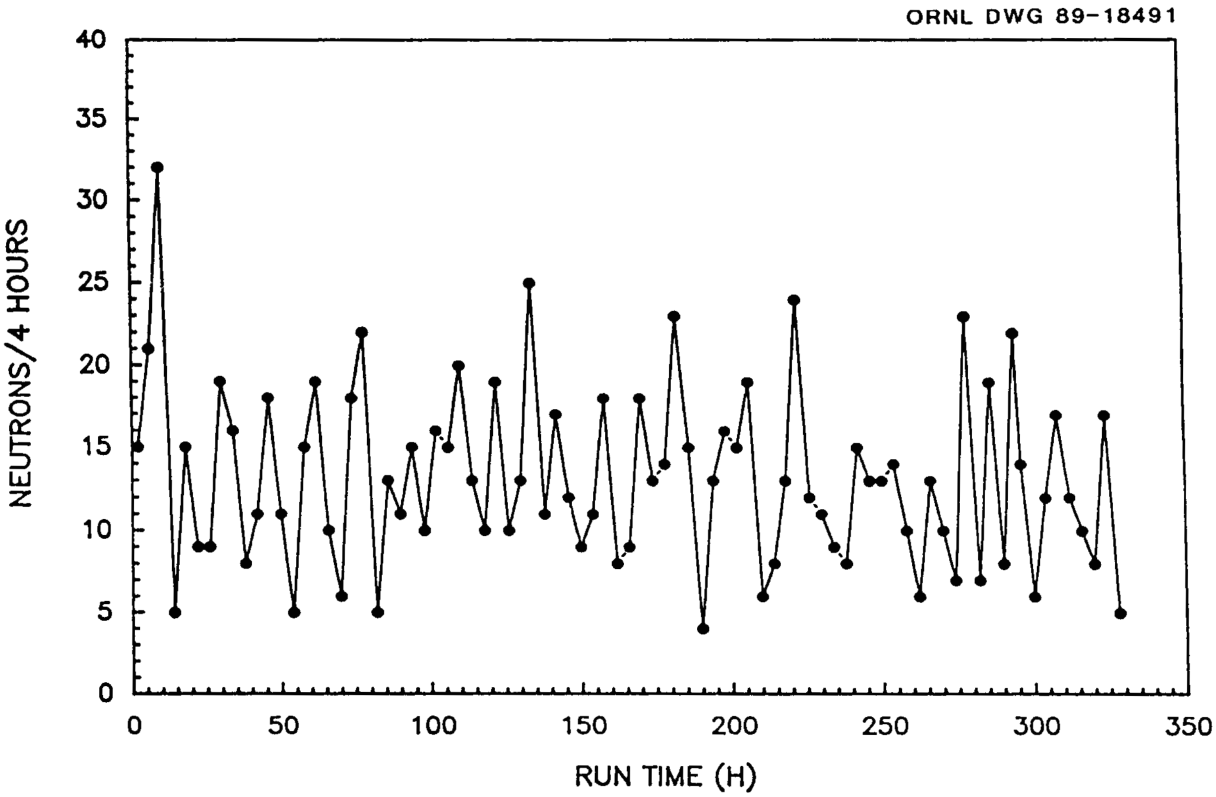

Fig. 5. Neutron count rate for an open-system test in which a 0.28-cm-diam x 8.5-cm palladium cathode was used in 0.2 N LiOD at a cathode current density of 100 mA/cm^2.

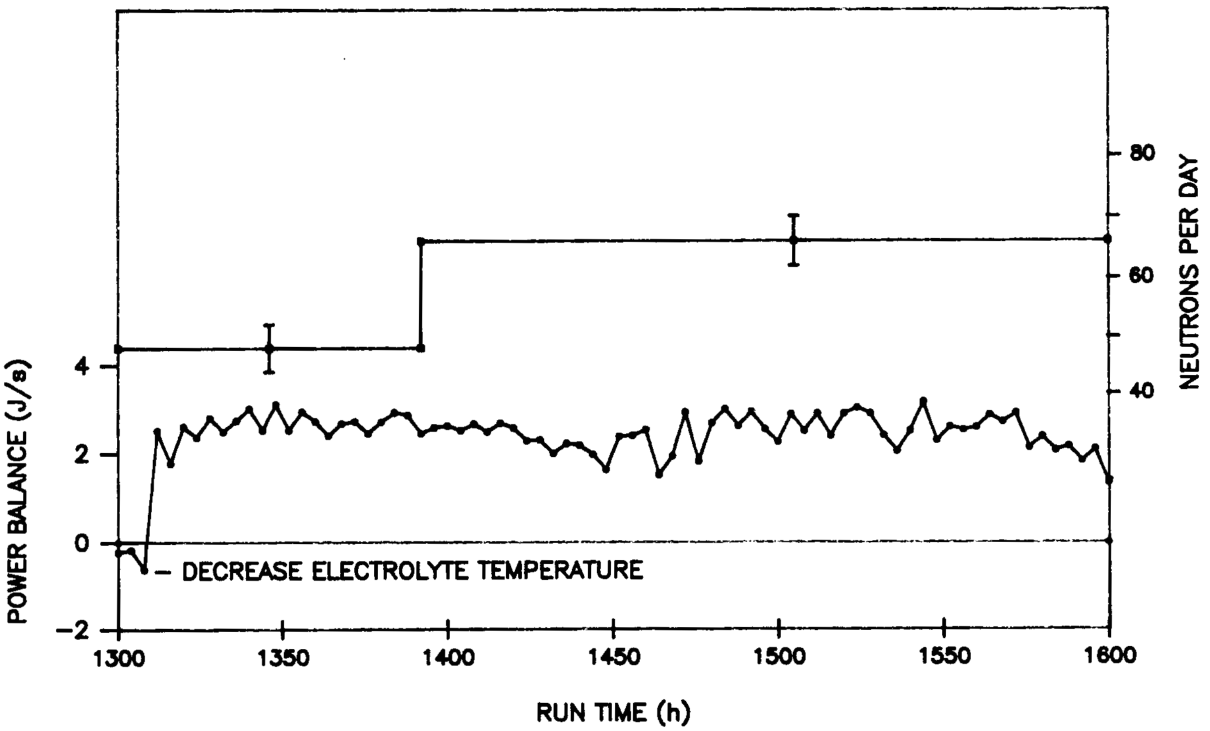

Fig. 6. Apparent coincidence of an increased neutron count rate during the period of induced excess power in a closed-system test in which a 0.28-cm-diam x 8.5-cm palladium cathode was used in 0.1 N LiOD at a cathode current density varying between 500 and 600 mA/cm^2. The error bars represent the 95% confidence level for neutron counts during the indicated period of time.

Another version of this graph with 100 days of data is shown below.

REFERENCES

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[2] S. E. Jones, E. P. Palmer, J. B. Czirr, D. L. Decker, G. L. Jensen, J. M. Thorne, S. F. Taylor, and J. Rafelski, "Observation of Cold Nuclear Fusion in Condensed Matter," Nature, 338, 737:1989.

[3] C. D. Scott, J. E. Mrochek, E. Newman, T. C. Scott, G. E. Michaels, and M. Petek, "A Preliminary Investigation of Cold Fusion by Electrolysis of Heavy Water," Martin Marietta Energy Systems, Inc., Report ORNL/TM-11322: 1989.

[4] C. D. Scott, J. E. Mrochek, T. C. Scott, G. E. Michaels, E. Newman, and M. Petek, "Measurement of Excess Heat and Apparent Coincident Increases in the Neutron and Gamma-Ray Count Rates During the Electrolysis of Heavy Water," submitted to Fusion Technology:1990.

Here is another version of Fig. 6. This is from a preprint uploaded here:

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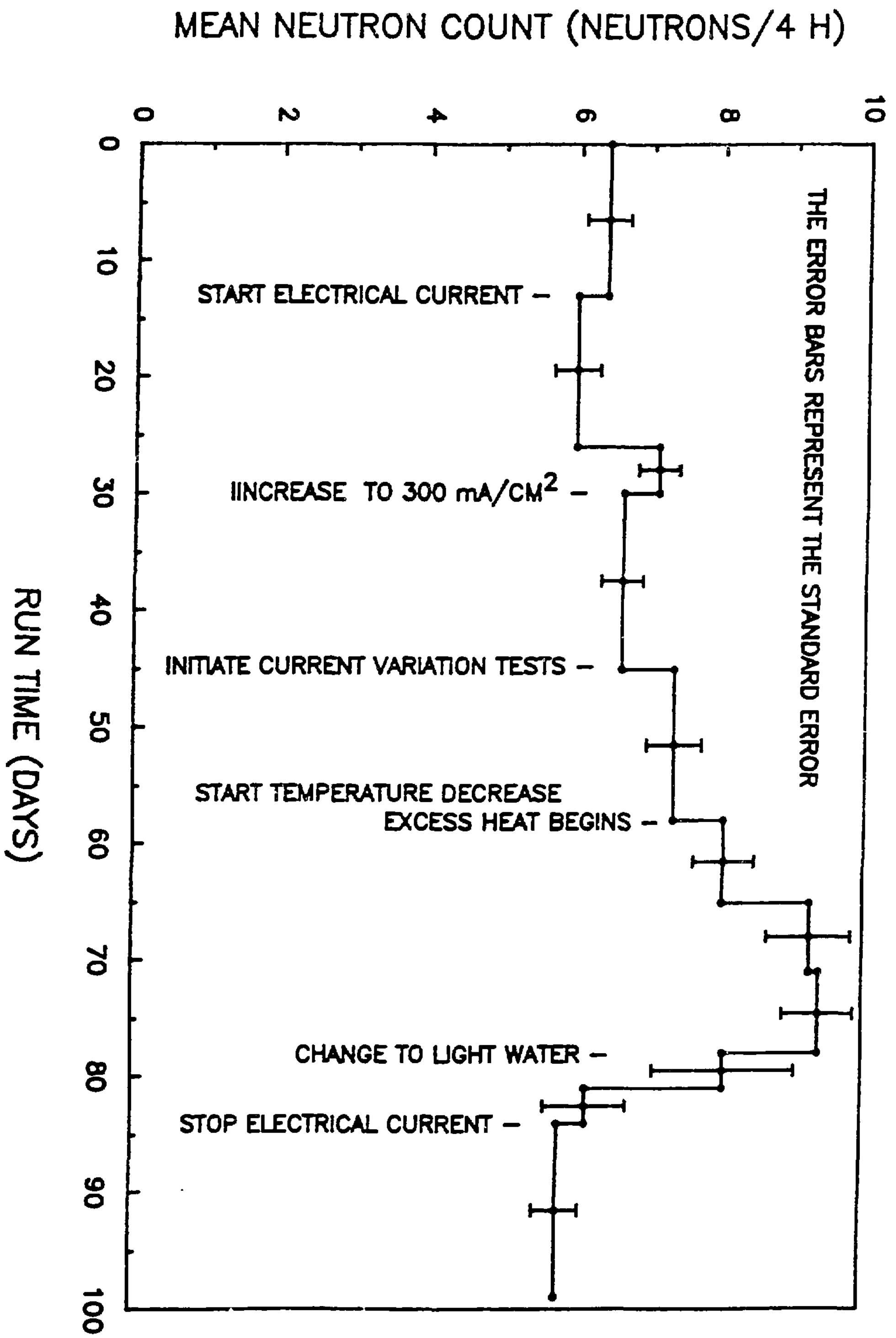

6. Apparent coincidence of an increased neutron count rate during the period of induced excess power in a closed-system test in which a palladium cathode 0.28-cm-diam x 8.5 cm was used in 0.1 N LiOD at a cathode current density varying between 500 to 600 mA/cm2.