



Research Article

# Excess Heat is Linked to Deuterium Loss in an Aqueous Nickel LANR System

Mitchell R. Swartz\* and Brian Ahern

*JET Energy Inc., Wellesley Hills, MA 02481, USA*

Charles Haldemann and Alan Weinberg<sup>†</sup>

*Lincoln Laboratory, Massachusetts Institute of Technology, Lexington, MA, 02421, USA*

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## Abstract

These results indicate a loss of deuterium (more precisely, “deuterons”) from ordinary water when excess heat is observed in an aqueous Ni CF/LANR system (Ni/ordinaryH<sub>2</sub>O/Pt) using a very large cathodic area. The exit gas, from the enclosed electrolytic cell, had an HD/H<sub>2</sub> isotopic ratio (3/2 ratio) which was significantly less than originally. When using  $V \cdot I$  as electrical input power, the maximum incremental power gain was  $\sim 4$  times electrical input; this occurred at lower electrical input power. The maximum excess power was circa 5 W.

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*Keywords:* Deuterium, Deuterium loss, LANR, Palladium

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## 1. Introduction

Many types of LANR systems exist, but few have extremely large cathodic surface areas or inline detection systems able to discern heavy hydrogen (D) from ordinary hydrogen (H). The MIT Lincoln Laboratory Electrolytic Cell system had a 3 l capacity. Electrical loading and driving were used because hard drawn nickel wire can be loaded with hydrogen to about  $1 \times 10^{-3}$  atomic fraction at room temperature ( $\sim 20$  times higher than the equilibrium level for gas phase loading). These results indicate a loss of deuterium (more precisely, “deuterons”) from ordinary water when excess heat is observed in an aqueous Ni CF/LANR system (Ni/ordinaryH<sub>2</sub>O/Pt) using a very large cathodic area. There are at least four important points. First, the loss of deuterons is linked to the excess heat (excess energy) which was repeatedly seen. Second, during these studies, the maximum excess power gains were 5–14 times electrical input when the thermoneutral correction was used. When using  $V \cdot I$  as electrical input power, the maximum incremental power gain was  $\sim 4$  times electrical input; this occurred at lower electrical input power. The maximum excess power

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\*Corresponding author. Dr. Mitchell R. Swartz ScD, MD, EE, E-mail: moac@nanortech.com.

<sup>†</sup>Presently at JET Energy Inc., Wellesley Hills, MA 02481, USA.

was ca. 5 W during MIT's Lincoln Lab. efforts from 1993 to 1996 [1]. The incremental excess power gains have since been increased using information and technology from JET Energy Inc. Third, the exit gas, from the enclosed electrolytic cell, had an HD/H<sub>2</sub> isotopic ratio (3/2 ratio) which was significantly less than originally. In addition, these results herald deuterons as the fuel in nickel-ordinary water CF/LANR systems, consistent with Swartz et al. [2,3] and the reports of helium production in Pd systems [4].

## 2. Experimental

### 2.1. Materials

The LANR electrolytic cell used, unfilled, is shown in Fig. 1. When filled, its 3 l capacity and large cathode earn its nickname: MOAC (“Mother of all Cathodes”). It has a 3 l capacity when filled. The electrolytic Ni/ordinary water/Pt system was designed to have a large electrode area. The cathode weighs 2.14 kg, and was made from No. 46 hard drawn smooth nickel wire (0.041 mm diameter, with an area of ca. 240,000 cm<sup>2</sup>). The anode was five-folded platinized sheets of titanium with an area of ~3200 cm<sup>2</sup>, for a surface area ratio of cathode to anode of 75:1.

The electrolyte was a carbonate solution (0.6 M K<sub>2</sub>CO<sub>3</sub>) using laboratory distilled deionized water with no additional heavy water was added. Two internal ohmic controls were used. Figure 1 shows the LANR cell used, unfilled and not connected to the power supply or the gas venting, after its removal from Lincoln Lab. The MOAC used for this report has in the last few years evolved through a series of changes, of both design and operation, which led to consecutive increases in incremental power gain. The cell underwent incremental engineering substitutions and changes (Cells 1, 1A, 2, 2A, 3, 4) for increased incremental power gain. Some of the changes and results are listed in Table 1.

### 2.2. Methods

For the calorimetry, calibration was determined by ohmic controls. The putative excess heat output (if any) was determined by the  $\Delta T$  at equilibrium. In these measurements, the instantaneous power gain (power amplification factor (non-dimensional)) is defined as  $P_{\text{output}}/P_{\text{input}}$ . Electrical input power ran to ~25 W at MIT; and to >125 W at JET Energy. In addition to energy measurements, gas measurements and isotopic measurements were obtained. Gas measurement and recombiner analyses were made three ways, as shown schematically in Fig. 2.

Figure 2 shows the arrangement of the sealed MOAC cell, the collection flask(s), the extra bubbler, the mercury catch basin and mercury filled collection vessels, and the water bath with the bath thermocouple.

The three types of gas collection systems which were used. For some experiments, gas collection was done with either a combustion tube or a bubbler flame suppressor used prior to either the mass spectrometer or a platinum glow wire.

Chemical absorption was measured by a Burrell Wet Analyzer. The absorbents in the tube analyzer were KOH (sol.), CrCl<sub>2</sub> (sol.) and CuO heated to 300°C for CO<sub>2</sub>, O<sub>2</sub>, and H<sub>2</sub>, respectively. Isotopic analysis was made by mass spectrometer (INFICON Quadrapole-102 V Energy) [1].

Gas flow absolute measurement was made by direct water displacement in 2000 cm<sup>3</sup> volumetric flasks ( $\pm 0.5$  cm<sup>3</sup>), with the temperature controlled to  $\pm 0.1^\circ\text{C}$ , using time measurements ( $\pm 0.02$  s). Barometric pressure was obtained from the National Weather Service barometer and that was corrected for temperature and latitude ( $\pm 0.1$  mm).

The measured volume was then corrected for ambient temperature, pressure and water vapor content. Cryo-condensation was also used. The exit gas from the enclosed electrolytic cell was ~100% collected by liquid nitrogen condensation. It was then sent to a recombiner.



**Figure 1.** The LANR electrolytic cell.

### 3. Results

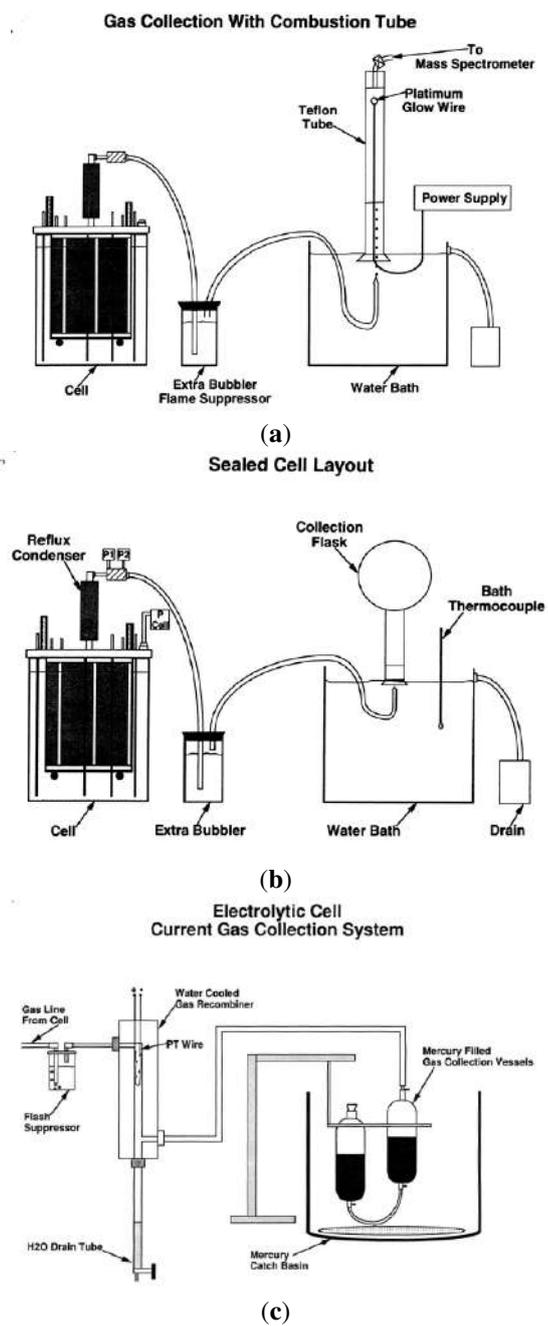
#### 3.1. Excess heat produced

There was excess heat (excess energy) seen, repeatedly. All calibrations had  $\Delta T$  less than  $0.2^\circ\text{C}$ . On the other hand, for the active MOAC cell, equilibrium  $\Delta T$ 's were  $0.5\text{--}2.5^\circ\text{C}$  above those expected from ohmic control calibration. These excess thermal outputs are shown in Fig. 3 for both DC runs and the pulsed runs for the electrolytic cell, and for the ohmic controls. These outputs are shown up to an electrical power input of about 25 W, characteristic of the (early) MIT experiments.

The maximum power gains were 5–14 times electrical input when the thermoneutral correction was used. When using  $V \cdot I$  as electrical input power, the maximum incremental power gain was  $\sim 4$  times electrical input; this occurred at lower electrical input power. The maximum incremental excess power was ca. 5 W.

Improved output of active cells increased with developmental changes. In Table 1 is shown the performance of the “summary of cells assembled”. It can be seen that Cells 1, 1A, 2, 2A, 3, 4 showed monotonically increasing incremental power gain. From no excess power gain to 50% increase to 14,000% (using the thermoneutral voltage correction) or 400% excess power gain (using  $V \cdot I$ ).

Table 1 shows information on the six versions of the MOAC were developed at MIT, and another two more at JET Energy, each with the differences in cathode, anode, and cathode to anode (C/A) ratio in columns 2,3, and 4, and other geometric arrangements. Column 5 lists the observed incremental energy gains.



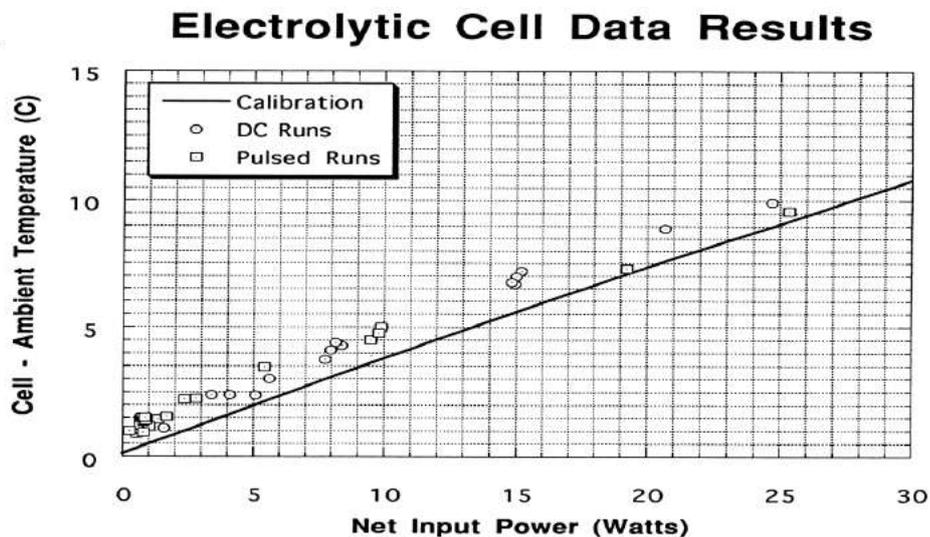
**Figure 2.** Several gas collection systems used (a)–(c).

**Table 1.** Summary of results of the LANR MOAC cell.

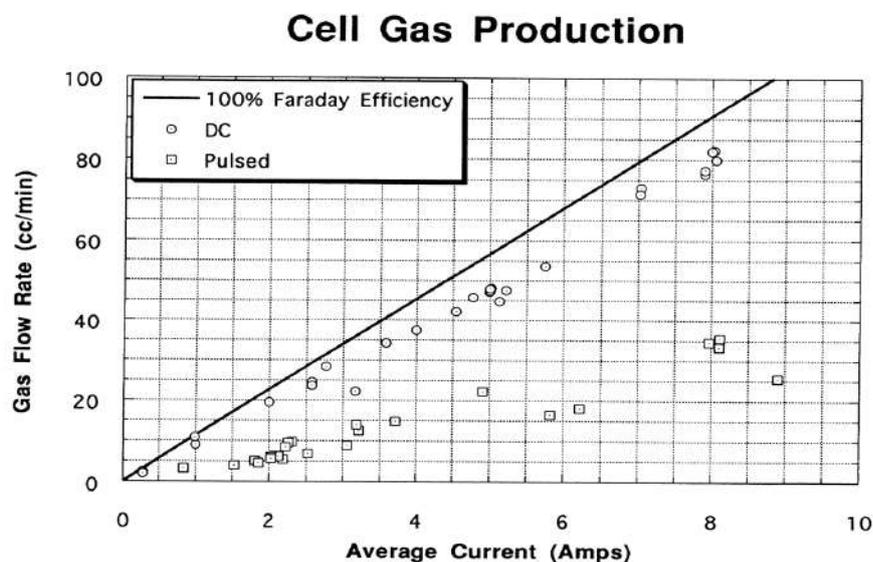
Cell No.	Cathode	Anode	Cathode/anode ratio	Results
1	Annealed No. 41 nickel 0.818 kg, 52,000 cm <sup>2</sup>	Platinized titanium 100 cm <sup>2</sup>	520:1	No excess energy
1A	Same wire Heat treated in H <sub>2</sub> 770°C	Soft nickel sheet 3000 cm <sup>2</sup> Platinized titanium 100 cm <sup>2</sup>	17:1	No excess energy
2	Hard drawn 0.5 mm nickel 16,000 cm <sup>2</sup>	Same	5:1	5–10% excess energy
2A.	New hard drawn 0.5 cm <sup>2</sup> nickel 15,000 cm <sup>2</sup>	Platinized titanium sheet 3100 cm <sup>2</sup>	5:1	5–30% excess energy
3	Hard drawn scratched No. 44 nickel 190,000 cm <sup>2</sup> 0.05 cm diameter	Same	61:1	20–50% excess energy
4	No.46 hard drawn smooth nickel wire 240,000 cm <sup>2</sup>	Same	75:1	20–1400% excess energy 4 * (V*I) input
4A,B	Same but configuration approaching Phusor®-type componen; augmented diagnostic; higher impedance solutio	Same	75:1	70 W peak excess power Demonstration of two driven electrical modes

### 3.2. MOAC cell gas production analysis

The exit gas from the enclosed electrolytic cell generated from 2 to 100 cm<sup>3</sup>/min (2.8–144 l/day). The rate of exiting gas flow is shown in Fig. 4 as function of input electrical current in amperes. The 100% efficient (theoretical) line is also shown.



**Figure 3.** Heat production achieved for the LANR system and the ohmic controls electrolytic and control thermal outputs for dc and pulsed runs.



**Figure 4.** Electrolytic cell gas production. The rate of exiting gas flow is shown as function of input electrical current in amperes. The 100% efficient (theoretical) line is also shown.

### 3.3. Recombiner analysis

The recombiner liquid was analyzed (Table 2). The recombiner volume production rate was 50–100 cm<sup>3</sup>/day, and it constituted 0.1–1.8% of the total gas flow. The residual gas from the recombiner had a content consistent with the gas measurements to  $\pm 1\%$ .

### 3.4. Isotopic ratios

Figure 5 shows the HD/H<sub>2</sub> isotopic ratios of the “ordinary distilled water”, of the air, of the exit gas, and of the recombined water. Figure 5 also lists the test pressures, in Torr, at each location. Of special note: the HD/H<sub>2</sub> isotopic ratio (3/2 ratio) was more than a third less for gas leaving the cell, with some recovery in the recombiner water. This result heralds deuterons as the fuel.

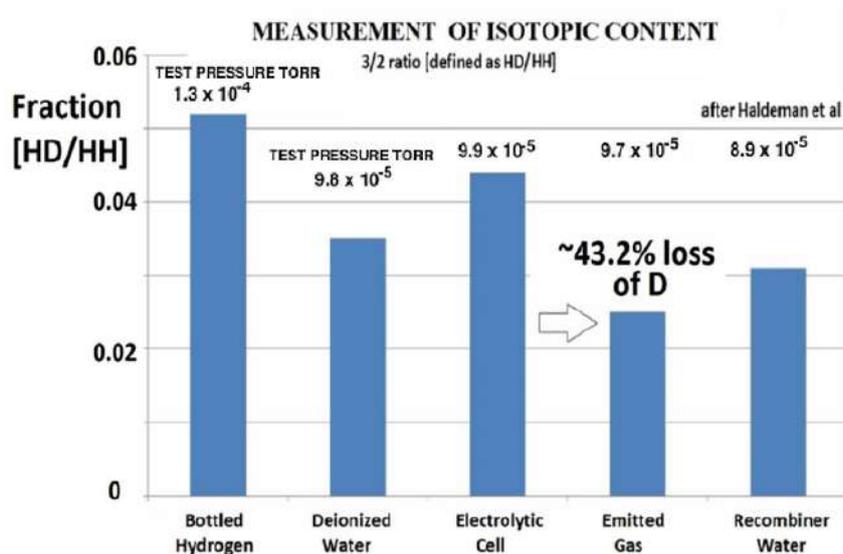
## 4. Conclusion: Excess Heat is Linked with Deuterium Loss

These experiments produced excess power up to 5 W over considerable amounts of time. But what is the source of the energy? These experiments indicate a possible loss of deuterium from ordinary water when excess heat is observed in

**Table 2.** Wet gas analysis. These are the results of the analysis of air, raw cell gas, and recombination gas.

Wet gas analysis results percent				
Sample	CO <sub>2</sub>	O <sub>2</sub>	H <sub>2</sub>	Residue
Air	0	21	0	79
Raw cell gas	0	32	67	1
Recombined cell gas many samples	0	18→22	0→0.2	Balance 78→82 called processed cell gas

Mass spec. analysis of processed cell gas shows N<sub>2</sub>, A, and H<sub>2</sub>O.



**Figure 5.** Results of measurement of isotopic content. The 3/2 ratios (HD/H<sub>2</sub> ratios) at various system locations. Also shown are the test pressure (torr) from each of the locations.

an aqueous Ni/H<sub>2</sub>O/Pt system using a very large cathodic area.

The loss of deuterium was not appreciated at the time since the investigators were looking for “hydrinos” or shrunken hydrogen (which has not been seen, and was not seen then) as the putative etiology of excess heat in LANR. The original report [1] concluded: “We cannot prove or disprove possible explanations for (the observed) excess heat”. However, helium production, and therefore possible deuterium loss has been shown to be the actual etiology of the excess heat repeatedly observed in active, aqueous Pd LANR systems [4].

Here, the issues of electrolytic separation of H over D, and over isotopic sequestration in the nickel cathode must be ruled out. However, the change in HD/H<sub>2</sub> isotopic ratio, consistent with possible deuterium loss could be very significant.

These results are consistent with Swartz et al. [2,3] and probably with the reports of helium production in Pd systems [4]. Importantly, deuterons and their isotopic flow [5], including in ordinary water systems, must be considered as the fuel for active aqueous nickel CF/LANR systems.

Present studies investigate the roles, and semi-quantitative contributions to the CF/LANR activity, of electrolytic separation and metallurgic selective binding to the cathode of D versus H, the changes which occur in the nickel from electrically driving it for the desired CF/LANR reactions, and the impact of the findings of this report.

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## References

- [1] C.W. Haldeman, E.D. Savoye, G.W. Iseler and H.H. Clark, Excess Energy Cell Final Report, 1996.
- [2] M.R. Swartz, G.M. Verner, A.H. Frank, The impact of heavy water ( $D_2O$ ) on nickel-light water cold fusion systems, *Proc. ICCF9*, China, Xing Z. Li (Ed.), May 2002, pp. 335–342.
- [3] M.R. Swartz, Excess power gain using high impedance and codepositional LANR devices monitored by calorimetry, heat flow, and paired stirling engines, *Proc. ICCF14*, 2008, p. 123; ISBN: 978-0-578-06694-3, p. 123, (2010); [www.iscmns.org/iccf14/ProcICCF14a.pdf](http://www.iscmns.org/iccf14/ProcICCF14a.pdf).
- [4] M. Miles et al., Correlation of excess power and helium production during  $D_2O$  and  $H_2O$  electrolysis using palladium cathodes, *J. Electroanal. Chem.* **346** (1993) 99–117.
- [5] M.R. Swartz, Quasi-one-dimensional model of electrochemical loading of isotopic fuel into a metal, *Fusion Technol.* **22** (20) (1992) 296–300.