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Dear Robert,

This letter is to provide a brief report on the iESi site visit that took place on February 13, 2005. This company has developed a new energy generation technology that is based on a highly unconventional approach, and I was requested to evaluate it to see whether I thought that it was suitable for investment purposes.

As you know, I have been involved in research in the area of cold fusion for nearly 16 years, and was the conference chair of the Tenth International Cold Fusion Conference held near MIT in 2003. I was also involved in the recent DoE review of cold fusion that was held last year. This is relevant as the new technology developed at iESi appears to be related to, or make use of, cold fusion phenomena as the basis of its operation.

I note that a previous site visit was done, and that iESi provided a demonstration of their technology at that time. This earlier report provides a detailed description of physical parameters associated with the test. The numbers in that report are similar to the numbers presented to me during my visit, so I will not overly belabor points that were covered earlier. I was interested in understanding some of the issues about how the technology works, as well as understanding the level of expertise of the researchers involved. For example, measurements of current, voltage, temperatures, and flow rates are reasonably straightforward, and the effects under discussion are not small. It was possible to verify by touch the presence of a sizeable temperature increase, and one could see discharge phenomena consistent with the production of significant charge imbalances. Hence the basic claims of energy and charge creation correspond to massive effects that are readily observable independent of any of their diagnostics.

Real or Faked?

It would be reasonable to ask whether the results presented might have been faked in some way. The production of excess heat would require roughly a 4 kW heater somewhere in the flow stream, along with a power supply from somewhere to drive it. If someone wished to simulate a large heat effect by cheating in this way, it could have been done with the apparatus presented under the conditions of the test. Let me be clear that I do not believe it was, but this cannot be ruled out by any tests or observations that I made.

An electrical discharge was readily observable inside the cell. The breakdown strength of the cell and oil are likely in excess of 100 kV/cm, with breakdown clearly evident, and 2-3 cm distances involved. I would not be surprised if internal voltages on the order of 500 kV were present. Had one been determined to fake this, one could have put in a charge source somewhere in the flow stream, and then taken advantage of an internal Van de Graaf effect to make a discharge. Once again, I do not believe that this was done, but the possibility cannot be ruled out by my observations.

I note also that in the course of my review, essentially no scientific data was presented. In this I was disappointed. However, Professor Yang provided me freely with many helpful pieces of information that were helpful in learning about their work and observations.

Focus of the Review

It would have been a simple matter to determine whether their system operates as claimed if it worked according to well known operating principles that one could look up in textbooks. As the research effort involves cold fusion effects, there are no textbooks explaining basic operating principles. Nevertheless, there have accumulated a fair amount of understanding of cold fusion systems and how they work over the past 16 years, and my goal was to try to understand how this device might be operating based on previous knowledge of the field.

Hence, my approach to the review is as follows. Since some of the experiment is inaccessible the possibility of being tricked is ever-present (once again, I do not believe that iESi is engaged in tricking people. The ultimate defense against such things is for an independent lab to construct a version of the device themselves and see it work.), I wanted instead to understand what it is they did and what they saw. Instead of reporting on temperatures and voltages, which has been done previously, I was more interested in understanding what the device was doing and why, based on iESi's experience, it was doing it. I note that within the scientific community, scientists interacting with other colleagues on experiments usually learn about the experiments over time from discussions, from papers, from data, and from working with the experiment. Over the course of a one-day visit and review, it is not possible to come away with a complete understanding, but one can make every attempt to learn some of the basics of an experiment.

Essential Claims

To make life simple, I will boil things down to a small number of basic claims:

The iESi team claims that a very large amount of energy is being generated as its primary claim, and that energy gain on the order of a factor of five is observed at a maximum temperature on the order of, but less than 100 C. By itself, this claim would seem to be amazing, but it is actually neither unique nor overly interesting for applications. Within the area of cold fusion research, several groups have reported higher gains, or experiments where the gains could easily have been higher with minor design modifications. A heat boost of a factor of five might be interesting for commercial applications were electricity priced lower. Thermal to electric energy conversion below 100 C through conventional means is sufficiently inefficient that it would be difficult if not impossible to run the system with its own converted power done this way. Highly significant is the amount of power being generated, as there have not been previous reports of excess power generation at this magnitude. Even more highly significant is the power per volume ratio that one might associate with the working area of the cell, which is on the order of a few kW per cubic centimeter, similar to power generation densities obtained in cold fusion cells. I note that the iESi team claims that power gains of 20 or more can be produced with their technology.

Also claimed is a very high rate of reproducibility, approaching 100%. The system was demonstrated successfully three times during my stay in Edmonton. I have no reason to doubt that it is reproducible in their hands.

Perhaps the most significant claim is one of an ability to generate large amounts of voltage, current, and electrical power. It was claimed that the team had observed DC electrical power production at a level of 200 kW [4 Amps at 50 kV] with the device under consideration, with a much lower electrical input power. To support this claim, the system was run under conditions where rather memorable discharges were generated, and voltages between 10 and 40 kV were measured on an electrode that extended out from the cell. The discharges were seen to dig tracks through more than an inch of Plexiglas surrounding the active chamber of the cell, which is consistent with the presence of high voltage as mentioned above. I note that a device that can produce electrical power gain significantly greater than unity would be of large commercial value. The iESi team did not demonstrate such a conversion during my visit, but was building up toward such a demonstration for the near future.

Excess Energy Generation Issues

As discussed above, the excess energy generation claimed, and demonstrated, is on the order of a few kW with an energy gain of about 5 [thermal energy out over electrical energy in]. I asked Professor Yang how he thought that the system produced energy. His explanation involved ideas about proton-proton reactions, and that he was creating conditions similar to that in the outer part of the sun in the discharge areas inside the cell. I will not go into an explanation here as to why such thoughts are not going to be helpful (Professor Yang's area of expertise is in mechanical engineering). Consequently, I came to the conclusion that while the research effort has discovered the effect, their understanding of what is happening is not very good. In essence, they have no relevant models for what is occurring within their cell.

After reviewing their cell design, and after thinking about things, I have tentatively come to the conclusion that the basic operation of their cell is ultimately very similar in many regards to that of a conventional cold fusion cell. The iESi design, viewed from this perspective, has present all of the elements that, according to my understanding of such devices, are required. There is fuel, there appears to be appropriate local matter conditions within the cell, and there is vibrational stimulation. Moreover, aspects of the operation of their cell appear to be consistent with such a picture. The cell appears to turn on and off in accordance with the presence of stimulation, as expected. A proprietary external stimulation increases the heat effect, also as expected. The cell seems to give a higher output at increased temperature, which is consistent with expectations associated with the availability of the fuel. Discussions about their experience with different local matter conditions appears to mesh with expectations. The power density associated with excess heat production appears to be very similar to those observed in a conventional cold fusion cell. The ``ash'' expected from this kind of experiment would be ^{3}He, and the iESi team is claiming to have observed ^{3}He from this kind of experiment in experiments elsewhere.

My present view is that they probably are seeing a very large excess heat effect that works very similarly to other experiments in terms of mechanism, and that the design of the iESi cell in this regard is very good, allowing practical access of a high power operating regime which has not been reported previously.

Verification: Energy

One would always like certainty, especially in matters of science and financial investments. Thinking about things after the visit, I was wondering what kinds of things might be done in order to verify the energy claim. How can one be certain that it works as claimed? How could one prove that the device operates according to one principle or another? The normal way these things are done in more normal scientific circumstances is to do tests of one sort or another. For example, sending a test unit out to a trusted independent lab for an independent measurement of the energy gain would be a simple way to arrange for a confirmation. A measurement of ^{3}He in quantitative measure to the energy produced would not only provide a confirmation of the underlying reaction pathway, but would provide an independent measurement of energy production. Simply measuring an anomalously large amount of ^{3}He would be provocative; as such an observation has so far eluded everyone that has tried within the cold fusion community (whereas quantitative ^{4}He has been measured in other experiments). There are a host of more subtle tests that can be done which could shed light on the underlying physical mechanisms. I would recommend that iESi seriously consider the possibility of an independent test in the relatively near future from a respected laboratory. Other tests and experiments should probably be part of a research effort devoted to understanding the device in the months and years to follow.

Charge Generation: Issues

The consequences of the appearance of electrical charge can be seen in the discharge effects associated with the experiment. I asked Professor Yang whether he understood how the charge was produced, and my understanding is that this has not yet been clarified in this experiment. Charge generation is known in association with cold fusion

experiments. The effect appeared in a number of gas-loading experiments that I was involved in at MIT in the mid-1990s, and has been reported by some of my colleagues elsewhere.

There are several things that are interesting about the charge generation in the iESi experiment. The charges are probably generated with reasonably high associated energies. This I conclude from observations that Professor Yang reported in which voltages on the order of 1 MV were measured. In addition, the iESi team reports the observation of a blue glow that can be seen in the oil and Plexiglas when charge is being generated when the lights are turned down. I was not able to see this effect during my visit, but the device was run during the daytime and there was no way to block incoming light from the outside. A nuclear radiation detector brought near the cell registered counts when the cell was running, but much less or none when the cell was off, consistent with the absence of accessible long-lived beta emitters in significant quantities. I asked whether they had attempted film exposure after their runs, and they had not done such a test. Apparently x-ray or gamma-ray measurements have been performed on the cells elsewhere, and a signal of some kind has been seen. One would expect a Bremsstrahlung signal in the presence of fast charged particles. It would be fun to see data of this kind.

In my view, this charge emission effect is probably real. I think that it is a cold fusion phenomenon that has been made to be dominant in this experiment. What is special about this device is that it has been pushed to maximize the charge emission effect so that it has become a primary reaction channel, such that it dominates the energy budget. This innovation allows for direct in-cell cold fusion to electrical energy conversion. This is really interesting, and probably makes obsolete other cold fusion electricity-generating technologies that require an external thermal to electrical energy conversion step.

Verification: Charge generation

The test that would have been nice to see would have been the application of the electrical output from the load to drive an electrical load. Such a demonstration is planned for the near future. Once again, the standard way that a confirmation is normally arranged for in scientific circles in such a situation is to arrange for an independent laboratory to run a test. There are a variety of tests that are possible that would help clarify the physical mechanisms involved, but these should more properly be part of a research effort devoted to understanding the device.

Summary

The primary functionality claimed for the new iESi technology that I reviewed in Edmonton is excess heat generation and electrical energy generation. The level of power generation in the demonstration was several kilowatts for about 15 minutes, and an energy gain in excess of 5. Higher power generation and energy gain was claimed in experiments carried out previously. The presence of high voltages was demonstrated, and the ability to drive electrical loads at high power levels (200 kW) with high energy gain was claimed in earlier experiments. The usual route to confirm such claimed results would be to send a unit to an independent lab for verification, in this case, of the excess energy generation and electrical output.

The goal of my review was primarily to try to understand what they had done. Thermal and electrical energy generation in this device is due to new physical processes not found in textbooks. In my view the iESi team has managed to get the technology to work in spite of a lack of understanding as to why it works. The thermal energy generation appears to be closely related to energy generation effects reported in smaller scale cold fusion experiments, with a comparable excess power density, but with a much larger operating volume than done previously due to an innovative design. The electrical energy generation also appears to be closely related to charge generation effects observed in a smaller scale in cold fusion experiments. In the development of the device, the iESi team has maximized the efficiency of the charge emission, resulting in the direct generation of electricity without a need for external thermal to electric conversion.

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