# Cold Fusion at NI Week 2013

**Dennis Cravens and Rod Gimpel**

National Instruments' annual NI Week hosts some of the most advanced electronic and instrumentation technologies on the planet. This year's event, held in Austin, Texas from August 5-8, was no exception. Electronically controlled robots roamed the aisles. Next year's auto electronics and advanced controls for cars, airplanes and missiles were displayed. There was even an 800 mph land speed car in the corner.

However, in our humble opinion, the most unique booth displayed two golden spheres resting in a bed of silver beads. But the left sphere is 4°C warmer than the right one and the bed it rests in. Why is it warmer? Cold fusion keeps it warm and it has been warm for 2½ months now. What's inside this warm sphere could change everything. The four-inch spheres don't look special except for the temperature sensor inserted to measure its core temperature. Calibration studies, using a similar sphere, show that the warm sphere is generating 1 watt heat at ΔT of 4°C

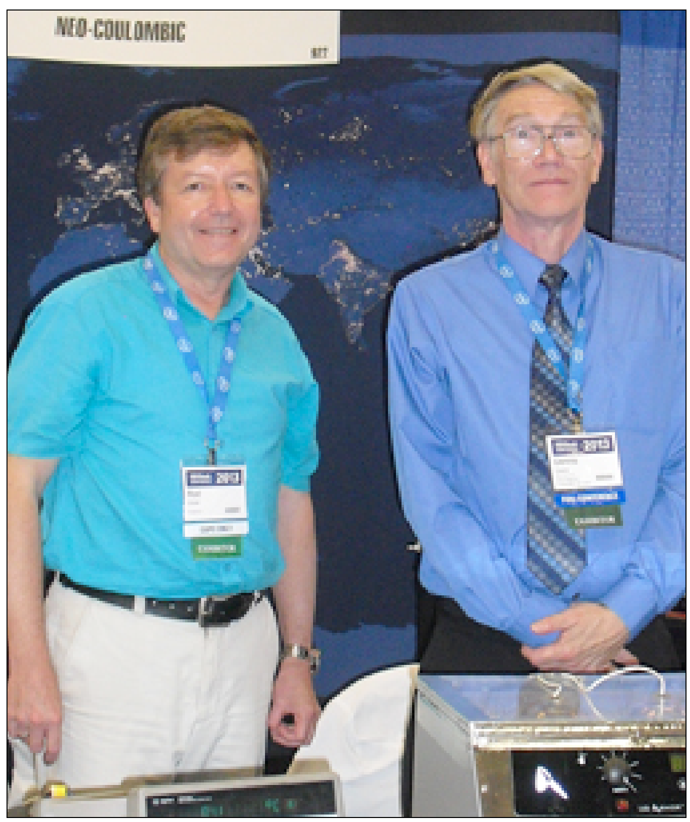
You might recall cold fusion as something that was announced, ridiculed and then forgotten by most. However, a small cadre of researchers around the world continues to explore cold fusion concepts amidst the scorn of most scientists.

Two weeks before NI Week, in conjunction with ICCF18, Defkalion did a live Internet demonstration where they claimed they produced 4 kW of heat out from 1 kW of electrical power. In other words, you get four times energy savings with their device, if true. However, there seems to be questions about some of their water flow and magnetic field measurements. The power levels we showed at NI Week were not nearly as high, but there are no water flow and input power uncertainties. There are no hidden calculations made inside a computer. Most importantly, there is no power connected to the sphere. It just sits and stays warm for days/months on end.


**Sample sphere at left (84.1°C), control sphere right (79.6°C), aluminum bed of beads (80.0°C).**

So what is in that warm golden ball? It contains an activated carbon that holds metal alloy within its pores, some magnetic powder, some hydrogen storage material and some deuterium gas. It is thought that the heat is coming from the fusion of deuterium nuclei to go to helium. However, there are as many ideas of the exact reaction as there are theorists. What is clear is the mixture produces heat because the sample sphere in it is warmer than the control sphere containing a little sand. The two spheres are in a highly conductive bath of aluminum beads in a constant temperature bath designed to be uniform and to hold the temperature constant.

The theory behind the cold fusion effect (also known as low energy nuclear reactions, LENR) is still being developed. So the physical understanding is lacking. To help guide the design of the demos in the NI Week booth, an empirical model by Dennis Letts was used. This paper, "A Method to Calculate Excess Power," will appear in *IE* #112. It predicts that the heat production is linearly proportional to the mass of the hydrogen-containing material and the magnetic field




**Dr. Dennis Cravens and Rod Gimpel at NI Week.**

surrounding the mass. It is exponentially proportional to the temperature and the energy of vacancy of formation. So a large sample and a magnetic field is good. To assure a strong magnetic field in the active material the spheres contain a ground samarium cobalt ($Sm_2Co_7$) magnet, which stays magnetized at higher temperatures. This was powdered and the powder is mostly random but it should provide a strong magnetic field within the sample.

High temperatures are beneficial but the demo needed to be operated at a moderate temperature due to safety concerns. Lower temps provided easier access, table top performance and did not require systems that would distract and be confusing for any zero input power claims. A Lab Armor® aluminum bead bath was used and set at 80°C. The aluminum beads are much more conductive than water so they assure a more uniform temperature. We wanted a stable and uniform bead bath.

The bulk of the material inside the active sphere is activated charcoal (carbon). The charcoal has a mesh of between 1350 and 2000 (micro mesh screening of 6 to 10 microns) with some larger pieces. That was selected to match the 8.2 micron peak wavelength of black body radiation at 80°C [*i.e.*, spectral radiance of about 0.02 $W/(cm^2 \cdot sr \cdot \mu m)$]. The charcoal's pores holding the metal alloy are nominally 9 nm. These were held to the inside wall of the sphere by first applying a black vinyl solution while rotating the balls. In previous lab experiments a ceramic material was used. The vinyl was quick and easy and appears to work at 80°C. The metal alloy is palladium and gold. Palladium is good at holding a lot of deuterium and the gold lowers the energy of vacancy of formation. It is those vacancies where much of the action occurs. The general rule of thumb is that if you alloy with something softer and with a lower melting point you lower the energy of vacancy of formation, its Debye temperature and its Curie points. It also interferes with the crystal structure of the major metal in the alloy and produces voids where atoms should be. These are the important vacancies mentioned. These voids provide places for hydrogen or deuterium to accumulate, but you want to form tight quarters for them.

Rod Gimpel developed a similar reactor to Dennis Cravens' spheres (see photo of horizontal and double Dewar reactors). Dennis lives in New Mexico and drove his apparatus to the exhibit. But, Rod had to fly from Washington state and his system had to be disassembled to pass airport security. Even so, air security took over half an hour inspecting every piece. Every piece was swabbed for explosives. Hydrazine and other chemicals were used in making the alloys in a similar fashion as Dennis did.

The double Dewar reactor is similar to the brass sphere concept except stainless steel cylinders replace the spheres. The glass tubes are actually Dewar bottles similar to a Thermos® bottle. These Dewars are submerged in a heated bath like the aluminum beads (not shown). The system can be run up to 200°C. The Dewars provide higher temperature readings with less sample material. The cylinder, containing the sample or active material, is inside the Dewar on the left. The control cylinder is in the Dewar on the right. This arrangement shows greater temperature difference with less material. Nine degrees excess heat was seen. The sample contains both Ni and Pd. Design of this reactor is also based on Dennis Letts' empirical theory. For example, there are four large samarium cobalt magnets between the sample and control cylinders. Connections are on the top to introduce pressurized hydrogen or deuterium. An electrical spark can also be introduced if desired. Also displayed was a reactor similar to Defkalion's latest—high temperature gas loaded nickel with spark plug "igniters." Rod has yet to get verifiable excess out of that one. After months of trying the calibration is still tricky and more complex than you might imagine.

## Theory

If you ask a "traditional physicist" about the possibility of deuterium fusing at such low temperatures, they will likely tell you it is impossible. There just isn't enough energy to overcome the Coulomb barrier around the atom's nucleus. They will calculate the rates based on static and average equilibrium values. But that is not what is going on here. Here is an analogy that we used when we tried to explain the operation of the material. In a convention center (*i.e.*, where NI Week was held) you can look around and see hundreds of people going from here to there. None of them touch each other. However, if someone yells "fire" everyone will run to the exit doors. Some will probably get their toes stepped on, pushing into the doorway, or worse into each other. These interactions at the doorway would never happen in a nice

**Dr. Dennis Cravens describing brass spheres.**

**Horizontal reactor (left) and double Dewar reactor (right).**

equilibrium environment. In this material, the deuterium is confined to move through vacancies on the order of Angstroms. If there is something that causes a flux or movement of deuterium within the vacancies then there will be interactions and reactions that would never be calculated in the bulk. Also when charged particles are within metal lattices, their wave functions and charges are spread over a wider volume than free particles. We often speak of the conjugate pair momentum and position. When position is known well then the momentum is not known well (Heisenberg). But there are other similar pairs energy/time, and for consideration here: charge/electric potential, and electric current and magnetic potential. The point being that within a metal lattice array the wavelike nature can come into play.

Notice the metal nano particles are held within 9 nm pores within carbon particles matched to the expected blackbody radiation. Nano particles alone have lower energy of vacancy of formation than large bulk material because they are more surface-like than bulk-like. However, they are only a few hundred atoms. If the reaction here is deuterium going to helium, we expect 24 MeV of energy to be released. The energy holding most chemical bonds is only on the order of a few eV. That means the reaction must "dump" energy to more than tens of millions of bonds or the reaction site would be destroyed. This is where the carbon framework comes in. It provides a path for the energy out of the reaction that does not destroy the reaction site which would have limited the useful lifetime of the material.

Also inside the sphere is powdered samarium cobalt. This is to help align (actually anti-align) the spins of the deuterium. A reaction pathway to helium-4 requires a net spin of zero to retain conservation of spin. It would end up with things other than helium-4—*i.e.*, tritium, neutrons, etc.—without the anti-alignment pathway. Also inside the sphere is a hydrogen storage material. We used material taken from a commercial fuel cell storage metal (Hydrofil) that was loaded with deuterium. This was added last at dry ice temperatures. The sphere was sealed and then brought to temperature. This avoided all the complications of having a gas system and explosive bottles of gas on the convention floor. At least one person thought they could hear the gas escaping when the sensor was removed prior to its being cut open.

One concern expressed about the demo was the role of self-heating of the thermistors. The internal temperature of the spheres was measured by Omega 44004 2252K interchangeable thermistors. These change (lower) their resistance as they are heated. They were measured by an Agilent data system. This is done by sending a small voltage (measured at around 250 mV at 80°C) to the thermistors. This could of course place a small amount of heat into the spheres when the resistance is read. The concern was that the sample might allow for more heating of its thermistor than the one in the control. It should be noticed that in both spheres the sensor was near the center and in contact with the gas instead of the powder or sand. Actually the Omega sensor was 4.5 inches long and the sphere was 4 inches in diameter. The probes were bent to fit and for the probe end (where the thermistor resides) to be near the center of the spheres. What should be recognized is that the control had air inside and the sample deuterium inside. The deuterium is about eight times as thermally conductive as the air so it actually would have allowed for less self-heating than the control in the air. That is to say this effect is conservative for our observed output. The Agilent used to monitor the thermistor resistance was turned to a single channel at a time. This allowed for a direct reading of the self-heating effect. First the data system was turned overnight to an empty channel (no current going in) and then in the morning the data system was turned to the sample for 30 minutes and the temperature rose by 0.1 degree. The effect was a 0.2 raise in control. This means that self-heating for the sample was less than the control even if the thermistor was polled for 30 minutes. This again is a conservative value since most of the time the data system was set to monitor the bead bath temperature. Also notice the self-heating in both demonstrations was much less than the observed 4 degrees differential between the sample and the bath.

## Reactions to the Demonstration

On the first day open to the public at large, we had the demo connected to an NI LabView software data system. It displayed a graph of the day's data and kept detailed records of the data. However, due to both the massive amount of data stored and electrical problems (elsewhere in the convention center) the computer failed during Monday night/Tuesday morning. We decided to just use the direct reading of the Agilent instead for the remaining part of the exhibit. This was largely because the expo was attended by software and LabView users. Some had voiced the concern that it would be easy for us to have hidden a single line of code to alter the data reading to our favor. We wanted to rule out the possibility and concern. The Agilent provided a direct reading of the temperatures with no software modifications (that is, no one could have just added degrees to the sample display). We also furnished direct test points between the thermistors and the Agilent so that their resistance could be measured directly and temperatures found directly from first principles. Only one person wanted to do that, and we obliged (246 ohms sample, 297 ohms control at the time).

Another concern expressed was the uniformity of the aluminum beads and their temperature. The Lab Armor aluminum bead bath has manufacturing "uniformity" specs of 1°C. Before the expo, Dennis measured the temperature of the bead bath at 80°C on a 1 inch grid 2 inches from the bottom. The standard deviation was 0.4°C. During the expo the built-in RTD controlling the bath temperature (near the bottom) was typically 80.0 while the thermistor in the bath 1 inch from the top typically read 79.7 which indicates the vertical uniformity was also about 0.3°C. Some will not like the term "about" for this, but realize that from time to time during the expo the convention center's temperature would change. Also two times someone wanted to "stir" the bead bath to verify that there wasn't anything in the bath or that beads at one end were different from the others. We tried to oblige such visitors and give access to such items when it was convenient between groups of people.

The spheres are 4 inch 1/8 thick brass (Wagner). They were smoothed and polished then lightly gold plated so they have a known and uniform emissivity (0.03) and a uniform surface smoothness for similar thermal contact.

The demo was only set up between Sunday, August 4 and Thursday afternoon, August 8. The short duration of the show did not allow running the demo long enough in public to rule out some conventional concealed power source. A non-rechargeable lithium battery the size of the sphere (one of the highest energy densities available for a sealed system) could, in theory, have yielded 1 watt of power for up to 20 days. So on the last day of NI Week the sphere was cut in half to show that the heat source was not anything conventional, *i.e.* lithium battery, a burning hydrocarbon. This was the hour before the expo was over so not a lot of people remained; however, a fair crowd gathered when the cutting started.

The demo was about as simple a demo as you can imagine. It wasn't designed to be a science experiment. It wasn't designed for exacting measurements. It was designed just to make people realize there must be some effect we don't understand going on inside the simple brass balls. Many will say you it needs more wires and exotic sensors, but a 4 degree signal above the bed the ball sits in and well above the room temperature means by simple thermodynamics that there must be some energy source inside. People can argue about what it is, but the bottom line is something strange is going on—something that cannot be easily explained but just might change the world.

It was interesting that only two people had serious doubts about the heat. It is just hard to argue with a 4 degree signal that is hotter than its surroundings. Most of the questions were targeted at: What can we do with it? When will it be commercialized? What are you selling? Can you scale it up? What would it cost? And my favorite: Can you make me a charger for my Tesla car? The questions were refreshing since we feared most people would doubt us or attack us. Perhaps they were just being nice, but we think that the tide on public acceptance of cold fusion is slowly changing. We came away feeling that we had accomplished our real goal: To make people think just perhaps cold fusion might be possible and real. That alone was worth the expense and effort to attend NI Week.

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