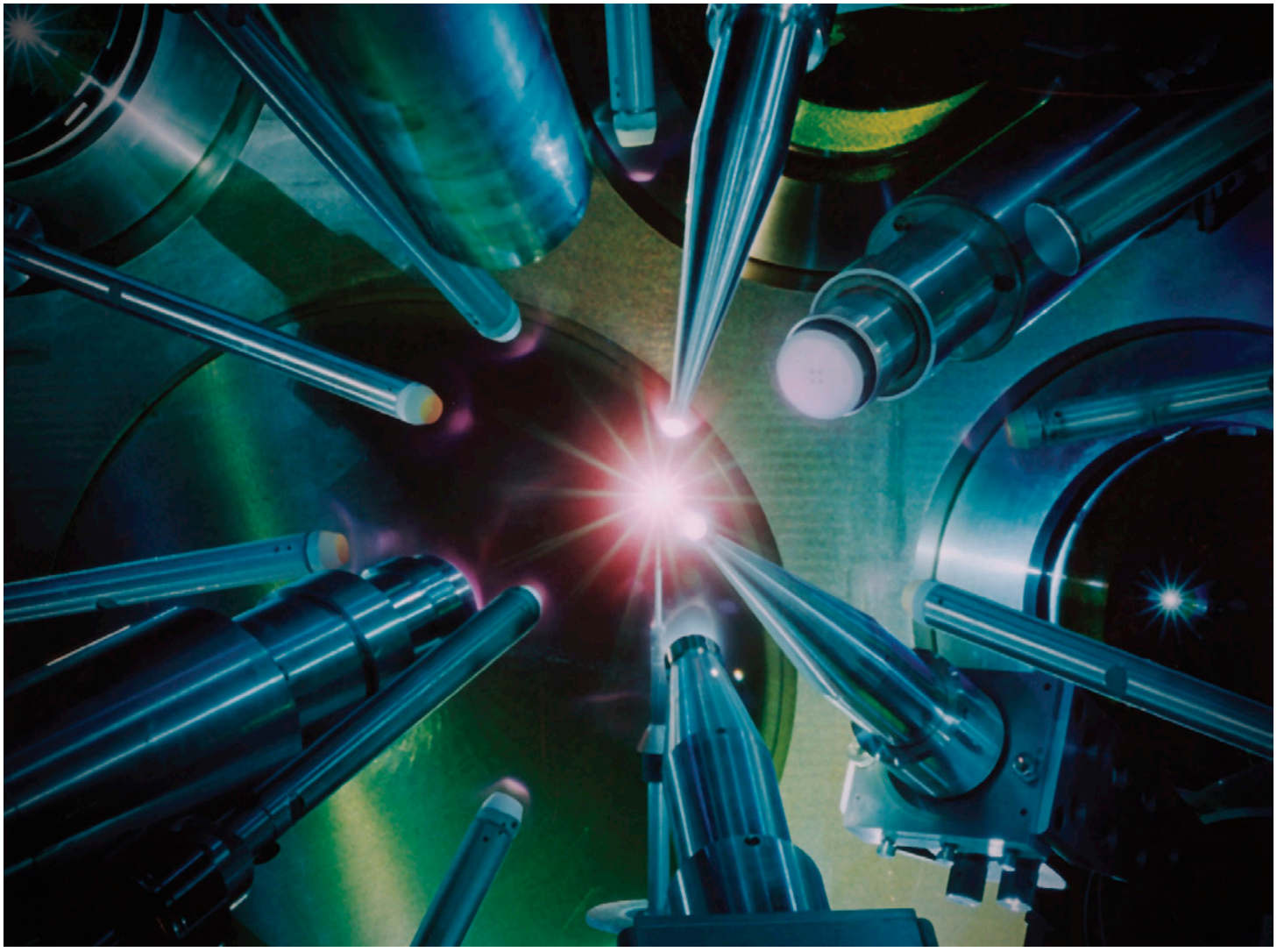
Accuracy for the World's Mightiest Laser

Overview

Lawrence Livermore National Laboratory (LLNL) is one of the Energy Department's 17 national laboratories. The National Ignition Facility (NIF) is a key LLNL facility containing the world's largest and highest energy laser system. Corrie Karlsen, a long-time LLNL engineer, had to find reliable flow instrumentation for the NIF laser amplifier cooling system air ducts. What he discovered is that some companies will say anything to get in the front door, and that these claims typically result in subpar instrumentation that ends up costing more through replacements, ineffectiveness, and inaccuracies.



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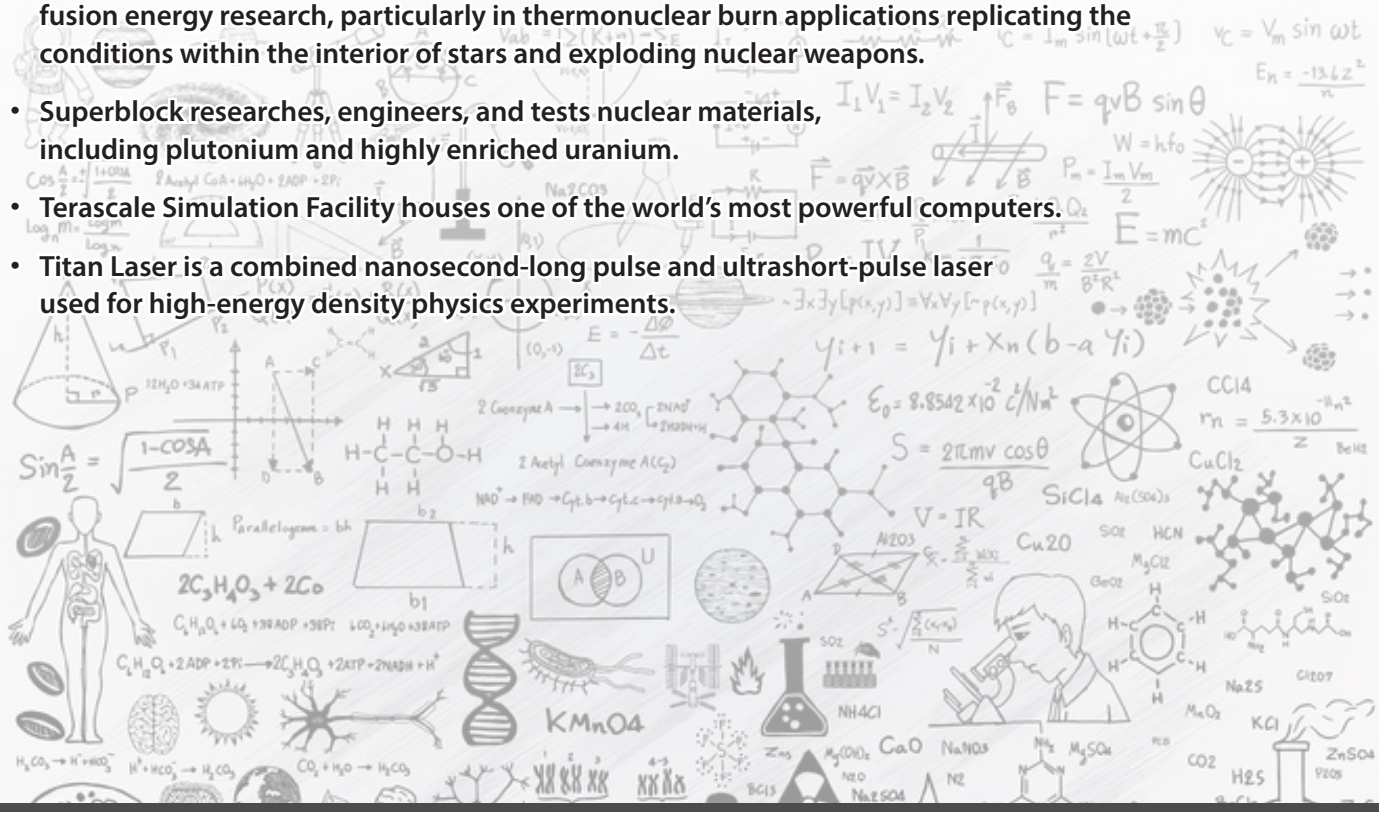
Lawrence Livermore National Laboratory

Lawrence Livermore National Laboratory (LLNL) in Livermore, California, is a federal research facility founded in 1952. LLNL is primarily funded by the U.S. Department of Energy (DOE) as a research and development institution for science and energy related to national security, principally ensuring the safety, security, and reliability of the country's nuclear weapons. It also uses its special expertise and multidisciplinary capabilities solving energy, basic science and economic competitiveness, and environmental concerns.

LLNL has several key facilities:

- Biosecurity and Nanoscience Laboratory develops technologies for detecting, identifying, and characterizing harmful biological pathogens and chemical toxins.
- Center for Accelerator Mass Spectrometry develops and applies tools related to isotopic and ion beam analysis.
- High Explosives Application Facility and Energetic Materials Centers research, develop, and test high explosives, pyrotechnics, and propellants.
- National Atmospheric Release Advisory Center provides national support, resources, and responses for emergencies, incidences, and hazards including nuclear, radiological, chemical, biological, and natural atmospheric emissions.
- **National Ignition Facility is the world's preeminent facility for studying matter at extreme densities, pressures, and temperatures. NIF conducts inertial confinement fusion and laser fusion energy research, particularly in thermonuclear burn applications replicating the conditions within the interior of stars and exploding nuclear weapons.**
- **Superblock researches, engineers, and tests nuclear materials, including plutonium and highly enriched uranium.**
- **Terascale Simulation Facility houses one of the world's most powerful computers.**
- **Titan Laser is a combined nanosecond-long pulse and ultrashort-pulse laser used for high-energy density physics experiments.**



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National Ignition Facility

The National Ignition Facility (NIF) provides support for national security by developing a better understanding of the complex physics of nuclear weapons without underground testing, and strives to develop fusion ignition as a clean energy source for future energy production.

The National Ignition Facility

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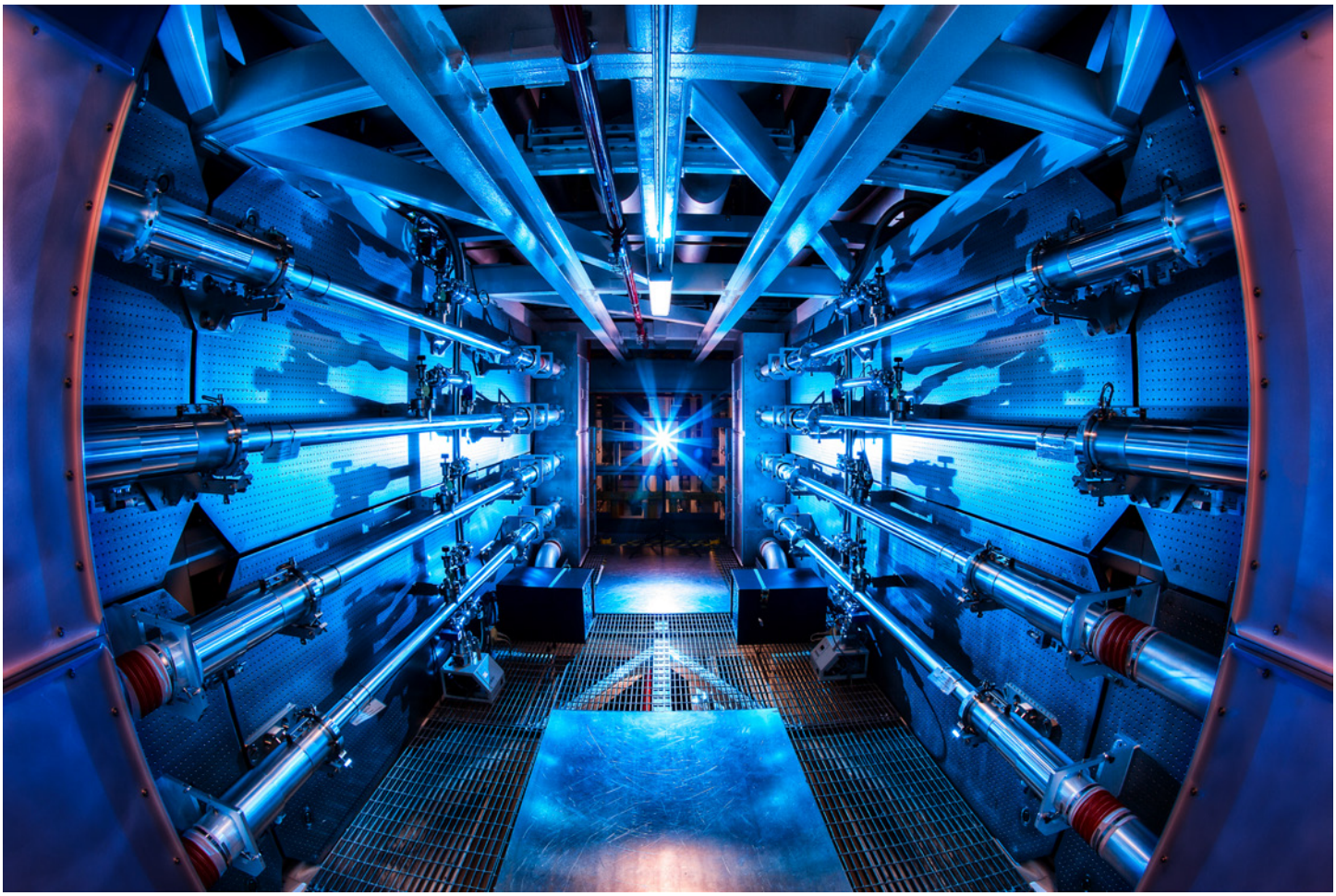
NIF is larger than three football fields, and it contains the largest and most precise laser system ever built. The 192 laser beams focus 1.8 million joules of ultraviolet laser energy and 500 trillion watts of power in billionth-of-a-second pulses into an area the size of a pencil eraser. When the NIF laser energy hits the target:

- Temperatures of more than 100 million degrees.
- Densities up to 100 times the density of lead.
- Pressures more than 100 billion times Earth's atmospheric pressure.



The three interconnected divisions of the NIF are the:

- Optics Assembly Building provides a cleanroom environment for assembling laser components.
- Laser and Target Area Building houses the laser beams aimed at a 10-meter-diameter, concrete-shielded, 130-ton target chamber.
- Operations Support Building (OSB) provides optics and materials handling labs and offices.

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Leadership in Energy and Environmental Design

The Leadership in Energy and Environmental Design (LEED) is an internationally recognized green building certification system developed by the U.S. Green Building Council (USGBC). The USGBC's mission is to enable environmental and social responsibility in the design, construction, and operation of buildings and communities. LEED certification represents resource efficiency, high performance, and cost-effectiveness in the design, construction, operation, and maintenance of a building.

NIF was already investing in improving efficiency. The OSB division was awarded LEED certification by diverting 90% of construction waste away from landfills, using regionally constructed materials, sourcing wood from renewable forestry programs, controlling air quality management during construction, and several other beneficial implementations.

The quest for improving efficiency isn't limited to just building design. Corrie Karlsen is an Engineer who has been with LLNL for more than 30 years. During the design, construction, and operation of NIF, Mr. Karlsen was the lead for instrumentation and industrial automation. The laser ducts for the facility require 68ºF air flow, and 100 flow meters were deemed necessary to ensure that the air flow remained uniform for the laser amplifier cooling.

LLNL has been using flow instrumentation developed by Kurz Instruments in the 1980s. The reliability of the Kurz meters made their devices the logical choice for ensuring accurate air flow through the laser ducts. Because of the large quantity of required devices, a competitive bid was required and it went out to manufacturers who could claim "equal functionality" to Kurz flow meters. However, not all thermal flow meters are the same.

- Constant temperature thermal devices heat the velocity sensor to a fixed temperature and use the process sensor to monitor the flow temperature. Mass flow is determined based on the amount of electrical current used to maintain a constant temperature difference between the two sensors.
- Constant power thermal devices heat the velocity sensor with constant fixed current and use the process sensor to monitor the flow temperature. Mass flow is determined based on the temperature difference between the velocity sensor and the process sensor.
  - The fixed current can cause the heated sensor to overheat when a lower flow does not draw off enough heat.
  - The closeness of the two sensors can cause the heated velocity sensor to transfer heat to the process temperature sensor and create erroneous readings.
  - If the sensors are not aligned correctly with the flow, heat from the heated sensor enters the flow stream without interacting with the gas velocity sensor.

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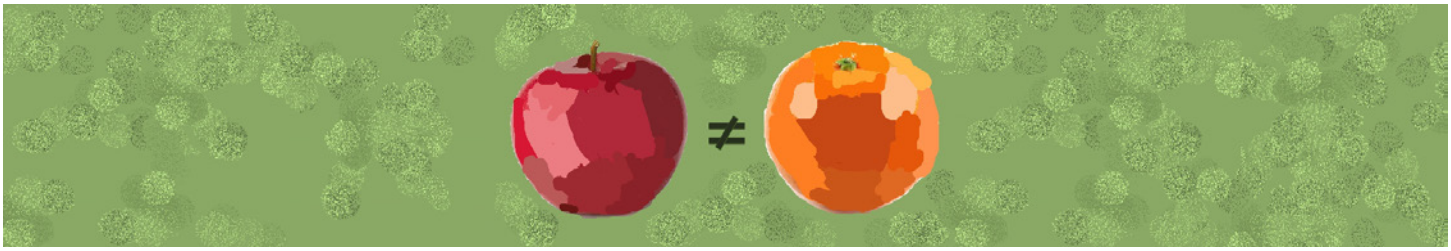
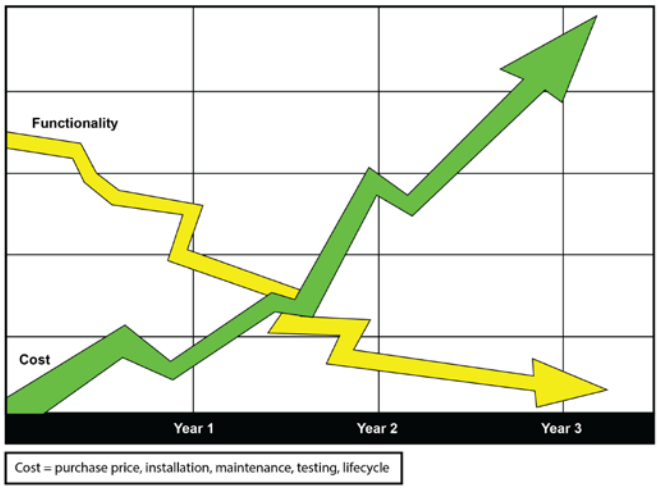
Unfortunately, Mr. Karlsen found that manufacturers will fictionalize device specifications in order to win a job. The bidding process required that all "equal functionality" devices with a less-than-or-equal-to bid had to be considered to the Kurz bid had to be considered. This results in manufacturers low-balling bids to initially get the job. The bidding process also required that any exceptions had to be shown critical to the operation; if not proven, then the bid had to be accepted. For example, there was a requirement for the meters to be explosion-proof to increase ruggedness. However, this feature wasn't critical for the flow conditions so this became an acceptable exception and lesser quality enclosures were permitted.



As a result, the bid went to a manufacturer that produces low-quality, low-reliability constant-power thermal flow meters. Problems started right out of the box with bent meter probes, and then proceeded over the next few weeks with over 15% of the new meters failing and requiring replacement.

The next 3 years experienced replacing more than 50% of the meters for a multitude of failures that caused the meters to just stop working, with the replacement costs more than doubling the initial purchase price. In addition, the flow meters were completely incapable of reading below 10% of the flow range. With all the issues surrounding the new flow meters including wasted time and money, Mr. Karlsen was able to specify Kurz as the formal replacement flow meter.



A low-cost thermal flow meter can end up costing more because of low-quality components and construction.

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Another NIF application involves the critical measurement of Argon and Air with the Argon System. The gas flow switches between the two gases.

The original low-quality flow meters never worked correctly and were swapped out for a different constant-power thermal flow meter. These meters measured the flow but were incapable of maintaining accuracy, and were eventually replaced with Kurz flow meters.

Kurz meters offer a feature for multiple gas calibrations so that customers can predefine up to 5 different gases or mixed gas compositions via manual or automatic adjustment. NIF is now obtaining accurate measurements under all conditions.

Conclusion

It would be nice to believe that all flow manufacturers have your company's best interest in mind. Unfortunately, many sellers of instrumentation simply watch their bottom line. This is not a condemnation of all instrumentation manufacturers, but it is important to recognize that there may be reasons a manufacturer is willing to heavily discount its product:

- Lower quality materials
- Reduced or eliminated support
- Minimal turndown (small flow range)
- Low repeatability or accuracy

Instrumentation should be built to last. For example, there are Kurz flow meters that have been working accurately for the last 40 years. And just as Mr. Karlsen experienced, when you find a reliable flow meter from a reputable manufacturer, sometimes it's better to stay with "tried and true" rather than trying to save money upfront.

He also learned the hard way that instrumentation engineers need to understand the different technologies well in advance of ordering and also include more detail in requirement specifications; such as, insist on a quick response time and a reading that starts at zero flow.

KURZ INSTRUMENTS INC.™

Tel: 800.424.7356
www.KurzInstruments.com

Article by Robert Morpeth

KURZ INSTRUMENTS INC.™

Tel: 800.424.7356
www.KurzInstruments.com

CLIPPER® CONTROLS
(844) 880-AHOY
ClipperControls.com