Tiny Targets, Massive Results

Ultra-precise HEIDENHAIN linear scales aid in manufacture of hydrogen targets for thermonuclear testing

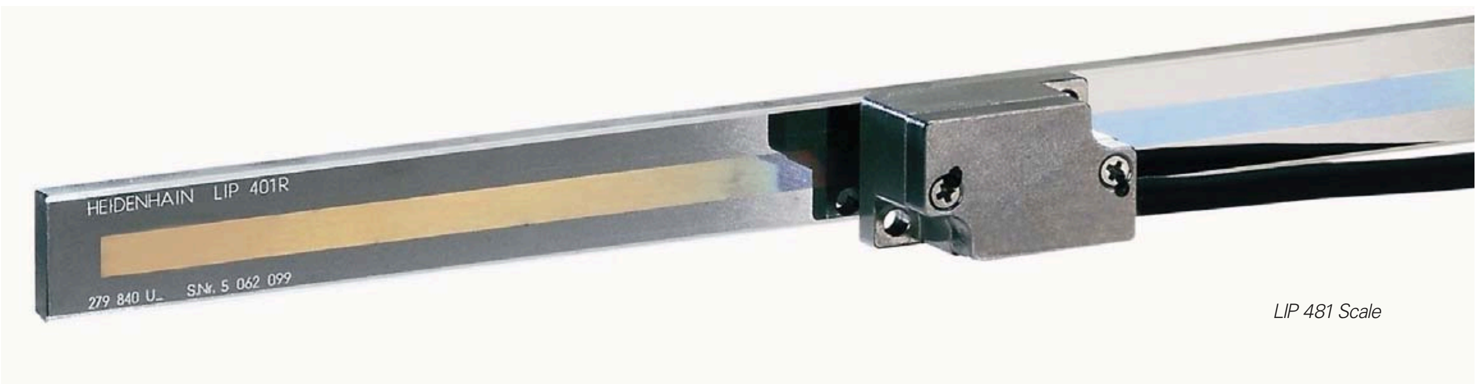
The development of small hydrogen targets to test thermonuclear ignition is like a science in itself. Or so says Ken Abbott, the owner of the company that manufactured the custom air-bearing motion system that builds those targets. This new custom machine from his company, ABTech (www.abtechmfg.com) in New Hampshire, is now in place at the National Ignition Facility (NIF) at Lawrence Livermore National Laboratory (LLNL), and has recently passed inspection to begin its work.

LLNL is at the University of California (employing 8,000 people) and is federally funded to do research in a variety of areas, including nuclear power, national defense and the environment. The NIF lab is currently on track to house the world's largest laser, which will involve 192 individual laser beams that will be repeatedly trained onto high precision tiny hydrogen targets. With each test, a double shell implosion target will be placed in a 30-foot diameter chamber with the laser beams fired simultaneously to explode it, demonstrating thermonuclear ignition. Its output will be measured for use in a variety of ways.

The manufactured hydrogen targets themselves each use capsules of fusion fuel, and are heated to thermonuclear ignition. The targets are made of a silica-based inner sphere, and the manufacturing requirements for surface finish and shell concentricity of the targets are essential to successful explosion. The shell halves are assembled on ABTech's custom 5-axis air bearing assembly station in order to achieve acceptable concentricity.

Weighing about 150 pounds, this air-bearing machine system includes mechanical arms that can slide, without friction, into position, with accuracy as little as 4 millionths of an inch. "Each target is 28 thousandths of an inch in size, smaller than the top of a ballpoint pen," said Abbott.

Custom 5-Axis Air Bearing Assembly Station



LIP 481 Scale

The overall components of this unique machine include three linear air bearings and two rotary air bearings, a motion controller, a host PC and application software. The system is capable of positioning the target shell halves to locations within 0.1 µm. "The only way this is now possible is with the use of today's ultra-precise linear scales for use on the linear slides," explained Abbott, "and because of the strict accuracies required in NIF's specifications, our only choice was the extremely high accuracy LIP 481 scales from HEIDENHAIN Corporation. It's really amazing what they can accomplish today."

The HEIDENHAIN LIP scales are exposed linear encoders characterized by high accuracy together with measuring steps as small as 0.005 µm, depending on the model. Their measuring standard is a phase grating applied to a substrate of glass, and they are typically used in the highest precision machines,, such as diamond lathes for optical components, facing lathes for magnetic storage disks and measuring microscopes and semiconductor equipment machines.

The ABTech air-bearing system at NIF includes three of these ultra-precise HEIDENHAIN scales, one on each of the X, Y and Z linear axes. The entire system is completed with a high resolution camera and surgical microscope that provide views of the mating components.

The new system's bearings produce a thin film of air similar to the layer of air that allows a puck to move smoothly across an air hockey table. Precision manufacturing takes place from there.

"This ABTech machine is a significant improvement from what NIF was using to develop early stage targets," continued Abbott. "Our project is a complicated device, having taken about eight months to develop. Because of the high accuracies, it was crucial that we received assistance from the HEIDENHAIN representative. His highly technical expertise was instrumental in helping with the installation alignments. This machine is now truly like no other."

With the new hydrogen targets, NIF's experiments promise to produce temperatures and densities like those present on the sun or in an exploding nuclear weapon. These experiments will help scientists sustain confidence in nuclear energy without doing actual nuclear weapons testing (stopped in the United States during the 1970s), as well as produce additional benefits in basic science and fusion energy research. ■

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