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BUCKLEY SYSTEMS
Ingenious at work

Buckley Systems Technical Bulletin

New Hall probe test bench

In the pursuit of ever greater accuracy, Buckley Systems has recently unveiled a new, high-precision test bench. Designed and constructed in-house by senior test engineer Steve Brown, the bench is designed to precisely map magnetic fields. The Hall probe is positioned using precision linear guides and stepper motors, mounted on a stable, precision machined, 1.5-ton block of solid granite.

Mapping a field containing thousands of coordinates can take several hours to complete. Once set up, the entire process, including water flow, temperature and current can be monitored remotely without direct operator intervention.

The test bench has recently been deployed to provide a detailed, 3D field map of a 15 ton, ultra-high precision dipole analyzer magnet.

Specifications:

Envelope: 1850 (x) x 1100 (y) x 500 (z) mm.

Resolution: 0.002 mm

Positional accuracy < 0.1 mm with a 1.4 m arm.

Upcoming Conferences and Events

Buckley Systems and/or D-Pace will have a presence at all these events. Please contact us if you would like to arrange a specific meeting with us while we are there.

- **October 15-20 ICIS 2017: Geneva, Switzerland**

  International Conference on Ion Sources

- **April 29-May 4 IPAC 2018: Vancouver, Canada**

  International Particle Accelerator conference

- **June 23-27 SNMMI 2018: Philadelphia, USA**

  Society of Nuclear Medicine and Molecular Imaging

- **July 10-12 Semicon West 2018**

- **August 12-17 CAARI 2018: Gaylord, Texas**

  Conference on Applications of Accelerators in Research and Industry

- **August 27-31 WTTC 2018 Coimbra, Portugal**

  Workshops on Targets and Target Chemistry

- **September 3-7 NIBS 2018: Novosibirsk, Russia**

  Negative Ion Beams and Sources

New resin infusion suite at Buckley Systems

To cope with increased volumes and demand for larger and larger coils, Buckley Systems has built a new resin infusion suite at their #6 Bowden Road premises. Comprised of a PLC controlled resin batching plant, three large-volume vacuum tanks and a PLC controlled oven, the new plant will focus on producing hollow-core conductor coils and fully-cast AC magnets.

Resin is kept at the correct temperature and degassed before being mixed and dispensed. CCTV cameras have been installed in the vacuum chambers to monitor the pour. Sensors will monitor and send data and/or alarms to a technician's mobile phone to enable remote monitoring of the process.

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Big magnets small magnets

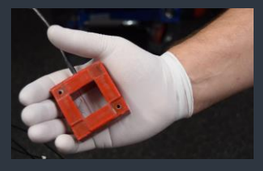
We love to promote our capability to produce large magnets but much of our work revolves around making small ones.

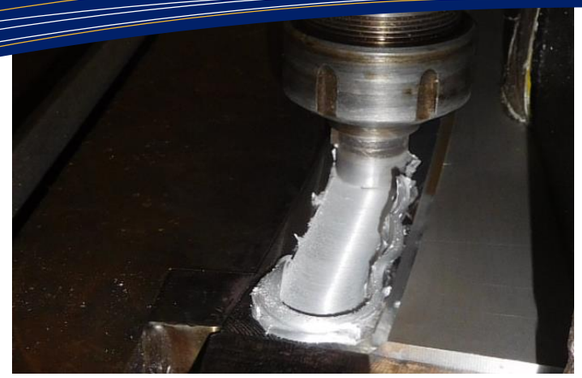
While it is great to show off big 15 ton dipole or 27 ton analyzer magnets, smaller magnets make up a considerable part of our production.

Manufacturing high-precision, compact coils involves careful design and intricate assembly techniques.

Efficient cooling is the biggest challenge in producing high - power, small magnets. With over 30 years' experience in design and using the latest materials we can provide excellent electrical insulation while keeping the coil temperature within the required temperature parameters.

Close collaboration between our clients, physicists, design and manufacturing teams ensure that the optimum result is achieved.





This issue

Friction stir welding for vacuum chambers

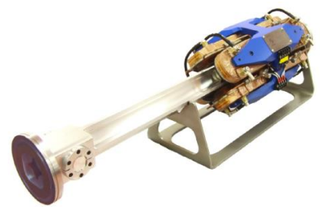
Traditionally, aluminum vacuum chambers were either machined out of solid or welded together using MIG or TIG welding. With traditional welded joints, great care in preparation and skilled welding techniques are required to create a leak proof, crack free join. Even using robotic welding or employing highly experienced tradesmen, perfect welds can be hard to achieve. With a chamber unable to be properly vacuum tested until finished, a lot of work is involved before the join can be leak checked. If a leak is subsequently discovered in a finished product, extensive re-work is often required.

Friction stir welding is the ideal solution to many of the problems associated with arc welding. Using a blunt, rotating tool forced along the join line, the materials either side of the seam are plastically deformed together before they solidify behind the tool. Advantages over conventional welding include, guaranteed full weld penetration, no shielding gas requirement and low distortion due to the solid-state nature of the process. However, the greatest advantage of friction stir welding is that the weld has very low porosity and can be machined afterwards without the risk of incurring a vacuum leak. When machined and polished, the weld zone is almost indistinguishable from the material on either side. Buckley Systems has been a pioneer in friction stir welding and we have developed tooling, fixtures and techniques to optimize the process. Our engineering team are experienced in designing seams that self-locate, offer maximum stability and provide zones for tool insertion and extraction.

Friction stir welds are so homogenous with the parent material that they can be machined without the danger of causing leaks and can even cross O-ring surfaces without affecting the seal. The technique has opened up new ways of fabricating chambers that would be impossible to create any other way.

The D-Pace Mini-PET beam tube is fabricated from two machined halves that are friction stir welded together before the end flanges are friction stir welded on to each end. The result is an extremely accurate tube with no visible welding.

Another example is large, 2000 mm x 815 mm x 800 mm analyzer beam manifolds that are fabricated from 60 mm thick 6061-T6 aluminum plate. Fabricating each box takes over 3.2 meters of welding and the welds cross over O-ring grooves 8 times. Over 220 of these boxes have been produced so far with zero in-service failures reported.



Mini-PET beamline integrated with IBA Cyclone® KIUBE radioisotope cyclotron

The D-Pace Mini-PET beamline is now offered as a fully-integrated accessory on IBA's latest PET cyclotron, the Cyclone® KIUBE.

Based in Belgium, IBA is a world leader in radio-pharmaceutical technology and its new Cyclone® KIUBE, released in mid-2016, is a result of 30 years of expertise in the field.

The Mini-PET beamline is perfectly suited to this brand new, compact, cyclotron with its lightweight (54 kilogram) construction requiring no additional support between the source and target. The compact quadrupole doublet with integrated steering coils also guarantees optimal control of the beam.

Bill Dodge

Buckley Systems CEO &President of Global Sales

Industry knowledge is paramount in this key role

Buckley Systems' newly appointed CEO, Bill Dodge splits his time between the head office in Auckland, New Zealand and the North American office in Rowley, Massachusetts.

Born in the Boston area, he attended Northeastern University where he studied both electrical engineering and mechanical engineering before getting interested in business management. He graduated with a degree in business management with a minor in engineering.

In 1974, Bill was offered a role managing Boston Transformer. It was an ideal position, allowing Bill to hone his business, and engineering skills while building up the business. When the opportunity to purchase the company came up in 1987, Bill jumped at the chance. Now fully in charge, Bill looked at diversifying and expanding the company. With many similarities between transformers and electromagnets, Bill found opportunities in the semiconductor industry and started making magnets for several companies including building long-term relationships with Varian Semiconductor (Applied Materials) and Axcelis Technologies.

After almost thirty years in charge of Boston Transformer, Bill was approached by Bill Buckley of Buckley Systems with an offer to buy the assets of BT and employ him as General Manager of a newly formed group named Buckley Systems International Ltd.

With Buckley Systems already a dominant player in the semiconductor market, it was a great opportunity to join a team backed by a state of the art manufacturing facility. Boston Transformer was purchased in 2001 with the premises and many of the staff retained to provide some manufacturing, warehousing and service facilities for North American customers. In 2007 Bill took on the position of President of Global Sales, focusing on servicing existing clients while developing new business, attending conferences around the world to showcase Buckley Systems' manufacturing prowess and keeping up to date with market trends. Bill's deep understanding of mechanical and electrical design and the manufacturing process makes sure customers got exactly what they want with no compromise.

Since the purchase of Boston Transformer and with Bill developing relationships within the high-performance electromagnet market, Buckley Systems has now grown to a $NZ 80+ million company and manufactures electromagnets, vacuum chambers, ion sources and analytical devices for scientific, medical and semiconductor use. Key projects Bill has been involved in includes magnets for light sources at Brookhaven NY, Victoria Australia and NSRRC, Taiwan. Given his experience in the field coupled with his leadership and interpersonal skills, Bill was asked to take on the role of CEO early in 2017. He now commutes between Auckland and Boston on a regular basis. He is also still involved in sales although to a lesser extent. Married with two grown children, Bill enjoys tennis, home projects and spending time with his friends and family. While in New Zealand on his regular visits to Buckley Systems, he uses his spare time to work on his golf swing.

NuBeam accelerator nears completion

Buckley Systems has recently completed manufacturing all the major components of the first nuBeam proton accelerator for Danvers, MA, USA based Neutron Therapeutics (NT). Final assembly & function testing is being conducted at NT before being shipped to Helsinki University Hospital in Finland. Once installed and tested, it will be utilized to replace a recently closed reactor facility for the purpose of continuing the Boron Neutron Capture Therapy cancer treatment program at the hospital. The system shall be commissioned in 2018.

The core of the nuBeam machine is a powerful yet compact 30 mA at 2.6 MeV DC proton accelerator. Designed from the beginning as a stand-alone accelerator system, D-Pace Founder and CSIO, Morgan Dehnel, sees additional opportunities for this accelerator system for R&D and Industrial purposes:

(i) the accelerator can be utilized as a high current DC proton machine, (ii) it can be configured as a high-flux DC neutron source, and (iii) it can be set-up as a multi-ion DC accelerator. For more information, please contact morgan@d-pace.com

Technology topic – Hollow core vs strip wound

Hollow core conductor has been a traditional choice of construction for high-power electromagnets of all types. However, for many magnets, strip wound coils can offer significant advantages including cost savings.

It's not all about power density

Historically, hollow core conductor was considered to be a better material for coil construction because of its ability to transmit more power through its cross-sectional area (power density). By internally cooling the copper, power density of around 6-8 A/mm^2 can be achieved in hollow core while strip wound coils are usually rated around 3-4 A/mm^2 (although in some special cases, current densities of up to 10 A/mm^2 can be achieved). However, hollow core conductor winding is difficult with complicated and expensive manifolds and water-tubing circuits required to minimize pressure drop in each pancake, and to achieve electrical isolation between the water-supply and electric power supply circuits. Strip coils on the other hand, can have a very simple water circuit and very simple electrical connections that are inexpensive and inherently isolated from each other.

Another assumption is that because of the difference in power density, a much larger strip coil is needed to produce the same field as a hollow core. However, hollow core conductor is less dimensionally accurate, more difficult to wind precisely to shape and requires thick (around 0.50 mm or .020") fiberglass insulation. Strip coil can be very accurately wound and is normally insulated with thin, 0.075 mm (0.003") Mylar.

For many applications, a strip coil can replace a hollow core coil within the same dimensional envelope.

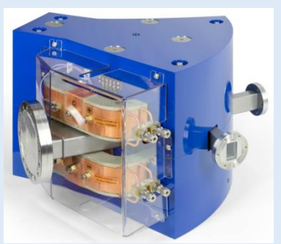
Strip coils aren't just round

Thin strip can be wound to a tighter radius than hollow core, and complex 2D shapes including convex curves can be achieved with the use of special formers. With precision-machined cooling plates helping to stabilize the coils, accuracy of the shape is ensured. Where high precision is required, molds can be constructed to keep the coil within a strict design envelope.

Buckley Systems currently manufactures strip coils from 260 g (9 oz) to 940 kg (2072 lbs). Larger strip coils can be made but the advantages of strip over hollow core generally reduce beyond this size. For very small coils, insulated wire, despite its lower power density is often the best option.

Cost savings

Per kilogram, copper strip is considerably cheaper than hollow core conductor. Hollow core conductor also needs to be wrapped with fiber-glass insulation before it is wound, adding another process and expense to the operation. Depending on the coil, savings of up to 15% can be achieved with no loss of performance by using a strip wound coil instead of a hollow core coil. Strip wound coils have proven to be just as reliable than their hollow core coil equivalents with some Buckley Systems manufactured strip coils still in use after over 30 years' service.



Accuracy

Copper strip is more dimensionally accurate than hollow core. When hollow core conductor is bent, the outside of the radius is stretched while the inside is compressed. As well as varying the cross section, the copper can work harden which in turn makes the assembly process difficult. The internal cooling of hollow core conductor can also be restricted when bent, increasing pressure drop. Strip coil performs much closer to calculated resistance measurements than hollow core.

Conclusions

For many 2D coils, copper strip is a cost effective, more efficient alternative to hollow core conductor for new magnets. Hollow core coils can often be swapped out for strip coils with little or no modification to existing magnets. However, for 3D saddle coils and very large magnets, hollow conductor is still the best option. Talk to the design team at Buckley Systems who will be more than happy to advise you on the best construction type for your next project.

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Mini transformer tester developed in-house

The most common test to detect interturn shorts in a coil is to employ it as a secondary of a transformer and use the formula $V_2 = N_2 * V_1/N_1$. As an interturn short will collapse the field, transformer testing is a quick and easy way to verify the integrity of the coil and is usually done at each stage of manufacture.

At Buckley Systems, most coils in the factory are tested with a 2kW generator driving the primary coil but this is overkill for many of our small coils.

Physicist, Hamish McDonald, has recently developed a miniature transformer tester based on an oscillator and an amplifier to provide the primary current.

Designed on open-source, circuit design software KiCad, the new tester is ideally suited to smaller coils and has a power consumption of around only 2W.

The transformer tester is one of many ongoing projects using in-house knowledge, experience and ingenuity to help automate and simplify testing procedures throughout the entire business.