Casting bismuth

Bismuth (Bi, atomic number 83) is a silver-white coloured metal that is 86% as dense as lead. It is used for radiation shielding and for neutron beam attenuation.

Bismuth has a few interesting properties that pose some manufacturing challenges. Being very brittle, blocks cannot be machined easily. However, its low melting point of 271°C makes it suitable for casting into shapes that are close to finished size.

Casting has its own problems in that bismuth expands when it solidifies and also tends to grow large internal crystals as it cools. A recent project at Buckley Systems was casting and machining 2.5 tons of bismuth blocks in various shapes. By careful mould design and control of the casting process, we were able to reliably manufacture high quality bismuth blocks to the customer's precise requirements.

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Upcoming 2018 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.

- **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: Grapevine, 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

- **September 24-27 SNEAP 2018: Madison, Wisconsin USA**

  51st Symposium of North Eastern Accelerator Personnel

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If you would like to subscribe to an email edition, please contact info@buckleysystems.com

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BUCKLEY SYSTEMS
Ingenious at work

Buckley Systems Technical Bulletin

Clean room for VHV and UHV vacuum components

To further improve the cleanliness of vacuum components, Buckley Systems is building a new, special purpose, clean-room.

Complete with two ultrasonic baths, ionized water and filtered air supply, the room has been designed to cope with the increasing demand for vacuum boxes, ion sources and beam measuring equipment.

Components destined for ultra-high vacuum applications can undergo further treatment in our vacuum bake-out oven with final cleanliness checked using our residual gas detection probe.

Buckley Systems is always striving to improve products and processes in order to provide clients with products that exceed expectations.

A high-vacuum procedure training module has also been developed in-house to ensure staff understand the importance of cleanliness during every step of manufacturing high-vacuum parts.

This issue

New machining centre for vacuum chambers

Buckley Systems has just commissioned a new MAZAK Vortex Horizontal Profiler 160 XP. This new-generation machining centre brings new levels of accuracy, surface finish and machining speed to large jobs.

Originally developed for the aircraft industry, the 160 XP is based around a very rigid box structure to maintain accuracy and eliminate vibration. The innovative design tilts the machining table from horizontal for setup to vertical for machining so that all debris falls straight into the swarf conveyor. The ability to rapidly clear chips from the tool area is a major advantage when machining large vacuum boxes and other components requiring vast amounts of metal removal. Traditional machines also struggle to clear metal chips when machining deep holes or cavities as the chips can clog the cutter and mar the machined surface. Machining the item vertically means that chips are easily flushed away from the work area.

The 160hp, 30,000 rpm spindle is the fastest and most powerful in the workshop and can handle both rapid material removal and superfine finishing without changing machines.

Having an auto-change magazine of sixty tools allows all machining, drilling, and tapping operations to be done without operator input meaning the machine can run 24/7 when required.

A 157" x 49" (4000 mm x 1250 mm) work table combined with full 360° - 5 axis articulation of the head means that large items can be machined all over without repositioning.

To take full advantage of the machine's high-speed machining capabilities, the 160 XP was ordered with the optional pallet change table, allowing the next job to be set up on the second pallet table while the machine is running.

A sophisticated coolant filter removes chips down to 10µm helping to improve surface finish. This reduces or eliminates the need for manual polishing of O-ring surfaces and the insides of vacuum boxes.

The Vortex 160XP is the flagship machine in our large production workshop and represents a $2 million investment in advanced machining capability, demonstrating Buckley Systems' commitment to the accuracy and ever-decreasing delivery deadlines our customers demand.

Baartman quadrupole pole tip research

Buckley Systems physicist Hamish McDonald is investigating new shapes for quadrupole pole tips based on the work done at TRIUMF by physicist Rick Baartman.

Baartman found that the traditional 2D hyperbolic pole tip, while suitable for long quadrupoles, actually produces a highly impure quadrupole field if the magnet length is small (compared to its aperture). He found that a 3-dimensional spherical pole tip produces a much purer quadrupole field.

Since Buckley Systems first manufactured a run of Baartman quadrupoles for TRIUMF, the design has been incorporated into some of Buckley Systems other magnets. Now McDonald, using Opera 3D FEA magnetic simulation software, is investigating additional refinements to the pole shape. He has discovered that a small dimple in the pole centre further improves the field quality; specifically the 6th and 10th harmonics can be reduced to zero by choosing the depth and radius of the dimple correctly for a given magnet aperture. The innovative design has been proposed to be trialed on a new quadrupole, with the intention of publishing the findings at a later date. For more information on magnet design and simulation, contact the physics team at Buckley Systems.

Anand George

Ph.D. student in residence

Deuterium research using Buckley Systems' Ion Source Test Facility

Anand George is the latest PhD student to take advantage of Buckley Systems' Ion Source Test Facility (ISTF). After achieving a Master of Physics at Cochin University of Science and Technology, Anand spent ten years on the research and development team at Venture Lighting, a subsidiary of Advanced Lighting Technologies LLC. His work there included developing energy efficient light sources including metal halide and thin-film coated halogen lamps.

After finding out about the ISTF at Buckley Systems, Anand saw the possibilities to further his knowledge in the plasma discharge process and high vacuum systems, applying for and winning a three-year PhD scholarship from Callaghan Innovation. Under the supervision of Dr Neil Broderick from the University of Auckland, Anand's PhD study will be based around the production of negative deuterium ions. Aside from his PhD work, Anand has also been contracted by Buckley Systems' business partner, D-Pace to undertake experiments to increase the H^- beam current of the D-Pace filament and RF negative hydrogen ion sources and to design better cooling systems for the ceramic window of the RF source. Buckley Systems is pleased to welcome Anand and his young family to New Zealand and is looking forward to helping him with his research.

Technology topics

Zirconium oxide coatings

As part of ongoing research into better manufacturing, Buckley Systems has been investigating new product coatings for aluminium and steel parts.

Driven by the European RoHS and other environmental organizations' requirements to eliminate chromium compounds, many new chromium-free coatings have been developed.

While for many industries, a straight swap for another type of coating is relatively easy, electro-magnets and vacuum systems have specific performance requirements that must be taken into consideration.

Examples include:

- Outgassing and ablation
- Magnetic properties
- Insulation or conductive properties
- Safe for use around particle beams and radiation
- Compatibility with gases, coolants and exotic compounds
- Safe for use in clean rooms

Staff health and environmental concerns are also key factors when investigating new products.

Excellent results have been achieved so far with a thin zirconium oxide coating which adheres well to both steel and aluminium and provides a tough, corrosion resistant layer that bonds well to the substrate.

Once full testing is completed, and key customer acceptance obtained, we will be offering this option to our customers.

For more information contact our CTO, Dr. Chris Philpott.

Large saddle coil

A project recently completed at Buckley Systems was a large, eight layer, saddle coil. Measuring 49⅜" x 33⅝" x 70¾" (1254 mm x 854 mm x 1797 mm) and weighing around 4000 lbs (1814 kg), it was wound from 0.7" x 0.47" (18mm x 12mm) hollow core conductor. Winding such a large, rectangular section into tight, multi-plane bends while keeping within a strict envelope, presented many challenges. This was overseen by Peter Schuetze who has worked at Buckley Systems since 1980. Careful tooling design and skilled operators ensured that each layer of the coil was shaped with minimal distortion and avoiding damage to the fiberglass insulation. Buckley Systems' new PLC controlled, 530 ft^3 (15 m^3) vacuum chamber and epoxy resin dispensing suite was employed to help ensure a successful infusion process.

High-current DC proton accelerator

Buckley Systems has recently acquired exclusive manufacturing and marketing rights to a brand new high-current, continuous beam proton accelerator.

Capable of producing 30+ mA @ 2.6 MeV, the accelerator incorporates innovative design features that give it many advantages over conventional accelerators.

The first accelerator manufactured to this design has already undergone trials and will soon be installed in Helsinki University Hospital in Finland where it will be used for experimental Boron Neutron Capture Therapy (BNCT) cancer treatment.

Designed and developed by USA based Neutron Therapeutics, Buckley Systems already manufacturers many of the components and has secured the rights to market the accelerator through their business partner D-Pace.

Potential uses for the proton beam include:

- Silicon and sapphire exfoliation
- Explosives detection

Neutron beam applications include:

- BNCT R&D
- Physics and material research
- Detection of fissile materials

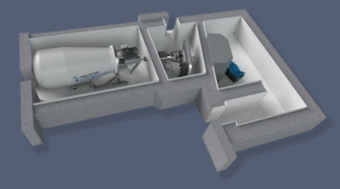
The accelerator has always been designed with the commercial end-user in mind. A compact footprint, safely enclosed high-voltage electronics, and easy installation means that for the first time a reliable, high-power, continuous proton beam is available as a turn-key system.

- The modular construction of 15 identical stages, each powered by its own alternator, means that wiring is minimised and servicing simplified.
- By housing all the high voltage systems inside an SF_6 filled tank, both reliability and electrical safety are improved over conventional systems.
- With an overall length of approximately 56 ft. (17 m) including the beamline and beam dump, the accelerator has an extremely compact footprint for its power.
- Exceptionally economical to run with a typical efficiency of 50% AC supply power to beam power output.
- For simplicity, a single electric motor powers the accelerator making it easy to install.
- The fully integrated cooling system requires only two connections to an appropriate sized water chiller.
- A highly efficient SF_6 transfer system allows for rapid tank evacuation and refilling to minimise downtime.
- Fully customizable to customer's requirements.

The accelerator is the culmination of decades of design experience by the team at Neutron Therapeutics backed by Buckley Systems' manufacturing know-how. Extensive investment in production tooling means that the accelerator and beamline can now be manufactured more economically than a one-off design. This opens up huge opportunities for businesses and research facilities that have previously found these powerful accelerators to be unaffordable.

Inquiries for the accelerator and its components should be made to Morgan Dehnel, Ph.D. at D-Pace.

Example of a typical installation for a BNCT treatment facility.
Design includes radiation shielding and robotic changing of lithium petals.



Internal copper plating of aluminium cans

While electro-plating copper on external surfaces is relatively simple, attempting to put an even layer of copper on the inside of a large aluminium resonator can is quite challenging.

After quality control checks revealed some inconsistencies in the copper plating, a complete review of the process was undertaken. Fortunately, our highly experienced plating department was up to the challenge and has now perfected the process to produce the high-quality results required by our customers.

Having complete control over the manufacturing, preparation and plating processes, allowed Buckley Systems to develop specialised preparation techniques, custom shaped electrodes, proven chemical formulae and robust procedures that allows the plating current to throw an even layer of copper to all surfaces with no bubbles or blemishes.

With the new process in place, the plating thickness is more even, and rework has been virtually eliminated.

One of the strengths of Buckley Systems is being able to keep control over manufacture from start to finish to ensure clients receive the quality products they demand.