Leaders in Slurry Systems Engineering

Our key strength is the intellect, creativity and commitment of the people who work for Paterson & Cooke

www.PatersonCooke.com
Paterson & Cooke is a recognised leader in the design and implementation of slurry systems and associated processes. Since our formation in 1991, we have consistently provided technologically superior slurry systems for projects located throughout the world. Engineering and test services are offered from our worldwide network of offices.

Our service capability includes the following key areas of expertise:

- Slurry testing services – clay behaviour analysis, sedimentation tests, filtration tests, cyclone tests, rheology, wear rates, pump performance and pipe loop tests.
- Dewatering circuit design – unit sizing and selection, control philosophy, water recovery estimates.
- Slurry systems engineering – slurry flow modelling, steady state and transient flow, stress analysis and detailed design and engineering of slurry systems.
- Mine backfill systems – hydraulic and paste backfill material selection and strength testing, detailed design and engineering of backfill preparation plants and distribution piping systems.
- Field services – site audits, process optimisation and equipment upgrades.
- Pilot plant – engineering, procurement and supply of specialised slurry process pilot plant facilities.
- Technology development – evaluation, testing, design and supply of specialised slurry handling technologies and process specific equipment.
- Specialised training courses – offered by our various offices.

Paterson & Cooke es un reconocido líder en el diseño de sistemas de transporte de pulpa y las tecnologías asociadas. Desde nuestra formación en 1991, hemos provisto consistentemente de sistemas de manejo de pulpas tecnológicamente superiores en diversos proyectos localizados alrededor del mundo. Ofrecemos servicios de ingeniería y de ensayos por medio de nuestra red de oficinas en el mundo.

Nuestra capacidad de servicios incluye las siguientes áreas de conocimiento:

- Ensayos de laboratorio – análisis de comportamiento de arcillas, sedimentación, reología, tasas de abrasión, rendimiento de bombas y pruebas en loop de cañerías.
- Diseño de circuitos de espesamiento – dimensionamiento, filosofía de control, estimación de recuperación de agua.
- Diseño de conducciones en tubería – modelación, análisis hidráulico en régimen permanente y régimen transiente, análisis de tensiones y diseño de detalles e ingeniería para sistemas de pulpas.
- Relleno de Minas – selección del material de relleno y ensayos de resistencia, diseño de detalles e ingeniería para plantas de preparación de pulpa de relleno y los sistemas de conducción.
- Servicios en terreno – auditorías de terreno, optimización de procesos y mejoramiento de equipos.
- Plantas piloto – ingeniería, adquisición y suministro de instalaciones de plantas piloto de procesos de pulpas especializadas.
- Desarrollo de tecnologías – evaluación, pruebas, diseño y suministro de tecnologías especializadas en manejo de pulpas y equipos específicos de procesos.
- Cursos de entrenamiento especializados – ofrecidos por varias de nuestras oficinas.
Our extensive network of offices and laboratories allows us to perform all the tests required for the design of our slurry handling projects. Our test work capability ranges from small bench top test work to large scale pilot plant and pipe loop tests.

**Our facilities include:**
- 25 to 300 mm diameter fully instrumented pipe loops
- Pump performance testing
- Rotational and tube viscometers
- Pipeline wear test apparatus
- Bench and pilot scale thickening equipment
- Vacuum and pressure filtration test equipment
- Cyclone performance testing facility
- Process equipment development and evaluation
- Backfill characterization test work including strength and permeability
- Mobile backfill flow test loop.

**Nuestras instalaciones incluyen:**
- Circuits de cañerías (loop) desde 25 hasta 300 mm de diámetro, totalmente instrumentados
- Ensayos de rendimiento de bombas
- Viscosímetros rotacionales y tubulares
- Aparatos para ensayo de desgaste en tuberías
- Equipos de espesamiento de tipo laboratorio y tipo semi-piloto
- Equipos para ensayos de filtración de vacío y de presión
- Instalaciones para ensayos de rendimiento de ciclones
- Desarrollo y evaluación de equipos de procesos
- Ensayos para la caracterización del material de relleno (backfill), incluyendo resistencia y permeabilidad
- Circuito de cañerías movil para ensayos de backfill.
Paterson & Cooke has designed and implemented numerous tailings systems throughout the world. Our capability includes filtration, thickening, cycloning, pump and pipeline transport, choke stations, gravity launder transport, deposition arrangements (including jacking header systems) and water recovery from the tailings facility.

The key to successfully implementing a reliable tailings system is close integration of the de-watering, classification, transport and deposition processes as well as consideration of the wide process design envelope associated with the process plant variability.

We have the skills and experience to take your project from conceptual development to start-up.

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Paterson & Cooke ha diseñado e implementado numerosos sistemas de manejo de relaves alrededor del mundo. Nuestra experiencia incluye filtración, ciclonaje, bombas y tuberías de transporte, estaciones de disipación, transporte por canales gravitacionales, arreglos de disposición (incluyendo sistemas de cabezales elevables) y recuperación de agua desde depósitos de relaves.

La clave del éxito en sistemas confiables de relaves es la integración estrecha de los procesos de desaguado, clasificación, transporte y depositación, considerando una envolvente de diseño de proceso amplia asociada con la variabilidad de la planta de procesamiento.

Tenemos las habilidades y la experiencia para desarrollar sus proyectos de relaves desde la etapa conceptual pasando por pre-factibilidad, ingeniería de detalles, construcción y puesta en marcha.
Notable Projects

Confidential Copper Mine, Arizona USA: Detailed design and commissioning of tailings pumping, cyclone and return water system for a new centerline raised tailings storage facility and planned concentrator expansion from 50 000 t/d to 113 000 t/d. The project includes a new tailings pump station, improvements for an existing tailings pump station, reclaim and seepage return water systems and a jacking header with a cyclone deposition system.

Orapa Diamond Mine, Botswana: The detailed design and commissioning of a booster pump station to transport 35 000 t/d of kimberlite tailings to the storage facility. Six pumps in series per pipeline deliver tailings via 450 mm diameter pipelines to the tailings dam. The total installed power is 11.4 MW.

Jwaneng Diamond Mine, Botswana: The detailed design and engineering of the upgraded tailings pump station to deliver 14 400 t/d of tailings to a new disposal facility via four 4 km pipelines.

Carletonville, South Africa: Bankable feasibility study for the slurry transport of reclaimed mine tailings from various facilities to a central treatment facility utilising up to five 35 km pipelines each transporting 22 000 t/d.

Hycroft Gold and Silver Mine, Nevada USA: The detailed design of a tailings delivery system to transport 118 000 t/d over 12 km in two 600 mm pipelines with two operating pump trains each equipped with four centrifugal pumps in series.

Karee Mine, South Africa: The detailed design, engineering and commissioning of a 6.5 km tailings pumping system transporting platinum tailings using six centrifugal pumps in series.

Phu Kham, Laos: The detailed design, engineering and assistance with commissioning of a 3.5 km long gravity flow pipeline transporting 38 000 t/d of copper tailings in 700 mm diameter pipelines.
Paterson & Cooke has considerable experience in the dewatering and transport of high concentration tailings. We are world leaders in the design and implementation of high density paste and thickened tailings systems through our experience developed over more than two decades. We remain at the forefront of developing and implementing filtered, paste and thickened tailings technology through the funding of both external and in-house research and development programs as well as by hosting process training courses.

In addition to the integration of the dewatering, transport and disposal systems, a key process element is the fundamental understanding and control of the sedimentation or filtration and flow properties of the dewatered fluid, particularly when clay minerals are present.

We are able to conduct our own in-house laboratory and semi pilot plant test work to provide process equipment design data and control specifications for dewatering and transport systems.

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Paterson & Cooke tiene una experiencia considerable en el desaguado y el transporte de sistemas de relaves de alta concentración.

Además de la integración de los sistemas de desagado, transporte y depositación, un elemento de proceso clave es una comprensión fundamental y el control de la sedimentación o filtración y las propiedades de flujo del fluido desagado, particularmente cuando están presentes minerales de arcilla.

Estamos en condiciones de llevar a cabo ensayos y pruebas de laboratorio y semi-piloto en nuestras propias instalaciones, para proveer de datos de diseño para equipos de proceso y especificaciones de control para los sistemas de desaguado y de transporte.
Notable Projects

**Combined Treatment Plant, South Africa**: The design, engineering and commissioning of five 15 m diameter paste thickeners and positive displacement pumping system for a 12 000 t/d diamond tailings circuit. Paste tailings are transported 5.5 km with a maximum pump discharge pressure of 12 MPa. The system has been operational for over 10 years.

**Fairbreeze Mine, South Africa**: The hydraulic and detailed design of the mineral sands fine residue disposal pipeline system. Three positive displacement pumps in parallel are required to pump the thickened residue 7 km in a 500 mm high pressure lined steel pipeline operating at 8 MPa.

**Khumani Iron Ore Mine, South Africa**: Paterson & Cooke completed the detailed process, mechanical and piping design, including the commissioning of the thickened tailings disposal systems transporting high concentration tailings from two deep cone paste thickeners to the deposition site.

**Minera Escondida, Chile**: On-site test work in support of a pre-feasibility study for a 230 000 t/d copper tailings paste thickening circuit cost study comparing high rate and paste thickening options.

**Muskeg River Mine, Canada**: Detailed design review of a 2 400 t/d paste thickened tailings pilot plant for treating Oil Sands tailings.

**Centinela Mining District, Chile**: Pre-Feasibility study for the 300 000 t/d Centinela Mining District copper thickened tailings circuit design and evaluation of different thickening and pumping technologies.
The design of deep level backfill distribution systems for hydraulic and paste backfill was revolutionized by Paterson & Cooke’s full flow design methodology. Our expertise covers recipe formation, backfill production plants, pump and pipeline delivery systems through to stope placement. Our services include laboratory testing, backfill mix design and binder optimization, feasibility studies, engineering, commissioning and start-up as well as on-site training and contracted backfill placement.

Paterson & Cooke continues to set the standard for backfill service by performing our own in-house test work. We understand the science behind the solution and are able to implement robust designs that have been proven in the field through feedback from our commissioning teams - we know what works and what doesn’t.

Our staff have experience in contracted paste backfill placement, particularly in filling abandoned tunnels with only remote access. We work with our equipment subcontractors to develop the feed materials and recipes, build the mobile process for backfill production and placement and implement the quality control and video monitoring program. Contract terms are negotiable and could involve a one-off system design and handover, or on-going delivery contracts where the owner pays by the hour or by the tonne placed.

El diseño de sistemas de llenado de minas subterráneas profundas fue revolucionado por la metodología de “Diseño a Flujo Completo” desarrollada por Paterson & Cooke. El conocimiento de Paterson & Cooke cubre las plantas de preparación de la pasta, el sistema de bombeo y la conducción pasando por la localización de los puntos de cierre.

Nuestros servicios incluyen desde las pruebas en laboratorio, la optimización de la mezcla y el aglomerante de la pasta, estudios de factibilidad, pruebas operacionales y puesta en marcha, además del entrenamiento especializado en terreno.

Paterson & Cooke continua estableciendo un estandar en servicios de relleno de minas por medio de la ejecución propia de ensayos. Entendemos la ciencia detrás de la solución y somos capaces de elaborar diseños robustos que han sido probados en terreno por medio de la retroalimentación de nuestros grupos de puesta en marcha - sabemos que funciona y que no funciona.

Nuestros equipos de trabajo tienen experiencia en la instalación de plantas de relleno de mina, particularmente en el llenado de cavidades abandonadas que disponen de accesos remotos. Trabajamos con nuestros contratistas de equipos para desarrollar los materiales de relleno y las dosis de mezcla, construir los elementos móviles de procesos para la producción del relleno y la implementación del control de calidad y del programa de monitoreo en video.

Paterson & Cooke
Efemçukuru Gold Mine, Turkey: Plant troubleshooting, design of upgrades, engineering of the underground distribution system, commissioning and training of this paste backfill system in western Turkey. Paterson & Cooke provides consulting support in the form of regular audits for management, plant manuals and training for new operators.

Vale’s Backfill Operations, Canada: Paterson & Cooke has expanded its backfill consulting network and Vale is one client in particular who has relied on us to cover hydraulic fill modelling (including software development), laboratory testing, reliability audits of most of their backfill systems and backfill support studies for their new mines.

Barrick Gold, North America: Engineering support to this world leader in paste operations, Paterson & Cooke worked with Barrick to develop their underground distribution system standards and designed the reticulation system and presented backfill workshops for their Goldstrike Mine in Nevada. Our work also extends to paste fill recipe improvement through cycloning and unique binder amendments.

Cleveland Potash Mine, United Kingdom: Detailed engineering and commissioning of a 1 km deep and 11 km horizontal potash backfill system. High pressure energy dissipaters developed by Paterson & Cooke allow the system to start up and shut down in a controlled manner ensuring that the system always operates under full flow conditions.

Raposos Mine, Brazil: System analysis and design, as well as material testing and modelling, of the Raposos Mine backfill pipeline distribution system for Mineração Morro Velho in Brazil.

Lisheen Mine, Ireland: Test work, hydraulic design, front end engineering and commissioning of the pumped paste fill system transporting 3 300 t/d of paste.

Dishaba Mine, South Africa: Backfill strength test campaign, de-watering and flow behaviour tests, and the completion of the feasibility study and front end design of the paste preparation plant and underground reticulation system.
Long distance slurry pipeline transport is a proven technology and is now widely accepted as a viable alternative to conventional bulk transport. Key to the success of a long distance system is minimizing operating costs by determining the optimum grinding requirements for pipeline transport. Our extensive laboratory services and in-depth knowledge of slurry flow behaviour means that we are able to determine the most efficient combination of material properties together with pump and pipeline requirements for long distance transport. We have completed numerous long distance slurry pipeline projects, from pre-feasibility to detailed engineering design, construction assistance and commissioning.

We have developed sophisticated simulation software used to determine the control requirements for long distance pipelines to ensure that overpressure due to transient events is minimised. With the software, control sequences such as start-up and shut down, are tested and the consequences of fault or trip conditions are simulated. The pumping system can be assessed with multiple slurry batches, covering a range of different densities and hydraulic properties including water batches in the pipeline, to simulate the effect that batches may have on the system behaviour and the response of the system to varying slurry properties.

El transporte hidráulico a través de tuberías de gran longitud es una tecnología probada y ampliamente aceptada como alternativa al transporte de sólidos masivo. La clave del éxito de un sistema de transporte de gran longitud es minimizar los costos de operación mediante la determinación del nivel de molienda óptimo para el transporte en tuberías. Nuestros completos servicios de laboratorio y el entendimiento del comportamiento fluido-dinámico de la pulpa implican que somos capaces de determinar la mejor combinación de las propiedades del material y los requerimientos de bombeo y de la conducción, para transportes de larga distancia. Hemos desarrollado numerosos proyectos de conducciones de pulpa a larga distancia, desde pre-factibilidad hasta diseños de ingeniería de detalles, asistencia a la construcción y puesta en marcha.

Hemos desarrollado sofisticados software de simulación que permiten determinar los requerimientos de control de conducciones de gran longitud para asegurar que las sobrepresiones debidas a los eventos transientes se minimicen. Usando el software se prueban secuencias de partida y parada, y se simulan las consecuencias de fallas. El sistema de bombeo puede ser analizado con operación simultánea de diferentes pulpas, considerando diferentes densidades y propiedades hidráulicas, y con tramos de agua en la tubería, para simular el efecto de ellos en el comportamiento del sistema y la respuesta del sistema al variar las propiedades de las pulpas.
Notable Projects

**Jorf Lasfar Phosphate Pipeline, Morocco:** Detailed design, engineering and commissioning support of the 186 km long phosphate ore pipeline from Khouribga Mine to Jorf Lasfar and the feeder pipeline systems from the process plants to the pump head station. The system will transport up to 38 MTA of phosphate ore and is the highest capacity slurry pipeline in the world, providing a significant proportion of global phosphate demand.

**Richard's Bay Minerals, South Africa:** Development of a 42 km heavy mineral concentrate slurry pipeline that comprises a main pump station and a booster pump station, each equipped with positive displacement pumps operating at 24 MPa.

**Nkomati Mine, South Africa:** Front end design of the 12.6 km pipeline system, including slurry test work, steady state hydraulic design, pressure transient analysis, PFD and P&ID development, control philosophy development, pipeline stress analysis and thrust anchor design, detailed design of the choke station and assistance with commissioning.

**Sandpiper Phosphate: Namibia:** Completion of a bankable feasibility study for the 25 km overland pipeline which transports mined marine deposits from the onshore buffer pond point to the process plant.

**Ramu Nickel Laterite Ore Pipeline, Papua New Guinea:** Review of feasibility study, supervision of test work in China and detailed hydraulic design for the 120 km long ore pipeline from the mine site to the process plant.

**Pebble Mine, Alaska:** Bankable feasibility study for the 140 km long proposed copper/gold concentrate pipeline from Pebble Mine to Anchorage.

**Ambatovy, Madagascar:** Bankable feasibility study, test work and route survey for the 234 km long Ambatovy nickel laterite pipeline.
Many processes are not fully optimised after start-up. Variability of the ore characteristics over time, for example, is one aspect that is often overlooked. Material properties may no longer be the same as the first bulk sample collected during pre-feasibility. Process performance affects recoveries and water conservation impacts operating costs. For these reasons, a dedicated group has been formed within Paterson & Cooke to focus on providing follow-up field services to our clients. This team provides the opportunity to apply our engineering and field experience in a way that optimises and upgrades the infrastructure already in place. We provide a range of field services including design reviews, audits, optimisation, retrofits, benchmarking, start-up, commissioning and training. The strength of our team comes from years of field experience and access to global Paterson & Cooke resources which enable us to tackle unique dewatering, rheological or pumping challenges.

Notable Projects

Kumtor Gold Mine, Kyrgyz Republic: Dynamic thickening, on site field trials to optimize settling process conditions and improve water conservation.

De Beers Snap Lake Mine, Canada: Audits, field trials, troubleshooting and made recommendations to improve the paste backfill system.

Minera Escondida, Chile: On site slurry behaviour and paste thickening test work in support of a cost study comparing High Rate and Paste thickening options.

Syncrude, Canada: Cold eye review of the hydrotransport and tailings pumping systems at North and Aurora Mines to optimize system reliability.

Minera Esperanza; Chile: On site review of three problematic 60 m diameter high density thickeners treating a combined 95 000 t/d of copper tailings.

Langer Heinrich Uranium, Namibia: On site pilot plant trials using existing mining equipment to characterise tailings flow properties.
Marine and Coastal

Offshore mining presents many challenges and the undersea hoisting of ore from the sea bed to the mining vessels is crucial to such operations. We have done extensive work on the design of offshore pumping systems using air lift pumps, remotely operated vehicles and conventional centrifugal pumping. Dredging, sand bypass systems and beach replenishment require a thorough understanding of the material transport requirements and correct equipment selection for the marine environment. Our extensive test facilities provide the necessary information needed for the design of robust marine slurry transport systems.

Notable Projects

**Durban Harbour Temporary Sand Bypass System, South Africa:** Design, engineering, specification and commissioning of a temporary sand bypass system for the Durban Harbour Widening Project. In addition, Paterson & Cooke completed a pre-feasibility study and detailed design for the new sand hopper and beach feeding system for implementation after the completion of the harbour widening project. The scope of work included process and control, pumps, piping, valves and instrumentation design and specification. Paterson & Cooke is currently assisting with tender reviews and construction for planned commissioning in 2014.

**Ngqura Harbour Sand Bypass System, South Africa:** Commissioning of water pumps, jet pumps, sand transport pumps and pipeline as well as modification of the control system. We provided further design and engineering services for system modifications, improvements and maintenance issues. We are conducting a study for the expansion of the existing system.

**Nautilus Minerals, Australia:** Analysis and review of the high pressure pump and pipeline requirements for the Solwara deep sea mining project at depths of up to 2000 m.

La minería de altamar presenta muchos desafíos y el izaje del mineral desde el fondo marino hasta el buque es crucial en dichas operaciones. Paterson & Cooke ha desarrollado un intenso trabajo en el diseño de sistemas de bombeo usando bombas de izaje por aire, vehículos operados remotamente y bombas centrífugas convencionales. Los sistemas de dragado y de izaje y la creación de playas requieren un completo entendimiento hidráulico y una selección apropiada de equipos considerando el ambiente costero. Nuestras instalaciones para pruebas nos permiten obtener la información necesaria para el diseño de sistemas de transporte de pulpa robustos para el ambiente marino.
Paterson & Cooke has process engineering expertise over a wide range of mineral processing technologies including crushing and grinding, classification, beneficiation, thickening and filtration. This, coupled with our in-depth knowledge of slurry flow behaviour, provides our clients with a unique approach to problem solving.

Our process design and engineering is supported by a number of in-house laboratories where we offer a range of services including material and slurry classification, rheology measurements, clay behaviour characterisation, bench and pilot scale thickening and filtration, pilot scale hydro-cyclone processing and conveyability studies.

Many projects require novel process solutions and our various laboratory facilities allow us to conduct research and develop process equipment and solutions specific to our clients’ needs.

Notable Projects

**Namdeb Floating Treatment Plant Elutriator, Namibia:** Development, test work and design of a novel elutriator to classify dredged material to maximize the processing capacity of the floating diamond treatment plant.

**De Beers Marine Peace in Africa, South Africa:** Development, test work and detailed engineering of novel high capacity dewatering bins for the Peace in Africa offshore mining vessel. The bins include an integrated fluidising jet pump at the discharge that is used to control the solids transfer rate. The dewatering bins receive head feed from a custom designed four-way splitter that was developed, tested and designed at our slurry test facilities. The compact splitter configuration and casting is designed to split the incoming flow into three or four equal streams while maximising wear life.

**Shell Muskeg River Mine Thickened Tailings Pilot Plant Design Review, Canada:** Detailed design review of a 2 400 t/d paste thickened tailings pilot plant, for treating Oil Sands tailings.

**Umm Wu’al Phosphate Project, Saudi Arabia:** Investigation into conveyability of filtered tailings in conjunction with the transportable moisture limit.
Paterson & Cooke supplies containerised slurry test pilot plant facilities that are used for research and development work or for small scale mineral processing. These plants are custom designed, constructed and supplied by Paterson & Cooke to meet specific client requirements. Our field engineers commission the facilities on-site and provide further operational support to meet specific test campaign requirements.

**Notable Projects**

**Anglo Platinum, South Africa:** Fully instrumented mobile slurry pipeline test facility. The plant is used to conduct field trials on thickened platinum tailings to characterise different ore body flow properties.

**Sasol, South Africa:** Design and supply of a complete batch operated paste plant. The major equipment includes ash loading stations, 20 m³ storage silos, paste mixers, control room and fully instrumented paste pump and pipeline system.

**Mogalakwena South Concentrator, South Africa:** Design, manufacture and supply of a paste thickener pilot plant to determine the thickening and depositional properties of a 14 000 t/d platinum tailings circuit.

**Codelco Chuquicamata, Chile:** Detailed design, construction support and five months operation of the thickened tailings slurry pipe loop facility on site, for a 232 000 t/d thickened tailings conceptual design project. The pilot plant included a 2.5 m diameter paste thickener to produce thickened underflow at a maximum rate of 70 t/d. The slurry test loop comprised a 110 kW slurry pump and 50 mm and 75 mm pipe test loops that were used to determine the slurry flow behaviour and pump performance. The slurry was stored and pumped to deposition test flumes for further geotechnical tests to determine consolidation and beach slopes.

**Antofagasta Minerals, Esperanza Sur Project, Chile:** 0.35 m diameter semi-pilot scale thickener and tube viscometer test work. The tests included various combinations of ore types, process water, sea water and desalinated water. Pilot scale flume tests were also conducted to determine beach slopes. The data was required for the feasibility study and design of a 100 000 t/d tailings pump and pipeline facility.

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Paterson & Cooke provee equipamiento de pruebas de pulpas de tipo transportables, que son usadas para investigación y desarrollo en trabajos de procesamiento de minerales en pequeña escala. Estas plantas transortables son de diseño ad-hoc, construidas y provistas por Paterson & Cooke para satisfacer los requerimientos específicos del cliente. Nuestros ingenieros de terreno ponen en marcha los sistemas en el sitio y proveen apoyo operacional adicional para satisfacer los requerimientos de la campaña de pruebas.

Leaders in Slurry Systems Engineering
We are committed to sharing our specialist knowledge and skills by hosting courses which provide participants with a sound theoretical and practical understanding of dewatering, slurry pipeline and paste technology.

We regularly present courses on the following topics:
- Slurry Pipeline Design / Diseño de conducciones de pulpa en tuberías.
- Thickening and Clay Slurry Behaviour / Espesaje y comportamiento de las arcillas en la pulpa.
- Paste and Thickened Tailings / Relaves espesados y en pasta.

Estamos comprometidos en compartir nuestros conocimientos y habilidades con nuestros clientes por medio del dictado de cursos en las distintas oficinas del grupo, los que proveen a los participantes de un entendimiento teórico y práctico de las tecnologías de desaguado, transporte en tuberías y de manejo de pastas.