The Konkola Copper Mines (KCM) in Zambia uses an ABEL HMT-160-1000 piston diaphragm pump to transport abrasive tailings through long pipelines at its Chingola mine. Located in a relatively remote region, the pump runs reliably and very efficiently. The copper tailings generated at the Chingola processing plant must be transported from a thickener and cyclone station a distance of 3.5 km to an underground mine, where it is used as backfill. The system must pump approximately 70 tons per hour of dry solid material. The solid concentration in the sludge amounts to 59%, the sludge volume is 90 m³/h, and the required pressure for that distance is 50 bar.

The operating costs have been extremely low since the system has been commissioned. Due to the high efficiency of the HMT pump, the power consumption amounts to 160 kW/hr. The parts replacement of the HMT pump has been limited to replacing the valves every 5,000 to 7,000 operating hours. The diaphragms are replaced every 12,000 to 16,000 hours as part of the preventative maintenance.

The reason the operating costs are so low is because the most important moveable parts of the pump are physically separated from the abrasive sludge using preformed rubber diaphragms. Only the product valves at the suction and pump side as well as the diaphragms are in direct contact with the sludge. The reciprocating principle of the piston diaphragm pump ensures a very high efficiency of at least 93%. The pump costs for this type of pump are minimal and more economic than compared with other methods of sludge removal and transport.

“Pump systems are an ideal way to transport tailings or sludge,” said Friedrich Wiechmann, head of development and construction for ABEL GmbH & Co. KG, located in Büchen, Germany. “The hydraulic transport of sludge can be best described as two-phase flow. This is a suspension consisting of solid particles mixed with a carrier liquid located in a closed-off pipeline. Certain flow rates must be maintained in the pipe to pump sludge from A to B, with different values applying depending on the consistency of the sludge.”

All solid materials have a specific hardness and it contributes significantly to the wear and abrasion of pump components, Wiechmann explained. “The shape and size of the particles is important as well,” Wiechmann said. “Different types of wear and abrasion—corrosion, erosion and/or combination of both—occur in pumps. There are also various methods to determine the type of wear and abrasion behavior. However, a method to predict the actual wear behavior accurately does not exist.”

Piston pumps used for high-pressure sludge applications are constructed similarly. The product valves, pump casings, as well as the pipeline dampening mechanisms on the suction and pressure side are primed with the sludge to be pumped. The
ABEL pumps for these applications are offered as models HMT (triplex, single-action) and HMQ (quadruple-action). The two models have different gear designs. Piston speeds are below 1 m/s; valve speeds range from 0.8 to 1.8 m/s. This results in very low pump rpms, which significantly reduce wear of the components in contact with the product.

The pipelines must have very thick walls because they are not only exposed to the pressures but also the abrasion of the sludge and sediment flowing through the pipe. Flow rates of 2.5 m/s are usually the limit. Such high speeds, coupled with the parameters hardness, size, shape, particle distribution, brittleness, and the weight of the sludge, generate high abrasion rates in the pipeline.

The pumps cannot be started directly because of the mass in the pump and the gearing. The liquid column in the pipeline must be accelerated slowly if the pump is to be started when connected to a filled pipeline. "Bypasses were used for this process in the past," Wiechmann said. "During the start phase, the pump's pressure and suction sides were short-circuited so the pump did not actually pump any liquid or sludge from the pipeline. The bypass was slowly closed once the pump had reached the working rpm; the flushing fluid starts to move slowly until the bypass is closed completely and the required flow rate has been reached." Modern sludge pumping systems, Wiechmann explained, use fluid couplings, soft starting drives and frequency converters to bring the system up to speed slowly.