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SAIW
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Pipeline welding – the complete set of solutions

As a result of ongoing oil and gas supply and security issues, the construction of pipelines is accelerating all over the globe. *African Fusion* talks to Nahanni Nagle of Lincoln Electric about the pipeline industry, his company's long history in pipeline welding and the comprehensive range of solutions now available from Lincoln Electric.

Lincoln Electric's experience with pipeline welding began in 1930 using Fleetweld® 5 on the construction of a 20-inch pipe 32 miles long in the USA. Pipeline welding really came of age, though, when the Trans-Alaska Pipeline System (TAPS) was built between 1974 and 1977 after the oil crisis caused by the Yom Kippur war. This war, along with an associated oil embargo against the West, caused a sharp rise in the oil price, from about US$3,00 per barrel to over US$12,00 by the end of 1974, and firmly entrenched OPEC as the new controller of crude oil prices. "Ever since then, the pipeline industry has been a very important business for us," says Nagle. Lincoln supplied much of the equipment and consumables used to weld the Alaskan pipeline, the cellulose 6010 electrodes and its true DC generators, the equivalents of Lincoln's current Classic range of DC welding generators.

The use of Lincoln's STT GMAW solution not only offers productivity advantages, it also obviates the need to remove 'wagon tracks' associated with an SMAW root. This can significantly reduce the amount of rework required.

"Welding is a critical component of any pipeline project and we at Lincoln like any project where welding is critical because this gives our equipment and consumables the best opportunity to be differentiated."

In South Africa, such an opportunity arose with the recent New Multi-Product Pipeline (NMPP) from Durban to Gauteng, currently nearing completion at an estimated cost of R23,4-billion. "Pipeline welding is an industry within an industry, and if you don't understand it, you won't be able to participate."

Pipeline industry drivers and trends

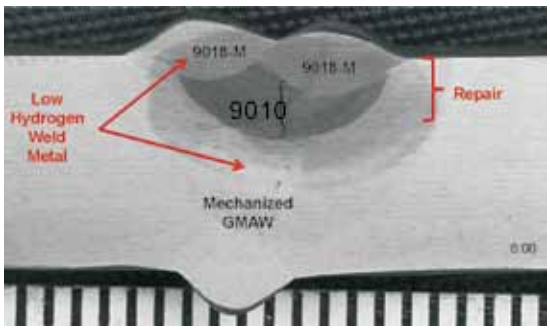
The demand for clean energy has led to a rise in world gas consumption of 435% since 1965. The Energy Information Administration, part of the US Department of Energy, forecasts that by 2030: world energy demand will have grown by 55%; gas consumption by 2,4% per year; oil consumption by 1,4% per year; and gas will account for 26% of global energy use. "The discovery of huge shale gas reserves in the US is drastically changing the energy equation there," Nagle informs *African Fusion*, "and new technology is now available to access these reserves. Similarly in South Africa, Shell has been given rights to explore some 185 000 km^2 of the Karoo basin for shale gas."

As a direct impact of the US shale gas discoveries, natural gas is predicted to double its share of the energy market, from 20 to 40%, by 2050. Within 10 years, it will account for more than 50% of the US gas supply. Breakeven costs on recovery are now down to $4,00/MMbtu and estimates are that the discovery can supply US demand for 90-115 years. "It is not yet clear if shale gas will impact on the future Alaska Gas Pipeline Project, but already, the building of new LNG terminals to cater for imports to the US has been halted. Instead, developers are hoping to use these terminals to export shale gas," says Nagle.

In order to increase flow rates in pipelines to meet energy demands, higher operating pressures, higher strength pipe materials and consumables, and larger pipe diameters are being used. "The Industry is going for higher and higher strength steel, either to run at higher pressures, to reduce the wall thickness, or a combination of both," explains Nagle. "We used to use X60 pipe, now X70 and X80 are common, and several test loops of X100 and X120 have already been installed in North America. The composition changes of these higher-strength steels means that consumables have to evolve too. There is now much more use of low hydrogen electrodes because, in some applications, traditional cellulose 6010 pipeline electrodes may not be the best choice, due to the cracking potential of such steels," he warns.

Following media coverage of several serious pipeline incidents, the industry is also facing increased attention with respect to environmental protection and public safety issues. According to Nagle, this translates

The self-shielded flux-cored wires, Pipeliner® NR-207s and 208s, are often the simplest wire solution. There is no stub loss, no gas shielding is required and these wires can be used to weld pipe grades of up to X80.



A hydrogen crack in the part of a repair weld completed with a standard electrode (9010) as opposed to a low hydrogen electrode.

into more rigorous inspection requirements on pipeline projects and much more emphasis on rehabilitation and maintenance of existing infrastructure. “In the US, Chevron was fined $423 000 for spilling 33 000 gallons of oil into a Salt Lake City creek and in June 2010, an Enbridge pipeline leaked a million gallons of oil, which cost them $400-million to clean up, not including fines,” he says.

Also changing the nature of pipeline construction is the large numbers of construction projects that have taken place over the last three years. To accommodate productivity needs, the lack of skilled welders and high labour costs, contractors are increasingly turning towards the use of semi-automatic and automatic welding processes. “Most pipelines (45%) are still welded using shielded metal arc (SMAW) with stick electrodes, but a total of 40% are now welded using flux-cored electrodes, with more than half of that (25%) being welded using self shielded flux-cored electrodes. The US and Canada, though, have a huge stick legacy, while flux-cored welding predominates in Latin America, Europe, Russia and Asia,” says Nagle.

He is expecting a very fast expansion in the number of pipeline projects across Africa. Lincoln worked on the West African Gas Pipeline to supply gas from Nigeria's Escravos region of the Niger Delta area to Benin, Togo and Ghana, the first regional natural gas transmission system in sub-Saharan Africa. “Nigeria has an insane amount of natural gas!” Nagle exclaims.

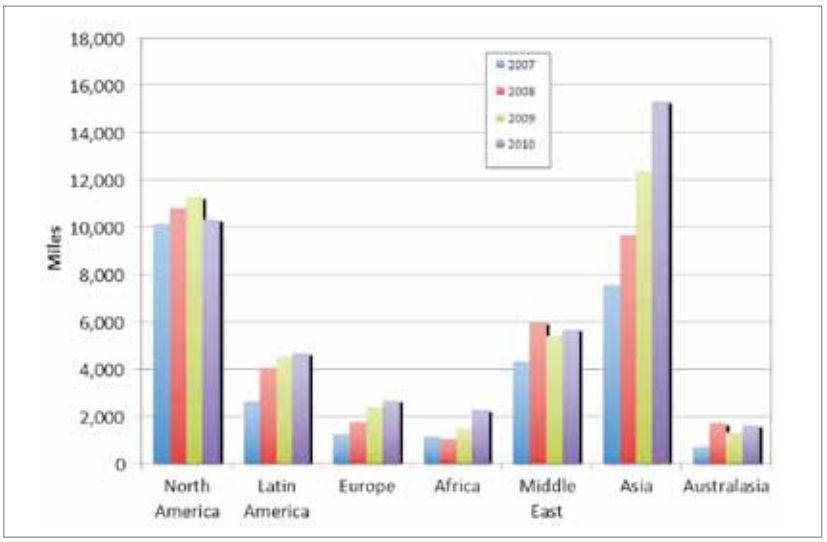
Lincoln’s pipeline welding solutions

Being a mission-critical process for pipeline projects, project engineers have a very low tolerance for problems with welding machines, equipment or consumables. “You have to be able to support your consumables with certificates of composition and compliance, for example,” says Nagle. To achieve the required productivity and quality and to satisfy the material property demands, premium quality is the minimum acceptable, and technical support, imperative. “Customer service and value via technical solutions are our key focus areas,” says Nagle.

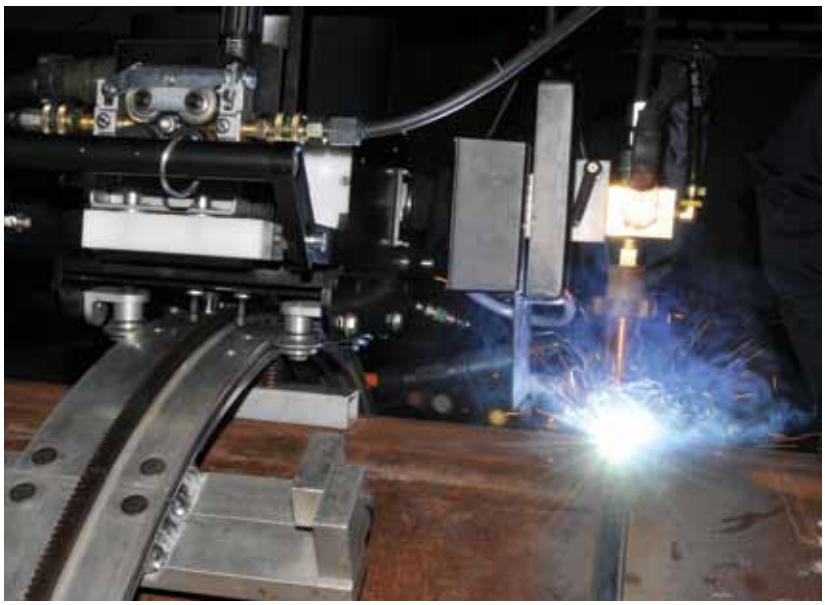
“Lincoln is the only welding company in the world to have designed, developed and packaged welding solutions especially for pipeline welders,” he claims. “We have a product line called ‘Pipeliner®’ that is specifically engineered to suit the demands of pipeline contracts.” The copper wound true DC generators are just the first example. “Very few people outside of Lincoln make these. They have been a part of Lincoln’s stable for more than 50 years and are still perfect for welding in places like Nigeria. They are insanely robust, have no PC boards and are very easy to fix. In many places of the world, these are still the most appropriate solution. When you rectify AC, you don’t get a clean DC signal, you get ripple, and pipe welding is very sensitive to ripple. Good pipe welders can always tell the difference and the true DC generator has long been a differentiator for us in the pipeline business,” he adds.

Stepping up from these, Lincoln has developed DC Chopper®, a technology which substantially smoothes the ripple that you get out of a rectified AC generator. “Choppers can approach true DC welding characteristics when using the input supply from a standard AC generator. The welding machines are a lot cheaper, though, and you get access to AC power, to run a grinder for example."

Modern inverters are also making their way into the pipeline industry. “Inverters produce very good arc characteristics and are now definitely robust enough for use in the field on pipeline projects,” Nagle suggests.



An overview of the growth in global pipeline construction between 2007 and 2010.



By using a Bugo Piper-Bug with solid wire STT for the root and gas-shielded FCAW for the fill passes, 30 joints per day can typically be achieved.

Inverters also enable the move into the whole range of wire welding processes, GMAW and FCAW, in particular. "We offer a whole range of suitcase feeders that support all of the GMAW and FCAW processes. For pipe GMAW welding, they are designed with a high/low switch to allow the welder to switch to lower current parameters on-the-fly to adjust for the transition from the vertical down to the overhead position at 8 o'clock and 4 o'clock. This allows the welder to go all the way around the pipe without having to stop because the weld metal is falling out. This is typical of a feature born out of a long engagement with the needs of pipeline welders," he confirms.

The newest inverter-based pipe welding initiative is the development of Surface Tension Transfer (STT®) technology. "The traditional way of doing pipe welding is to put in a stick root, which gives a concave weld bead with 'wagon tracks' on either side caused by undercut at the fusion boundary. Then you do a hot pass, with the sole purpose of digging out the wagon tracks that have been created during root welding. This procedure has an inherent risk of quality problems because one is putting in defects and then, if the welder is skilful enough, digging them out again. The STT process completely eliminates the undercutting problem and therefore the risk. There are no wagon tracks to dig out and therefore no need for a hot pass.

"The use of STT has always been justified based on a productivity argument, but there is also a huge quality advantage," Nagle points out. "It's now a very, very reliable process, which can usually be coupled with CO_2 shielding gas to give spectacular penetration. STT controls the arc so well that the CO_2 becomes much easier to use and spatter is significantly reduced," he adds. The first STT welding machines were stand-alone machines but Lincoln has now adopted a modular approach at a much lower cost. "STT can now be added to our new Power Wave S350 simply by adding an optional bolt-on module. The latest technology also has a much better inverter, upgraded from 40 to 120 kHz."

Lincoln's monitoring and recording features, built into all of its Power Wave inverter solutions, are also helpful in the drive to enhance pipe welding quality.

"True Energy, for example, can help contractors to track and record the true heat input of every weld, which helps with quality assurance. Also, WeldScore® data monitoring gives a full data record of the welding parameters and an instant pass/fail indication immediately after each weld is completed. This is a very useful feature for any weld-critical application," believes Nagle. "If a welder remains between the preset parameters of a good weld, then the procedure used for that weld is deemed acceptable, but if not, the deviation is highlighted and noted as a possible problem," he explains. This tool provides greater traceability and confidence in making quality welds. "Clearly it doesn't replace the normal quality acceptance criteria, but rather adds another indicator for inspectors and engineers looking for potential problems"

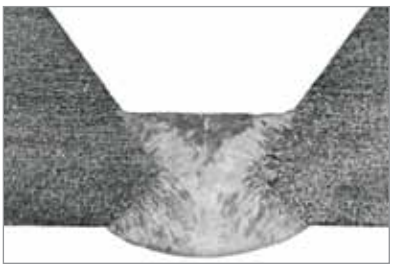
Turning his attention to Lincoln's consumable range, Nagle says that the consumable business has changed considerably over its 80 years of pipeline welding applications. "Now, high strength steels are the norm, toughness requirements are high and so diffusible hydrogen is a critical issue. Also, because of the need for traceability and quality assurance, you need certificates for every consumable used to weld any part of a pipeline. We have therefore designed a whole range of welding consumables to cater for the current needs of the pipeline industry."

One common feature of Lincoln's Pipeliner consumable range is the packaging: "All consumables are protected in hermetically sealed packages for example, sealed pails for fluxes and flux cored consumables, sealed cans for stick electrodes and vacuum sealed foil bags for solid GMAW wires. It's all about making the packaging robust because we know the consumables will be used for critical applications in some of the harshest environments in the world, the slopes of Siberia or the forests of the Congo. We know that production requirements demand the most stringent adherence to quality, and any lack of consistency cannot be tolerated," says Nagle. A material test report is therefore issued for every lot of consumables – stick electrodes, shielded and self-shielded flux cored wires, and solid GMAW wires.

"The Pipeliner consumable range is a large family of products," says Nagle. It begins with the original cellulosic range, Pipeliner® 6P+, 7P+ and 8P+. "With diffusible hydrogen of 40 ml/100g, these are not low hydrogen product, though," he points out.

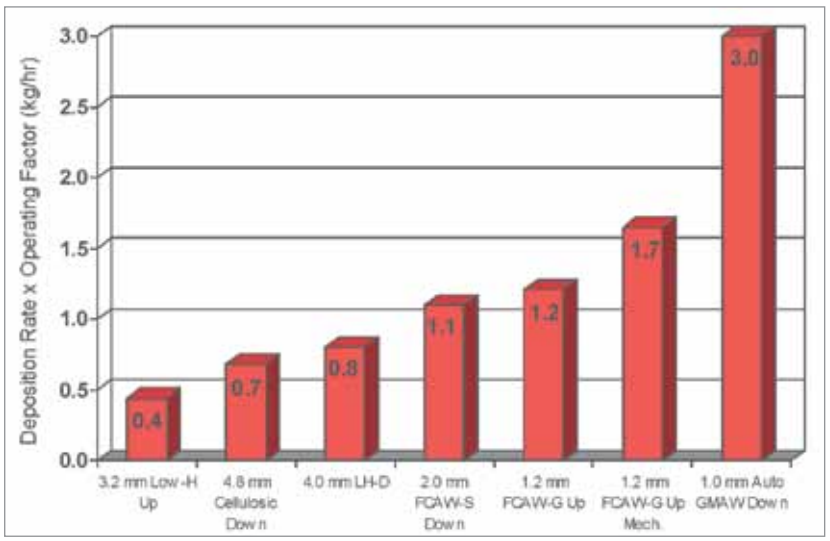
The low hydrogen range of mild steel and low-alloy stick electrodes includes the Pipeliner® 16P,17P and 18P, for X60 and X70 pipe and for the new X80 and X90 pipe materials, Pipeliner® LH-D80, LH-D90 and LH-D100. All of these are low hydrogen electrodes and come with Charpy V-notch test certificates down to -29˚C.

For GMAW, Lincoln offers the Pipeliner® 70S-G, 80S-G and the 80Ni1 with root pass capability on



The STT process completely eliminates undercut. The root thickness is also large (5,6 mm), which eliminates burn through on next weld pass.

The use of Lincoln's true DC generators with its Pipeliner range of SMAW electrodes remains the most appropriate pipe welding solutions in many places of the world.



Productivity gains (deposition rate × operating factor) for different pipeline welding processes.

X100 steel and Charpy V-notch values of between 68 and 95 J at -50°C. These wires are all designed to give a good back bead shape when using Lincoln's STT process.

"The self-shielded flux-cored wires, Pipeliner® NR-207s and 208s, are often the simplest wire solution. Designed for vertical-down fill passes, the process is continuous and therefore offers productivity advantages over stick electrodes," says Nagle. "There is no stub loss, no gas shielding is required and these wires can be used to weld pipe grades of up to X80."

Completing the consumable range are the gas shielded flux-cored wires, the Pipeliner® G70M, G80M and the new 81M, These are suitable for vertical-up fill passes using Argon/CO_2 shielding gas mixtures. They offer improved toughness and strengths of up to that of X100 pipe. "But to use them you will need shielding gas and, in the field, a tent for protection against wind," Nagle suggests.

The move towards automation

Productivity in pipeline welding is all about achieving a high number of quality joints per day. Deposition rate and the arc-on time (operating factors) of different processes are key drivers of productivity. Continuous productivity improvements are essential because of ever tighter project schedules and budgets and an abundance of planned projects. Higher quality requirements, the need to reduce repair rates, smaller allowable defects and the need for consistent weld properties are all factors driving contractors towards automation. Internationally, there is also a lack of skilled pipeline welders.

Nagle describes two basic approaches to mechanisation on pipeline contracts. "There are some welding services contractors, like CRC-Evans or Serimax, who will not only supply the necessary pipe-welding equipment, but they will also take responsibility for the welding itself," he says.

Using narrow groove GMAW with a relatively expensive bevelled weld preparation, a welding services subcontractor with high expertise and expensive mechanised systems can typically produce 100 to 150 joints per day on 36-inch pipe. "This is an expensive, high-risk, high reward scenario," Nagle advises.

But by using a lower cost solution, Bug-O Piper-Bug, for example, with STT for root welding and fill passes using gas shielded FCAW, 30 joints per day can typically be achieved. "This is a much simpler automation option and much more suitable for Africa. It's a medium risk, medium reward alternative to full scale automation," he suggests.

"There are going to be a lot of opportunities for pipeline contractors all over the African continent," Nagle predicts. "The people who offer the solutions best suited to the environment, be they simple, robust and reliable or mechanised, effective and productive, are going to be chosen as partners," he says.

"We believe that Lincoln Electric has, more than anybody else, the experience and the solutions to meet the demands of pipeline welding anywhere in the world," he concludes. ■

Lincoln's VRTEX 360 virtual welding solution is an ideal tool for training and qualifying pipe welders in this scarce skill.