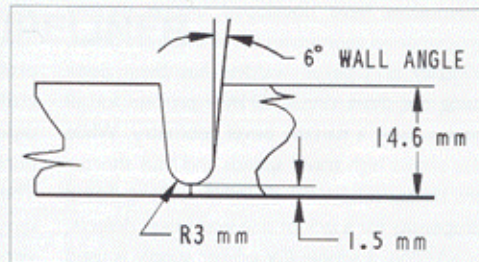


# Orbital narrow gap MCW pipe welding

Set-up for vertical down welding of Cr13WS2.5 (13Cr-6.5Ni-2.5Mo) super martensitic pipe material by NKK with the ESAB OK Tubrod 15.55-1.2mm metal cored wire, using pulse-MIG process in 99.5%Ar and 0.5%CO<sub>2</sub>. The pipe segments are fixed with an internal clamp with a copper backing providing weld metal support. Pipe dimensions: OD 322mm, WT 14.6mm. Orbital welding equipment supplied by MAGNATECH. Internal clamp supplied by WELD-TECH/VALK IPS. Weld head and power source. Internal pipe clamp can be seen protruding from pipe end.

The term orbital pipe welding generally refers to equipment used when an application calls for pipe to be welded in a fixed position and the torch must be rotated around the circumference of the pipe by a mechanism, commonly referred to as a weld head or bug. The term is misleading, however, when referring to equipment using the GMAW/FCAW processes. If the pipe is in the 5G (pipe horizontal) position, welding is done using either a double up (6 to 12 o'clock CW, followed by 6 to 12 o'clock CCW) or a double down technique (12 to 6 o'clock CW, followed by 12 to 6 o'clock CCW). (The only true orbital welding with GMAW/FCAW is when the pipe is in the 2G or vertical orientation.)

GMAW welding with solid wire is done both double up and double down. Flux cored arc weld-



Narrow Gap J-preparation.

ing is only done using the double up technique because of the possibility of flux entrapment when welding downhill. Metal cored wires are a variant of flux cored wires, but differ in that the flux consists almost entirely of metal. The significant difference, however, is that unlike more conventional flux cored wires which form a slag which must be removed following each weld pass, the metal cored wires do not. Small isolated islands of silicon on the solidified weld bead may be removed by brushing between passes or simply welding over as they will remelt and float to the weld puddle surface. This feature allows metal cored wires to be used welding either double up or double down.

FCAW filler wire is generally available in two formulations: downhand or all-position. All-position flux cored wire uses a different flux chemistry to allow pipe welding in all orientations including overhead. For orbital pipe welding, a rutile flux cored wire can be used in either the spray or pulse spray modes successfully. It should be noted that metal cored wires are available in one formulation. For all position welding with a metal cored wire, a pulsing power supply must be used to properly control the weld puddle.

With a proper groove geometry, double down welding can be done using relatively high average travel speeds in the 38-75cm/min (15-30 ipm) range. One technique to provide better puddle control at these high speeds downhill is to use a narrow groove bevel geometry. The joint geometry will be narrow enough to allow each pass to bridge from wall to wall either by using a relatively high speed torch oscillation motion, or by using a stringer bead technique without torch oscillation (weave).

Orbital or mechanised pipe welding equipment has been used in the cross country and marine pipeline

**A new metal cored wire (MCW) allows an old technique to be used for defect-free welding in 13%Cr supermartensitic stainless steel pipe material. John Emmerson familiarises us with narrow bevel orbital welding and provides a behind the scenes glimpse at the trials for the new filler wire.**



# Orbital welding

	Amperage (A)	Arc voltage (V)	Wire feed (m/min)	Welding speed (cm/min)	Torch oscillation
Root	178	17.5	6.0	22-70*	No
Fill (2 passes)	175	17.5	6.0	22-50*	No
Cap	140	18.0	3.0	18	Yes-minimal

Typical parameters used in the trials. Torch gas 99.5% Ar/0.5% CO<sub>2</sub>; Backing gas – None (Copper Backing). Total welding time = 14 minutes: four passes total. \*Welding speed was changed in different gravity positions, the data shows the range of speeds used.

industries for almost 30 years. Equipment manufacturers, or in some cases the contractors themselves have developed unique narrow groove bevel geometries to minimise arc times. Virtually all pipeline welding has been done using the short circuit GMAW process for all passes using a narrow bevel geometry. While this allows high travel speeds and thus shorter arc times, solid wire downhill welding has a propensity for a lack of side wall fusion defects. In addition, a simple CV power supply is used which cannot optimally control the process, leading to other types of weld defects.

## Trend towards higher strength alloys

The trend today is to operate gas pipelines at much higher pressures and flow levels than in the past. Rather than simply using heavy wall pipe, pipeline owners are increasingly opting to use new higher-strength alloys with relatively thinner wall pipe to minimise manufacturing, handling, and weld out time costs required by increased pipe wall thicknesses.

Certain pipeline applications require unique solutions. As new fields are being developed, the oil/gas may contain high levels of H<sub>2</sub>S, CO<sub>2</sub> or chlorides that aggressively attack standard pipeline steels. To date, there have been two conventional solutions to this problem: use of a pipe with an interior cladding of corrosion resistant material, or pipe fabricated completely of one of the duplex/super-duplex ferritic-austenitic alloys. The cost of the pipe using either approach is very high and great care must be taken in the welding technique for either ID clad or duplex to ensure the corrosion resistance is not lost during the welding process.

Pipes fabricated from 13%Cr Martensitic steels have been used with good success, showing excellent corrosion resistance for 'sour gas' applications in the gas production industry. Pipe fabricated of this material is significantly lower in cost than ID clad pipe and the duplex stainless steels. The original alloy developed, however, had shortcomings in its weldability, and a new alloy was developed (13 Cr–6.5 Ni –2.5 Mo) to overcome these limitations.

Pipes fabricated from 13%Cr Martensitic steels have been used with good success, showing excellent corrosion resistance for 'sour gas' applications in the gas production industry. Pipe fabricated of this material is significantly lower in cost than ID clad pipe and the duplex stainless steels. The original alloy developed, however, had shortcomings in its weldability, and a new alloy was developed (13 Cr–6.5 Ni –2.5 Mo) to overcome these limitations.

Pipes fabricated from 13%Cr Martensitic steels have been used with good success, showing excellent corrosion resistance for 'sour gas' applications in the gas production industry. Pipe fabricated of this material is significantly lower in cost than ID clad pipe and the duplex stainless steels. The original alloy developed, however, had shortcomings in its weldability, and a new alloy was developed (13 Cr–6.5 Ni –2.5 Mo) to overcome these limitations.

Pipes fabricated from 13%Cr Martensitic steels have been used with good success, showing excellent corrosion resistance for 'sour gas' applications in the gas production industry. Pipe fabricated of this material is significantly lower in cost than ID clad pipe and the duplex stainless steels. The original alloy developed, however, had shortcomings in its weldability, and a new alloy was developed (13 Cr–6.5 Ni –2.5 Mo) to overcome these limitations.

than ID clad pipe and the duplex stainless steels. The original alloy developed, however, had shortcomings in its weldability, and a new alloy was developed (13 Cr–6.5 Ni –2.5 Mo) to overcome these limitations.

The new alloy offers corrosion resistance for mildly sour environments in combination with high strength and good low temperature toughness and is specifically designed for field welding where the use of long-term post-weld heat treatment is impractical.

Many pipeline owners are reconsidering permissible defects when using these new high alloy materials. Although conventional short circuit GMAW has been used, owners and contractors are increasingly looking for other alternatives to the high defect and repair rate while maintaining the speed of double down solid wire welding.

The applied 'narrow cap' J-joint has a small land. Backing gas is not used.



Metal cored wires provide an impressive solution to the problem. Used with a pulsing power supply, the process is precisely controlled and more forgiving of welding technique than solid wire. Metal cored wires used in the pulsed mode ensure excellent sidewall fusion and good penetration into the parent material.

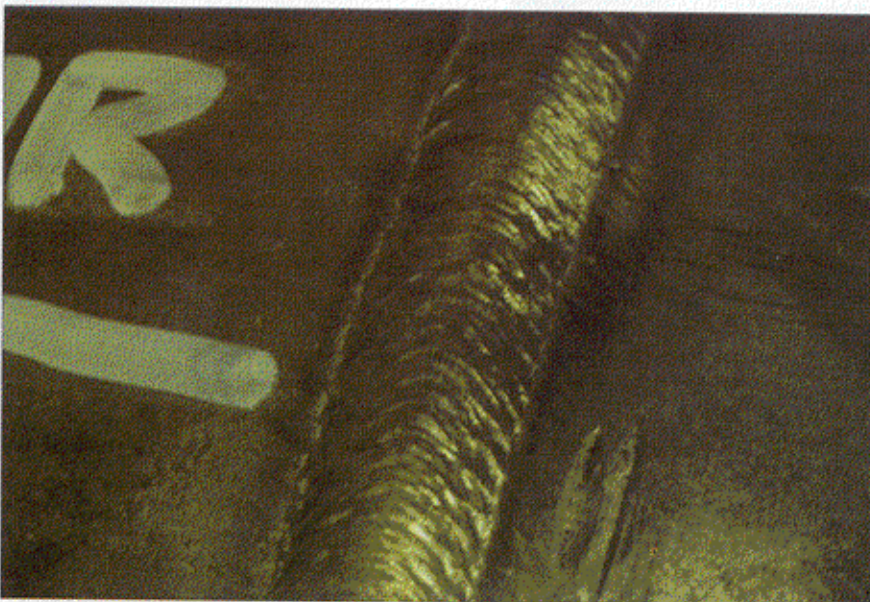
## Developing a new cored filler

A new metal cored filler wire had to be developed to weld this supermartensitic material. The new consumable was required to:

- Match the strength of the parent material.
- Match corrosion resistance.
- Achieve sufficient toughness.
- Maintain hardness at an acceptable level.
- Eliminate any post weld heat treatment.

ESAB formulated a 'matching' composition supermartensitic filler wire, OK Tubrod 15.55. When used with an appropriate weld procedure, this consumable will produce a high quality weld deposit consisting of a Martensitic microstructure.

Four companies undertook a collaborative



project to evaluate the performance of the new filler with the new 13% Cr pipe material and to demonstrate acceptability for orbital pipeline welding. A narrow groove J-prep bevel geometry was selected for use with the pipe ends butted tightly together. An expanding clamp with copper backing shoes was used to ensure precise pipe alignment and uniform root bead penetration. The Pipeliner System, manufactured by Magnatech, was used for the trials. This consists of a weld head which mounts on a track or band, sized to the specific pipe OD. The weld head rotates the torch around the pipe and manipulates the torch with capabilities of programmed torch weave or oscillation, and provides motorized adjustment of contact tip to workpiece distance. (This is known as a 'bug and band' type system in pipeline industry parlance.) The wire feeder is mounted on the head using a 5kg (10 lb) spool for precise wire delivery.

The Pipeliner System was interfaced with an ESAB Aristo LUD320W power source. This is a synergic type power source, meaning that there is a preprogrammed relationship between the pulsing parameters/power output and wire feed speed. A special program was created specifically for the new formulation ESAB filler wire (OK Tubrod 15.55 of 1.2mm diameter). Samples of 12 inch (322mm) pipe with a wall thickness of 14.6mm was supplied by NKK for the trials (13Cr-6.5Ni-2.5Mo).

Sample welds were made and used to develop a procedure. It can be seen from the weld cross section that excellent fusion was obtained in all gravity positions. Welds were destructively tested.

While the trials provided a solution for a particular problem faced by the pipeline industry, the techniques, equipment and consumables used, would be just as applicable for many welding applications in other industries. It was clearly demonstrated that with the proper equipment, a narrow groove bevel geometry with metal cored wires allows welds to be made in a fraction of the time of other techniques. Metal cored wires suitable for a wide range of pipe materials and strength requirements are readily available.

Orbital pipe welding requires a machined bevel on the end of the pipe. Portable end prep tools are available from numerous suppliers to machine rapidly a precise bevel in a fabrication shop or at a field work site. To machine a narrow groove J-preparation requires no additional time as compared to a conventional 37.5° or 30° 'V' bevel. The additional cost of metal cored wire versus other consumables is cost

efficient because of the significant reduction in filler metal required using a narrow groove bevel geometry. Both reduced weld out times

and defect-free welds significantly improve productivity and can cost justify investment in the equipment required. ■

*John Emmerson has a Bachelor of Science from Boston University, and a Master of Science from Cornell University. He has spent 24 years in the welding industry, and serves on the AWS D. 10 Committee of Piping and Tubing. For the last 14 years he has been President of Magnatech, based in Connecticut, USA with a European office in The Netherlands. Magnatech specialises in the manufacture of orbital pipe and tube welding equipment. The author would like to extend his gratitude for ESAB BV's invitation to participate in this project, and to the following companies which contributed in the project and provided materials for this article: Welding Consumables - ESAB BV; Pipe Material - NKK Europe Ltd; Internal Clamp - Weld-TechWalk IPS.*

## PIPELINER

The Pipeliner offers significant productivity improvement by increasing duty cycle, reducing repair rates, and producing welds of consistent quality meeting all Code standards.

The Pipeliner incorporates a "smart" digital power source, eliminating complex programming of interactive parameters. This new generation inverter power source uses dynamic process control for instantaneous response to changes in the welding arc. True adaptive control of the arc characteristics make the Pipeliner II extremely "forgiving" (both of workpiece variability and welder skill). The complex relationships between parameters such as wire feed speed, welding current, and arc voltage are pre-programmed, allowing variable control of a complex process which is totally transparent to the welder.

The Pipeliner has the capability of reproducing the precise motions of a skilled manual welder.

### WIRE FEED OPTIONS

Systems are available in Wire Feeder on Floor (WFOF) and Wire Feeder on Head (WFOH) configurations, allowing use for a wide variety of applications.

- **WFOF** - uses a conventional wire feeder mounting standard 15 kg (25 lb.) spools for lower wire costs. Ideal for fabrication shop use with smaller workpieces and when the wire feeder can be conveniently located near the weld Head.
- **WFOH** - uses a standard 5 kg (10 lb.) spool of wire mounted on the rotating Head with the feed mechanism. Ideal for use on large workpieces or for field erection where the weld Head must be operated at a distance (15m or more) from the power source and a floor-mounted feeder would be inconvenient.

### FEATURES

- Multi-pass welding of pipes in all gravity positions
- Broad pipe size range capability - 16.8 cm (6" pipe) and larger
- Very low spatter
- Small stable molten puddle
- Good penetration characteristics
- No cold lap or lack of fusion defects
- Water-cooled 300 amp torch using standard components
- Synergic (single knob) control of electrode speed/power source output
- Fix-Track allows ID and OD tank welding