Rotary Vertical Drilling System RVDS

MICON DRILLING

Drilling Equipment Made in Germany

MICON-Drilling GmbH
Im Nordfeld 14, 29336 Nienhagen, Germany
www.micon-drilling.de

Specifications are current at the time of printing.

Contents

Company Profile

The MICON-Drilling GmbH is a worldwide operating service company, specialized in sales and rental of drilling equipment. Decades of experience, high quality standards and focused customer orientation are our unique selling points.

We are a member of the MICON Group, established in Nienhagen/Germany, in 1994. The privately owned company specializes in design, production, inspection and repair of drill string components, drill bits, sophisticated directional drilling systems and additional equipment. Our main focus lies on the technical service for drilling applications in the mining, oil & gas, tunneling and geothermal industries.

An innovative engineering department ensures continuous optimization of all MICON products. Additionally, we are in close contact with a network of several German universities to foster research and development activities.

The MICON Group manufactures drilling equipment in two independent facilities on state-of-the-art CNC milling, turning and welding machines. Latest technology and implementation of German engineering guarantee the highest degree of efficiency and quality.

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MICON Buildings “Im Nordfeld”, Nienhagen/Germany

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Quality Policy

MICON stands for high quality products Made in Germany. This high quality standard builds the basis for our success and is an integral part of the company policy. This is reflected by long-term and trustful cooperation with our customers.

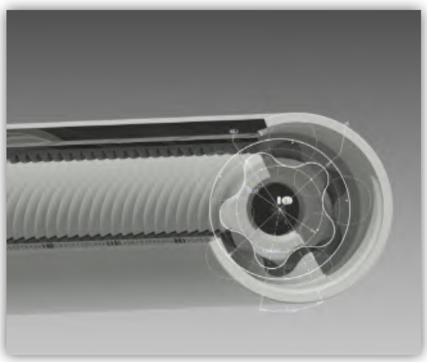
In order to achieve our high quality objectives the MICON Group manufacturing companies have implemented quality management systems certified according to international standards. The actual certification status of the Group companies is as follows:

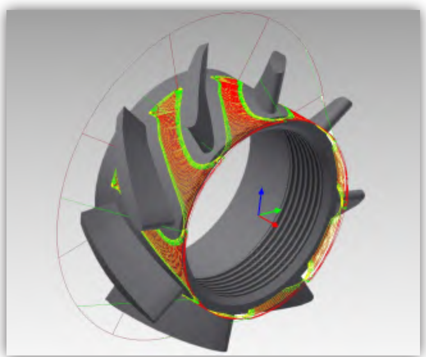
MICON Downhole-Tools GmbH:
- ISO 9001:2015 - 0019058
- API Spec. Q1 (No. Q1-4689)
- API Spec. 7-1 (Monogram License 7-1-1271)

MICON GmbH & Co.KG:
- ISO 9001:2015 - 00007159
- ISO3834-2:2006 (D-ZE-16083-01-00-ISO3834-2019.0013.002)

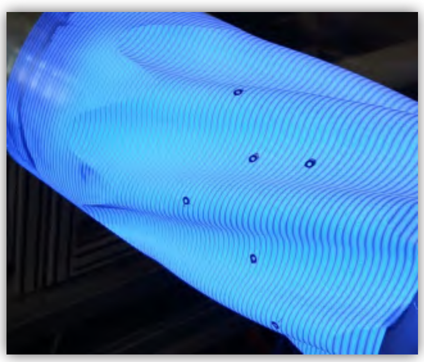
7-1-1271 Q1-4689

Our global quality objectives lead to specific targets, which are defined by the top management in cooperation with the quality manager. The fulfilment of these specific quality targets is evaluated at least every 12 months in the management review. Our ambition is product reliability and quality that meets the customer requirements as well as your high quality standards. The MICON product cycle includes different process steps. Rigorous acceptance criteria at every process step ensure a consistent high quality level of each product.


CAD based product development


CAD – CAM manufacturing


Permanent quality checks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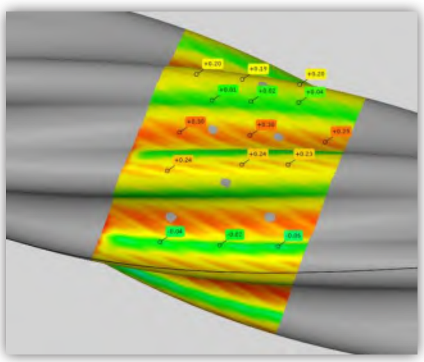
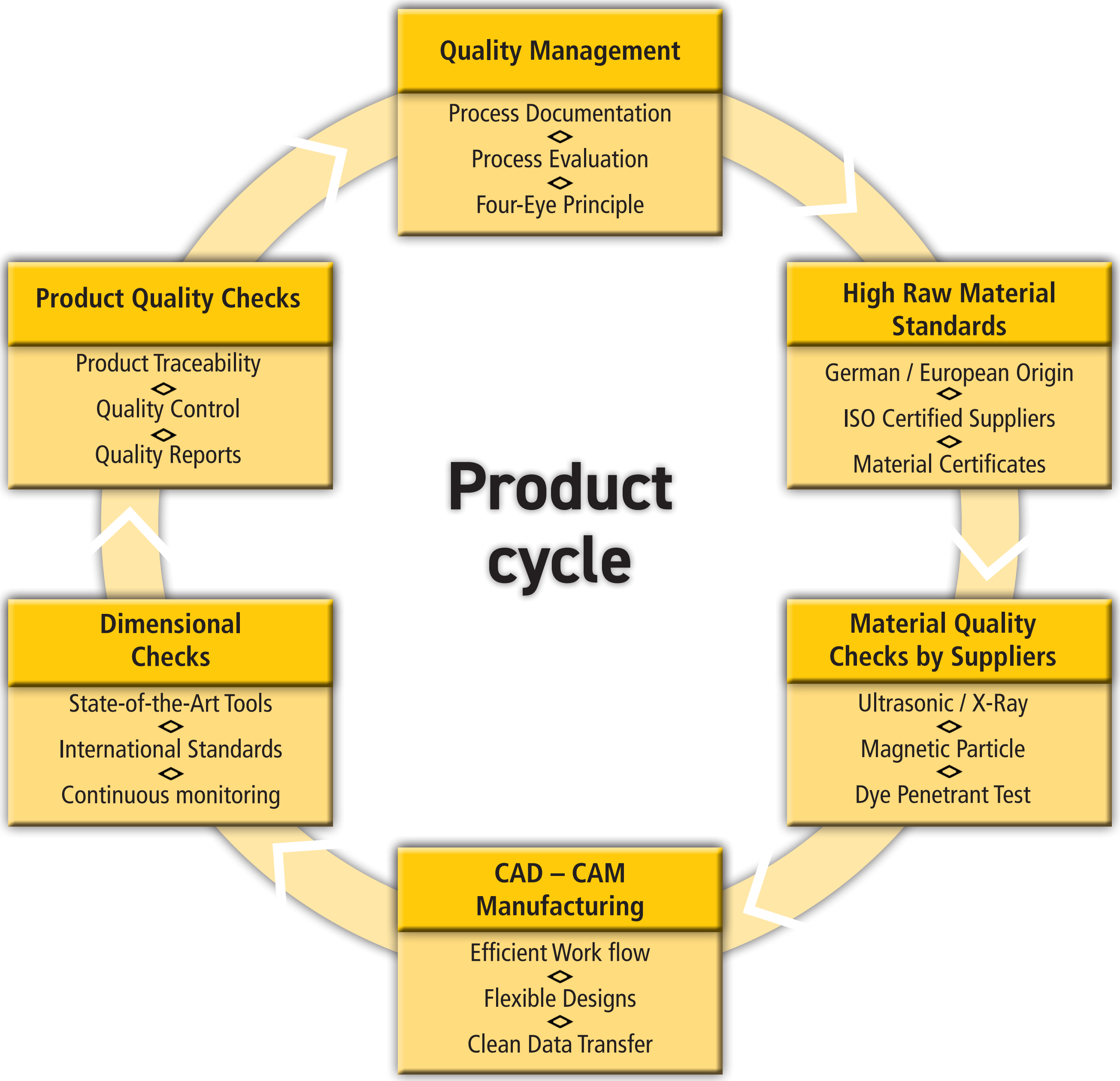

3-D scan evaluation


Quality Management
Process Documentation
Process Evaluation
Four-Eye Principle
High Raw Material Standards
German / European Origin
ISO Certified Suppliers
Material Certificates
Material Quality Checks by Suppliers
Ultrasonic / X-Ray
Magnetic Particle
Dye Penetrant Test
CAD – CAM Manufacturing
Efficient Work flow
Flexible Designs
Clean Data Transfer
Dimensional Checks
State-of-the-Art Tools
International Standards
Continuous monitoring
Product Quality Checks
Product Traceability
Quality Control
Quality Reports
Product cycle

The MICON RVDS

Improving the existing and designing new equipment for the raise boring industry is a core business and motivation for MICON. The well-known Rotary Vertical Drilling System (RVDS) targets drilling service for pilot-h ole drilling and opens new fields of activities for the raise boring industries. In more than 450 projects around the world the RVDS has proven its reliability and accuracy. In average the RVDS pilot holes deflect less than 0.1 % on the drilling distance, even under roughest conditions.

The RVDS is a pre-programmable, self-steering device for drilling vertical holes. It consists of two modules which are integrated in the lower part of the BHA between the drill bit and the first string stabilizer. A read out unit consisting of a pressure transducer, an interface unit and a computer in the driller cabin complete the system.

The data is submitted from the RVDS via positive mud pulse technology to the surface unit computer in real-time. This feature enables permanent control of the proper tool function and steering action. The steering capabilities can be improved by optimizing the drilling parameters, and so is direct and active steering not necessary.

For drilling in explosion-hazard sensitive areas the surface data-display equipment can be provided with ATEX certificates.

Lifetime and Accuracy Records

The RVDS shows outstanding reliability and accuracy. The tool is able to operate more than 600 hours without maintenance. Since 1993 an overall deviation of less than 0.1 % was achieved on over 130,000 drilling meters world wide.

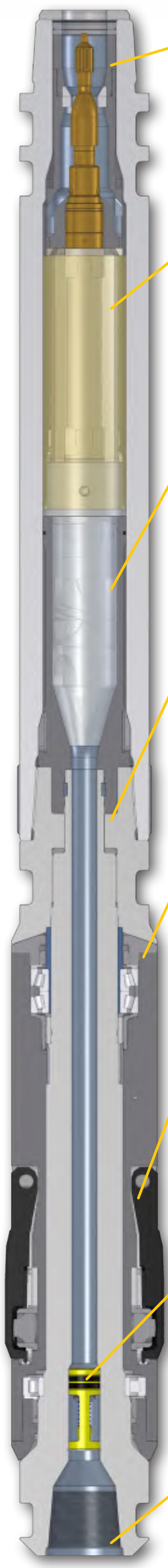
RVDS Accuracy Records (Example Selection)					
Year	**Country**	**Location**	**Meterage [m]**	**Deviation [m]**	**Deviation [%]**
2022	France	TELT I & II	505	0.21	0.042
2022	Ghana	Obuasi	928	0.32	0.034
2022	RSA	Venetia BAC	535	1.43	0.267
2022	RSA	Ivanplats Vent Shaft	940	0.43	0.046
2022	Canada	Thompson Mine I	1012	0.12	0.012
2022	Australia	Cadia VR11/3	761	0.25	0.033
2022	Portugal	Somincor CPV 25	620	0.1	0.016
2022	Australia	GF-Mine I	745	0.2	0.027
2021	Canada	Macassa IV	1004	0.1	0.010
2021	Sweden	Rävliden II	745	0.12	0.016
2021	Australia	Goldfields Waroonga	700	0.1	0.014
2021	Ireland	Tara Mine	559	0.23	0.041
2021	RSA	Venetia Mine IV	540	0.2	0.037
2021	Canada	Macassa Mine III	675	0.18	0.027
2020	Canada	Niobec	875	0.19	0.022
2020	Sweden	Rävliden I	745	0.19	0.026
2019	Poland	Knurow	810	0.16	0.020
2019	Australia	Cadia Mine II	850	0.22	0.026
2018	Australia	Gwalia Leonora VR7	926	0.2	0.022
2017	Australia	Cobar Mine III	816	0.18	0.022
2015	Australia	Callie Mine	782	0.22	0.028
2015	South Africa	Phalaborwa I	1184	0.22	0.019
2015	Ireland	Tara Mine	849	0.19	0.022
2015	Poland	Rescue Well Wujek	1054	0.41	0.039
2014	Zambia	Synclinorium I	670	0.22	0.033
2013	Australia	CSA Cobar	751	0.19	0.025
2012	South Africa	Doornkop M+R	815	0.19	0.023
2011	Mongolia	Mongolia	766	0.19	0.025
2010	Chile	Rescue Well San Jose	597	0.19	0.032
2009	Tasmania	Zinifex II	622	0.25	0.040
2008	South Africa	Karee Shaft	1074	0.42	0.039
2007	Italy	Brissogne	558	0.01	0.002
2006	Poland	Lagoszow	655	0.09	0.014
2005	Australia	Cracow Mine	260	0.10	0.038
2004	South Africa	Premierer Mine	708	0.07	< 0.001
2003	Taiwan	Pingling Tunnel	501	0.23	< 0.001
2002	Switzerland	Gotthard Basistunnel	785	0.38	< 0.001

Schematic View

The RVDS tool incorporates two modules. The upper part carries the hydraulic oil reservoir tank, the turbine-generator unit, the hydraulic pumps and the mud pulser unit. The lower module is situated directly behind the drill bit. It carries a non-rotating sleeve with hydraulically activated steering ribs and the electronic components. 2-axis inclinometers measure the actual deviation against the vertical axis in real-time while drilling. Deviations are corrected automatically by four steering ribs that push against the borehole wall and bring the RVDS back into vertical position. The steering action is performed continuously while drilling.

The RVDS is not carrying batteries or accumulators. Water or drill mud flushing through the tool activates the turbine. The generator reaches 25-75 volts and up to 2A in standard configuration at a defined flow rate. A float valve prevents reverse flow and prevents cuttings entering the tool when flushing is interrupted. The internal hydraulic pressure of the tools is restricted to 100 bars.

The collected and processed data is transmitted from the RVDS to the surface unit by positive mud pulse technology. A conical piston partially interrupts the flow through the RVDS and creates pressure drop in the tool. This pressure change is measured by the transducer that is installed in line between the pump and the drilling machine. A predefined sequence of pressure pulses creates a signal which is logged by the transducer. The surface unit, located between the transducer and the computer, decodes the signal which is then displayed on the screen. The data recording about deviation against the vertical axis and the actual tool status is continuous but the information displayed on the computer screen is refreshed every 2 minutes.



Mud Pulser Unit

Data transmission to the surface via positive mud pulse

Hydraulic Oil Tank

Hydraulic oil reservoir for the pressure cycle

Generator Unit

Provides electric power and carries the internal electronic boards

Conn. Upper / Lower Section

Enables to split the tool into two smaller subunits

Non-Rotating Stabilizer

Internally mounted. Carries the inclination sensors

Steerable Ribs

Hydraulic activated ribs enable automatic vertical drilling

Float Valve

Prevention of cuttings / mud entering the tool

Bit Box

API REG box connecting RVDS tool and drill bit

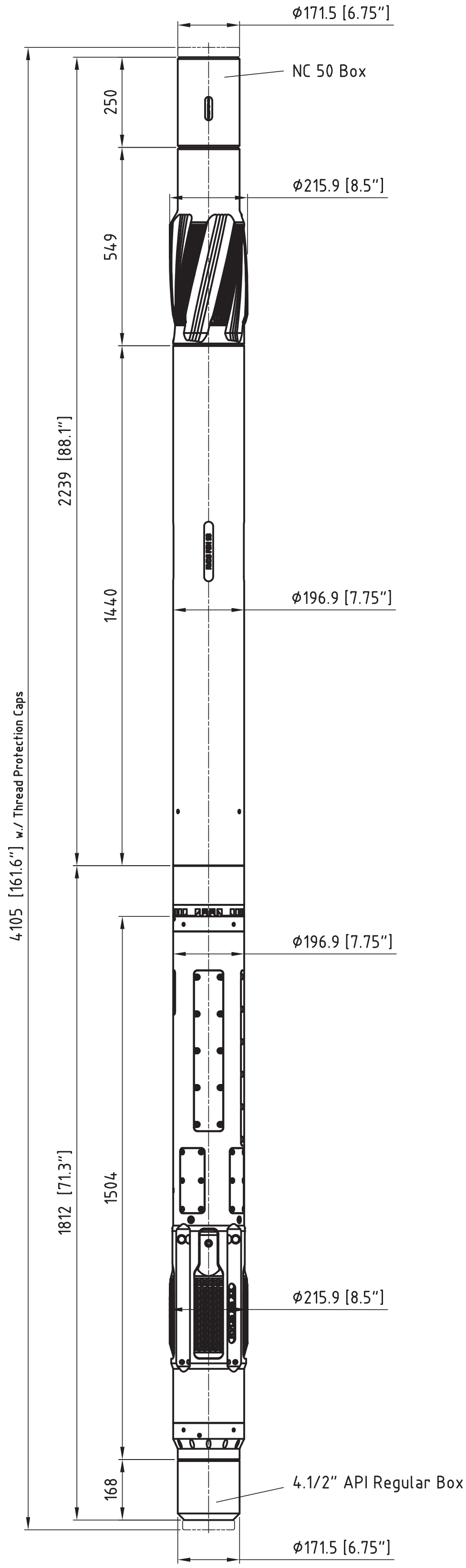
Overview RVDS Tools

	RVDS Tool 7 ¾″ Borehole Diameter 8 ½″ - 9″		RVDS Tool 10″ Borehole Diameter 12 ¼″ - 13 ¾″		RVDS Tool 12⅞″ Borehole Diameter 15″ - 17 ½″	
	Metric	*Imperial*	*Metric*	*Imperial*	*Metric*	*Imperial*
Make-up Torque						
Bit - Steerable Stabilizer Sub	9 kNm	6,600 ft-lbs	20 kNm	14,500 ft-lbs	30 kNm	22,000 ft-lbs
Steerable Stabilizer - Saver Sub	15 kNm	11,000 ft-lbs	70 kNm	51,000 ft-lbs	500 kNm**	370,000 ft-lbs**
Saver Sub - Drill string	20 kNm	14,700 ft-lbs	70 kNm	51,000 ft-lbs	250 kNm* / 320 kNm**	180,000 ft-lbs* / 320,000 ft-lbs**
Flow Rate						
Minimum	750 l/min	198 gpm	750 l/min	198 gpm	MFT = 1000 l/min HFT = 1200 l/min	MFT = 265 gpm HFT = 315 gpm
Maximum	1,100 l/min	290 gpm	1,500 l/min	400 gpm	MFT = 1,600 l/min HFT = 2750 l/min	MFT = 425 gpm HFT = 725 gpm
Internal RVDS Pressure Drop (Without pulser and drill string)						
Minimum Flow (750 l/min)	10 bar	150 psi	8 bar	116 psi	10bar	150 psi
Maximum Flow (1,100 l/min)	15 bar	220 psi	15 bar	217 psi	25 bar	360 psi
Total Pressure Drop (With pulser and drill string)						
Recommended Pump 80 kW (1,100 l/min)	40 bar	580 psi	40 bar	580 psi	50 bar	725 psi
Axial Forces						
Maximum WOB ***	8 t	17,500 lbs	20 t	44,000 lbs	25 t	55,000 lbs
Maximum Pull (bit stuck)	30 t	66,000 lbs	300 t	66,000 lbs	100 t	220,000 lbs
Maximum Pull (steerable stab. stuck)	10 t	22,000 lbs	10 t	22,000 lbs	10 t	22,000 lbs
Rotational Speed						
Operational RPM	10 - 100 1/min	10 - 100 1/min	10 - 60 1/min	10 - 60 1/min	10 - 60 1/min	10 - 60 1/min
Maximum RPM	110 1/min	110 1/min	65 1/min	65 1/min	70 1/min	70 1/min

Parameters RVDS Tool 7 ¾"

RVDS Tool 7 ¾" for Borehole Diameter 8 ½" - 9"		
	Metric	Imperial
Make-up Torque		
Bit - Steerable Stabilizer Sub	9 kNm	6,600 ft-lbs
Steerable Stabilizer - Saver Sub	15 kNm	11,000 ft-lbs
Saver Sub - Drill string	20 kNm	14,700 ft-lbs
Flow Rate		
Minimum	750 l/min	198 gpm
Maximum	1100 l/min	290 gpm
Internal RVDS Pressure Drop*		
Minimum Flow (750 l/min)	10 bar	150 psi
Maximum Flow (1100 l/min)	15 bar	220 psi
Total Pressure Drop**		
Recommended Pump 80 kW (1100 l/min)	40 bar	580 psi
Axial Forces		
Maximum WOB	8 t	17,500 lbs
Maximum Pull (bit stuck)	30 t	66,000 lbs
Maximum Pull (steerable stab. stuck)	10 t	22,000 lbs
Rotational Speed		
Operational RPM	10 - 100 min^{-1}	10 - 100 min^{-1}
Maximum RPM	110 min^{-1}	110 min^{-1}

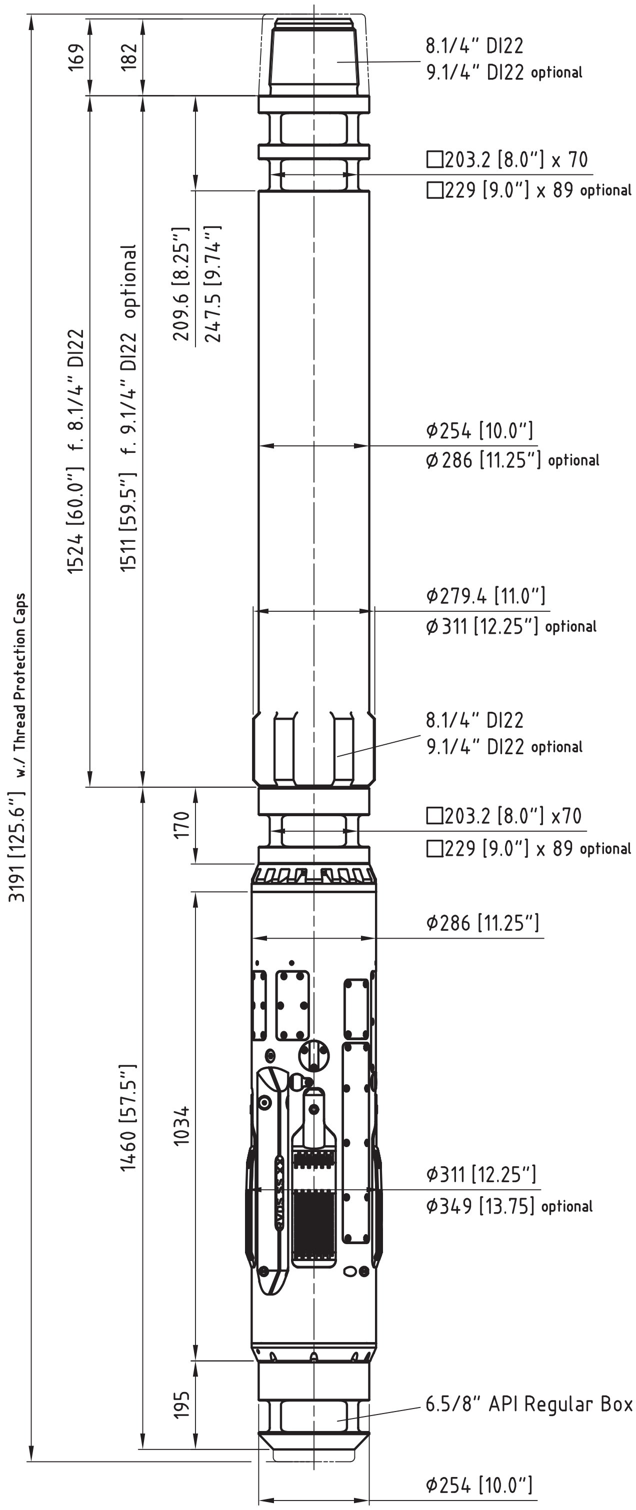
* Without pulser and drill string
** With pulser and drill string



Operation Parameters RVDS Tool 10"

RVDS Tool 10" for Borehole Diameter 12 ¼" - 13 ¾"		
	Metric	Imperial
Make-up Torque		
Bit - Steerable Stabilizer Sub	20 kNm	14,500 ft-lbs
Steerable Stabilizer - Saver Sub	70 kNm	51,000 ft-lbs
Saver Sub - Drill string	70 kNm	51,000 ft-lbs
Flow Rate		
Minimum	750 l/min	198 gpm
Maximum	1500 l/min	400 gpm
Internal RVDS Pressure Drop*		
Minimum Flow (750 l/min)	8 bar	116 psi
Maximum Flow (1500 l/min)	15 bar	217 psi
Total Pressure Drop**		
Recommended Pump 80 kW (1100 l/min)	40 bar	580 psi
Axial Forces		
Maximum WOB	20 t	44,000 lbs
Maximum Pull (bit stuck)	300 t	66,000 lbs
Maximum Pull (steerable stab. stuck)	10 t	22,000 lbs
Rotational Speed		
Operational RPM	10 - 60 min^{-1}	10 - 60 min^{-1}
Maximum RPM	65 min^{-1}	65 min^{-1}

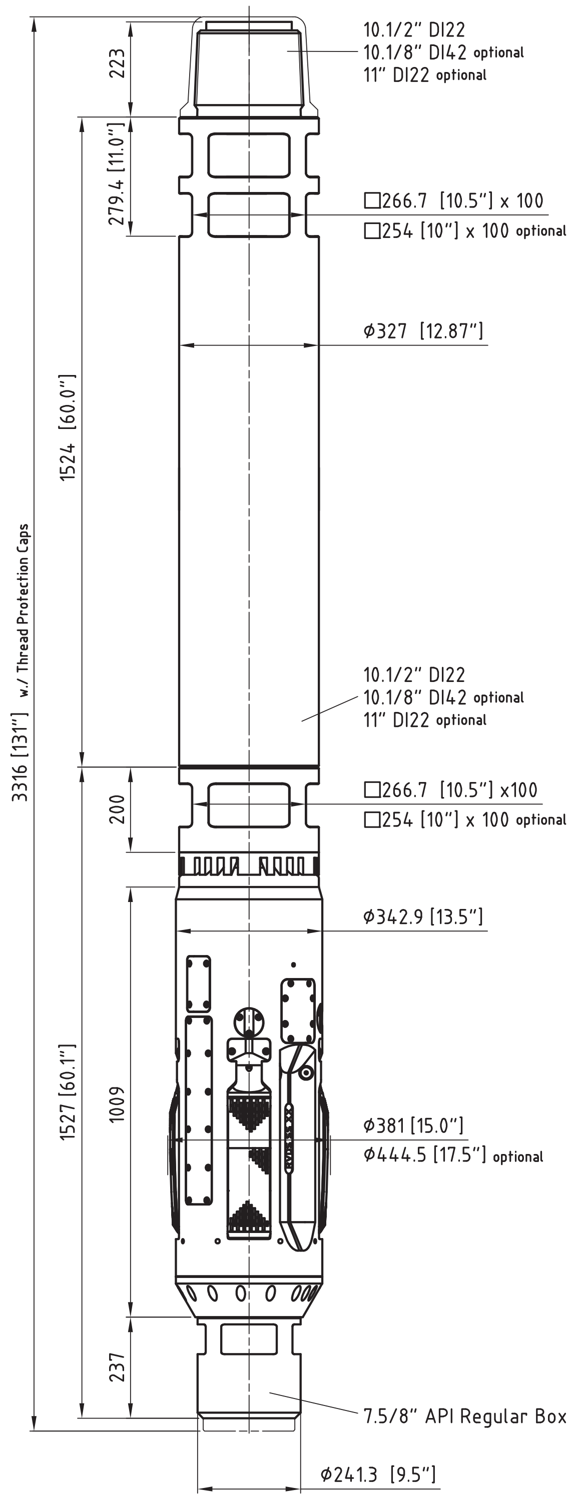
* Without pulser and drill string
** With pulser and drill string



Operation Parameters RVDS Tool 12 ⅞"

RVDS Tool 12 ⅞" for Borehole Diameter 15" - 17 ½"		
	Metric	Imperial
Make-up Torque		
Bit - Steerable Stabilizer Sub	30 kNm	22,000 ft-lbs
Steerable Stabilizer - Saver Sub	500 kNm	370,000 ft-lbs*
Saver Sub - Drill string	250 kNm* / 320 kNm**	180,000 ft-lbs* / 320,000 ft-lbs**
Flow Rate		
Minimum	1000 l/min	265 gpm
Maximum	1600 l/min	425 gpm
Internal RVDS Pressure Drop* **		
Minimum Flow (1000 l/min)	10 bar	150 psi
Maximum Flow (1600 l/min)	25 bar	360 psi
Total Pressure Drop******		
Recommended Pump 100 kW (1500 l/min)	50 bar	725 psi
Axial Forces		
Maximum WOB	25 t	55,000 lbs
Maximum Pull (bit stuck)	100 t	220,000 lbs
Maximum Pull (steerable stab. stuck)	10 t	22,000 lbs
Rotational Speed		
Operational RPM	10 - 60 min^{-1}	10 - 60 min^{-1}
Maximum RPM	70 min^{-1}	70 min^{-1}

* DI22 String Thread
** DI42 String Thread
***Without pulser and drill string
**** With pulser and drill string



Use of automatically controlled vertical drilling systems in drilling projects with the highest requirements on accuracy

Dipl.-Ing. Kai Schwarzburg, Managing Director, MICON Drilling GmbH, Nienhagen, Germany

Because of the increasing depths automatically controlled directional drilling systems are being used to an increasing extent in the surveying and development of deposits in the international mining industry. Two completed projects, in which the function and handling of these systems are explained, are described in the contribution.

The surveying and development of deposits in the worldwide mining industry require the wider use of reliably operating automatically controlled directional drilling systems. The fields of application of these systems extend over the entire spectrum of drilling technology in the mining industry – from freezing boreholes via degasification boreholes to pilot boreholes for raise boring. Two completed projects, in which the function and handling of these systems defining the state of the art are explained, are described below.

Drilling of freezing boreholes with a diameter of 8 ½" to a final depth of 650 m in a specified target window of 0.3 m diameter for a shaft sinking project in Poland.

Drilling a pilot borehole with a diameter of 13 ¾" to a depth of 865 m in a specified target window of likewise 0.3 m diameter for a subsequent raised borehole in the Canadian gold mining industry.

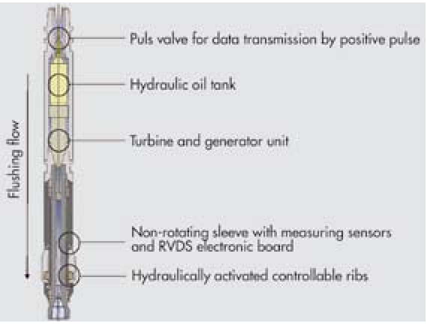


Figure 1. Sectional representation of MICON-RVDS.

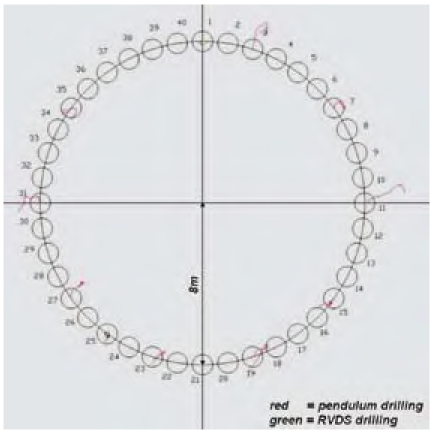


Figure 2. Arrangement of the freezing boreholes in Lagoszow, Poland, with representation of the drilling results of conventional methods compared to the use of the RVDS.

The possible combinations of this system originally developed for specific applications with the different available drilling rods and rigs as well as the widely varying geology in the different areas of the mining industry with a uniform and reliable method of operation distinguish these automatically controlled systems from conventional directional drilling technology.

Construction and method of operation of the MICON-RVDS

In the drilling rod the so-called rotary vertical drilling system (RVDS) is installed immediately behind the roller bit. The MICON-RVDS consists of two 1.5 m long components (Figure 1). The lower component carries the control ribs as well as the electronic control and measuring system on a non-rotating sleeve. The power supply, data transmission and the hydraulic tank are incorporated in the upper component.

The actual inclination values are measured and adjusted continuously with the required values during drilling. If the measured values deviate from the required values – i.e. the tool moves from the vertical – the control ribs are activated and act against the build-up of deflection. The measured inclination values are converted into signals and are transferred from the lower to the upper component for transmission to the surface. At the same time these measured values as well as other relevant data such as flushing floor, borehole temperature and control status in the RVDS are stored internally.

The incoming signals are transmitted by so called positive pulse technology from the upper component to the surface. Furthermore, a turbine and hydraulic tank are incorporated in the upper component. This turbine is driven by the flushing flow. An electrical generator and the hydraulic pumps are connected to the turbine. With the turbine running both the required electrical energy for the internal power supply as well as the hydraulic pressure for actuation of the control ribs are generated. The hydraulic oil for equalisation of small leakages is stored in the hydraulic tank.

Depending on the application the RVDS is supplied in individual components or fully assembled – usually in 1.5 m long components for use on raise bore machines or fully assembled in a length of 3 m for use on rotary drilling rigs. Different RVDS adapted to the borehole diameter are used.

The usual RVDS diameters are as follows:
7 ¾",
10" and
12 7/8"
with the suitable control ribs in the borehole diameter.

Common borehole diameters are as follows:
8 ½".
9 ½".
13 ¾".
15".
17 ½".
The systems are adapted for diameters deviating from the above.

Fields of application

The RVDS are used almost exclusively in areas, in which the highest accuracy requirements have to be met with regard to the course of the borehole and target window.

The borehole diameter of 8 ½", for example, is a common diameter for freezing boreholes. In this case a small target window has to be hit with the straightest possible course of the borehole from the start of drilling to the final depth.

The borehole diameters of 12 ¼", 13 ¾" and 15" are customary diameters in raise boring. In this case the requirements are again the same as those for freezing boreholes, viz. the straightest possible course of the borehole from the start of drilling to final depth in a small target window. Regardless of the borehole diameter the accuracies achievable with the RVDS are in the per thousand range referred to the borehole length – on average accuracies of 0.25 m referred to 500 m borehole length have been achieved over the past 15 years (Table 1).

Other fields of application are gas storage boreholes and boreholes for supply pipes in the mining industry. The borehole diameters in these applications of 16" and 17 ½" respectively differ from the above-mentioned diameters.

Use of RVDS in freezing boreholes in Lagoszow, Poland

It was necessary to stabilise the rock by freezing boreholes before sinking a winding shaft in Lagoszow, Poland (Figure 2). A total of 36 boreholes were drilled with the 7 ¾" x 8 ½" RVDS to depths of 430 m and 650 m.

The bottom hole assembly (BHA) for depths up to 430 m consisted of an IADC 1-1-7 or 1-1-8 roller bit, the 7 ¾" x 8 ½" RVDS, an undersize stabiliser behind the RVDS, 6 ½" heavy rods and 5" API drilling rod. Because of the harder rock

Table 1. RVDS field results from 1993 to 2008 (153 projects).

RVDS	Drilled distance by continent		Average deviation
7 3/4" (8 ½" – 9 ⅞" holes)	18,739 m	Europe	0.05 %
	–	Asia	–
	–	Australia	–
	–	Africa	–
	–	North America	–
	–	South America	–
Total	**18,739 m**	**Worldwide**	**0.05 %**
9 1/2" (12 ¼" – 13 ¾" holes)	7,948 m	Europe	0.13 %
	3,879 m	Asia	0.23 %
	1,738 m	Australia	0.08 %
	753 m	Africa	0.23 %
	1,010 m	North America	0.10 %
	–	South America	–
Total	**15,328 m**	**Worldwide**	**0.15 %**
10" (12 ¼" – 13 ¾ holes)	1,290 m	Europe	0.04 %
	1,104 m	Asia	0.04 %
	573 m	Australia	0.10 %
	–	Africa	–
	835 m	North America	0.08 %
	–	South America	–
Total	**3,802 m**	**Worldwide**	**0.06 %**
12 ⅞" (15" – 17 ½" holes)	3,056 m	Europe	0.05 %
	–	Asia	–
	3,315 m	Australia	0.07 %
	3,818 m	Africa	0.06 %
	2,062 m	North America	0.21 %
	1,399 m	South America	0.34 %
Total	**15,591 m**	**Worldwide**	**0.10 %**
Total all RVDS-Sizes	**53,460 m**	**Worldwide**	**0.09 %**

Figure 3. Photograph of the RVDS on the rig floor.

Figure 4. View of drilling rigs in Lagoszow, Poland.

Figure 5. Installation of the RVDS in RBM Robbins 85R.

Figure 6. Break-through with RVDS in Rouyn, Canada.

the deeper boreholes below 430 m to the final depth were drilled with an IADC 4-3-7 roller bit, but otherwise the same BHA. In addition three monitoring boreholes were drilled to depths of 650 and 850 m outside the actual freezing circle (Figure 3).

During the entire project boreholes were drilled in parallel with two rigs. On average a gross drilling rate of 3.6 m/h was achieved over the entire project period. The nett drilling rate was higher by a factor of 2 than the gross drilling rate. A total of 18,000 m freezing boreholes and 2,100 m monitoring boreholes were drilled.

All boreholes remained over their full length within a "target cylinder" with a diameter of 0.3 m – including the borehole diameter of 0.2 m (Figure 4).

Use of RVDS in a pilot borehole for subsequent raise boring in Rouyn, Canada

A 13 ¾" pilot borehole for the subsequent raising of a ventilation shaft in Rouyn, Canada, was drilled with the RVDS. The borehole was drilled to a final depth of 865 m in a target window of 0.3 m diameter. The BHA from the start of drilling to the final depth consisted of an IADC 5-1-7 roller bit, the 10" x 13 ¾" RVDS, a roller reamer behind the RVDS, three 12 ⅞" x 10 ½" DI raise bore rods, an undersize stabiliser and subsequently 12 ⅞" x 10 ½" DI raise bore rods, an undersize stabiliser and subsequently 12 ⅞" x 10 ½ " DI 22 raise bore rods (Figure 5).

No deviation (dogleg) was measurable over the total borehole length, i.e. the straight borehole could be used without restriction for the raising in the planned diameter of 4.5 m. The drilling rate of 1.5 m/h usual in raise boring was always achieved. When the worn bit was changed the RVDS was also changed. Two round trips over a drilling length of 865 m were required for this purpose (Figure 6).

Prospects

The following RVDS further developments are currently at the planning stage or are nearing completion. The development of a 3-D-tool, a system which can drill in any direction after suitable programming is being planned. Development of an RVDS for drilling by the airlift method will be completed in April/May 2009. Both the EM data transmission system and the bidirectional communication with the RVDS, which will permit "reprogramming" and communication during drilling, will be completed in May/June 2009.

It is foreseeable that automatically controlled systems will be more widely used in future. This is associated firstly with the fact that the increasing complexity of imminent projects requires new approaches to solutions and secondly that the mere availability of these systems now permits the planning and execution of specific projects, which had already been planned five years ago, but at the time were feasible only at high costs. Only completed raise boring in the mining industry to a final depth of more than 1,000 m from existing roadways and freezing boreholes with the highest requirements on the course of the borehole and target accuracy are mentioned here as examples.

Notes

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