

CENTERFIRE LWD SYSTEMS OVERVIEW

Rev 1.0

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INNOVATION | TECHNOLOGY | SERVICES

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Black Diamond

Black Diamond is a proud successor to Tensor™ and Centerfire™ MWD-LWD line of downhole directional guidance tools produced by GE Oil & Gas (now Baker Hughes, a GE Company).

Our senior leadership team is comprised of industry professionals skilled in technology, operations, service delivery, and business management. We continually invest in improving the technology platform and enhancing the ease of doing business — all geared to improve our customers' operational efficiency and profitability.

With manufacturing, R&D, and engineering based in Houston, TX, Black Diamond also maintains a local presence in key international growth markets. Our diverse customer base includes service branches of major network operations centers and independent service providers worldwide.

The platform of choice for low cost operations, our product offerings and custom solutions that range from addressing product reliability, improvements in drilling efficiency, precise wellbore placement, and reduction in non-productive time.

The Tensor™ MWD platform offers directional-gamma measurements via a probe-based retrievable architecture that supports 175°C high-temperature and 20,000psi high-pressure applications.

The Centerfire™ LWD provides signature 2MHz & 400KHz fully compensated propagation resistivity measurements via a collar-based architecture that also supports high-temperature and high-pressure applications.

Centerfire Resistivity System

The Centerfire resistivity system is Black Diamond's high-temperature LWD offering. Rated to 175°C the system is available in three standard sizes - 4.75", 6.91" and 8.25". The collar uses an industry standard transmitter-receiver design to provide eight different depth of investigation [DOI] borehole compensated resistivities.

The Centerfire collar is designed to provide existing Tensor Elite MWD customers an easy upgrade from directional or directional-gamma services to LWD while minimizing the total cost of ownership.

Black Diamond's commitment to customer success is demonstrated by an exemplary support network encompassing market leading repair services, comprehensive training (both e-learning and hands-on), localized support teams, and a dedicated website delivering best in class support materials.

Features and Benefits

Borehole Compensated Measurements

Industry standard antenna layout with 483 mm & 1041 mm antenna spacings, measuring both phase difference and attenuation, provides eight borehole compensated measurements, any of which can be transmitted in real time.

Deep-Reading Measurements

The deep-reading 400 kHz measurements from the 1041 mm antenna spacings are ideal for geosteering and bed-boundary detection when combined with the shallower reading 2 MHz measurements from the 483 mm antenna spacings. The 2 MHz measurements also offer excellent vertical resolution for thin bed identification.

High Temperature as Standard

The Centerfire system is recognized as the system of choice for hot hole applications, with 175 °C operating temperature as a non-price premium standard.

Retrievable MWD String

The Smart Connect System provides connection between the MWD string and the resistivity collar enabling retrieval of the directional module if the BHA becomes stuck or lost in the hole.

Cost Effective Fleet Management

Use of standard Tensor MWD and Gamma modules, together with the Tensor surface system, allows Centerfire users to maximize their fleet usage.

Easily Maintained

Centerfire was designed to enable simple maintenance. Wear parts are easily serviced and all electronics are accessible below hatch covers to allow drop-in replacement, where required. Calibration by way of air hang can be completed in less than 1 hour.

Proven Performance

With a history of successful deployments, including notable multi-lateral applications in China and Russia, the Centerfire system enables independent service companies to expand their

service options, allowing them to compete in technologically advanced markets, with a cost-effective, proven platform.

History and Experience

Covering 20 years, over 200 collars have been successfully deployed in many of the most important global markets. During this time systems were sold to operators and so collection of accurate operational metrics was very difficult. The system has been operated extensively at the top end of the 175 °C temperature through scores of operations in China. Cumulative footage on all collars must be well in excess of 1 million feet.

Continuous development of the system has focused on reliability and operating cost. Since 2021 major improvements have been made on the Smart Connection system delivering both ease of use with unmatched physical and electrical connection reliability.

The continued success of the system is demonstrated by its long, and globally diverse operational history:

- China – Over 100 collars have been operating in China for over 15 years. Customers range from research institutes, through independent service providers to state oil companies.

Refer to Appendix 1 - Case Studies China

Based on the continued success of the operations in China CNPC tasked the Centerfire team to design and deliver two bespoke offerings:

DDDC has quantity 34 Centerfire Resistivity tools. At present, it served 213 wells, with 46,241.5 downhole working hours, 24,9721.5 circulating hours, and well completed footage of 264,397 meters. Centerfire Resistivity tools produced by Tensor Drilling Technologies have made great contribution to our company's market development, revenue generation.

Directional Drilling Services Company
BHDC, CNPC 2021.7.8

- Russia – The second largest Centerfire market saw tools supplied to five independent service companies for over 10 years.

Refer to Appendix 1 - Case Studies China

- Americas – Deployed both onshore and offshore in North and South America. Most recent deployment saw Black Diamond running the operation In Louisiana, November 2022.
- Africa – First deployment of Memory Only systems in Congo 2020



Specifications

Mechanical Specifications - Imperial			
	4.75 in.	6.91 in.	8.25 in.
Tool OD	5.0 in. at antennas, 5.25 in. at wearbands	6.91 in. at antennas, 7.16 in. at wearbands	8.25 in. at antenna, 8.5 in. at wearbands
Length	14.5 ft (174 in.)	14.5 ft (174 in.)	15.16 ft (182 in.)
Tool Connections	3½ in. IF (NC-38)	4½ in. IF (NC-50)	6⅝ in. API Reg
Equivalent Collar Stiffness (OD x ID)	5.00 in. x 2.81 in.	6.58 in. x 2.81 in.	8.25 in. x 2.81 in.
Make-Up Torque	9,600 lbf-ft	30,000 lbf-ft	54,000 lbf-ft
Max. Flow Rate	100 - 350 usgpm	300 - 750 usgpm	450 - 1200 usgpm
Max. Dogleg Rotating	12.2°/100 ft	8°/100 ft	7°/100 ft
Max. Dogleg Sliding	25°/100 ft	17°/100 ft	14°/100 ft
Max. Temperature - Operating	347°F		
Max. Pressure	20,000 psi		
Max. Sand Content	1% (volume)		
Max. LCM Tolerance	As per Tensor		

Telemetry Type	Positive pulse		
Resistivity Measure Points from Tool Bottom	Directional Resistivity Gamma		
	22.2 ft (266 in.)	22.2 ft (266 in.)	22.9 ft (275 in.)
	6.1 ft (73.2 in.)	6.1 ft (73.2 in.)	6.8 ft (81.6 in.)
	2.8 ft (33.6 in.)	2.5 ft (30 in.)	2.2 ft (26.4 in.)
Memory Capacity	14 MB (~250 hours with 10 second recorder rate)		
Min. Data Sampling	Every 8 seconds		
Battery Life	~150 hours		

Mechanical Specifications - Metric

	4.75 in.	6.91 in.	8.25 in.
Tool OD	127 mm at antennas, 133 mm at wearbands	176 mm at antennas, 182 mm at wearbands	210 mm at antennas, 216 mm at wearbands
Length	4.42 m	4.42 m	4.62 m
Tool Connections	3½ in. IF (NC-38)	4½ in. IF (NC-50)	6⅝ in. API Reg
Equivalent Collar Stiffness (OD x ID)	127 mm x 72 mm	176 mm x 72 mm	210 mm x 72 mm
Make-Up Torque	13.0 kNm	40.6 kNm	73.1 kNm
Max. Flow Rate	379 - 1325 lpm	1136 - 2839 lpm	1703 - 4542 lpm
Max. Dogleg	12.2°/30.5 m	8°/30.5 m	7°/30.5 m
Max. Dogleg Sliding	25°/30.5 m	17°/30.5 m	14°/30.5 m
Max. Temperature - Operating	175°C		
Max. Pressure	137.9 MPa		
Max. Sand Content	1% (volume)		
Max. LCM Tolerance	As per Tensor		
Telemetry Type	Positive pulse		
Resistivity Measure Points from Tool Bottom	Directional Resistivity Gamma		
	6.77 m	6.77 m	6.98 m
	1.86 m	1.86 m	2.07 m
	0.85 m	0.85 m	0.67 m
Memory Capacity	14 MB (~250 hours with 10 second recorder rate)		
Min. Data Sampling	Every 8 seconds		
Battery Life	~150 hours		

Sensor Specifications				
	Spacing	Frequency	Range	Accuracy
Phase Difference	41 in. / 1041 mm	2 MHz	0.1 to 2,000 ohm-m	± 2% (0.1 to 20 ohm-m) ± 1 mmho/m (>20 ohm-m)
		400 kHz	0.1 to 500 ohm-m	± 2% (0.1 to 10 ohm-m) ± 2.0 mmho/m (>10 ohm-m)
	19 in./ 483 mm	2 MHz	0.1 to 1,000 ohm-m	± 1% (0.1 to 10 ohm-m) ± 1 mmho/m (>10 ohm-m)
		400 kHz	0.1 to 250 ohm-m	± 3% (0.1 to 5 ohm-m) ± 6 mmho/m (>5 ohm-m)
Attenuation	41 in. / 1041 mm	2 MHz	0.1 to 50 ohm-m	± 5% (0.1 to 16 ohm-m) ± 3 mmho/m (>16 ohm-m)
		400 kHz	0.1 to 10 ohm-m	± 3% (0.1 to 3 ohm-m) ± 10 mmho/m (>3 ohm-m)
	19 in./ 483 mm	2 MHz	0.1 to 50 ohm-m	± 5% (0.1 to 8 ohm-m) ± 6 mmho/m (>8 ohm-m)
		400 kHz	0.1 to 10 ohm-m	± 5% (0.1 to 3 ohm-m) ± 15 mmho/m (>3 ohm-m)
Vertical Resolution	6 in./ 152 mm ¹			

¹ In conductive beds <10 ohm-m

	Spacing	Frequency	Diameter of Investigation ²
Phase Difference	41 in. / 1041 mm	2 MHz	49 in. / 1245mm
		400 kHz	66 in. / 1676 mm
	19 in./ 483 mm	2 MHz	32 in. / 813 mm
		400 kHz	42 in. / 1067 mm
Attenuation	41 in. / 1041 mm	2 MHz	71 in. / 1803 mm
		400 kHz	104 in. / 2642 mm
	19 in./ 483 mm	2 MHz	47 in. / 1194 mm
		400 kHz	73 in. / 1854 mm

² Diameter of Investigation - Radial diameter, centered on the tool axis, at which the Integrated Geometric Factor is 50%. Data presented relates to a modeled formation with Rt = 10 ohm-m and Rxo = 1 ohm-m

Centerfire Collar

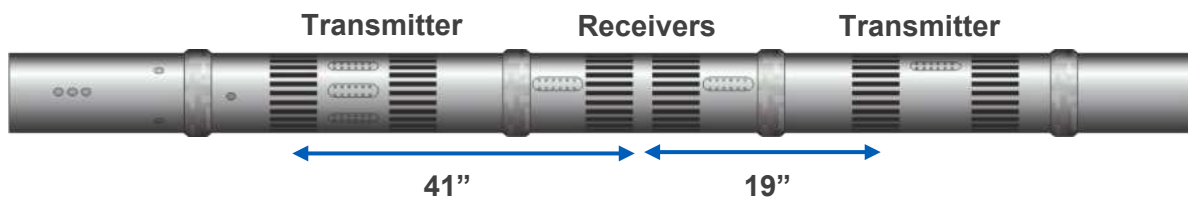
The Centerfire tool is available in three standard sizes - 4.75", 6.91" and 8.25" (120.7mm, 175.5mm and 209.6mm).

It can be run in MWD mode or Memory-only mode.,

The Centerfire Resistivity tool has two receivers and four transmitters giving two Tx-Rx spacings (19" and 41") providing two different phase-derived resistivity measurements at two depths of investigation. In addition, measurements are taken at two frequencies to provide a total of four phase derived resistivity measurements at four depths of investigation. The four depths of investigation together with the high accuracy and high vertical resolution phase difference-based measurements ensure a comprehensive and accurate evaluation of the formation resistivity. In addition to the four phase-derived resistivities, the Centerfire system also provides four attenuation-based resistivities (two spacings, two frequencies). The attenuation resistivities provide deeper depths of investigation than the phase difference resistivities, but are limited to lower resistivity formations with reduced accuracy and vertical resolution.

Gamma Sensors measure the naturally occurring radiation:

- 4.75" and 6.91" tools have a Gamma module connected to the Tensor Rotary Interface Bottom [TRIB] below the collar.
- 8.25" tools have two collar-mounted gamma sensors, 180° apart in the collar



6 electronic boards control the operation of the Centerfire tool which are customer replaceable, thus greatly reducing the cost of maintenance:

- 2 x Transmitter Boards – a single board controls the operation of the two uphole transmitters, and another board controls the downhole transmitters. The boards generate the high frequency signals output by the transmitter antennas.
- 2 x Receiver Boards – a single board controls the operation of each receiver antenna.
- DSP/ Power Supply Board - regulates power for the Centerfire systems and processes the signal from the receiver coils.
- Recorder Board - 14 Mb memory has 294 hours of recording capacity at a 10 second update rate. Records Resistivity, Gamma and diagnostic data. Once the memory is full the recording stops.

The collar has the customer maintainable internal components:

- Smart Connect - A male/ female connector assembly on top of the Centerfire tool and on the bottom of the MWD tool allows power transfer from the batteries to the Centerfire tool (and any modules below the collar) and Resistivity data transfer from the Centerfire tool to the Directional Module [DM]. Data transferred from the Centerfire is transmitted to the surface by the MWD tool. The Female Smart Connect is bolted

to the ID of the collar and contains five internal contact rings that match up to external contact rings on the Centerfire Pulser Male Smart Connect.

- Muleshoe - A modified version of the standard Muleshoes used with the Tensor MWD system is located in the Centerfire collar.
- Tensor Rotary Interface Bottom [TRIB] - Located in the bottom of the Centerfire collar the TRIB allows a Gamma or Directional module to be connected below the Centerfire. These modules are housed in a short non-magnetic drill collar. In the 4.75" tool the TRIB is held in the collar by bolts which are accessible on the collar OD. In the 6.91" and the 8.25" tools the TRIB bolts are found below a Hatch Cover.

MWD Toolstring

In most operations the Centerfire collar is run with an MWD toolstring. The tool is compatible with most of the components of the standard Tensor Elite MWD toolstring. The toolstring performs the following functions:

- Supplies power for the Centerfire collar
- Transmits real time data
- Controls the realtime operation of the Centerfire collar in terms of what data is transmitted and how it is transmitted
- Controls the memory operation of the Centerfire collar in terms of what data is recorded and how it is recorded
- Acts as a second memory location for data generated by the Centerfire collar

The toolstring is, like any Tensor Elite toolstring, fully configurable to meet the operational requirements of the job. It is also retrievable from surface should the drilling assembly become stuck downhole.

The main components of the tool string are:

- Centerfire Pulser
- Directional Module [DM]
- Batteries
- Gamma Module (4.75" & 6.91" collars only)

Centerfire Pulser

The Centerfire Pulser is located at the top of the Centerfire collar and generates the pulses which transmit real time data to surface. The Pulser also serves to provide electrical connections for both power and data between the Centerfire collar and the MWD string above.

The Lower End of the Pulser is the same as the standard MWD Pulsers and keys into the Muleshoe which is located within the Centerfire collar.

The Male Smart Connect is located between the Lower End and the hydraulic section of the Pulser. The Smart Connect allows connection across five lines between the MWD tool above and the Centerfire collar below.



Two options of Pulser are available:

- Motor Driven – The standard offering delivers pulse widths down to 0.5 seconds with market leading power consumption. Currently rated to 150°C a high temperature upgrade is soon to be released.
- Solenoid Driven – Rated to 175 °C the legacy offering has a proven operation record in thousands of wells.

Batteries

The Centerfire system is powered by standard batteries in the Tensor MWD string. The batteries are either rated to 150 °C/ 165 °C for standard operations or 180 °C for high temperature operations.

When running Centerfire tools it is strongly recommended that two or three battery packs are used to power the string. Exceeding the maximum current limit of Lithium Chloride batteries reduces the rated capacity of the batteries. When running the Centerfire tool with a gamma sensor and an MWD string the current draw (~0.5 A) will exceed the maximum current limit of a single battery (~0.4 A). Therefore, to maximise the life of batteries it is essential that at least two batteries are run together in parallel (using the Battery Jumper) to ensure the effective current draw on each battery pack remains below the maximum current draw to allow the quoted battery capacity to be achieved.

As an approximate estimate of battery life with various set ups refer to the table below. The battery life displayed is based batteries being run with the standard Motor Driven Pulser at 100°C (212°F).

	Double Battery		Triple Battery	
Pulse Width	Standard	High Temp	Standard	High Temp
0.8	175	145	262	216



Gamma Module

4.75" and 6.91" Centerfire tools use Scinturian II Gamma Modules to detect natural gamma ray radiation. The module is rated to 175 °C and 20,000 psi and uses GE sensors which deliver unmatched stability of calibration together with unique packaging ensuring consistent performance in the roughest conditions.

Gamma Sensor	Nal Scintillation
Memory Update	72 samples/ft at 15 m/hr
Real Time Update	36 samples/ft at 15 m/hr
Gamma Ray Resolution	1 API
Gamma Ray Sensitivity	2.5 counts/API with housing
Memory	32 MB (memory is in MWD Directional Module)
Minimum Sampling Period	programmable 1 - 60 seconds (memory every 1 second, telemetry every 2 seconds)
Memory Capacity	Up to 500 hrs (at 10 second sampling)
Supply Voltage	18-32 Vdc
Current Draw	10-20 Ma
Pulse Output Line	0-5 Vdc pulses

Directional Module

The Directional Module [DM] is rated to 175 °C and 20,000 psi and provides market leading calibration stability across the entire operational range.

The DM offers the following features:

- 32 MB Memory – delivering over 10+ days of recording with usual setup parameters
- Rotation Sensing - The MPU can use either accelerometers or magnetometers to measure drill string rotation. The tool can be programmed to transmit different data parameters based on the measured rotation. This enables the tool to transmit data that is relevant to the current drilling operation.
- Re Sync Capability - Allows the tool to automatically recover telemetry signals when the tool signal is lost, without having to stop the drilling process to regain signal.
- Downlink Capability - Allows the user to change the operating behaviour of the tools while downhole resulting in fewer trips out of hole to reconfigure the MWD system.
- Shock Evaluation – Allows the user to monitor lateral, transverse, and total shocks. A real-time evaluation of shocks while drilling is displayed, and recorded enables better maintenance scheduling for the MWD string.

Sensor Specifications			
Directional Sensor	Tri-axial fluxgate magnetometers and Q-Flex accelerometers		
Directional Measurement	Range	Resolution	Accuracy
Inclination	0 – 180°	0.1°	+/- 0.1°
Azimuth	0 – 360°	1.0°	+/- 0.25°
Toolface – Magnetic	0 – 360°	1.0°	+/- 0.5°
Toolface – Gravity	0 – 360°	1.0°	+/- 0.5°
Magnetic Field	-100 – +100 μ T	0.1 μ T	+/- 0.075 μ T
Dip	-90 – 90°	0.1°	+/- 0.15°
Gravity	-2.000 - +2.000 g	0.001 g	+/- 0.0015 g
Temperature Sensor	Internal		
Temperature	-35 - 200°C	0.1°C	+/- 0.5°C

Surface System

The Centerfire System uses the Axel Surface System which has the following benefits:

- Advanced Signal Processing – An extensive suite of flexible filter chains are available to maximize signal detection.
- Fully Configurable Data Visualization – intuitive user interface and powerful data presentation deliver consistent results of the highest quality. All industry standard outputs are available to be configured to meet all end-user needs: PDF, LAS, WITS
- Integrated Centerfire Support – integration between the systems was completed in 2020 and has been deployed in multiple global operations. All Centerfire variables and corrections are in-built in the Axel software
- Onboard Memory – up to 2 TB of onboard memory ensures data is never lost as a result of a PC crash.
- Integrated Depth Tracking – Sensors, cabling and integrated control software are available for operations where the rig cannot provide Depth data using a WITS feed.
- Wireless Rig Floor Display Connection
- Small footprint – The Safe Area system comprises a single interface box and Laptop. It can easily be set up in an existing unit/ cabin.



Axel Surface System	Specification
Operating Temperature	0 – 70 °
Storage Temperature	-10 – 85 °
Power Supply	10-240 V, 50-60 Hz, 10 W
Pressure Sensor	4-20 mA Current Loop
Hookload Sensor (optional)	4-20 mA Current Loop
Depth Encoder (optional)	Dry contact or NAMUR input
Certification	Intrinsic Safety, Zone 1 Divis. 2

Centerfire Operations

Equipment

The system is provided with all required tooling and support equipment. By supporting customers in the most remote of operations Black Diamond has defined a comprehensive understanding of all equipment that is need to successfully run the system.

Modules, hand tools and surface equipment is shipped in a single Aluminum tool box. Depending on configuration, collars can be shipped in dedicated tool baskets or as loose assemblies.



Programming and Data Sets

Centerfire data is stored in two locations, typically every 10 seconds:

- Centerfire collar – Raw R&X data and gamma sets together with tool diagnostic data
- Directional Module – Compensated Phase Difference and Attenuation and gamma sets

The Centerfire transmits values of Phase Difference [PD] or Attenuation [AT] in real time. When deciding which data to transmit the following should be considered:

- The maximum expected resistivity should be estimated to allow required transmission resolution to be defined
- Only compensated data is available for transmission
- It is normal to transmit 2 or 3 data sets. More than 2 data sets could result in a lack of resolution of all Toolface/ Logging Data
- Attenuation should only be transmitted when expected resistivities are low
- Measurements which offer very different depths of investigation are favourable
- A diagnostic word can be transmitted to confirm correct operation of the system



Configurations

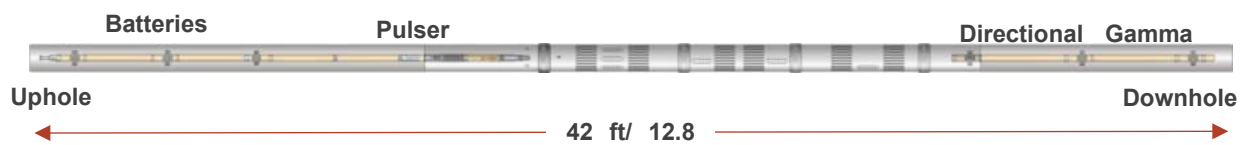
The flexibility of the Centerfire system allows configuration to meet all operational requirements. Two main configurations are available:

Workshop Assembly

The standard configuration has the following benefits:

- Minimal rig time during BHA handling
- Greatly reduced risk of operator error during rigsite handling and make up

The entire system is assembled in the workshop before shipping to the rigsite. At the rigsite the system is powered and configured before lifting to the rigfloor and made up to the BHA. The directional drilling offset is then measured before running into hole.



The position of the Directional and Gamma modules can be reversed to move directional measurements closer to the bit.



Alternatively, the Directional Module can be run above the Centerfire to move both gamma and resistivity measurements closer to the bit.

Rigfloor Assembly

The Centerfire collar has the Gamma, and if required, the Directional Module connected in the workshop before shipping to the rigsite.



Individual tool modules are then assembled at the rigsite and the toolstring is assembled on the deck.



The Centerfire collar is made to the BHA and the NMDC installed above.



The toolstring is then lifted and seated in the Centerfire.



The assembly is then configured, and the directional drilling offset measured.

Support

Drawing on over 25 years' experience supporting customers in the use of M/LWD systems, Black Diamond offers a Technical Services and Training network which is second to none. By working closely with all types of customers, from small independent MWD companies to NOCs and multi-national service companies, in every global oil producing region, Black Diamond has developed a real understanding of the customer support requirements which are critical to the delivery of success with their systems. This knowledge is used to deliver a multi-faceted support network which develops and reinforces every function of the customer organisation, throughout the entire operational life of the systems.

A best-in-class training program builds the foundations of success which is reinforced by a global Technical Services network focussed on the rapid delivery of the most up-to-date information and issue resolution, primarily through our dedicated on-line Support Portal. The Technical Services group brings together a diverse team with extensive experience in all aspects of operation, maintenance, support, logistics and management of M/LWD services.

Training

The dedicated Black Diamond training team delivers a modular development program, or bespoke learning sessions, which ensures customer competency with Tensor DT systems.

Initial customer operations are supported by a standard training program comprising three distinct, but complimentary, steps:



- E-learning – Completed by registered trainees through a dedicated support portal these units cover industry fundamentals and product specific theory
- Classroom/ Workshop Training – Short schools focussed on the practical use and/or maintenance of the systems. Designed to ensure trainees are competent in core usage of the tools.
- On the Job – Black Diamond field engineers support all aspects of initial operations

E-learning

The modules are bundled, at no extra cost, with traditional training courses. All attendees of the training courses must first complete the e-learning to ensure a standard level of theoretical knowledge. E-learning can also be purchased as stand-alone training. E-learning is the optimal delivery method for theoretical training:

- Can be taken remotely without the need to travel
- Can be completed at desired pace, reviewed and revisited any time
- Theory elements and principles can be covered in advance, making classroom training more effective and focussed on practical elements and troubleshooting
- Ensures a common and consistent level of technical and operational knowledge among all trainees

The interactive modules are broken into sections, each taking no longer than 1 hour to complete. Entire modules take up to 6 hours. Understanding is managed by way of integrated tests which review the content of each section, the results of which are managed to allow detailed reporting on both performance and course effectiveness.

Although aimed primarily at the field and shop operators, many of these trainings will also enable sales and support teams to more effectively service their customers' needs. The following modules are available.

- Introduction to MWD [IMWD]
- Introduction to Drilling [INDRL]
- Gamma Ray Principles [GAMP]
- Directional Drilling and Surveying [DDSU]
- Advanced Magnetic Surveying [AMS]
- Drilling Dynamics [DRDY]
- Drilling Failure Analysis and Reporting [FAAR]
- Tensor Elite MWD [TMWD]

Workshop/ Classroom Courses

Schools are offered at the Black Diamond facility or at customer facilities and delivered by dedicated trainers with extensive experience in the operation and maintenance of the systems, with course development being centrally controlled to ensure consistent delivery. A strong focus is placed on practical training and simulation, to build system confidence and troubleshooting ability. Ideally, courses are limited to 6 attendees to maximise hand-on training. Examinations and observation prove proficiency and allow meaningful feedback. The following courses are offered:



- Centerfire Operations, 3 days
- Centerfire Maintenance, 3 days

On the Job Commissioning

Typically purchased in 30-day blocks, the Black Diamond field engineer works with the customer, advising and supporting the first deployments of the systems. They first support workshop set up and tool preparation before working with the customer at the rig site during initial operations. Post operation maintenance is then completed, thus ensuring total competence at every step of the operational cycle.



Technical Support

Black Diamond is committed to the continuation of support, to all levels of the customer organization, throughout the life-cycle of the Centerfire system.

Onsite Support

Where required, dedicated Black Diamond Field Engineers can be assigned to customer projects. These engineers can provide the following functions:

- Rigsite presence where required by operator to support local engineers
- In-country remote support
- On-going training and development of customer employee base
- Audit on all activities

Remote Support

Dedicated experts provide 24-hour support for all Centerfire operations.

The Black Diamond team is complemented by the highly responsive Axel support network providing focussed support on the surface system.

Technical Support Portal

The Black Diamond Technical Support Portal is the central hub for all support of the Black Diamond systems. Any customer employee can enter the site to gain access to the latest information, and support tools, designed to maximise success with the systems.

The Portal offers the following materials:

Help Requests

Close relationships between customers and the regional teams means that most support requests are communicated by direct contact by phone or e-mail. In addition, customers who wish to contact their Regional Support Team for technical assistance, to request a quote or provide additional information about products or services can raise a ticket in the Portal. The system allows full visibility to the customer and the entire global Black Diamond support network. Analysis of case metrics allow Technical Services to drive product development and address common gaps in customer knowledge.

Training

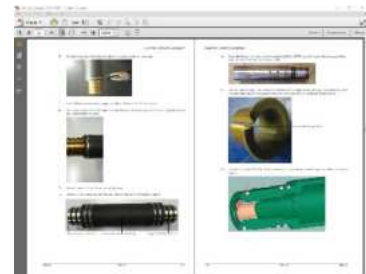
E-learning modules, content and assessments are available to registered users.

Manuals

Customer documentation delivers all the information required to prepare, operate, maintain and troubleshoot the systems. The manuals are continually updated to incorporate product development and updated best practice. Assembly drawings, with full parts listings, are available for all assemblies.

Software

Based on the continuous development of the systems to meet ever evolving customer requirements, software and firmware for the systems are periodically updated and released. Download packages are available for customer installation.



Maintenance Videos

Further support to customer maintenance functions is offered by way of videos which detail the strip down, test, inspection and rebuild of the systems. The videos are designed to work in parallel with the manuals and are updated in line with product development.

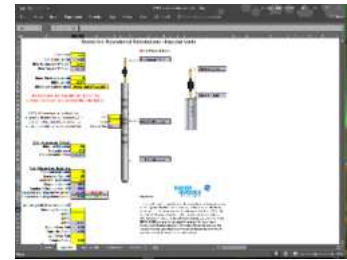


Frequently Asked Questions

Drawing on Black Diamond's extensive experience, an exhaustive list of FAQs is presented to support new and experienced users of the systems.

Operations & Maintenance Calculators

A suite of spreadsheets and calculators are available for download which perform the standard calculations required when setting up, and running, the systems at the rigsite. Additional spreadsheets are available to aid troubleshooting and track parts usage during maintenance.



Technical Information Letters

Technical Information Letters [TILs] are used to share critical information with customers. TIL subjects include system and service updates, product releases, best practice advice and safety alerts. They are initially e-mailed directly to customers and are also posted on the Portal to ensure all customer employees have access. The information they contain is incorporated into manuals and other support material, during the continual update process.

Repair & Maintenance

The Centerfire system has been designed for ease of customer maintenance and troubleshooting. This allows a range of R&M models to be employed:

- Full Black Diamond R&M – Black Diamond take responsibility for all aspects of the service and preparation of the system. Tools are maintained at in-country Black Diamond facilities with dedicated service teams. Systems are shipped to the rigsite in field-ready state.
- Full Customer R&M – The customer is enabled, through training and supply of all required tooling/ plant, to perform all standard service and preparation of the systems. Systems need only be returned to Black Diamond for detailed electronic repairs.
- Shared R&M – The customer and Black Diamond work to a clear framework which defines responsibility for any aspect of service. For example, the customer is responsible for basic rigsite service after which tools are returned to the in-country Black Diamond center for turnaround, service, calibration etc.

Customer Test & Maintenance

All required training, support documentation, tooling, equipment and spare parts can be supplied.

Spare parts are presented in defined kits which are populated to cover all standard servicing for a given number of operational hours. These tie directly to the definition of service levels for the systems.



Maintenance Schedule

Routine maintenance schedules are defined in three levels. Each tool module has a specific schedule, detailed in the maintenance manuals, which defines to what level the maintenance proceeds and recommendations on parts replacements. In addition to routine maintenance, the customer can complete various non-standard repairs.

The service levels typically follow the schedules for the downhole tools:

NOTE: Timings are based on worst case operating environment – high temperature, poor quality drilling fluid, harsh drilling etc.

- **Service Level 1** – After every job (200 circulating hours)
Cleaning, inspection, test, and replacement of seals and elastomers.
Calibration verification of Centerfire, Directional Module and Gamma Module.
- **Service Level 2** – After 500 - 600 hours
As Level 1 with additional possible replacement of stabilisation components, electrical connectors and wear parts
- **Service Level 3** – After 800 -1000 hours
As Level 2 with additional possible replacement of housings and other external components.
- **Non-Standard Customer Maintenance** – Directional Module board replacement. Pulsar Driver replacement. Basic rewiring.
- **Tensor DT Maintenance** – Directional Module, Gamma Module repair and recalibration, Centerfire rewiring, Centerfire Antenna repair.

Spare parts are supplied in three types of kits:

- **O-ring Kits & Spares Kits** – With normal system operation can be expected to cover 2000 circulating hours. Contain all seals, or spare parts, used during field and workshop maintenance of a single tool module.
NOTE: Muleshoe Kits contain both seals and spare parts to cover the service of two assemblies
- **Start-Up Kits** contain high value, insurance items that are not replaced during standard maintenance. Maintaining a low level stock of these items allows for replacement, out-with the standard service schedule, should any component fail. Start-Up Kits are typically purchased at the time of initial system order. As items from the Start-Up Kits are consumed, they should be replaced individually as opposed to ordering an entire replacement kit.

Shop Tooling

All specialist and standard tooling required to maintain and test the systems is delivered in defined kits.

Appendices

Appendix 1 - Case Studies/ Testimonials China

Click on the images to open the files.

Liohe Oilfield Logging



DDDC Letter 2013



DDDC Testimonial.JPG

Xi Bu



DDDC 2021



DDDC Certification.jpg

Tianjin Botenear



Appendix 2 – Case Studies/ Testimonials Russia

Smith Siberian Services (Integra) BNGF

