



# LWT™

## LOGGING WHILE TRIPPING™

### LWT Full Combo

- SGR / GR / CN / DEN / DUIN
- requires composite collar

#### Other Available Tool Combinations:

### LWT Triple Combo

- GR / CN / DEN / DUIN
- requires composite collar

### LWT Double Combo

- GR / CN / DEN
- steel collar only

### LWT Double Combo w/SGR

- SGR / GR / CN / DEN
- steel collar only

### LWT Neutron

- GR / CN
- steel collar only or cased hole

### LWT Neutron w/SGR

- SGR / GR / CN
- steel collar only or cased hole

#### LWT PUMP-DOWN ASSEMBLY

**MEMORY LOGGER (MEMBAT)**  
 Diameter: 43.0 mm / 1 11/16 in  
 Weight: 6.6 kg / 14.6 lbm  
 Length: 1.22m / 4.03 ft

**SPECTRAL GAMMA RAY (SGR)**  
 Diameter: 52.0 mm / 2.0 in  
 Weight: 10.3 kg / 22.7 lbm  
 Length: 1.20 m / 3.94 ft

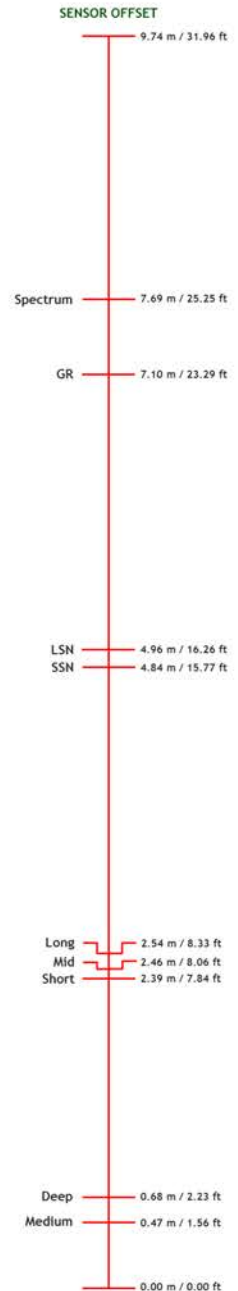
**COMPENSATED NEUTRON (CN)  
 GAMMA RAY (GR)**  
 Diameter: 52.0 mm / 2.0 in  
 Weight: 26.5 kg / 58.4 lbm  
 Length: 3.07 m / 10.07 ft

**KNUCKLE JOINT**  
 Diameter: 43.0 mm / 1 11/16 in  
 Weight: 7.3 kg / 16.1 lbm  
 Length: 0.70 m / 2.30 ft

**TRIPLE DETECTOR DENSITY (DEN)**  
 Diameter: 52.0 mm / 2.0 in  
 Weight: 17.4 kg / 38.4 lbm  
 Length: 1.65 m / 5.43 ft

**DUAL INDUCTION (DUIN)**  
 Diameter: 43.0 mm / 1 11/16 in  
 Weight: 8.0 kg / 17.6 lbm  
 Length: 1.89 m / 6.19 ft

Maximum Diameter: 52.0 mm / 2.0 in  
 Total Weight: 76.10 kg / 167.8 lbm  
 Total Length: 9.74 m / 31.96 ft





# LWT™ LOGGING WHILE TRIPPING™

## 3102 MEMORY LOGGER (MEMBAT)

The 3102 Memory Logger records data acquired by the connected logging instruments. Sleep time, start time, logging duration, and sample rate are programmed into the logger before tool deployment. The Memory Logger contains a lithium battery which provides power for both the logger and connected tools during recording. The MEMBAT includes an accelerometer to record shock encountered during deployment/recording.

### OPERATING PRINCIPLE

A PC and LWT Readout Box is used to program the MEMBAT and read data from memory after logging. The MEMBAT is connected to the downhole logging instruments and logging parameters programmed. It is then separated from the PC and LWT readout box and deployed downhole with the programmed logging tools. Beginning at the programmed start time, the logging instrument data is recorded to non-volatile memory against a real-time clock. Logging depth is recorded at the surface versus time by a PC and a Depth Processing Unit connected to the drilling recorder/encoder and hook load sensor. Depth is tracked electronically and monitored stand by stand. Once the depth/time record is merged with memory data, a depth indexed log can be played back, edited, displayed and printed. The onboard axial accelerometer enables analysis of forces on tools during pump-down deployment, logging, and well intervention.

### SPECIFICATIONS

Weight: 6 kg (13.2 lbs)  
Maximum Temp: 150 deg C (300 deg F)  
Maximum Pressure: 100 MPa (14,000 PSI)

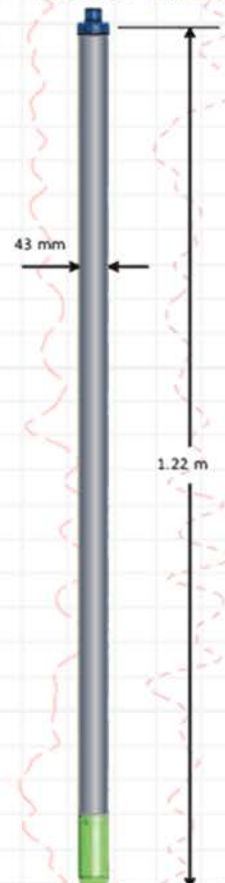
Battery Type: High-Temp Lithium  
Battery Voltage (4 cell): 14.4 V  
Battery Capacity: 24 Ah (72 hours)  
Battery Max Temp: 150 deg C (300 deg F)

Sample Rate: 0.1/sec to 1/hr

#### Measured Data:

Supply Current: mA  
Remaining Battery Capacity : Ah  
Memory Logger Temperature: deg C  
Battery Voltage: mV  
Z-Axis acceleration: -8g to +8g

Operating voltage: 12-15 VDC  
Operating current: 15 mA  
Memory Size: 128 MB







# LWT™ LOGGING WHILE TRIPPING™

## 1473 COMPENSATED DUAL NEUTRON (CN) & GAMMA RAY (GR)

The 1473 Compensated Dual Neutron / Gamma Ray is a combination slim borehole logging instrument providing porosity measurement and natural gamma radiation readings from within the steel LWT drill collar.

### OPERATING PRINCIPLE

The 1473 Dual Detector Neutron instrument employs a chemical nuclear source and two thermal neutron detectors. The source emits neutrons which are slowed down and then captured, primarily by hydrogen atoms in the formation fluids. The detectors count the neutrons deflected back to the tool. The ratio of the short space over the long space count rate is processed to calculate the porosity which relates to the hydrogen content of the formation. Using a scintillation detector, the combined Gamma Ray tool measures the total natural radioactivity of the formation caused by the emission of gamma rays by unstable radioactive isotopes of elements in formation.

### SPECIFICATIONS

Weight: 20 kg (44 lbs)  
Maximum Temp: 150 deg C (300 deg F)  
Maximum Pressure: 100 MPa (14,000 PSI)

Recorded Curves: SSRaw (cps)  
LSRaw (cps)  
GR (cps)

Neutron Detector: He3  
Radioactive Source: AmBe - 592 GBq (15 Ci)  
GR Detector: NaI

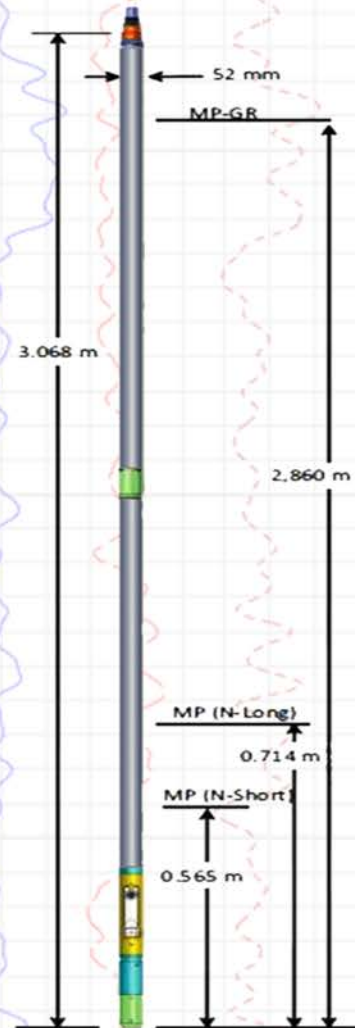
Calculated Curves: Count Rate Ratio (SS/LS)  
Matrix Neutron Porosity (PU)  
- Sandstone  
- Limestone  
- Dolomite  
GR (API)

### LOGGING PARAMETERS

Logging Speed: 11 m/min (36 ft/min)  
(max. recommended speed)  
Sample Rate: 1 sample / sec  
CN Depth of Invest.: 260 mm (10.0 in) @ 20 PU  
CN Vertical Resolution: 570 mm (22.4 in)  
Minimum Hole Size: 125 mm (4.9 in)  
Maximum Hole Size: 250 mm (9.8 in)

Measurement Range: Porosity: 0-60%  
Gamma Ray: 0-400 API

Accuracy: Porosity:  
- 0-10 PU: +/- 0.5 PU  
- 10-30 PU: +/- 8%  
- 30-60 PU: +/- 10%  
Gamma Ray:  
- +/- 2% of measured values







# LWT™ LOGGING WHILE TRIPPING™

## 1481 TRIPLE DETECTOR DENSITY (DEN)

The 1481 Triple Detector Density tool is a slim borehole logging instrument designed to provide omnidirectional formation density measurement through the proprietary LWT composite collar.

### OPERATING PRINCIPLE

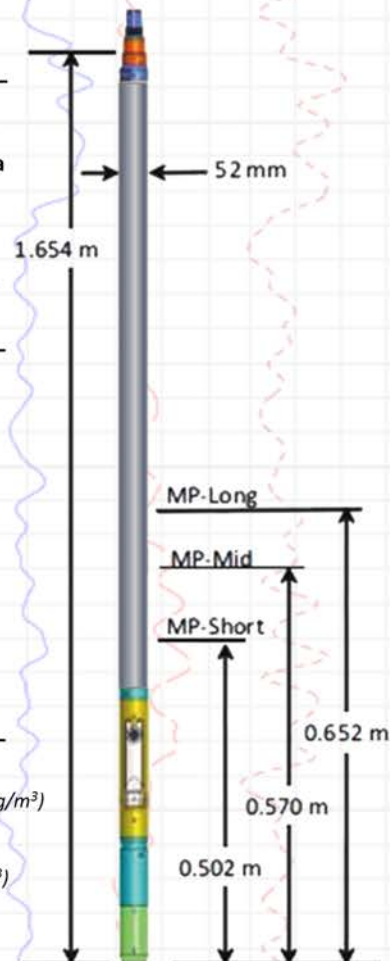
The 1481 Triple Detector Density contains a gamma ray source and three high-sensitivity scintillation detectors. Gamma radiation from the source is back scattered by the formation and is measured by three detectors equipped with proprietary shielding designed to optimize gamma ray collimation. Borehole effects are removed through computed stand-off and mud density measurement derived from differential relative readings of the multiple spaced detectors with reference to calibrated, modeled, and empirical responses. An apparent bulk density is then calculated from borehole compensated data as well as an average caliper and density correction.

### SPECIFICATIONS

Weight:	15 kg (33 lbs)	Recorded Curves:	SSRaw (cps)
Maximum Temp:	150 deg C (300 deg F)		MSRaw (cps)
Maximum Pressure:	100 MPa (14,000 PSI)		LSRaw (cps)
Detector Type:	Nal	Calculated Curves:	SS density, borehole corrected
Radioactive Source:	Cs <sub>137</sub> - 74 GBq (2 Ci)		MS density, borehole corrected
			LS density, borehole corrected
			Apparent Bulk Density (g/cc - kg/m <sup>3</sup> )
			Average Caliper
			Density Correction

### LOGGING PARAMETERS

Logging Speed:	11 m/min (36 ft/min) <i>(max. recommended speed)</i>	Measurement Range:	Bulk Density: 1-3 g/cm <sup>3</sup> (1000-3000 Kg/m <sup>3</sup> )
Sample Rate:	1 sample / sec	Accuracy:	Bulk Density: +/- 0.05 g/cm <sup>3</sup> (50 Kg/m <sup>3</sup> )
Depth of Invest.:	100 mm (3.9 in)		
Vertical Resolution:	448 mm (17.6 in)		
Minimum Hole Size:	125 mm (4.9 in)		
Maximum Hole Size:	250 mm (9.8 in)		





# LWT™ LOGGING WHILE TRIPPING™

## 1185 DUAL INDUCTION (DUIN)

The 1185 Slim hole Dual Induction instrument measures induction conductivity and calculates resistivity for deep and medium depths of investigation through the proprietary LWT composite collar.

### OPERATING PRINCIPLE

Tuned transmitter coils induce an electromagnetic field in the borehole and adjacent formations. The magnitude of the magnetic field's ground loop current induces voltages in the receiver coils proportional to variations in the total localized conductivity which is then converted to resistivity. Corrections including geometric factor, borehole, skin effect, coil temperature, and salinity are applied through software during acquisition. The DUIN operates from inside the electrically invisible LWT composite drill collar.

### SPECIFICATIONS

Weight: 8.2 kg (18lbs)  
 Maximum Temp: 150 deg C (300 deg F)  
 Maximum Pressure: 100 MPa (14,000 PSI)

Recorded Curves: Deep Conductivity (mmho): Cdeep  
 Medium Conductivity (mmho): Cmedium  
 Sonde Temperature (deg C): temp

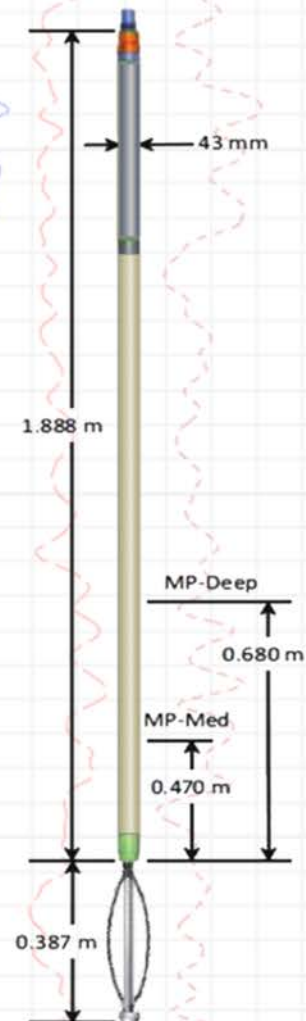
Receiver Coils: 2  
 Transmitter Coils: 6  
 - Deep: 1 emitting, 3 focusing  
 - Medium: 1 emitting, 1 focusing  
 Operating Frequencies (@ 10 mS/m):  
 - Deep: 50 kHz  
 - Medium: 100 kHz

Calculated Curves: Deep Resistivity (ohmm): Rdeep  
 Medium Resistivity (ohmm): Rmedium

### LOGGING PARAMETERS

Logging Speed: 11 m/min (36 ft/min)  
(max. recommended speed)  
 Sample Rate: 1 sample / sec  
 Depth of Invest.: (@ Rt/Rm = 10)  
 - Deep: 1.3 m (51.1 in)  
 - Medium: 0.65 m (25.6 in)  
 Vertical Resolution:  
 - Deep: 1.3 m (51.2 in)  
 - Medium: 0.65 m (25.6 in)  
 Minimum Hole Size: 125 mm (4.9 in)  
 Maximum Hole Size: 250 mm (9.8 in)

Measurement Range:  
 - Conductivity: 10 - 2000 mS/m  
 - Resistivity: 0.5 - 100 ohmm  
 Accuracy:  
 - Maximum Error: 5% (@ 2000 mS/m)







# LWT™ LOGGING WHILE TRIPPING™

## 1460 SPECTRAL GAMMA RAY (SGR)

The 1460 Spectral Gamma Ray Tool is a slim borehole logging instrument used for measurement of the isotope constituents of natural gamma radiation. It provides quantitative calculations of Potassium, Thorium, and Uranium.

### OPERATING PRINCIPLE

The 1460 Spectrum Gamma Ray tool measures the entire gamma spectrum from 0 to 3000 keV. All detected gamma rays which exceed a threshold level energy are counted to produce the total gamma ray curve. A spectrum fitting algorithm uses all of the available counts to determine the quantitative content of the main three unstable isotopes contributing to the natural radiation emission (Potassium, Uranium, Thorium). Environmental corrections for KCl mud, hole size, and casing are applied through software.

### SPECIFICATIONS

<b>Weight:</b>	8 kg (17.6 lbs)	<b>Recorded Curves:</b>	Spectrum (256 channels) Total Gamma Ray: GR Raw (cps)
<b>Maximum Temp:</b>	150 deg C (300 deg F)	<b>Calculated Curves:</b>	Gamma Ray (gAPI): GR Thorium Content (ppm) (Bq/kg): TH Uranium Content (ppm) (Bq/kg): U Potassium Content (%) (Bq/kg): K Potassium plus Thorium Content : KTh Ratio Uranium/Thorium: RUK Ratio Thorium/Potassium: RThK Ratio Thorium/Uranium: RThU Spectrum fitting quality indicator: ChiSq
<b>Maximum Pressure:</b>	100 MPa (14,000 PSI)		
<b>Detector Type:</b>	CsI crystal		
<b>Spectrum Range:</b>	0 - 4.2 MeV		

### LOGGING PARAMETERS

<b>Logging Speed:</b>	>30 GAPI: 7 m/min (23 ft/min) <30 GAPI: 3m/min (10 ft/min) (max. recommended speed)	<b>Measurement Range:</b>	GR: 0-3000 API K: 0-100 % U: 0-1000 ppm Th: 0-1000 ppm
<b>Sample Rate:</b>	1 sample / 2 sec	<b>Accuracy:</b>	GR: +/- 2% of measured values K: +/- 2% of measured values U, Th: +/- 3% of measured values
<b>Depth of Invest.:</b>	300 mm ( 11.8 in)		
<b>Vertical Resolution:</b>	150 mm (5.9 in)		
<b>Minimum Hole Size:</b>	125 mm (4.9 in)		
<b>Maximum Hole Size:</b>	250 mm (9.8 in)		

