

Explosives Engineers' Guide



DYNO[®]
Dyno Nobel

Groundbreaking Performance[™]

Who we are, what we do

Explosives users in the mining, quarry, construction, pipeline and geophysical exploration industries know that Dyno Nobel, a global leader in commercial explosives, delivers Ground-breaking Performance through Practical Innovation by focusing on Safety and Continuous Improvement.

Our founder, Alfred Nobel, changed the world with his invention of dynamite and the detonator in the 1860s and changed it again when he founded the world famous Nobel Prizes. Dyno Nobel's roots also include William Bickford's invention of Safety Fuse in 1831. Our corporate history is built on this legacy of safety and innovation.

With Zero Harm as our goal - for our employees, our customers and the environment - our safety standards are among the highest in the industry. Because we are all responsible for working safely, we rigorously apply internationally recognized safety standards at all our locations and in everything we do, from storage and transport to handling and use.

Together with our owners, Incitec Pivot Limited, we are a global force in nitrogen-based chemical manufacturing, holding foremost positions in the commercial explosives and fertilizer markets. Incitec Pivot's explosives business will continue to be identified by the well known Dyno Nobel brand as we take care of our customers in the industries we serve.

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- Is anything different?
- Has anything changed since you last performed this task?
- If so, Take 5! minutes to Take 5! steps



1. Identify the job you are about to do



2. Break the job into steps and identify hazards involved in each step



3. Assess the HAZARDS using the Hazard Assessment Tool



4. Develop CONTROLS and apply to HAZARDS



5. Record the CONTROLS

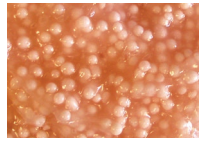
TAKE 5! Rapid Hazard Assessment



ANFO



Augerable Emulsion/ ANFO Blend



Pumpable Emulsion/ANFO Blend



TITAN® Emulsion



TITAN LD / TITAN SD Emulsion



TITAN 7000 RU Emulsion

Bulk Explosives

	Percent Emulsion	Average Density g/cc	Minimum Diameter in/mm	Energy cal/g (AWS)	Energy cal/cc (ABS)	Velocity ft/sec	Velocity m/sec	Water Resistance	Loading Method P= Pump A= Auger	Usage Code
DYNAMIX™ (ANFO)										
• poured 50 lb. bag	0	0.82	2¼ / 57	880	720	11,800	3,597	None	-	S,U
• augered	0	0.86	4½ / 115	880	755	12,800	3,901	None	A	S,U
• pneumatically placed	0	0.93	1¼ / 32	881	837	10,700	3,261	None	-	S,U
FRAGMAX®	0	1.05	4½ / 115	880	925	15,600	4,750	None	A	S
TITAN 7000 RU	100	1.20	1¾ / 45	690	830	18,000	5,500	Excellent	P	R,U
TITAN 7000 RUS	100	1.22	3 / 75	670	840	17,100	5,200	Excellent	P	R,U
TITAN 7000 RUSC	100	1.22	2½ / 65	670	820	17,100	5,200	Excellent	P	R,S
TITAN 7000 RU-A	100	1.20	1¾ / 45	690	830	18,000	5,500	Excellent	P	R,U
TITAN 7000 RU-SX	100	1.20	1¾ / 45	680	815	18,000	5,500	Excellent	P	R,U,SO
The TITAN 7000 RU Series is designed for use only with DynoMiner® delivery systems.										

TITAN 1050	50	1.32	8 / 200	780	1,030	16,400	5,000	Good	A	S
TITAN 1040	40	1.25	6 / 150	800	1,000	15,800	4,800	Fair	A	S
TITAN 1030	30	1.15	5 / 125	820	945	15,300	4,700	Poor	A	S
TITAN 1025	25	1.10	4 / 100	830	915	15,000	4,600	Poor	A	S
TITAN 1000 G	100	1.20	2½ / 65	680	815	14,800	4,500	Excellent	P	S,G
TITAN 1070 G	70	1.20	3 / 75	740	890	14,100	4,300	Excellent	P	S,G
TITAN 1060 G	60	1.20	4 / 100	760	910	13,500	4,100	Excellent	P	S,G
TITAN 1050 G	50	1.25	6 / 150	780	975	14,100	4,300	Good	A	S,G
TITAN 1000 SD	100	1.20	3 / 75	680	815	18,400	5,600	Excellent	P	S,R
TITAN 1080 SD	80	1.23	3½ / 90	720	885	17,700	5,400	Excellent	P	S,R
TITAN 1070 SD	70	1.24	4 / 100	740	920	15,700	4,800	Excellent	P	S,R
TITAN 1050 SD	50	1.27	5 / 125	771	980	15,400	4,700	Good	A	S
TITAN 1030 SD	30	1.15	4½ / 115	815	935	14,400	4,400	Fair	A	S
TITAN 1020 SD	20	1.05	3½ / 90	835	880	13,800	4,200	Poor	A	S
TITAN 1000 LD	100	1.25	3½ / 90	680	850	19,000	5,800	Excellent	P	S,R
TITAN 1070 LD	70	1.29	4½ / 115	740	955	18,500	5,600	Excellent	P	S,R
TITAN 1050 LD	50	1.30	6 / 150	780	1,015	17,700	5,400	Good	A	S
TITAN 1040 LD	40	1.25	5 / 125	800	1000	16,400	5,000	Fair	A	S
TITAN 1030 LD	30	1.15	5 / 125	820	945	15,300	4,700	Poor	A	S
TITAN XL 1000	100	1.20	2½ / 65	680	815	17,100	5,200	Excellent	P	S,G
TITAN SME™	100	1.20	2½ / 65	680	815	17,100	5,200	Excellent	P	S,G,SM

Usage Codes S = Surface Blasting U = Underground Blasting R = Repumpable SM = Site Mixed
G = Gassed or Gassable SO = Sulfide Ore Compatible

Relative Weight Strength (RWS) and Relative Bulk Strength (RBS) can be calculated based on ANFO = 1.00 @ density of 0.82 g/cc
Energy cal/g = Absolute Weight Strength Energy cal/cc = Absolute Bulk Strength

Bulk Explosives



Dynamite in Paper Tube Shell with NG Vapor Barrier



Dynamite in Paper Shell



Presplitting Dynamite in Paper Tube Shell with Plastic Coupler



Emulsion in Plastic Chub



Emulsion in Paper Shell



Emulsion in Plastic Chub



Seismic Charge in Plastic Shell

Dynamite

	Density g/cc	Diameter(s) inches	Energy cal/g (AWS)	Energy cal/cc (ABS)	Velocity ft/sec	Velocity m/sec	Water Resistance	Usage Code
UNIGEL®	1.30	1¼ to 3	955	1,240	14,100	4,300	Good	D,G,U
UNIMAX®	1.51	1 to 3	1,055	1,510	19,700	6,000	Excellent	D,G,U
DYNAMAX™ PRO	1.45	1¼ to 3	1,055	1,510	19,700	6,000	Excellent	D,G,RS
Z POWDER	1.37	1¼	965	1,351	16,400	5,000	Excellent	D,U,P
STONECUTTER®	1.02	⅞ to 2	842	859	4,820	1,470	Poor	D,PS
DYNOSPLIT® D	1.40	¾ to 1	995	1,440	8,900	2,700	Good	D,PS,U
DYNOSPLIT D1	0.95	⅞	990	1,230	9,800	3,000	Good	D,PS,U

Emulsion

	Density g/cc	Diameter(s) inches	Energy cal/g (AWS)	Energy cal/cc (ABS)	Velocity ft/sec	Velocity m/sec	Water Resistance	Usage Code
DYNO® AP	1.15	1 to 3½	775	890	15,400	4,700	Excellent	D,G,U
DYNO AP PLUS	1.15	1 to 2½	860	990	15,100	4,600	Excellent	D,G,U
DYNO SL	1.15	1 to 1½	770	885	15,400	4,700	Excellent	D,SL,U
DYNO SL PLUS	1.15	1 to 1¼	850	980	15,100	4,600	Excellent	D,SL,U
DYNOSPLIT® AP	1.08	1 to 1½	775	840	15,400	4,700	Excellent	D,PS,U
DYNOSPLIT C	1.20	⅞ to 2	800	960	23,000	7,000	Excellent	D,PS,U
DYNOSPLIT RiGHT™	1.11	1 to 2	775	860	16,100	4,900	Excellent	D,PS,U
DYNO E-5	1.05	1¼ to 1½	740	777	14,800	4,500	Excellent	D,U,P
DYNO TX (chub)	1.17	1¼ to 3½	1,000	1,170	16,400	5,000	Excellent	D,RD,U
DYNO TX (paper)	1.10	1½ to 3	985	1,085	16,400	5,000	Excellent	D,RD
BLASTEX®	1.26	2 to 3½	740	930	16,400	5,000	Excellent	B,G,U
BLASTEX PLUS	1.26	2 to 3½	800	1,010	16,100	4,900	Excellent	B,G,U
BLASTGEL® 1000	1.22	3 to 7	650	800	19,000	5,800	Excellent	B,G
BLASTGEL 1070	1.27	4 to 7	730	935	18,000	5,500	Excellent	B,G

ANFO

DYNAMIX™	0.82	50 lb. bag	880	720	12,800	3,900	None	B,G,U
DYNAMIX WR	0.87	50 lb. bag	880	748	11,350	3,460	Limited	B,G,U

Seismic

	Density g/cc	Diameter(s) inches	Calories per Gram	Gas Volume	Velocity ft/sec	Velocity m/sec	Detonation Pressure Kbars	Usage Code
GEOPRIME® dBX	1.70	1½ to 2¼	1,880	20.5	23,950	7,300	227	D,S
GEOPRIME	1.63	2¼	1,500	27.9	24,600	7,500	230	D,S
VIBROGEL®	1.43	1 to 2.4	1,250	26.0	20,000	6,100	133	D,S
SEISPRO®	1.18	1.4 to 2.4	1,000	35.5	19,350	5,900	103	D,S

Usage Codes D = Detonator Sensitive B = Booster Sensitive G = General Purpose PS = Presplitting
P = Permissible U = OK for underground Use RD = Resistant to Dead-Pressing
RS = Resistant to Sympathetic Detonation SL = Use with Swedish Loader S = Seismic Energy Source

Relative Weight Strength (RWS) and Relative Bulk Strength (RBS) can be calculated based on ANFO = 1.00 @ density of 0.82 g/cc
Energy cal/g = Absolute Weight Strength Energy cal/cc = Absolute Bulk Strength

Packaged Explosives



Trojan® Cast Boosters

	Weight gram	Weight oz	Diameter x Length inches	Density g/cc	Velocity ft/sec	Velocity m/sec	Detonation Pressure Kbars	Water Resistance
Spartan®	90g	3.2	1.1 x 4.7	1.65	24,800	7,550	235	Excellent
	150g	5.5	1.5 x 4.7	1.65	24,800	7,550	235	Excellent
	200g	7	1.6 x 4.6	1.65	24,800	7,550	235	Excellent
	350g	12	2.0 x 4.7	1.65	24,800	7,550	235	Excellent
	400g	14	2.1 x 4.7	1.65	24,800	7,550	235	Excellent
	450g	16	2.2 x 4.7	1.65	24,800	7,550	235	Excellent
	900g	32	3.1 x 5.6	1.65	24,800	7,550	235	Excellent
SuperPrime® NBU	350g	12	2.0 x 4.7	1.60	25,600	7,800	245	Excellent
	450g	16	2.3 x 4.7	1.60	25,600	7,800	245	Excellent
	900g	32	3.1 x 5.1	1.60	25,600	7,800	245	Excellent
Spartan® SL Slider	450g	16	2.2 x 4.7	1.65	24,800	7,550	235	Excellent
Spartan® Twinplex	450g	16	2.2 x 4.6	1.60	24,800	7,550	245	Excellent
Spartan® SR	350g	12	2.0 x 4.7	1.65	24,800	7,550	235	Excellent
	400g	14	2.2 x 4.7	1.65	24,800	7,550	235	Excellent
	450g	16	2.3 x 4.7	1.65	24,800	7,550	235	Excellent
SuperPrime® Stinger	10g	0.353	0.75 x 2.1	1.60	25,600	7,800	245	Excellent
	20g	0.705	0.65 x 3.5	1.60	25,600	7,800	245	Excellent

• Spartan, Spartan SL Slider, Spartan Twinplex and SuperPrime Stingers are detonator sensitive and have nominal energy of 1,370 cal/g and 2,190 cal/cc.

• SuperPrime NBU boosters are detonating cord sensitive (3.6 g/m and higher), and have nominal energy of 1,880 cal/g and 3,120 cal/cc.

Detonating Cord

	Coreload		Tensile (minimum)		Application		Color / Counter Color / Stripe	Jacket T = Textile P = Plastic
	g/m	gr/ft	kg	lbs	Downline*	Presplit Trunkline		
PRIMACORD® 1	1.5	7.5	68	150	✓		yellow / 5 black	T
PRIMACORD 2.5	2.4	12	27	60	✓	✓	orange / 4 black	T
PRIMACORD 3	3.2	15	113	250	✓		red / 1 black + 1 white	T
PRIMACORD 4Y	3.6	18	68	150	✓	✓	yellow / 1 black	T
PRIMACORD 4R	3.6	18	68	150	✓	✓	red	T
PRIMACORD 5	5.3	25	68	150	✓	✓	red / 1 black	T
PRIMACORD 8	8.5	40	90	200	✓	✓	red / 2 black	T
PRIMACORD 10	10.8	50	90	200	✓	✓	yellow / 2 black	T
PRIMALINE® 4D	3.6	18	45	100		✓	pink	P
PRIMALINE 4HS	3.6	18	45	100		✓	clear / black	P
PRIMALINE 5	5.3	25	50	110		✓	orange + wax coating	P
PRIMALINE 5D	5.3	25	45	100		✓	orange	P
PRIMALINE 8D	8.5	40	45	100		✓	yellow	P
PRIMALINE 8HT	8.5	40	45	100		✓	yellow	P
PRIMALINE 21	21.3	100	79	175	✓	✓	clear	P
PRIMALINE 31	31.5	150	90	200	✓	✓	clear	P
PRIMALINE 42	42.5	200	90	200	✓	✓	clear	P
PRIMALINE 85	85.0	400	136	300	✓	✓	light green	P
PRIMASHEAR® 4	3.6	18	23	50	✓		clear	P
PRIMASHEAR 5	5.3	25	45	100	✓		clear	P
PRIMASHEAR 8	8.6	40	50	110	✓		clear	P
PRIMASHEAR 8C	8.6	40	50	110	✓		yellow	P
PRIMALINE SMS	is a green self-consuming 0.9 g/m (4 gr/ft) detonating cord connected to a high strength detonator. Available in 18 delay periods from 0 to 3800 ms.							

* Detonating cord downlines may adversely impact explosives in the borehole. Please consult your Dyno Nobel representative

Additional specialty cords are available.

Detonating Cord & Cast Boosters

Dyno Nobel Electronic Initiation Systems



DigiShot®

- Wired Firing
- 2-Wire Busline Hookup
- Up to 300 Detonators per Blaster
- Fully Programmable with Auto-Programmability
- Delays from 0 to 20,000 msec in 1 msec Increments
- Requires Password, Coded Signal & Blast Key to Fire



DigiShot® Plus

- Wired or Wireless* Remote Firing
- 2-Wire Busline Hookup
- Up to 1800 Detonators per Blaster (7,200 per blast)
- Fully Programmable with Auto-Programmability
- Delays from 0 to 20,000 msec in 1 msec Increments
- Requires Password, Coded Signal & Blast Key to Fire

Wire Length meters	feet	Case quantity	Cable Tensile Strength		DigiShot Cable Color	DigiShot Plus Cable Color
2**	6.5	90	374 N	84 lbs	N/A	Green
9	30	84	374 N	84 lbs	Red	Green
15	50	60	374 N	84 lbs	Red	Green
18	60	50	374 N	84 lbs	Red	Green
24	80	40	374 N	84 lbs	Red	Green
30	100	32	374 N	84 lbs	Red	Green
37	120	24	374 N	84 lbs	Red	Green
46	150	24	374 N	84 lbs	Red	Green
55	180	18	374 N	84 lbs	Red	Green
75	245	18	374 N	84 lbs	Red	Green

* up to 3.5 Km line-of-sight

** 2m units are manufactured with bunch block

Additional length configurations are available, please consult your Dyno Nobel representative for details.

DigiShot®, DigiShot® Plus, GeoShot®, DriftShot® and SmartShot™ are registered trademarks of DetNet South Africa (Proprietary) Limited

SmartShot™

- Wired or Wireless Remote Firing (up to 3.5Km line-of-sight)
- Leaky Feeder Underground Remote Firing
- 4-Wire Daisy-Chain Hookup
- Up to 2400 Detonators per Blaster (dependent on shot layout)
- Delays from 0 to 20,000 msec in 1 msec Increments
- Requires Password, Coded Signal & Blast Key to Fire



Downline meters	feet	Surface meters	feet	Case quantity	Cable Tensile Strength		SmartShot Cable Color
10	33	7	23	18	>250 N	>56 lbs	Dark Green
15	49	10	33	18	>250 N	>56 lbs	Dark Green
20	66	0.2	0.66	18	>250 N	>56 lbs	Dark Green
30	98	0.2	0.66	18	>250 N	>56 lbs	Dark Green
35	115	0.2	0.66	18	>250 N	>56 lbs	Dark Green
45	148	0.2	0.66	18	>250 N	>56 lbs	Dark Green

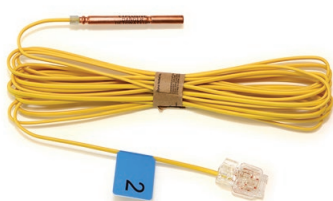


GeoShot™

Electronic Detonator for Initiation of Seismic Charges

- Wired Firing
- 2-Wire Direct Hookup
- Maximum of 7 Detonators per Array
- Firing Accuracy of <0.1ms Deviation
- Fires Only With encrypted Signal from GeoShot SIU
- High Visibility Orange Cable Color

GeoShot is available in lengths from 3.5m (12 ft) to 54m (180 ft). See the GeoShot Technical Info Sheet or consult your Dyno Nobel representative for details.



DriftShot™

Electronic Detonator for Underground Development

- Pre-Numbered Periods with Electronic Accuracy
- 2-Wire Busline Hookup
- Fired via Blast Control Unit (BCU)
- Remote Firing Available
- Easy to Use - All Timing via Preset Templates in BCU
- Requires Password, Coded Signal & Blast Key to Fire

Wire Length meters	feet	Case quantity	DriftShot Cable Color
5	16	N/A*	Yellow
7	22	80	Yellow
10	33	45	Yellow

* Please consult your Dyno Nobel representative for details.

Electronic Initiation



Electric Super Seismic

Electric Super SP

Electric Super Coal

Electric Super LP

Electric Super Starter

Electric Super™ Seismic

A high strength detonator designed to initiate seismic explosives used in geophysical exploration.

Delay	Legwire Color
Instant	Copper wire (single) Yellow & Yellow (duplex) Yellow

Electric Super™ Starter

An instant electric detonator in a plastic bunch block for easy connection to both shock tube and detonating cord.

Delay	Legwire Color
Instant	Copper wire (single) yellow & turquoise

Electric Super™ Coal

Designed to meet MSHA requirements in underground coal mining.

Delay Periods	Coal Series Nominal Firing Time (msec)	Legwire Color
1	25	both white
2	100	both pink
3	175	both light blue
4	250	both orange
5	325	white & dark green
6	400	both gold
7	500	both red
8	600	both light green
9	700	light blue & white
10	800	pink & orange
11	900	light blue & orange
12	1,000	light blue & pink

Electric Super™

The SP series features 26 precise "short period" millisecond delays. The LP series features 19 "long period" delays.

Delay Periods	SP Series Nominal Firing Time (msec)	LP Series Nominal Firing Time (msec)
0	5	-
1	25	25
2	50	200
3	75	400
4	100	600
5	125	800
6	150	1,000
7	175	1,200
8	200	1,400
9	225	1,600
10	250	1,900
11	275	2,200
12	300	2,500
13	325	2,900
14	350	3,300
15	375	3,800
16	400	4,400
17	425	5,100
18	450	-
19	475	-
20	500	-
22	550	-
24	600	-
26	650	-
28	700	-
30	750	-

Legwire Color - SP & LP Series:

- SP copper wire (single) = yellow & turquoise
- SP copper wire (duplex) = turquoise
- SP copper clad iron (single) = orange & orange
- LP copper wire (single) = red & yellow

Average Resistance (ohms)

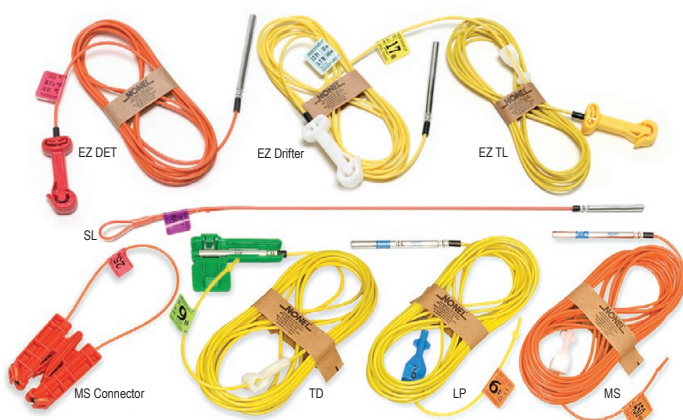
Legwire Length (feet)	Legwire Length (meters)	Electric Super SP & LP	Electric Super Coal	Electric Super Seismic	Electric Super Starter
8	2.4	-	-	-	-
12	3.6	1.92	-	1.20	1.92
14	4.2	-	4.30	-	-
16	4.8	2.03	-	-	-
20	6.1	2.14	-	-	-
24	7.3	2.25	-	1.40	-
30	9.1	2.40	-	-	-
35	10.7	-	-	1.65	-
40	12.2	2.66	-	-	-
45	13.7	-	-	1.85	-
55	16.8	-	-	2.05	-
60	18.3	3.19	-	-	-
65	19.8	-	-	2.25	-
75	22.8	-	-	2.50	-
85	25.9	3.85	-	2.70	-
100	30.2	-	-	3.00	-
120	36.6	-	-	3.40	-
160	48.8	-	-	4.25	-

Resistance (ohms)

Copper Wire

Average Wire Gauge	1000 ft
12	1.59
14	2.52
16	4.02
18	6.38
20	10.15
21	13.26
22	16.14
23	21.09
24	25.67

Electric Initiation



NONEL® EZ DET®

EZ DET units consist of a precise in-hole delay detonator and a surface delay detonator housed in a plastic EZ Connector™ block and linked by a length of orange shock tube.

Nominal Time msec	Nominal Time msec	Nominal Time msec	EZ Connector Color
17 / 350	17 / 500	17 / 700	Yellow
25 / 350	25 / 500	25 / 700	Red
42 / 350	42 / 500	42 / 700	White
25 / 375			Red

NONEL® EZTL™

EZTL trunkline delay detonators consist of a length of yellow shock tube attached to a low strength millisecond delay detonator housed in a plastic EZ Connector™ block on one end and sealed with a plastic J-hook attached to the other end.

Nominal Time msec	EZ Connector Color	Nominal Time msec	EZ Connector Color
9	Green	42	White
17	Yellow	67	Blue
25	Red	100	Black
33	Green	109	Black

NONEL® EZ DRIFTER®

EZ DRIFTER units consist of a 200 ms out-of-hole detonator housed in a white plastic EZ Connector block on one end of a length of yellow shock tube with a 5400 ms in-hole detonator on the other end.

Nominal Time (msec)	EZ Connector Color
200 / 5400	White

NONEL® LP

LP nonelectric long period delay units consist of a long period delay detonator assembled to a length of sealed yellow shock tube with a blue plastic J-hook at the opposite end.

Delay Period	Delay Tag Color	Nominal Time (msec)	Delay Period	Delay Tag Color	Nominal Time (msec)
0	Pink	0	10	Green	3500
1	White	500	11	Yellow	3900
2	Blue	800	12	Red	4400
3	Orange	1100	13	White	4900
4	Green	1400	14	Blue	5400
5	Yellow	1700	15	Orange	5900
6	Red	2000	16	Green	6500
7	White	2300	17	Yellow	7200
8	Blue	2700	18	Red	8000
9	Orange	3100			

NONEL® SL

SL nonelectric short lead millisecond delay units consist of a precise millisecond delay detonator assembled to a 30 inch (76 cm) length of sealed orange shock tube with a looped end.

Nominal Time (msec)	Tag Color	Nominal Time (msec)	Tag Color
0	Orange	325	White
25	Red	350	Green
50	Tan	375	White
75	Green	400	Blue
100	Blue	425	White
125	Orange	450	Orange
150	Purple	475	White
175	Gray	500	Purple
200	Lt Blue	525	White
225	White	600	Gray
250	Red	700	Lt Blue
275	White	800	Red
300	Tan	900	Tan
		1,000	Green

NONEL® MS

MS (millisecond) units consist of a precise millisecond delay detonator assembled to a length of sealed orange shock tube with a white plastic J-hook at the opposite end.

Nominal Time msec	Tag Color	Nominal Time msec	Tag Color
0	Orange	325	White
25	Red	350	Green
50	Tan	375	White
75	Green	400	Blue
100	Blue	425	White
125	Orange	450	Orange
150	Purple	475	White
175	Gray	500	Purple
200	Lt Blue	525	White
225	White	600	Gray
250	Red	700	Lt Blue
275	White	800	Red
300	Tan	900	Tan
		1,000	Green

NONEL® TD

TD nonelectric surface trunkline delay detonators consist of a precise surface delay detonator housed in a plastic Bunch Block assembled to a sealed length of yellow shock tube with a white plastic J-hook attached to the opposite end.

Nominal Time (msec)	EZ Connector Block Color	Nominal Time (msec)	EZ Connector Block Color
9	Green	42	White
17	Yellow	67	Blue
25	Red	100	Black
33	Green	109	Black

NONEL® MS Connector

MS nonelectric bi-directional trunkline delay connectors consist of an 18-inch (46 cm) length of shock tube with millisecond detonators of the same delay, inside connector blocks, on each end.

Nominal Time (msec)	MS Connector Block Color
9	Green
17	Yellow
25	Red
35	Black
42	White
50	Orange
65	Purple
67	Blue
109	Black

Starter & Lead Line

NONEL® Starter is a spool of shock tube that is factory-assembled to a nonelectric detonator. Available in 200, 500 or 1,000 foot lengths.

NONEL® Lead Line consists of a 2,500 foot spooled length of shock tube without a detonator. When initiated, the shock tube propagates a low energy signal to the detonator at a rate of 6,500 ft/second.



NONEL® Nonelectric Initiation

Loading Density (kg) & Rock Volume (m³)

Explosive Diameter	Loading Density (g/cc)																			
	mm	inches	0.50	0.75	0.82	0.85	0.90	0.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.54
19.0	0.75	0.14	0.21	0.23	0.24	0.25	0.27	0.28	0.30	0.31	0.33	0.34	0.35	0.37	0.38	0.40	0.41	0.42	0.44	0.44
22.0	0.87	0.19	0.28	0.31	0.32	0.34	0.36	0.38	0.40	0.42	0.44	0.46	0.47	0.49	0.51	0.53	0.55	0.57	0.58	0.58
25.0	0.98	0.25	0.37	0.40	0.42	0.44	0.47	0.49	0.51	0.54	0.56	0.59	0.61	0.64	0.66	0.69	0.71	0.74	0.76	0.76
32.0	1.26	0.40	0.60	0.66	0.68	0.72	0.76	0.80	0.84	0.88	0.92	0.96	1.00	1.04	1.08	1.12	1.16	1.20	1.24	1.24
35.0	1.38	0.48	0.72	0.79	0.82	0.86	0.91	0.96	1.01	1.06	1.11	1.15	1.20	1.25	1.30	1.35	1.39	1.44	1.48	1.48
38.0	1.50	0.57	0.85	0.93	0.96	1.02	1.08	1.13	1.19	1.25	1.30	1.36	1.42	1.47	1.53	1.59	1.64	1.70	1.74	1.74
41.0	1.61	0.66	0.98	1.08	1.11	1.18	1.25	1.31	1.38	1.44	1.51	1.57	1.64	1.70	1.77	1.84	1.90	1.97	2.02	2.02
45.0	1.77	0.79	1.19	1.30	1.35	1.43	1.51	1.59	1.67	1.75	1.83	1.91	1.99	2.07	2.14	2.22	2.30	2.38	2.45	2.45
48.0	1.89	0.90	1.36	1.48	1.54	1.63	1.72	1.81	1.90	1.99	2.08	2.17	2.26	2.35	2.44	2.53	2.62	2.71	2.78	2.78
50.0	1.97	1.02	1.47	1.61	1.67	1.77	1.86	1.96	2.06	2.16	2.26	2.35	2.45	2.55	2.65	2.75	2.84	2.94	3.02	3.02
57.0	2.24	1.27	1.91	2.09	2.17	2.29	2.42	2.55	2.68	2.80	2.93	3.06	3.19	3.31	3.44	3.57	3.70	3.82	3.93	3.93
65.0	2.56	1.66	2.49	2.72	2.82	2.98	3.15	3.31	3.48	3.65	3.81	3.98	4.14	4.31	4.47	4.64	4.81	4.97	5.10	5.10
70.0	2.76	1.92	2.88	3.15	3.27	3.46	3.65	3.84	4.04	4.23	4.42	4.61	4.81	5.00	5.19	5.38	5.57	5.77	5.92	5.92
75.0	2.95	2.21	3.31	3.62	3.75	3.97	4.19	4.41	4.63	4.85	5.07	5.30	5.52	5.74	5.96	6.18	6.40	6.62	6.80	6.80
90.0	3.54	3.18	4.77	5.21	5.40	5.72	6.04	6.35	6.67	6.99	7.31	7.63	7.94	8.26	8.58	8.90	9.21	9.53	9.79	9.79
100.0	3.94	3.92	5.88	6.43	6.67	7.06	7.45	7.85	8.24	8.63	9.02	9.41	9.81	10.20	10.59	10.98	11.38	11.77	12.08	12.08
110.0	4.33	4.75	7.12	7.78	8.07	8.54	9.02	9.49	9.97	10.44	10.92	11.39	11.87	12.34	12.81	13.29	13.76	14.24	14.62	14.62
115.0	4.53	5.19	7.78	8.51	8.82	9.34	9.86	10.38	10.89	11.41	11.93	12.45	12.97	13.49	14.01	14.53	15.04	15.56	15.98	15.98
125.0	4.92	6.13	9.19	10.05	10.42	11.03	11.64	12.26	12.87	13.48	14.10	14.71	15.32	15.94	16.55	17.16	17.77	18.39	18.88	18.88
140.0	5.51	7.69	11.53	12.61	13.07	13.84	14.61	15.38	16.15	16.91	17.68	18.45	19.22	19.99	20.76	21.53	22.30	23.06	23.68	23.68
145.0	5.71	8.25	12.37	13.53	14.02	14.84	15.67	16.49	17.32	18.14	18.97	19.79	20.62	21.44	22.27	23.09	23.92	24.74	25.40	25.40
150.0	5.91	8.83	13.24	14.47	15.00	15.89	16.77	17.65	18.53	19.42	20.30	21.18	22.06	22.95	23.83	24.71	25.59	26.48	27.18	27.18
160.0	6.30	10.04	15.06	16.47	17.07	18.08	19.08	20.08	21.09	22.09	23.10	24.10	25.10	26.11	27.11	28.12	29.12	30.12	30.93	30.93
165.0	6.50	10.68	16.02	17.51	18.15	19.22	20.29	21.36	22.43	23.49	24.56	25.63	26.70	27.77	28.83	29.90	30.97	32.04	32.89	32.89
170.0	6.69	11.34	17.00	18.59	19.27	20.40	21.54	22.67	23.81	24.94	26.07	27.21	28.34	29.47	30.61	31.74	32.87	34.01	34.91	34.91
187.0	7.36	13.72	20.57	22.50	23.32	24.69	26.06	27.43	28.80	30.18	31.55	32.92	34.29	35.66	37.03	38.41	39.78	41.15	42.25	42.25
200.0	7.87	15.69	23.54	25.73	26.67	28.24	29.81	31.38	32.95	34.52	36.09	37.66	39.23	40.79	42.36	43.93	45.50	47.07	48.33	48.33
203.0	7.99	16.16	24.25	26.51	27.48	29.10	30.71	32.33	33.94	35.56	37.18	38.79	40.41	42.03	43.64	45.26	46.88	48.49	49.79	49.79
230.0	9.06	20.75	31.13	34.03	35.28	37.35	39.43	41.50	43.58	45.65	47.73	49.80	51.88	53.95	56.03	58.10	60.18	62.25	63.91	63.91
250.0	9.84	24.52	36.77	40.21	41.68	44.13	46.58	49.03	51.48	53.93	56.39	58.84	61.29	63.74	66.19	68.64	71.10	73.55	75.51	75.51
270.0	10.63	28.60	42.89	46.90	48.61	51.47	54.33	57.19	60.05	62.91	65.77	68.63	71.49	74.35	77.21	80.07	82.93	85.79	88.07	88.07
311.0	12.24	37.94	56.91	62.22	64.50	68.29	72.08	75.88	79.67	83.47	87.26	91.05	94.85	98.64	102.43	106.23	110.02	113.82	116.85	116.85
380.0	14.96	56.64	84.96	92.89	96.29	101.95	107.62	113.28	118.95	124.61	130.27	135.94	141.60	147.27	152.93	158.59	164.26	169.92	174.45	174.45

Kilograms of Explosive Per Meter of Blasthole = 0.0007854 x Explosive Diameter² x Loading Density

Cubic Meters of Rock per Meter of Blasthole

Explosive Diameter	Burden (meters)																	Spacing (meters)																																																																																																																																																																																																																																																																																																																																																																																																																																																												
	mm	inches	1.00	1.25	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75		5.00	5.25	5.50	5.75	6.00	6.25	6.50	6.75	7.00	7.50	8.00	8.50	9.00	9.50	10.0	10.5																																																																																																																																																																																																																																																																																																																																																																																																																																												
19.0	0.75	0.14	1.25	1.56	2.19	2.50	2.81	3.13	3.44	3.75	4.06	4.38	4.69	5.00	5.31	5.62	5.93	6.24	6.55	6.86	7.17	7.48	7.79	8.10	8.41	8.72	9.03	9.34	9.65	9.96	10.27	10.58	10.89	11.20	11.51	11.82	12.13	12.44	12.75	13.06	13.37	13.68	13.99	14.30	14.61	14.92	15.23	15.54	15.85	16.16	16.47	16.78	17.09	17.40	17.71	18.02	18.33	18.64	18.95	19.26	19.57	19.88	20.19	20.50	20.81	21.12	21.43	21.74	22.05	22.36	22.67	22.98	23.29	23.60	23.91	24.22	24.53	24.84	25.15	25.46	25.77	26.08	26.39	26.70	27.01	27.32	27.63	27.94	28.25	28.56	28.87	29.18	29.49	29.80	30.11	30.42	30.73	31.04	31.35	31.66	31.97	32.28	32.59	32.90	33.21	33.52	33.83	34.14	34.45	34.76	35.07	35.38	35.69	36.00	36.31	36.62	36.93	37.24	37.55	37.86	38.17	38.48	38.79	39.10	39.41	39.72	40.03	40.34	40.65	40.96	41.27	41.58	41.89	42.20	42.51	42.82	43.13	43.44	43.75	44.06	44.37	44.68	44.99	45.30	45.61	45.92	46.23	46.54	46.85	47.16	47.47	47.78	48.09	48.40	48.71	49.02	49.33	49.64	49.95	50.26	50.57	50.88	51.19	51.50	51.81	52.12	52.43	52.74	53.05	53.36	53.67	53.98	54.29	54.60	54.91	55.22	55.53	55.84	56.15	56.46	56.77	57.08	57.39	57.70	58.01	58.32	58.63	58.94	59.25	59.56	59.87	60.18	60.49	60.80	61.11	61.42	61.73	62.04	62.35	62.66	62.97	63.28	63.59	63.90	64.21	64.52	64.83	65.14	65.45	65.76	66.07	66.38	66.69	67.00	67.31	67.62	67.93	68.24	68.55	68.86	69.17	69.48	69.79	70.10	70.41	70.72	71.03	71.34	71.65	71.96	72.27	72.58	72.89	73.20	73.51	73.82	74.13	74.44	74.75	75.06	75.37	75.68	75.99	76.30	76.61	76.92	77.23	77.54	77.85	78.16	78.47	78.78	79.09	79.40	79.71	80.02	80.33	80.64	80.95	81.26	81.57	81.88	82.19	82.50	82.81	83.12	83.43	83.74	84.05	84.36	84.67	84.98	85.29	85.60	85.91	86.22	86.53	86.84	87.15	87.46	87.77	88.08	88.39	88.70	89.01	89.32	89.63	89.94	90.25	90.56	90.87	91.18	91.49	91.80	92.11	92.42	92.73	93.04	93.35	93.66	93.97	94.28	94.59	94.90	95.21	95.52	95.83	96.14	96.45	96.76	97.07	97.38	97.69	98.00	98.31	98.62	98.93	99.24	99.55	99.86	100.17	100.48	100.79	101.10	101.41	101.72	102.03	102.34	102.65	102.96	103.27	103.58	103.89	104.20	104.51	104.82	105.13	105.44	105.75	106.06	106.37	106.68	106.99	107.30	107.61	107.92	108.23	108.54	108.85	109.16	109.47	109.78	110.09	110.40	110.71	111.02	111.33	111.64	111.95	112.26	112.57	112.88	113.19	113.50	113.81	114.12	114.43	114.74	115.05	115.36	115.67	115.98	116.29	116.60	116.91	117.22	117.53	117.84	118.15	118.46	118.77	119.08	119.39	119.70	120.01	120.32	120.63	120.94	121.25	121.56	121.87	122.18	122.49	122.80	123.11	123.42	123.73	124.04	124.35	124.66	124.97	125.28	125.59	125.90	126.21	126.52	126.83	127.14	127.45	127.76	128.07	128.38	128.69	129.00	129.31	129.62	129.93	130.24	130.55	130.86	131.17	131.48	131.79	132.10	132.41	132.72	133.03	133.34	133.65	133.96	134.27	134.58	134.89	135.20	135.51	135.82	136.13	136.44	136.75	137.06	137.37	137.68	137.99	138.30	138.61	138.92	139.23	139.54	139.85	140.16	140.47	140.78	141.09	141.40	141.71	142.02	142.33	142.64	142.95	143.26	143.57	

Loading Density (lbs) & Rock Volume (yd³)

Pounds of Explosive per Foot of Blasthole

Explosive Diameter inches	Loading Density (g/cc)																																																																																																																																																																																																																																																															
	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.54																																																																																																																																																																																																																																										
0.750	19.1	0.10	0.14	0.16	0.17	0.18	0.19	0.20	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.29	0.30	0.31	0.32	0.33	0.34	0.35	0.36	0.37	0.38	0.39	0.40	0.41	0.42	0.43	0.44	0.45	0.46	0.47	0.48	0.49	0.50	0.51	0.52	0.53	0.54	0.55	0.56	0.57	0.58	0.59	0.60	0.61	0.62	0.63	0.64	0.65	0.66	0.67	0.68	0.69	0.70	0.71	0.72	0.73	0.74	0.75	0.76	0.77	0.78	0.79	0.80	0.81	0.82	0.83	0.84	0.85	0.86	0.87	0.88	0.89	0.90	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	1.00	1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.31	1.32	1.33	1.34	1.35	1.36	1.37	1.38	1.39	1.40	1.41	1.42	1.43	1.44	1.45	1.46	1.47	1.48	1.49	1.50	1.51	1.52	1.53	1.54	1.55	1.56	1.57	1.58	1.59	1.60	1.61	1.62	1.63	1.64	1.65	1.66	1.67	1.68	1.69	1.70	1.71	1.72	1.73	1.74	1.75	1.76	1.77	1.78	1.79	1.80	1.81	1.82	1.83	1.84	1.85	1.86	1.87	1.88	1.89	1.90	1.91	1.92	1.93	1.94	1.95	1.96	1.97	1.98	1.99	2.00																																																																				
0.875	22.2	0.13	0.20	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.29	0.30	0.31	0.32	0.33	0.34	0.35	0.36	0.37	0.38	0.39	0.40	0.41	0.42	0.43	0.44	0.45	0.46	0.47	0.48	0.49	0.50	0.51	0.52	0.53	0.54	0.55	0.56	0.57	0.58	0.59	0.60	0.61	0.62	0.63	0.64	0.65	0.66	0.67	0.68	0.69	0.70	0.71	0.72	0.73	0.74	0.75	0.76	0.77	0.78	0.79	0.80	0.81	0.82	0.83	0.84	0.85	0.86	0.87	0.88	0.89	0.90	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	1.00	1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.31	1.32	1.33	1.34	1.35	1.36	1.37	1.38	1.39	1.40	1.41	1.42	1.43	1.44	1.45	1.46	1.47	1.48	1.49	1.50	1.51	1.52	1.53	1.54	1.55	1.56	1.57	1.58	1.59	1.60	1.61	1.62	1.63	1.64	1.65	1.66	1.67	1.68	1.69	1.70	1.71	1.72	1.73	1.74	1.75	1.76	1.77	1.78	1.79	1.80	1.81	1.82	1.83	1.84	1.85	1.86	1.87	1.88	1.89	1.90	1.91	1.92	1.93	1.94	1.95	1.96	1.97	1.98	1.99	2.00																																																																									
1.000	25.4	0.17	0.26	0.28	0.29	0.31	0.32	0.34	0.36	0.37	0.39	0.41	0.43	0.44	0.46	0.48	0.49	0.51	0.52	0.53	0.54	0.55	0.56	0.57	0.58	0.59	0.60	0.61	0.62	0.63	0.64	0.65	0.66	0.67	0.68	0.69	0.70	0.71	0.72	0.73	0.74	0.75	0.76	0.77	0.78	0.79	0.80	0.81	0.82	0.83	0.84	0.85	0.86	0.87	0.88	0.89	0.90	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	1.00	1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.31	1.32	1.33	1.34	1.35	1.36	1.37	1.38	1.39	1.40	1.41	1.42	1.43	1.44	1.45	1.46	1.47	1.48	1.49	1.50	1.51	1.52	1.53	1.54	1.55	1.56	1.57	1.58	1.59	1.60	1.61	1.62	1.63	1.64	1.65	1.66	1.67	1.68	1.69	1.70	1.71	1.72	1.73	1.74	1.75	1.76	1.77	1.78	1.79	1.80	1.81	1.82	1.83	1.84	1.85	1.86	1.87	1.88	1.89	1.90	1.91	1.92	1.93	1.94	1.95	1.96	1.97	1.98	1.99	2.00																																																																																									
1.125	28.6	0.22	0.32	0.35	0.37	0.39	0.41	0.43	0.45	0.47	0.49	0.51	0.52	0.54	0.56	0.58	0.59	0.62	0.63	0.65	0.66	0.67	0.68	0.69	0.70	0.71	0.72	0.73	0.74	0.75	0.76	0.77	0.78	0.79	0.80	0.81	0.82	0.83	0.84	0.85	0.86	0.87	0.88	0.89	0.90	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	1.00	1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.31	1.32	1.33	1.34	1.35	1.36	1.37	1.38	1.39	1.40	1.41	1.42	1.43	1.44	1.45	1.46	1.47	1.48	1.49	1.50	1.51	1.52	1.53	1.54	1.55	1.56	1.57	1.58	1.59	1.60	1.61	1.62	1.63	1.64	1.65	1.66	1.67	1.68	1.69	1.70	1.71	1.72	1.73	1.74	1.75	1.76	1.77	1.78	1.79	1.80	1.81	1.82	1.83	1.84	1.85	1.86	1.87	1.88	1.89	1.90	1.91	1.92	1.93	1.94	1.95	1.96	1.97	1.98	1.99	2.00																																																																																																					
1.250	31.8	0.27	0.40	0.44	0.45	0.48	0.51	0.53	0.56	0.59	0.61	0.62	0.64	0.66	0.68	0.71	0.72	0.74	0.77	0.78	0.80	0.82	0.83	0.84	0.85	0.86	0.87	0.88	0.89	0.90	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	1.00	1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.31	1.32	1.33	1.34	1.35	1.36	1.37	1.38	1.39	1.40	1.41	1.42	1.43	1.44	1.45	1.46	1.47	1.48	1.49	1.50	1.51	1.52	1.53	1.54	1.55	1.56	1.57	1.58	1.59	1.60	1.61	1.62	1.63	1.64	1.65	1.66	1.67	1.68	1.69	1.70	1.71	1.72	1.73	1.74	1.75	1.76	1.77	1.78	1.79	1.80	1.81	1.82	1.83	1.84	1.85	1.86	1.87	1.88	1.89	1.90	1.91	1.92	1.93	1.94	1.95	1.96	1.97	1.98	1.99	2.00																																																																																																																				
1.375	34.9	0.32	0.48	0.53	0.55	0.58	0.61	0.64	0.68	0.71	0.74	0.77	0.80	0.84	0.87	0.90	0.93	0.97	0.99	1.00	1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.31	1.32	1.33	1.34	1.35	1.36	1.37	1.38	1.39	1.40	1.41	1.42	1.43	1.44	1.45	1.46	1.47	1.48	1.49	1.50	1.51	1.52	1.53	1.54	1.55	1.56	1.57	1.58	1.59	1.60	1.61	1.62	1.63	1.64	1.65	1.66	1.67	1.68	1.69	1.70	1.71	1.72	1.73	1.74	1.75	1.76	1.77	1.78	1.79	1.80	1.81	1.82	1.83	1.84	1.85	1.86	1.87	1.88	1.89	1.90	1.91	1.92	1.93	1.94	1.95	1.96	1.97	1.98	1.99	2.00																																																																																																																																								
1.500	38.1	0.38	0.57	0.63	0.65	0.69	0.73	0.77	0.80	0.84	0.88	0.92	0.96	1.00	1.03	1.07	1.11	1.15	1.18	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.31	1.32	1.33	1.34	1.35	1.36	1.37	1.38	1.39	1.40	1.41	1.42	1.43	1.44	1.45	1.46	1.47	1.48	1.49	1.50	1.51	1.52	1.53	1.54	1.55	1.56	1.57	1.58	1.59	1.60	1.61	1.62	1.63	1.64	1.65	1.66	1.67	1.68	1.69	1.70	1.71	1.72	1.73	1.74	1.75	1.76	1.77	1.78	1.79	1.80	1.81	1.82	1.83	1.84	1.85	1.86	1.87	1.88	1.89	1.90	1.91	1.92	1.93	1.94	1.95	1.96	1.97	1.98	1.99	2.00																																																																																																																																																											
1.625	41.3	0.45	0.67	0.74	0.76	0.81	0.85	0.90	0.94	0.99	1.04	1.09	1.15	1.20	1.25	1.30	1.36	1.41	1.46	1.51	1.56	1.61	1.66	1.71	1.76	1.81	1.86	1.91	1.96	2.01	2.06	2.11	2.16	2.21	2.26	2.31	2.36	2.41	2.46	2.51	2.56	2.61	2.66	2.71	2.76	2.81	2.86	2.91	2.96	3.01	3.06	3.11	3.16	3.21	3.26	3.31	3.36	3.41	3.46	3.51	3.56	3.61	3.66	3.71	3.76	3.81	3.86	3.91	3.96	4.01	4.06	4.11	4.16	4.21	4.26	4.31	4.36	4.41	4.46	4.51	4.56	4.61	4.66	4.71	4.76	4.81	4.86	4.91	4.96	5.01	5.06	5.11	5.16	5.21	5.26	5.31	5.36	5.41	5.46	5.51	5.56	5.61	5.66	5.71	5.76	5.81	5.86	5.91	5.96	6.01	6.06	6.11	6.16	6.21	6.26	6.31	6.36	6.41	6.46	6.51	6.56	6.61	6.66	6.71	6.76	6.81	6.86	6.91	6.96	7.01	7.06	7.11	7.16	7.21	7.26	7.31	7.36	7.41	7.46	7.51	7.56	7.61	7.66	7.71	7.76	7.81	7.86	7.91	7.96	8.01	8.06	8.11	8.16	8.21	8.26	8.31	8.36	8.41	8.46	8.51	8.56	8.61	8.66	8.71	8.76	8.81	8.86	8.91	8.96	9.01	9.06	9.11	9.16	9.21	9.26	9.31	9.36	9.41	9.46	9.51	9.56	9.61	9.66	9.71	9.76	9.81	9.86	9.91	9.96	10.01	10.06	10.11	10.16	10.21	10.26	10.31	10.36	10.41	10.46	10.51	10.56	10.61	10.66	10.71	10.76	10.81	10.86	10.91	10.96	11.01	11.06	11.11	11.16	11.21	11.26	11.31	11.36	11.41	11.46	11.51	11.56	11.61	11.66	11.71	11.76	11.81	11.86	11.91	11.96	12.01	12.06	12.11	12.16	12.21	12.26	12.31	12.36	12.41	12.46	12.51	12.56	12.61	12.66	12.71	12.76	12.81	12.86	12.91	12.96	13.01	13.06	13.11	13.16	13.21	13.26	13.31

Material	Specific Gravity	Weight Lbs / Cubic Ft	Weight Tons / Cubic Yd	Percent of Swell	Swell Factor	Loose Weight Tons / Cubic Yd
Ashes, soft coal, ordinary	.64 - .72	40 - 45	0.539 - 0.607	8	0.93	0.501 - 0.564
Basalt	2.8 - 3.0	175 - 187	2.359 - 2.527	-	-	-
Bauxite	1.6 - 2.5	100 - 156	1.348 - 2.106	33	0.75	1.011 - 1.580
Clay, dense, wet	1.7	106	1.432	33	0.75	1.074
Coal, anthracite	1.3	81	1.095	35	0.74	0.810
Coal, bituminous	1.1	69	0.927	35	0.74	0.686
Copper Ore	2.0	125	1.685	35	0.74	1.247
Diabase	2.6 - 3.0	162 - 187	2.190 - 2.527	-	-	-
Diorite	2.8 - 3.0	175 - 187	2.359 - 2.527	-	-	-
Dolomite	2.8 - 2.9	175 - 181	2.359 - 2.443	-	-	-
Earth, dry	1.6	100	1.348	25	0.8	1.078
Earth, wet	2.0	125	1.685	25	0.8	1.348
Earth, with sand & gravel	1.8	112	1.516	18	0.85	1.289
Earth and rock mixture	1.4 - 1.7	87 - 106	1.179 - 1.432	30	0.77	0.908 - 1.103
Gneiss	2.6 - 2.9	162 - 181	2.190 - 2.443	-	-	-
Granite	2.7	169	2.274	65	0.62	1.410
Gravel, dry	1.9	119	1.601	12	0.89	1.424
Gravel, wet	2.1	131	1.769	14	0.88	1.557
Gypsum	2.3 - 3.3	144 - 206	1.938 - 2.780	-	-	-
Iron ore, hematite	4.5 - 5.3	281 - 331	3.791 - 4.465	-	-	-
Iron ore, limonite	3.6 - 4.0	225 - 250	3.033 - 3.370	-	-	-
Iron ore, magnetite	4.9 - 5.2	306 - 325	4.128 - 4.380	-	-	-
Lead ore, galena	7.5	468	6.318	-	-	-
Limestone, Florida	2.5	155	2.089	15	0.65	1.358
Limestone, blasted	2.6	162	2.190	71	0.60	1.314
Limestone, marble	2.7	169	2.274	71	0.60	1.365
Loam	1.6	100	1.348	20	0.83	1.119
Mica, schist	2.5 - 2.9	156 - 181	2.106 - 2.443	-	-	-
Phosphate rock	3.2	200	2.696	-	-	-
Quartzite	2.0 - 2.8	125 - 175	1.685 - 2.359	-	-	-
Rock, hard, well blasted	2.4	150	2.022	50	0.67	1.355
Rock and stone, crushed	1.9 - 2.1	119 - 131	1.601 - 1.769	35	0.74	1.184 - 1.309
Salt, rock	2.1 - 2.6	131 - 162	1.769 - 2.190	-	-	-
Sand, dry	1.9	119	1.601	12	0.89	1.424
Sand, wet	2.2	137	1.853	-	-	-
Sandstone	2.5	156	2.106	50	0.79	1.664
Shale, riprap	2.4 - 2.8	150 - 175	2.022 - 2.359	33	0.75	1.516 - 1.769
Slate	2.7 - 2.8	169 - 175	2.274 - 2.359	30	0.77	1.751 - 1.816
Talc	2.6 - 2.8	162 - 175	2.190 - 2.359	50	0.67	1.467 - 1.580
Traprock	3.0	187	2.527	-	-	-

Weight of Various Solid Materials

This Unit → Multiplied by → Equals

Length

m (meters)	39.37	in
m (meters)	3.281	ft
mm (millimeters)	0.001	m
mm (millimeters)	39.37	mils
cm (centimeters)	0.3937	in
in (inches)	25.40	mm
ft (feet)	0.305	m
mi (miles statute)	1609	m
mi (miles statute)	5280	ft
nm (miles nautical)	1.15	mi
km (kilometers)	0.62	mi

Volume

cm ³ (cc) (cubic cm)	0.061	in ³
in ³ (cubic inches)	16.39	cc
m ³ (cubic meters)	1.31	yd ³
ft ³ (cubic feet)	0.028	m ³
yd ³ (cubic yards)	0.7646	m ³
Imperial gallon	3.785	liter
Imperial gallon	0.1337	ft ³
Imperial fluid ounces	29.57	cc

Density

lb / cu ft (pound / ft ³)	16	kg / m ³
lb / cu ft (pound / ft ³)	0.01602	g / cm ³
g/cc (gram / cm ³)	62.43	lb / ft ³
g/cc	0.8428	tons / yd ³

Energy

joule	0.24	calorie
calorie	4.184	joule
kilowatt	1.34	horse-power

Equals ← Divided by ← This Unit

Temperature

°F (degrees Fahrenheit)	-32° x 0.556	°C
°C (degrees Celcius)	x 1.8 + 32°	°F

This Unit → Multiplied by → Equals

Mass / Weight

kg (kilograms)	2.2	lb
grains	0.0648	g (gram)
grains	0.000143	lb
g (grams)	15.43	grains
oz (ounce)	28.35	g
lb (pound)	0.4536	kg
tonne (metric ton)	1.1023	short tons

Powder Factor

lb / yd ³	0.593	kg / m ³
kg / m ³	1.686	lb / yd ³

Loading Factor

lb / ft	1.4882	kg / m
g / m (grams / meter)	4.7	grains / ft
grains / ft	0.212	g / m

Speed / Velocity / Rate

m / s (meters / sec)	3.281	ft / s
ft / s (feet / sec)	0.3048	m / s
in / s (inches / sec)	2.54	cm / s
km / hour	0.62	miles / hr

Pressure

psi (pound / in ²)	0.0703	kg / cm ²
atm (atmospheres)	14.696	psi
one ft of H ₂ O @ 15°C	0.4335	psi
KBar	14,504	psi
KBar	10 ⁵	kPa

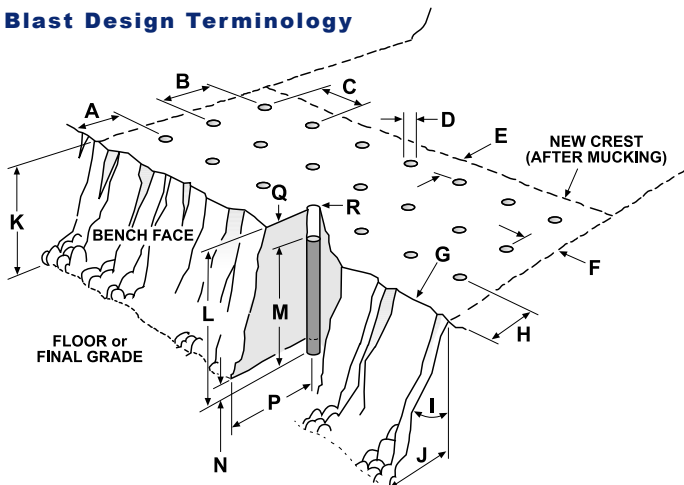
Area

cm ² (square cm)	0.155	in ²
m ² (square meter)	1550	in ²
in ² (square inch)	6.45	cm ²
ft ² (square feet)	0.0929	m ²
acre	43560	ft ²
square mile	640	acre

Equals ← Divided by ← This Unit

Unit of Measure Conversions

Blast Design Terminology



A Hole - to - Crest	G Crest	M Explosive Column Height
B Apparent Burden*	H Crest Burden	N Subdrilling
C Apparent Spacing*	I Bank Angle	P Toe Burden
D Hole Diameter	J Toe	Q Stemming
E Back Break	K Bench Height	R Drill Hole Collar
F Side Break	L Hole Depth	

* True Burden and True Spacing may be different than Apparent Burden and Apparent Spacing due to delay pattern.

Definitions

- Airblast** The airborne shock wave or acoustic transient generated by an explosion.
- Backbreak** Rock broken beyond the limits of the last row of blastholes. Same as overbreak.
- Blast Area** The area of the blast within the influence of flying rock, gases, and concussion.
- Blaster-In-Charge** The blaster who is in charge of and responsible for the design, loading and firing of a blast at a specific job site.
- Blast Site** The area where explosive material is handled during loading of blastholes including 50 feet in all directions from the perimeter formed by loaded blastholes.
- Blasting Agent** A mixture intended for blasting that cannot be detonated with a No. 8 detonator when unconfined and has very little probability of detonation under normal conditions in transport.
- Blasting Log** A written record of information about a specific blast as may be required by law.
- Bootleg** The end of a blasthole remaining when the explosion does not break the rock completely.
- Booster** An explosive charge in the initiation sequence between the initiator and main charge.
- Borehole Pressure** The pressure which the gasses of detonation exert on the borehole wall.
- Burden** The linear dimension between the blasthole and the nearest free face.
- Critical Diameter** The minimum diameter for propagation of a stable detonation.
- Cutoff** A break in the path of detonation or initiation caused by extraneous interference.
- Date-Shift Code** A code required by the BATF on explosives packaging to aid in identification.
- Decoupling** The use of explosives having a smaller volume than the volume of the blasthole.
- Deflagration** An explosive reaction that moves at a velocity less than the speed of sound.
- Delay Blasting** Use of delay detonators or connectors to separate charges by a defined time.

- Detonation** An explosive reaction that moves at a velocity greater than the speed of sound.
- Detonation Pressure** The pressure produced in the reaction zone of a detonating explosive.
- Detonation Velocity** The speed at which a detonation progresses through an explosive.
- Detonator Sensitive Explosive** An explosive that detonates with a No. 8 detonator when unconfined. Same as Cap Sensitive Explosive.
- Effective Burden** The distance between a blasthole and the position of the nearest free face at the time of detonation of the blasthole, taking into consideration the direction of initiation.
- Effective Spacing** The linear dimension between successively detonating blastholes, taking into consideration the direction of initiation.
- Electric Detonator** A detonator that is initiated by electric current.
- Electronic Detonator** A detonator that utilizes stored electrical energy to power an electronic timing element and to fire the base charge.
- Emulsion Explosive** A stabilized dispersion of small droplets of an aqueous oxidizer solution (the internal phase) surrounded by a continuous oil and/or wax external phase, which is sensitized by air voids or sensitizing agents.
- Explosive Density** The mass of an explosive per unit of volume, expressed in g/cc or lbs/ft³.
- Free Face** A rock surface that provides the rock with room to expand when blasted.
- Flyrock** Rocks propelled from the blast area by the force of an explosion.
- Fumes** The gaseous products of an explosion. To determine fume classification of explosive materials, only poisonous or toxic gases are considered.
- Gap Sensitivity** The gap across which a detonation will travel to initiate a second charge.
- Ground Vibration** Shaking of the ground by elastic waves emanating from a blast; usually measured in inches per second of particle velocity.
- Hangfire** The detonation of an explosive charge some time after its expected firing time.
- Highwall** A nearly vertical face at the edge of the bench, bluff or ledge on a surface excavation.
- Initiation** The start of deflagration or detonation in an explosive by any means.
- Misfire** A blast, explosive charge or specific blastholes that failed to detonate as planned.
- Nonelectric Detonator** A detonator that does not require the use of electric energy to function.
- Overbreak** Rock broken beyond the limits of the last row of holes. Same as backbreak.
- Permissible** Explosives approved for use in gassy and dusty atmospheres, usually underground.
- Preblast Survey** Documentation of the existing condition of structures near an area to be blasted.
- Repumpable Emulsion** A previously manufactured bulk emulsion with sufficient shelf life and fluidity to be pumped, with reasonable pressures, through a hose without deterioration in performance.
- RF Energy** The energy radiated as electromagnetic waves in the radio frequency spectrum.
- Primer** A unit of explosives containing a detonator used to initiate other explosives.
- Presplit** A controlled blast in which decoupled charges are fired in blastholes on the perimeter of the excavation prior to firing the main charge to prevent backbreak (overbreak).
- Relative Bulk Strength (RBS)** The energy per unit volume of an explosive compared to ANFO when ANFO = 1.00 at a density of 0.82 g/cc.
- Relative Weight Strength (RWS)** The energy per unit mass of an explosive compared to ANFO when ANFO = 1.00 at a density of 0.82 g/cc.
- Scaled Distance** A factor relating blast effects from explosive charges at various distances.
- Shelf Life** The maximum storage period during which an explosive retains adequate performance.
- Shunt** The shorting together of the free ends of electric detonator legwires or a blasting circuit.
- Steady State Velocity** The final velocity of detonation achieved by a specific explosive at a given diameter, density and degree of confinement.
- Stemming** Inert material (crushed rock) used to confine the gasses generated during detonation.
- Swell Factor** The ratio of the volume of broken rock to the volume of in-situ rock.
- Watergel Explosive** A thickened (and optionally crosslinked) aqueous oxidizer solution containing dissolved and/or dispersed fuels, which is sensitized by air voids or sensitizing additives.

Expected Ground Vibration

When an explosive is detonated in the ground, three types of seismic waves are generated; compressive, shear and surface. These waves can result in structure response and on rare occasions, structure damage. Extensive research has provided for safe blasting criteria based on peak particle velocity measured from the wave event. Peak particle velocity (PPV) values can be estimated using the following formulas.

Imperial

$$PPV = \left(\frac{\sqrt{\text{pounds per delay}}}{\text{feet to seismograph}} \right)^{1.6} \times H$$

Where:
 PPV = Peak particle velocity (in/sec)
 H = Ground response factor

"H" Factors

Lower limit, little or no confinement	24.2
Average value, typical confinement	160
Upper limit, heavy confinement	242

Metric

$$PPV = \left(\frac{\sqrt{\text{kilograms per delay}}}{\text{meters to seismograph}} \right)^{1.6} \times H$$

Where:
 PPV = Peak particle velocity (mm/sec)
 H = Ground response factor

"H" Factors

Lower limit, little or no confinement	172
Average value, typical confinement	1140
Upper limit, heavy confinement	1725

Scaled Distance

$$D_s = \frac{D}{\sqrt{W}}$$

or

$$D = D_s \times \sqrt{W}$$

or

$$W = \left(\frac{D}{D_s} \right)^2$$

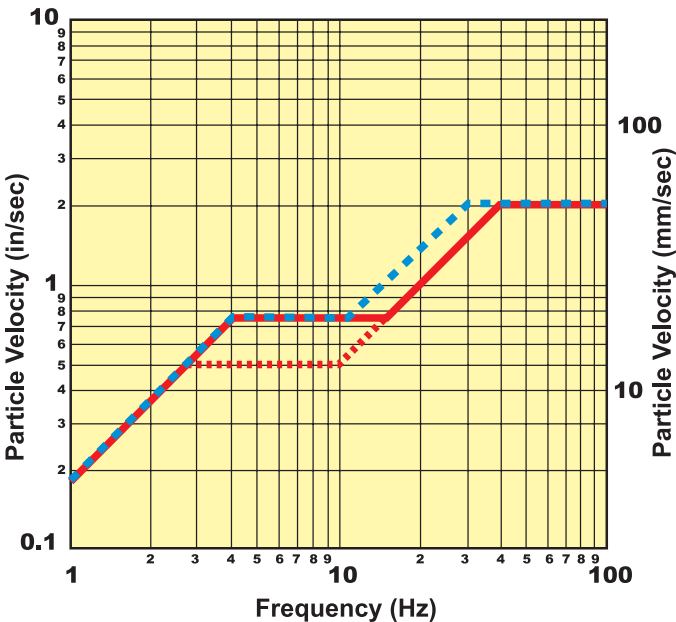
Where D_s = Scaled Distance
 D = Distance (ft) to nearest structure
 W = Weight of explosives (lbs) maximum per delay

The adjoining table provides the maximum pounds of explosives that can be detonated within an 8 millisecond delay at the given distances, without monitoring, according to the Office of Surface Mining (OSM) recommendations.

Distance	$D_s = 50$ (0 - 300 ft)	$D_s = 55$ (301 - 5,000 ft)	$D_s = 65$ (5,001 ft +)
25	0.25		
50	1.00		
75	2.25		
100	4.00		
150	9.00		
200	16.00		
250	25.00		
300	36.00		
301		29	
350		40	
400		52	
500		82	
600		119	
700		161	
800		211	
900		267	
1,000		330	
2,000		1,322	
3,000		2,975	
4,000		5,289	
5,000		8,264	
5,001			5,919
6,000			8,520
10,000			23,668

Safe Level Blasting Criteria

- USBM RI 8507
- - - - - - - - - - OSM REGULATIONS



Wet Hole Calculations

- To determine the final height of water in the borehole when the top of the last cartridge is at water level

$$FH = \frac{H_0 \times D_B^2}{D_B^2 - D_E^2}$$

FH = Final height of water in feet
 H₀ = Original height of water in feet
 D_B = Diameter of borehole in inches
 D_E = Diameter of explosive package in inches

- To determine the number of cartridges needed to build out of borehole water

$$N_E = \frac{FH \times 12}{L_E}$$

N_E = Number of cartridges needed
 FH = Final height of borehole water rise (from equation 1)
 L_E = Length of cartridge in inches



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