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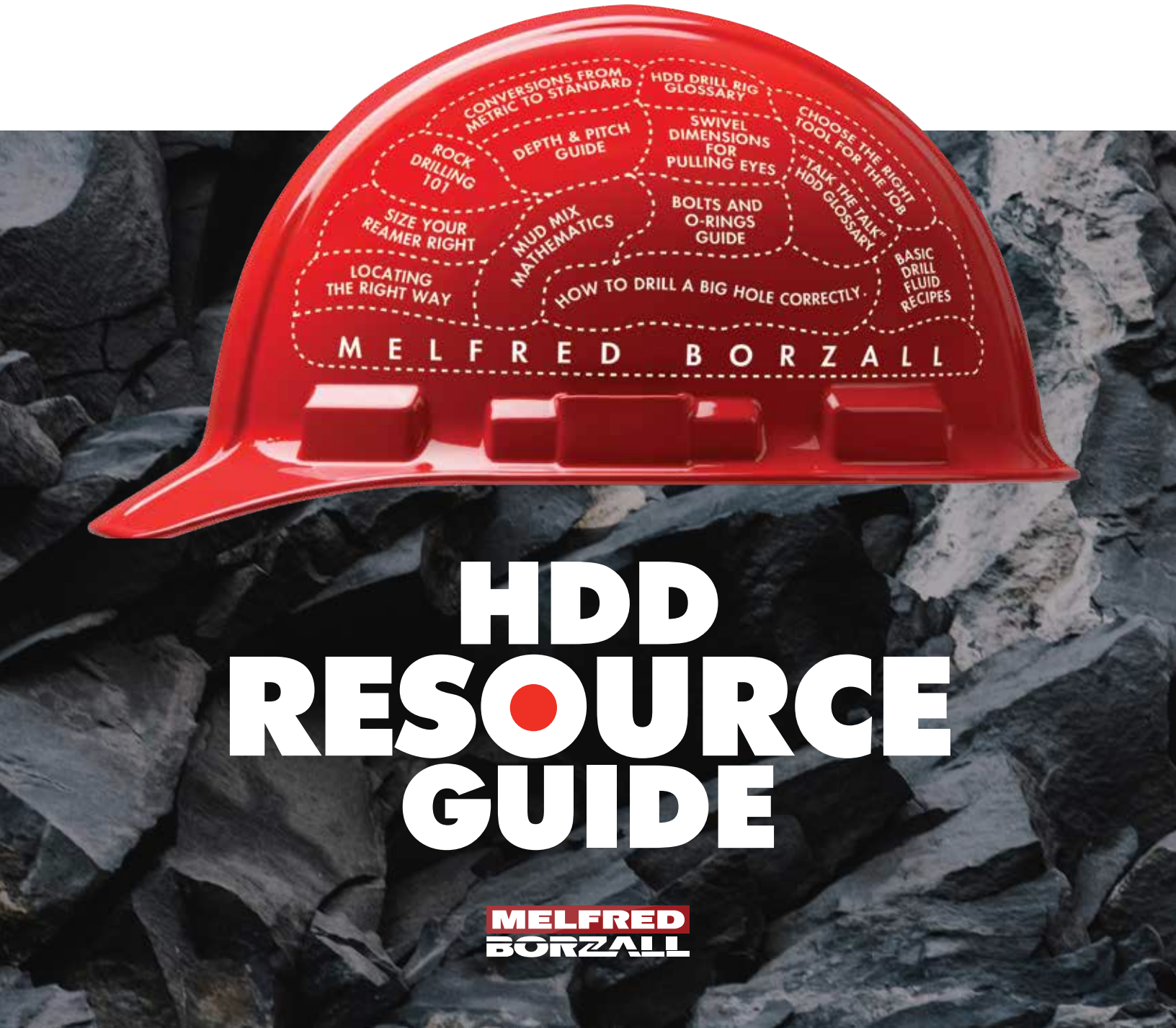


HDD RESOURCE GUIDE

MELFRED BORZALL

CONVERSIONS

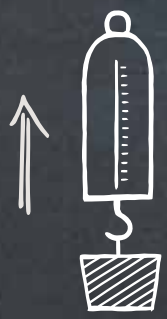
Metric to Standard

Weight/Force:

kilograms (kg) to pounds (lb)

lb = (kg x 2.2 lbs.)

Ex: 70 kg = 154.3 lbs.



Flow:

liters per min (lpm) to gallons per min (gpm)

gpm = (lpm x 0.264)

Ex: 500 lpm x 0.264 = 132.1 gpm

Volume:

liter (l) to US gallon (gal)

gal = (l x 0.264)

Ex: 10l x 0.264 = 2.64 gal

1 UK Imperial gallon is about 1.2 US gallons

Temperature:

degrees Celsius (C) to degrees Fahrenheit (F)

°F = (°C*9/5) +32

Ex: If it is 30°C: (30x9/5) + 32 = 86°F

Length:

meters (m) to feet (ft)

ft = (m x 3.28)

Ex: 10m x 3.28 = 32.8 ft

millimeters (mm) to inches (in)

in = (mm x 0.0394)

Ex: 50mm x 0.0394 = 1.97 in

Torque:

newton-meters (Nm) to pounds-foot (lb-ft)

lb-ft = (Nm x 0.738)

Ex: 200Nm x 0.738 = 147.6 lb-ft

Pressure:

kilopascal (kPa) to pounds per square inch (psi)

psi = (kPa x .145)

Ex: (300kPa x 0.145) = 43.51 psi

Melfred Borzall

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FIND THE RIGHT MELFRED BORZALL PRODUCT FOR THE JOB

When you're deep in an HDD job, you need tools you can count on. Our expert team of engineers has bored through every type of soil, sand and rock there is.

BITS	DIRT/ SAND LOAM	SAND	CLAY	SHALE	SANDSTONE	HARDPAN	GRAVEL	COBBLES	CALICHE
RED DIAMOND page 23				BEST	GOOD	GOOD	GOOD	BEST	BEST
ULTRABIT 3 page 26		GOOD		BEST	BEST				GOOD
ROCK SAW page 24						BEST	BEST	GOOD	
STEEP TAPER ULTRABIT page 25				GOOD			GOOD	BEST	BEST
EXCALIBUR page 27	GOOD	BEST	BEST			GOOD			
BEAR CLAW page 30	GOOD	BEST						BEST	
EAGLE CLAW SD page 29				BEST	BEST	GOOD			GOOD
IRON FIST page 28							BEST	BEST	GOOD

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REAMERS

	DIRT/ SAND LOAM	SAND	CLAY	SHALE	SANDSTONE	HARDPAN	GRAVEL	COBBLES	CALICHE
TORNADO page 37 	GOOD	GOOD	BEST	BEST	GOOD	BEST			
SHREDDER page 36 	GOOD			BEST	BEST	GOOD	GOOD		GOOD
JUGGERNAUT page 35 	BEST			GOOD			BEST	GOOD	
OGRE page 39 				BEST	GOOD	GOOD	BEST	BEST	BEST
TURBO page 44 	BEST	BEST	GOOD						
SABERTOOTH page 42 				BEST	BEST	GOOD	GOOD		GOOD
HEDGEHOG page 43 	BEST		GOOD	BEST	GOOD				

The information provided are general suggestions. There are many variables in horizontal directional drilling including job conditions, equipment, tooling, etc. Use the information as a guide only. Feel free to contact us for more guidance with your specific job.

HDD DRILL RIG GLOSSARY

	PULLBACK	TORQUE	FLUID PUMP	DRILL ROD SPECS	DRILL ROD THREAD		QUICK-DISCONNECT THREAD		
	LBS	FT-LBS	GPM	LENGTH X TUBE DIAMETER X JOINT DIAMETER	OEM	MB#	OEM OPT 1	MB# OPT 1	OEM OPT 2
VERMEER®									
D6X6	5,500	550	5	6′ x 1.32″ x 1.88″	FS200	31	1.625 LP	L42	QF300
D7X11A, S2	7,000	1,100	9	6′ x 1.66″ x 1.88″	FS200	31	1.625 LP	L42	QF300
D8X12	7,850	1,200	9	6′ x 1.66″ x 1.88″	FS200	31	1.625 LP	L42	QF300
D9X13, D9X13 S2	9,000	1,300	9 OR 15	6′ x 1.66″ x 1.88″	FS200	31	1.625 LP	L42	QF300
D9X13 S3	9,000	1,300	15	6′ x 1.66″ x 1.88″	FS200	31	1.625 LP	L42	QF300
D10X15	10,000	1,500	13.5	10′ x 1.66″ x 1.88″	FS200	31	1.625 LP	L42	QF300
D10X15 S3	10,000	1,500	15	6′ x 1.66″ x 1.88″	FS200	31	1.625 LP	L42	QF300
D16X20	16,000	2,000	13.5	10′ x 1.90″ x 2.13″	FS250	32	2.125 LP	L43	QF400
D16X20 S2	16,000	2,000	25	10′ x 1.90″ x 2.13″	FS250	32	2.125 LP	L43	QF400
D18X22	18,000	2,200	25	10′ x 1.90″ x 2.13″	FS250	32	2.125 LP	L43	QF400
D20X22 S2, S3	20,000	2,250	25	10′ x 1.90″ x 2.13. OR 10′ x 2.06″ x 2.25″	FS250 / FS400	32 / 30	2.125 LP	L43	QF400
D23X30 S3	24,000	3,000	35	10′ x 2.06″ x 2.25″. OR 10′ x 2.38″ x 2.63″	FS400 / FS600	30 / 40	2.125 LP	L43	QF400
D24X26	24,000	2,600	28	10′ x 2.06″ x 2.25″	FS400	30	2.125 LP	L43	QF400
D24X33	24,000	3,300	42	10′ x 2.06″ x 2.25″ OR 10′ x 2.38″ x 2.63″	FS400 / FS602	30 / 33	2.125LP	L43	QF400
D24X40, D24X40A	24,000	4,000	38	10′ x 2.38″ x 2.63″	FS600	40	2.125 LP	L43	QF400
D24X40 S2	24,000	4,000	50	10′ x 2.38″ x 2.63″	FS600	40	2.125 LP	L43	QF400
D24X40 S3	28,000	4,200	50	10′ x 2.38″ x 2.63″	FS600	40	2.125 LP	L43	QF400
D33X44	33,000	4,400	50	10′ x 2.38″ x 2.63″. OR 15′ x 2.38″ x ?2.75″	FS602 / FS650	33 / 46	2.125 LP	L43	QF400
D36X50, D36X50 S2	36,000	4,900	50	10′ x 2.38″ x 2.63″. OR 15′ x 2.38″ x 2.75″	FS602 / FS650 / FS700	33 / 46 / 41	2.125 LP	L43	QF460
D36X50 DR S2	38,000	5,500	50 OR 70	Inner - 10′ x 1.66″ x 1.88″; Outer - 10′ x 2.63″ x 3.31″	Inner - FS200; Outer - FS750*		2.125 LP	L43	QF700
D40X40	40,000	4,000	60	15′ x 2.38″ x 2.63″	FS600	40	2.125 LP	L43	QF400
D40X55 S3	40,000	5,500	50 OR 70	10′ x 2.38″ x 2.75″. OR 10′ x 2.63″ x 3.10″. OR 15′ x 2.63″ x 3.10″	FS650 / FS700	46 / 41			QF700
D40X55 DR S3	40,000	5,500	70	Inner - 10′ x 1.66″ x 1.88″; Outer - 10′ x 2.63″ x 3.31″	Inner - FS200; Outer - FS750*				QF700
D50X100	50,000	10,000	150	15′ x 2.88″ x 3.25″	FS900	50			
D60X90	60,000	9,000	150	15′ x 2.88″ x 3.25″	FS900	50			
D60X90 S3	60,000	9,000	150	15′ x 2.88″ x 3.25″. OR 15′ x 3.50″ x 3.63″	FS900 / FS800	50 / 80			
D80X100, D80X100 S2	80,000	10,000	150	15′ x 3.50″ x 3.63″	FS800	80			
D80X120	80,000	12,000	200	15′ x 3.50″ x 3.63″	FS802	81			
D100X120	100,000	12,000	200	20′ x 3.5″ x 4.38″	FS802	81			
D100X120 S2	100,000	12,000	150	20′ x 3.5″ x 4.38″	FS1000	82			
D100X140, D100X140 S3	100,000	14,000	230	15′ x 3.50″ x 4.38″. OR 20′ x 3.50″ x 4.38″	FS1000	82			
D220X300	242,000	30,200	330	20.3′ x 5″ x 6.63″	4.5″ IF DS	47			
D220X300 S3	242,000	30,750	345	20′ x 5″ x 6.63″	4.5″ IF DS	47			

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	PULLBACK	TORQUE	FLUID PUMP	DRILL ROD SPECS	DRILL ROD THREAD		QUICK-DISCONNECT THREAD		
	LBS	FT-LBS	GPM	LENGTH X TUBE DIAMETER X JOINT DIAMETER	OEM	MB#	OEM OPT 1	MB# OPT 1	OEM OPT 2
DITCH WITCH®									
JT520	5,000	500	5	4.9′ x 1.13″ x 1.75″	1.21-6	04	1.31-6	L52	
JT920, JT921	8,600	1,100	9	6′ x 1.58″ x 2.00″	1.41-6	01A	1.63-6	L55	HE275
JT920L	8,600	1,100	13	10′ x 1.63″ x 2.00″	1.41-6	01A	1.63-6	L55	HE275
JT922, JT9	9,000	1,100	9	6′ x 1.58″ x 2.13″	1.30-5	09	1.63-6	L55	HE275
JT10	10,000	1,100	16 OR 20	6′ x 1.58″ x 2.13″	1.30-5	09	1.63-6	L55	HE275
JT1220 M1	12,000	1,400	15	10′ x 1.82″ x 2.38″	1.47-4	34	1.88-6 EZ-3	L58	HE275 / HE350
JT1720, JT1720 M1	17,000	1,800	18 OR 25	9.8′ x 2.06″ x 2.63″	1.69-6	86	2.00-6	L54	HE350
JT20, JT2020	20,000	2,200	25	10′ x 2.06″ x 2.63″	1.94-4	20	2.00-6	L54	HE350
JT25	27,000	4,000	50	9.8′ x 2.38″ x 2.75″	2.11-4	36	2.25-6 EZ-3	L59	HE350 / HE390
JT2720	27,000	3,300	47	9.8′ x 2.38″ x 2.75″	1.94-4	35	2.00-6	L54	HE350
JT2720 M1	27,000	3,200	47	9.8″ x 2.38″ x 3.00″	2.11-4	36	2.25-6	L56	HE350 / HE390
JT2720 AT	27,000	3,200	47	9.33′ x 2.23″ x 3.25″. OR 9.33″ x 2.94″ x 3.25″	2.77 DS	36AT	2.25-6	L56	
JT3020, JT30	30,000	4,000	50	9.8′ x 2.38″ x 2.75″	2.11-4	36	2.25-6 EZ-3	L59	HE350 / HE390
JT30 AT, JT3020 AT	30,000	4000, 800	50	9.33′ x 2.23″ x 3.25″. OR 9.33″ x 2.94″ x 3.25″	2.77 DS	36AT	2.25-6 EZ-3	L59	HE350 / HE390
JT40	40,000	5,500	70	15′ x 2.81″ x 3.13″	2.10	48	2.63-6	L57	
JT40 AT	40,000	5500, 2000	70	15′ x 3.07″ x 3.75″	2.95	48AT	2.85-6	L60	
JT4020	40,000	5,000	119	14.75′ x 2.63″ x 3.25″	2.40-4	42	2.63-6	L57	HE350 / HE390
JT4020 M1	40,000	5,000	120	14.75′ x 2.81″ x 3.50″	2.59-4	43	2.63-6	L57	HE350 / HE390
JT4020 AT	40,000	5,000	70	14.25′ x 3.63″ x 4.13″	3.25	43AT			
JT60	60,000	9,000	150	15′ x 3.06″ x 3.50″	2.46-4 / FS900	60 / 50	2.85-6	L60	
JT60 AT	60,000	9000, 2000	150	14.25′ x 3.63″ x 4.13″	3.25	60AT			
JT7020, JT7020 M1	70,000	10,000	160	14.75′ x 3.63″ x 4.13″	3.27-4	72	3.50-4		
JT8020 M1	80,000	10,000	230	14.75′ x 3.63″ x 4.13″	3.27-4	72	3.50-4		
JT100 M1	100,000	12,000	230	14.75′ x 3.63″ x 4.13″	3.27-4	72	3.50-4		
JT100 AT	100,000	12000, 2000	120	14.13′ x 3.63″ x 4.50″	3.44 SS	72AT			
ASTEC®/TORO®									
DD65	6,500	500	5	5′ x 1.25″ x 1.75″	FS200	31		L65	
DD1215, DD1416	12,000	1,500	15	10′ x 1.66″ x 2.00″	FS250	32	1.88-6	L58	
DD1416	14,000	1,600	15	10′ x 1.90″ x 2.13″	FS250	32	1.88-6	L58	
DD2024	20,000	2,400	30	10′ x 2.06″ x 2.25″	FS400	30	2.00-6	L54	
DD2226	22,000	2,600	30	10′ x 2.06″ x 2.25″	FS400	30			
DD3238	32,000	3,800	47	10′ x 2.38″ x 2.63″	FS600 / 38	40 / 38	2.125 LP	L43	
DD4045	40,000	4,500	70	10′ x 2.38″ x 2.75″	FS602	33	2.125 LP	L43	
DD4050	40,000	5,000	70	10′ x 2.38″ x 2.75″	FS602	33	2.125 LP	L43	
DD9014	90,000	13,600	200	20′ x 3.5″ x 4.125″	2-7/8 IF	27			
AMERICAN AUGERS®									
DD4	40,000	4,000	100	10′ x 2.38″ x 2.63″	2-3/8 MJ & FS400	13 & 30			
DD5	50,000	10,000	130	15′ x 3.5″ x 4.13″	2-7/8 IF	27			
DD6	60,000	10,000	250	15′ x 3.5″ x 4.13″	2-7/8 IF	27			
DD8	80,000	13,600	250	15′ x 3.5″ x 4.13″	2-7/8 IF	27			
DD10	100,000	14,000	250	20′ x 3.5″ x 4.13″	2-7/8 IF & FS802	27 & 81			
DD220T	220,000	60,000	650	34′ x 5.00″ x 6.63″	4 1/2 IF RANGE 2	47			

Information subject to change. Call OEM for most recent information.

BASIC DRILL FLUID ADDITIVES

Solving your fluid related production challenges. Check out our pro tips.

DRILL KLEEN PLUS – CONCENTRATED LIQUID DETERGENT

Concentrated proprietary liquid detergent that helps keep down-hole tooling free from sticking clay formations.

Problem: Your reamer isn't mixing effectively and large clay chunks are building up behind the reamer and stopping the flow. You're worried this might cause inadvertent returns.

Pro tip: Adding Drill Kleen Plus to the slurry keeps sticky chunks of clay from packing on the reamer surface and allows clay chunks to blend into a flowable slurry reducing the possibility of inadvertent returns.

Getting your drilling fluid right is critical to being productive, but it's also really confusing. We have fluid experts to answer your questions plus all the additives you need to maximize production. Call 800-558-7500.

SODA ASH

Dry granular additive to raise PH of make up water to maximize the performance of bentonite and polymers.

Problem: You got a jump on things by mixing your drill fluid the night before the job. By morning the mud has separated! Now you're adding more bentonite to get the viscosity right. Your head start just took a backward turn.

Pro tip: Soda Ash raises the pH of your water to enhance water quality so bentonite and polymer mix at optimum levels and viscosity and helps keep the product from separating. Have confidence your mud is right on mark, even when mixing ahead of time.

WALL PAC – DRY POWDER POLYMER

Dry powder (PAC) polymer used to control fluid loss in unconsolidated/porous formations without increasing viscosity.

Problem: The soil is soaking up the fluid, pulling it away from the borehole and not keeping it full. This is causing the top of the bore to cave in and you're worried it might eventually collapse on your reamer.

Pro tip: Wall Pac XL added to existing bentonite drilling fluid seals off porous formations and forms a thin wall on the bore hole aiding in transporting cuttings to the bore pit and stabilizing the hole. Sandy soil? No problem with Wall Pac XL.

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CARRY-IT – DRY POWDER BIO-POLYMER

Dry powder bio-polymer that increases gel strength of drilling fluids to transport larger cuttings in suspension throughout distance of bore.

Problem: You notice that plenty of fluid is returning to the bore pit, but you don't see any cuttings or solids. Those larger cuttings are collecting in the bottom of the bore hole and it's causing rotary pressures to increase.

Pro tip: Carry-It increases the suspension characteristics of your drilling fluid to help transport larger, heavier cutting throughout the bore and out to the surface. Increase your returns and decrease the wear on your reamer with Carry-It.

CLAY SLAYER – SPECIALLY FORMULATED POLYMER

Specially formulated liquid polymer that breaks down the reactiveness of wet clays that get sticky and swell.

Problem: The clay soil you're drilling in is sticky; so bad it's sticking to the reamer and the drill rod. The rotary pressure is climbing and you can definitely feel the pressure increase on the pullback.

Pro tip: Adding Clay Slayer to your drilling fluid not only helps break down clay formations and reduce swelling, but also helps eliminate the problem of clay sticking to the tooling. Use Clayslayer on the pilot bore to start neutralizing reactive clays and during all reaming processes

SLICK VIS PLUS – PHPA POLYMER

Liquid or dry PHPA polymer is used to increase the viscosity of drilling fluid. It encapsulates clay to reduce swelling and stickiness while its high lubricity reduces rotary and pullback pressures.

Problem: You've finished the pilot bore and now you're pulling in the product, but the rotary and pullback pressures are starting to increase. You just know the clay you're drilling in is causing the pipe to stick and it's starting to stretch. Not good.

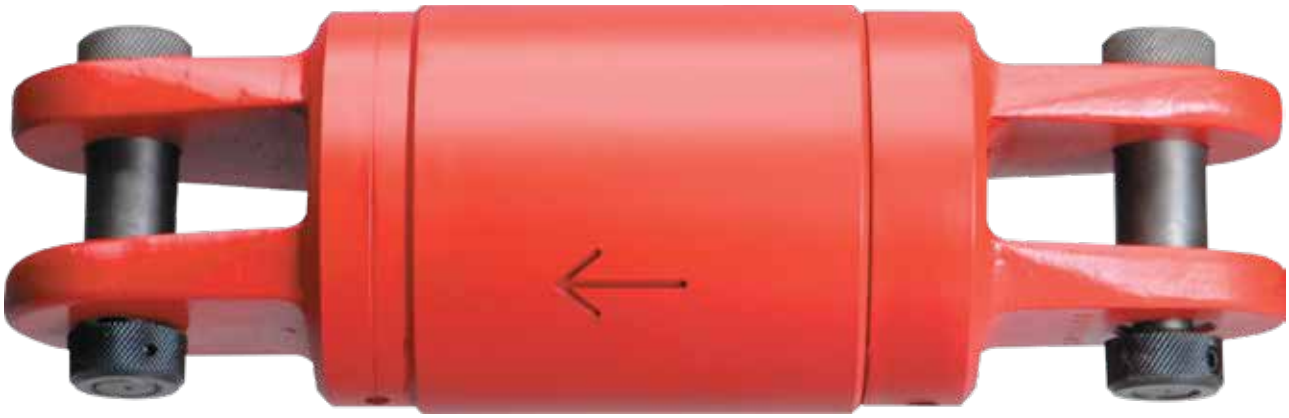
Pro tip: The simple solution is adding Slick Vis Plus or Slick Vis Dry to your drilling fluid to aid in coating clay formations and reduce sticking and swelling. Keep your job running smooth and efficient with Borzall's Slick Vis.

SWIVEL DIMENSIONS FOR PULLING EYES

We want to make sure your swivel is a good match for the pulling eye on your reamer. So here are all the dimensions you need to ensure a safe and secure fit between reamer and swivel.

What to look for when choosing your swivel

- **SEALS:** Your swivel should feature a strong sealing system. The seals keep the drilling fluid, sand, and environmental conditions from getting to the bearings. If any of this reaches the bearings, it's not long before your swivel is just a shaft. For drilling in harsh environments, consider a multi-stage sealing system.
- **GREASE PRESSURE PROTECTION:** The IDEAL HDD SWIVEL should have internal design features to protect the seals from being damaged by excessive pressure during greasing.
- **SAFETY:** Make sure your swivel has a high safety factor rated for HDD. Utilize a swivel at 10% above its rated capacity and you will decrease bearing life by 25%. Use a swivel at 10% below its rated capacity and you will increase bearing life by 40%.



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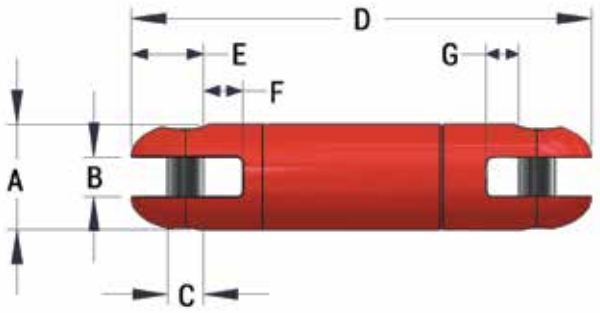
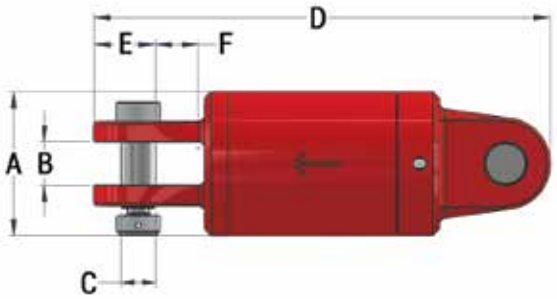
00503-202 to 00503-215

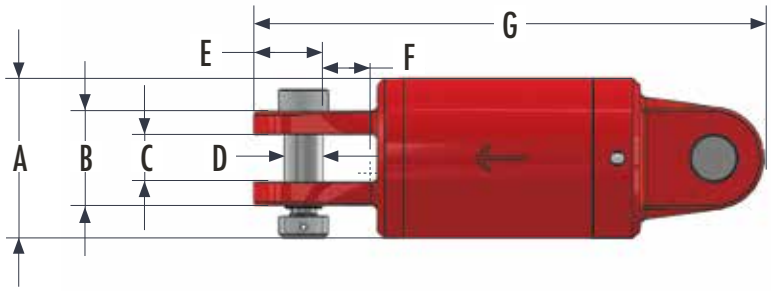


00503-220 to 00503-245



VALUE DUB®

PART NO.	3:1 SAFE WORKING LOAD	ULTIMATE LOAD	A	B	C	D	E	F	G	WEIGHT
00503-202	5,000 LB	15,000 LB	1-1/4″	1/2″	13/32″	4-31/32″	3/4″	1/2″	9/16″	1 LB
00503-204	8,500 LB	25,500 LB	2″	3/4″	11/16″	8-3/4″	1-3/8″	5/8″	3/4″	5 LB
00503-205	10,000 LB	30,000 LB	2-1/4″	7/8″	3/4″	9-5/8″	1-1/2″	3/4″	7/8″	7 LB
00503-208	15,000 LB	45,000 LB	2-1/2″	1″	7/8″	11-1/4″	1-3/4″	7/8″	1″	10 LB
00503-210	20,000 LB	60,000 LB	2-1/2″	1″	7/8″	11-7/8″	1-3/4″	7/8″	1″	11 LB
00503-215	30,000 LB	90,000 LB	3″	1-5/16″	1-1/8″	14″	2-1/4″	1-1/8″	1-1/4″	17 LB
00503-220	40,000 LB	120,000 LB	4-3/4″	1-3/4″	1-1/8″	16-1/2″	2-1/16″	1-7/16″	-	49 LB
00503-230	60,000 LB	180,000 LB	5-3/4″	1-3/4″	1-3/8″	18-1/4″	2-1/2″	1-7/16″	-	76 LB
00503-245	90,000 LB	270,000 LB	6″	1-3/4″	1-3/8″	19-3/8″	2-1/2″	1-7/16″	-	88 LB



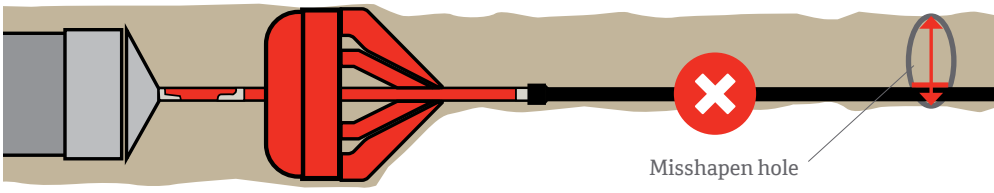
DELUXE DUB®

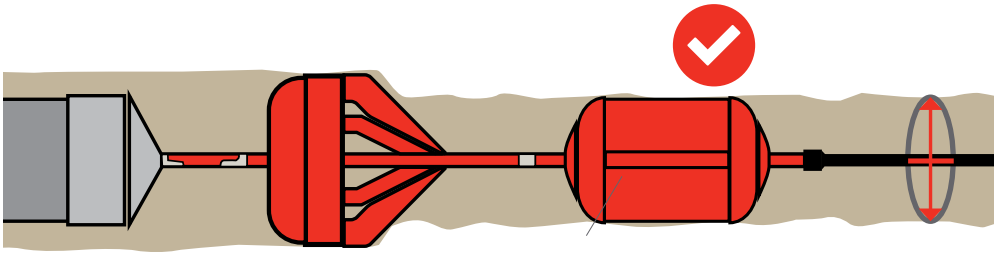
PART NO.	5:1 SAFE WORKING LOAD	ULTIMATE LOAD	A	B	C	D	E	F	G	WEIGHT
00508-202	5,000 LB	25,000 LB	2″	2″	1″	11/16″	1-3/16″	13/16″	7-1/2″	4 LB
00508-205	10,000 LB	50,000 LB	3-1/8″	2-1/4″	1-1/4″	3/4″	1-1/4″	1-1/4″	11-1/16″	15 LB
00508-210	20,000 LB	100,000 LB	3-3/4″	2-3/4″	1-1/2″	1″	1-5/8″	1-1/16″	13-9/16″	27 LB
00508-215	30,000 LB	150,000 LB	4-3/4″	3-1/4″	1-3/4″	1-1/8″	2-1/16″	1-7/16″	17-3/8″	57 LB
00508-220	40,000 LB	200,000 LB	5-3/4″	3-1/2″	1-3/4″	1-3/8″	2-1/2″	1-9/16″	18-1/2″	83 LB
00508-230	60,000 LB	300,000 LB	6″	3-1/2″	1-3/4″	1-3/8″	2-1/2″	1-9/16″	18-1/2″	85 LB
00508-240	80,000 LB	400,000 LB	6-1/2″	4-5/8″	2-1/8″	1-3/4″	3-1/4″	2-1/4″	24-11/16″	150 LB
00508-250	100,000 LB	500,000 LB	7-1/2″	5-1/2″	2-3/4″	2-1/8″	3-5/8″	2-5/8″	26-3/8″	230 LB
00508-260	120,000 LB	600,000 LB	7-1/2″	5-1/2″	2-3/4″	2-1/8″	3-9/16″	2-1/4″	28-1/2″	250 LB
00508-280	160,000 LB	800,000 LB	9″	6″	3-1/4″	2-1/2″	4-13/16″	2-7/8″	33-7/8″	380 LB

DRILLING A BIG HOLE? USE A BARREL STABILIZER

Reaming multiple times without supporting your drill rod can result in an oval-shaped hole, making pullback difficult and affecting the depth of the product. Melfred Borzall Barrel Stabilizers are the solution.

1. Big holes (approx. 18" or more), require you to pay close attention to your tooling and processes. Otherwise, you end up with a misshapen hole.
2. Backreamers must be held steady and centered in the hole, or they will sink under their own weight.
3. Barrel stabilizers fit perfectly inside the previous bore hole, to make sure that the reamer proceeds perpendicular to your hole (centered), not at a slope.
4. Since you will drill the same hole several times, it's important to use a stabilizing barrel in front of each cutting reamer. The result will be a clean and stable hole at a depth you can control.





Stabilizing barrel in front of each cutting reamer

Barrel Stabilizer Features to Look For

- Works in all soil conditions
- "Floating" water free body for weight reduction
- Front and rear water ports to clear cutters and help carry out cuttings
- Hardfacing on high wear areas to extend barrel life
- Front and rear cutter blades to help take wear off barrel caps

DEPTH & PITCH GUIDE

So your locator tells you the pitch (up and down) of your HDD drill head in degrees or % slope. But what does that actually mean to your change in depth? This table will help you easily figure that out. Example: If you're drill head is going down at a slope of 5%, you will gain 6" in depth in your 10' of drilling.

Angle of Drill Head (degrees)

Change in Depth	Distance Drilled (feet)									
	1	2	3	4	5	6	10	15	20	30
1	0.2	0.4	0.6	0.8	1.0	1.3	2.1	3.1	4.2	6.3
2	0.4	0.8	1.3	1.7	2.1	2.5	4.2	6.3	8.4	12.6
3	0.6	1.3	1.9	2.5	3.1	3.8	6.3	9.4	12.6	18.9
4	0.8	1.7	2.5	3.4	4.2	5.0	8.4	12.6	16.8	25.2
5	1.0	1.4	2.1	2.8	3.5	4.2	7.0	10.5	14.0	21.0
6	1.3	2.5	3.8	5.0	6.3	7.6	12.6	18.9	25.2	37.8
7	1.5	2.9	4.4	5.9	7.4	8.8	14.7	22.1	29.5	44.2
8	1.7	3.4	5.1	6.7	8.4	10.1	16.9	25.3	33.7	50.6
9	1.9	3.8	5.7	7.6	9.5	11.4	19.0	28.5	38.0	57.0
10	2.1	4.2	6.3	8.5	10.6	12.7	21.2	31.7	42.3	63.5
15	3.2	6.4	9.6	12.9	16.1	19.3	32.2	48.2	64.3	96.5
20	4.4	8.7	13.1	17.5	21.8	26.2	43.7	65.5	87.4	131.0
25	5.6	11.2	16.8	22.4	28.0	33.6	56.0	83.9	111.9	167.9
30	6.9	13.9	20.8	27.7	34.6	41.6	69.3	103.9	138.6	207.8
35	8.4	16.8	25.2	33.6	42.0	50.4	84.0	126.0	168.0	252.1
40	10.1	20.1	30.2	40.3	50.3	60.4	100.7	151.0	201.4	302.1
45	12.0	24.0	36.0	48.0	60.0	72.0	120.0	180.0	240.0	360.0

Angle of Drill Head (% slope)

Change in Depth	Distance Drilled (feet)									
	1	2	3	4	5	6	10	15	20	30
1	0.1	0.2	0.4	0.5	0.6	0.7	1.2	1.8	2.4	3.6
2	0.2	0.5	0.7	1.0	1.2	1.4	2.4	3.6	4.8	7.2
3	0.4	0.7	1.1	1.4	1.8	2.2	3.6	5.4	7.2	10.8
4	0.5	1.0	1.4	1.9	2.4	2.9	4.8	7.2	9.6	14.4
5	0.6	1.2	1.8	2.4	3.0	3.6	6.0	9.0	12.0	18.0
6	0.7	1.4	2.2	2.9	3.6	4.3	7.2	10.8	14.4	21.6
7	0.8	1.7	2.5	3.4	4.2	5.0	8.4	12.6	16.8	25.2
8	1.0	1.9	2.9	3.8	4.8	5.8	9.6	14.4	19.2	28.8
9	1.1	2.2	3.2	4.3	5.4	6.5	10.8	16.2	21.6	32.4
10	1.2	2.4	3.6	4.8	6.0	7.2	12.0	18.0	24.0	36.0
15	1.8	3.6	5.4	7.2	9.0	10.8	18.0	27.0	36.0	54.0
20	2.4	4.8	7.2	9.6	12.0	14.4	24.0	36.0	48.0	72.0
25	0.0	6.0	9.0	12.0	15.0	18.0	30.0	45.0	60.0	90.0
30	3.6	7.2	10.8	14.4	18.0	21.6	36.0	54.0	72.0	108.0
35	4.2	8.4	12.6	16.8	21.0	25.2	42.0	63.0	84.0	126.0
40	4.8	9.6	14.4	19.2	24.0	28.8	48.0	72.0	96.0	144.0
45	5.4	10.8	16.2	21.6	27.0	32.4	54.0	81.0	108.0	162.0

ROCK DRILLING 101

Mud Motors – drill and steer through solid rock with the drill fluid powering the bit

The drill fluid going through your drill string and into the motor causes the rotor to spin inside the power section.

Power Section Rotor/Stator

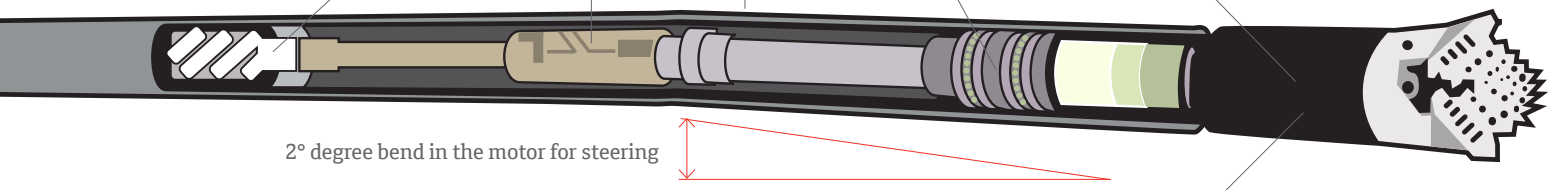
Universal Section (Flexible Shaft)

Bent Sub

Sealed Bearing Section

Bit Box

Rotational Power is transmitted from the Rotor all the way through to the Bit Box. This allows the drill bit to spin, without spinning the drill pipe.



2° degree bend in the motor for steering

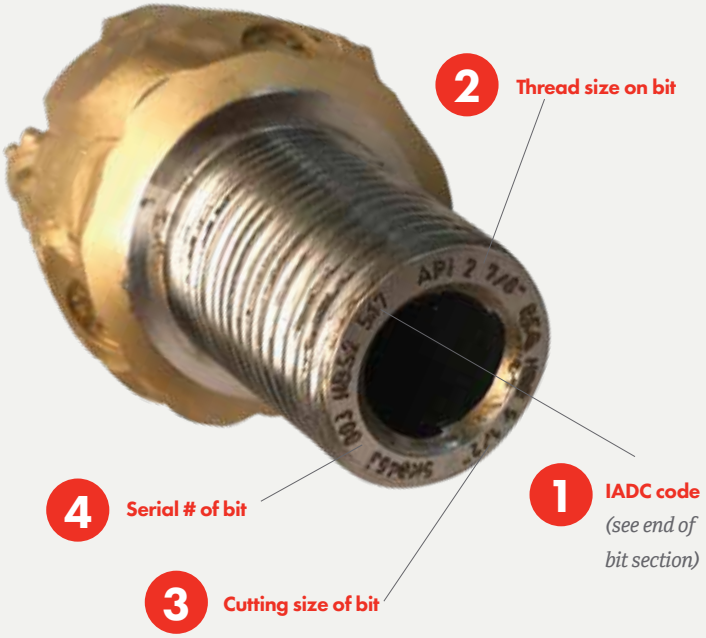
- **Drill fluid flow = speed of rotation of the bit (rpm)**
- **Drill fluid pressure = torque output by the bit (lb-ft)**

The bit is always rotating, allowing for steering while drilling through solid rock

Two most common HDD bits for drilling solid rock

PDC BITS Polycrystalline Diamond Compact bits	**TRICONE BITS** Most common in HDD for drilling solid and loose rock conditions
	
• **Fixed cutters that do not move** • **Longer lifespan since no moving parts, bearings or seals** • **Combine artificial diamonds and tungsten carbide** • **Drill faster than tricone bits when in established rock formations and correct PDC is selected** • **Good at shearing rock**	• **Consist of 3 roller cones (moving parts)** • **Action of the individual rollers on a tricone bit serves to fracture the rock** • **Require lubricated bearings and a grease reservoir** • **Drill from soft to hard formations** • **Softer formations use steel-tooth bits (Mill Tooth)** • **Harder formations use tungsten carbide inserts (TCI)** • **Better for harder formations, gravel, and varied rock formations**

What are all the #'s on my bit?

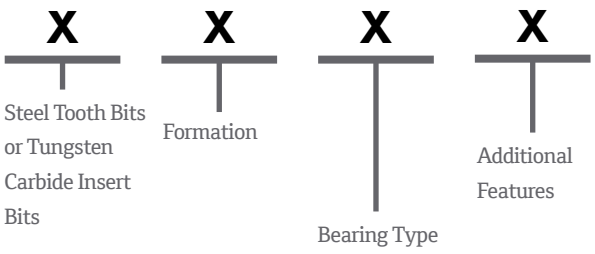


IADC code reference for Tricone Bits

The International Association of Drilling Contractors came up with a system to describe any tricone bit through a simple 4 digit number. This streamlines the process of ordering a new tricone bit for drillers everywhere.

By coming up with a simple 4 digit code to describe and categorize any tricone bit they eliminated any confusion that can arise when ordering. This classification system dedicates the first 3 digits to the design and function of the tricone, with the final digit being an alphabetical code for any additional features of the bit.

HOW TO READ THE IADC CODES



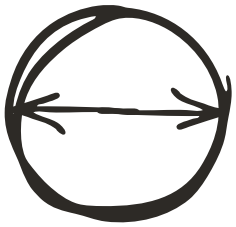
1		2		3							4 (not required)	
Series		Formation Type		Bearing/Gauge							Additional Features	
				1	2	3	4	5	6	7		
Steel Tooth	1	Soft	1	Standard open roller bearing	Standard open roller bearing, air-cooled	Standard open roller bearing with gauge protection	Sealed roller bearing	Sealed roller bearing with gauge protection	Sealed friction bearing	Sealed friction bearing with gauge protection	A	Air application (journal bearing with air nozzles)
			2								B	Special bearing seal
			3								C	Center jet
			4								D	Deviation control
	2	Medium	1								E	Extended jets (full length)
			2								G	Extra gauge/body protection
			3								H	Horizontal/steering application
			4								J	Jet deflection
	3	Hard	1								L	Lug pads
			2								M	Motor application
			3								S	Standard steel tooth model
			4								T	Two cone
Tungsten Carbide Tooth	4	Soft	1								W	Enhanced cutting structure
			2								X	Predominantly chisel tooth inserts
			3								Y	Predominantly conical inserts
			4								Z	Other shape inserts
	5	Soft to Medium	1									
			2									
			3									
			4									
	6	Medium	1									
			2									
			3									
			4									
	7	Hard	1									
			2									
			3									
			4									
	8	Very Hard	1									
			2									
			3									
			4									

SIZE YOUR REAMER RIGHT

When SELECTING THE RIGHT BACKREAMER, you should generally size your back reamer so that it is 1.5x larger than the outside diameter of the pipe you're pulling in. Of course, there are some exceptions. Let's look.

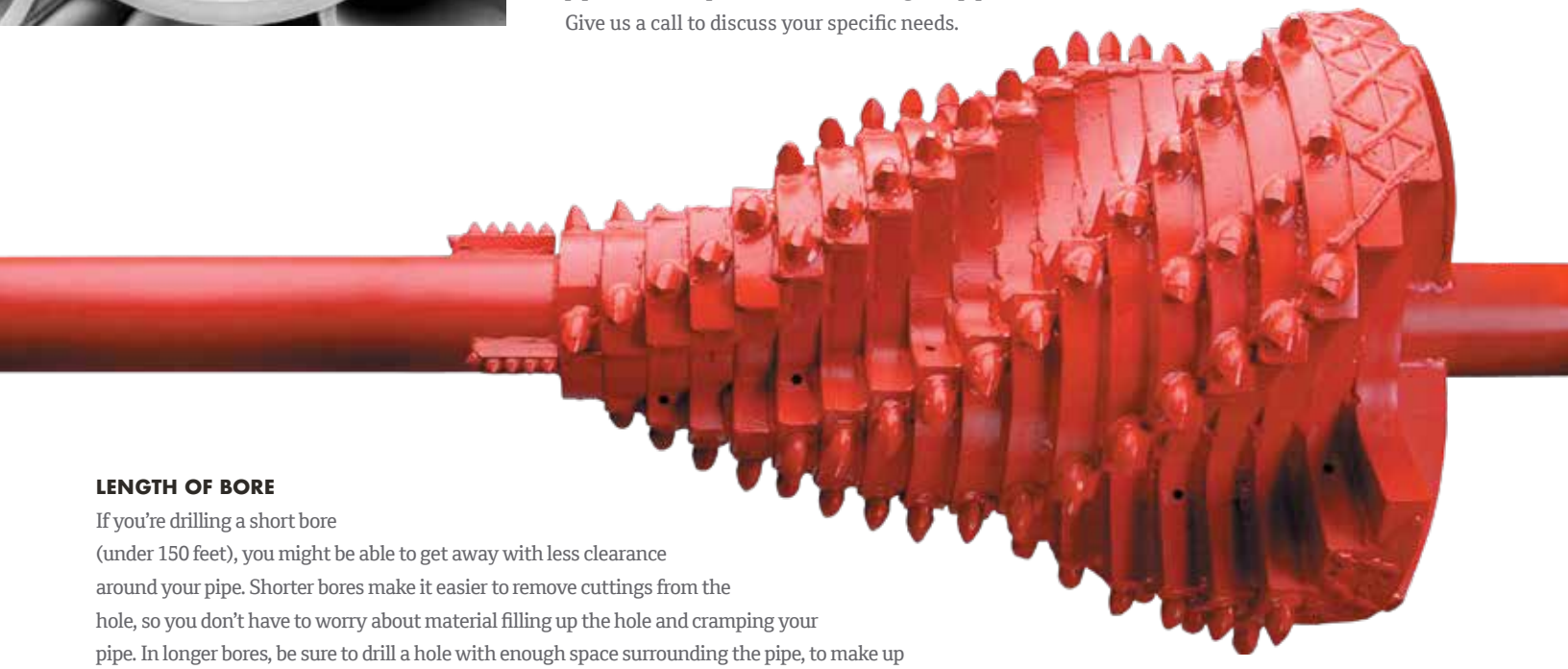
PRODUCT PIPE DIAMETER

Base your "1.5x" measurement on the widest part at any point in the pipe.



ON-GRADE BORES

Drilling to match a grading specification, like in the case of sewer lines, usually means that there's a tighter tolerance for bore size. Bore paths must be within a few percentage points of the diameter of the pipe. In this case, you'll want to drill as tight of a hole as possible without risk of squeezing or stretching the product pipe. You'll want to choose a reamer that is just an inch or two larger than the largest diameter of the product pipe. But take your time or you'll run the risk of stretching the pipe. We build special reamers for on-grade pipe installations.
Give us a call to discuss your specific needs.



LENGTH OF BORE

If you're drilling a short bore (under 150 feet), you might be able to get away with less clearance around your pipe. Shorter bores make it easier to remove cuttings from the hole, so you don't have to worry about material filling up the hole and cramping your pipe. In longer bores, be sure to drill a hole with enough space surrounding the pipe, to make up for unreachable cuttings that are left behind.

CLAY. In this soil type, it's important to strictly adhere to the 1.5x diameter rule–or even add a little extra. Clay swells when liquid (like your drill fluid) is introduced, then shrinks back down as it dries. Drilling an insufficient hole might seem permissible when the hole is wet, but your pipe could feel the pressure as the clay solidifies.

UNSTABLE CONDITIONS. In cobble, sand or other unstable material, extra space makes it easier to pull product through. Make sure to allow sufficient clearance in these situations by drilling a hole that is 1.5x the size of your diameter.

SOLID ROCK. is not in danger of collapse or ground swelling so your 1.5x measurement may not apply so you can come down to a hole diameter closer to the pipe.

Why does this matter?

Too small of a hole and your job takes forever, you risk humping the road during pullback, or your product pipe can stretch or break. Too big, and you require more expensive tooling and more drill fluid.

LOCATING THE RIGHT WAY

How to deal with a poor signal:

PROBLEM:
Loss of signal or intermittent signal

Cause:
Anything that creates its own magnetic field, like tracer tone lines, underground or overhead electric power lines, two-way radios, and invisible dog fences. The rule of thumb is: if it's conducting electricity, it's emitting a radio frequency.

Solution:
Scan for a new frequency on your receivers.

PROBLEM:
Weakened signal

Cause:
Underground sources such as buried pipe can block, distort, absorb, or weaken the signal that you're trying to pick up. One of the most common culprits is the rebar found in reinforced concrete.

Solution:
The lower the frequency scale, the better a locator can overcome the negative effects of passive interference sources. Falcon Rebar transmitters can broadcast at Sub-k frequencies–less than 1kHz–to deal with interference resulting from rebar, mesh, chain link, etc.

"TALK THE TALK" HDD GLOSSARY

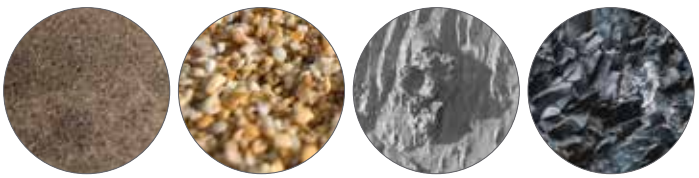
HDD Tooling & Equipment Terms

TERM & ALTERNATE TERMS	DEFINITION
A **ADAPTER** *Sub, Crossover, Tailpiece*	Configurable adapter piece that allows drillers to use various manufacturer's drill bits and blades with others' starter rods, housings, and other configurations. Often customizable to fit specific needs of a jobsite tooling setup.
AIR HAMMER	Tool used in HDD designed to bore through difficult rock formations using a combination of thrust, pressure and rotation to chip and carve rock from a hole.
B **BACKREAMER** *Reamer, Hole Opener, Expander*	Cutting head attached to the leading end of a drill string to enlarge the pilot bore during a pull-back operation to enable the product pipe to be installed.
BARREL *Stabilizer, Pig, Centralizer*	A large cylindrical add-on tool that centers reamer. It centers and stabilizes the drill rod, reamer and product pipe on center to create a round hole and successful bore.
BENTONITE	A natural clay material having thixotropic properties which is used as a basic ingredient for drilling muds and lubricants.
BIT *Blade, Duck Bill, Drill Bit, Paddle, Steer Plate*	Tools that excavate soil or rock and facilitate steering at the face of the bore. Common types of drill bits used in HDD include slant-face bits, slanted-face rock bits, rotary rock bits, and percussive bits.
BREAKOUT WRENCH	Manual or hydraulic tool used to connect or break tool joints at access points forward of the drill rig.
BURP HOLE	A hole dug along the bore path to relieve downhole pressure to help prevent inadvertent returns or hydrolocking.
C **CUTTINGS** *Spoil, Slurry*	Earth, rock, and other materials removed during drilling
D **DETERGENT** *Soap*	One of several drilling fluid additives that reduces clay balling and keeps tooling clean.
DRILL FLUID *Mud Mix, Slurry*	Largely comprised of water, drilling fluids usually include bentonite and if warranted other additives such as soda ash, polymers, and detergents to address water and soils properties that could compromise the successful completion of the HDD installation.
DRILL HEAD *Housing, Transmitter Housing, Head, Sonde Housing*	The lead portion of the drilling process that houses the transmitter inside to enable the locator to see where the drill bit is located underground. It comes in different bolt patters and can connect to various types of blades and bits depending upon the ground condition.
DRILL RIG *Rig, Drill*	A trenchless machine that installs pipes and cables by drilling a pilot bore to establish the location of the underground utility before enlarging the hole if needed and pulling back the product.
DRILL ROD *Pipe*	High strength hollow steel pipes joined to form a string used to transmit rotational torque and thrust, and to transport drilling fluid from the drill rig to the downhole tools.
DUCT PULLER *Puller, Carrot, Towing Head, Pull Head*	Device that connects duct, pipe or utility to a pullback device to ensure it won't disconnect downhole.
F **FILTER CAKE**	A thin layer of bentonite drilling fluid that seals the borehole preventing the flow of liquids from the borehole into the native soil.
FLY CUTTER *Wagon Wheel*	Style of reamer that has an open blade configuration.
H **HOLE OPENER** *Rock Reamer*	Downhole tool that uses rolling cutters to enlarge a hole in hard soil and rock formations.
L **LOWBOY** *(low-loader in British English, low-bed in western Canada and South Africa or float in Australia)*	A semi-trailer with two drops in deck height: one right after the gooseneck and one right before the wheels. This allows the deck to be extremely low compared with other trailers.
M **MIXING SYSTEM**	A system of pumps, hoppers, venturi mixers, hoses and tanks used to create the proper drilling fluid mixture suitable for the local geological conditions.
MUD MOTOR	Downhole tool for drilling in rock using pressurized fluid to power rotating cutterheads.
P **PDC BIT**	PDC (Polycrystalline Diamond Compact) bits are suited to rocky conditions and offer extremely high ROP (rates of penetration) and long life in rock.
PDC REAMER	PDC (Polycrystalline Diamond Compact) Reamers are used in the same difficult rocky formations as PDC bits to give greater penetration power and life to your reamer.

PILOT BORE *Pilot, Bore, Pilot Phase, Initial Bore*	First, usually steerable, pass of any boring operation which later requires back-reaming or other enlargement. Most commonly applied to guided drilling, directional drilling and 2-pass microtunnelling systems.
PIPE ROLLER	Bearings placed beneath the pipe to prevent it from dragging on the ground before entering the pit.
R **RECEIVER** *Locator, Guider, Magic Box*	An electronic instrument used to determine the position and strength of electro-magnetic signals emitted from a transmitter sonde in the pilot head of a boring system, or an impact mole tool or from existing underground services which have been energised. Sometimes referred to as a Walkover System.
RECEIVING PIT *Exit hole, Exit Pit*	This is the final pit dug in which the successful bore will emerge at the end of the line. The reamer, utility or pipe being pulled back is attached in this pit.
RECYCLER *Reclaimer*	As part of the mud mix system, this machine separates solids from drilling fluid, and recirculate cleaned fluids back into the drill. Once only used on large pipeline jobs it is fast becoming common place on all HDD jobs due to the rising cost and scarcity of fluid disposal.
REMOTE DISPLAY *Monitor, Display*	A monitor, usually located on the drill rig, that allows the locator to view where the transmitter is located.
S **SHACKLE** *Anchor Shackle, Clevis*	Piece to connect the pulling grips and pullers to your swivel when connection type doesn't match up directly.
STARTER ROD *EZ Connect, Quick Connect, Transition Rod*	Threaded connector piece that allows for easy detachment and exchange of directional heads and reamers.
SWIVEL *Pullback Swivel, Clevis Swivel, Thread-on Swivel*	Devices placed between the reamer and the duct puller or pulling head to eliminate rotation of the product during pullback.
T **TRANSITION SUB** *Flex Sub*	Transition subs connect directly between the drill pipe and the housing or backreamer. The overall length of the transition sub allows you to pull into the machine wrenches to make up or break loose from the drill pipe.
TRANSMITTER *Beacon, Sonde, Probe*	Transmitter located near the front of an HDD drill string that sends an electronic signal that provides location and depth of the drill string near the bit. The sonde signal also transmits pitch, roll, temperature, and battery status to the receiver.
V **VACUUM** *Sucker*	Another word for "vacuum". This is a stand-alone piece of equipment used to suck drill fluid and slurry out of the pit or from burp holes while drilling.
Z **ZAPALERT** *Strike Alarm*	System that installs to HDD rigs to alert crews to the possibility of a strike on an underground power line.

Soil Conditions

TERM & ALTERNATE TERMS	DEFINITION
B **BOG**	Wetland that accumulates peat, a deposit of dead plant material—often mosses, and in a majority of cases, sphagnum moss. It is one of the four main types of wetlands.
C **CALICHE**	This is a sedimentary rock, a hardened natural cement of calcium carbonate that binds other materials—such as gravel, sand, clay, and silt.
COBBLES	Rounded rock formations that come in various sizes. Best to find a way to push them out of the way rather than cut through them
D **DECOMPOSED GRANITE**	Rock of granitic origin that has weathered to the point that it readily fractures into smaller pieces of weak rock.
GRAVEL	This is a loose aggregation of rock fragments. Classified by particle size, it can make for tricky drilling conditions if not using the proper equipment
H **HARD PAN**	A layer of firm detrital matter, as of clay, underlying soft soil.
L **LIMESTONE**	A hard sedimentary rock, composed mainly of calcium carbonate or dolomite, used as building material and in the making of cement
R **RIVER ROCK**	River rock can come in all sizes and colors depending upon the source. But all river rock has been smoothed by the forces of water and friction so that there are no sharp edges.
RUNNING SAND	Running sand hazards can occur where excavations in the sand go below the water table, where springs occur at the base of sand outcrops, around leaking drains or mains water supply pipes or in entire sand bodies if vibrated (liquefaction) e.g. by an earthquake.
S **SANDSTONE**	Sedimentary rock consisting of sand or quartz grains cemented together, typically red, yellow, or brown in color.
SHALE	Soft, finely stratified sedimentary rock that formed from consolidated mud or clay and can be split easily into fragile slabs.



HDD Terms

TERM & ALTERNATE TERMS	DEFINITION
BEARING LIFE	The number of hours an individual bearing will operate before the first evidence of metal fatigue develops in the rings or rolling elements.
BEND RADIUS	The minimum radius one can bend a pipe, tube, sheet, cable or hose without kinking it, damaging it, or shortening its life. The smaller the bend radius, the greater is the material flexibility.
BORE	Void which is created to receive a pipe, conduit or cable.
BOX *Female*	The portion of an adapter or rod with a female thread connection type.
BREAK-OUT	The opposite of Make-up, Break-out is the uncoupling of threaded connections.
CYCLE RODS	The action of "cycling" rods refers to pushing forward then pulling back drill rod in the hole, in repetition, to clean or swab the path and avoid disruption.
FALL	Refers to the drop in slope over a given distance.
FRAC-OUT *Inadvertent Returns*	The inadvertent loss of drilling fluid from the borehole annulus to the surrounding soil as a result of excess downhole fluid pressure.
GEL STRENGTH	The measure of electrical attractive forces of the drilling fluid that allows the drilling fluid to suspend drilled solids as they are transported by the slurry out of the bore hole.
HYDROLOCK	This occurs when you lose flow and create a hydraulic cylinder in front of the reamer and/or compactor and/or product line that can exert more pressure than your rig has thrust.
MAKE-UP	Any point in the drilling system that has a tightened threaded connection.
ON-GRADE	The process of keeping a constant and correct grade between the pilot hole and receiving pit.
PIN *Male*	The portion of an adapter or rod with a male thread connection type.
PULLBACK	That part of a guided boring or directional drilling operation in which the drill string is pulled back through the bore to the entry pit or surface rig, usually installing the product pipe at the same time.
PULLBACK FORCE	Tensile load applied to a drill string during pull-back. Guided boring and directional drilling rigs are generally rated by their maximum pull-back force.
PUSH	The action of stopping rotation of the drill bit and progressing slowly through soil to avoid objects or correct direction.
PUSH REAM *Forward Reaming*	Push reaming is a technique to resolve the issue of preventing drilling fluid from ending up in the exit recovery pit during the reaming process. It has been used on larger boring rigs for some time. Keeping the mud returns coming to the entrance recovery pit makes the recovery, cleaning and reuse of drilling fluid a lot more practical-particularly if there is no easy way to get fluid from the exit recovery pit back to the entrance recovery pit for processing.
ROTATE	The action of rotating around a center. The rotation of a drill pipe will always turn to the right.
SLOPE	A percentage of the grade, or line of the bore is at a higher or lower level than another.
THRUST	Measured in pounds or similar measurements of force; along with torque and pump capacity, one of three measurements typically used to describe and classify drill rigs and their suitability to successfully perform an installation.
TORQUE	Measured in Foot-pounds or similar measurements of rotational force; along with thrust/pullback and pump capacity, one of three measurements typically used to describe and classify drill rigs and their suitability to successfully perform an installation.
TRIP OUT	When all pipe and/or drill rod is pulled back out of the bore hole, whether it be prematurely or finishing the pullback process.
VISCOSITY	The resistance of a fluid to flow.

BOLTS AND O-RINGS

QUICK DISCONNECT BOLTS

LEAD ROD	COLLAR BOLT	O-RING
DLR2-04M-L52M	HHCS 5/16X1/2	O-RING 022
DLR2-05M-L52M	HHCS 5/16X1/2	O-RING 022
DLR2-01AM-L55M	HHCS 10X12	O-RING 027
DLR2-09M-L55M	HHCS 10X12	O-RING 027
DLR2-34M-L58M	SHCS 3/8X5/8	O-RING 221
DLR2-86M-L54M	HHCS 1/2X3/4	O-RING 130
DLR2-20M-L54M	HHCS 1/2X3/4	O-RING 130
DLR2-35M-L54M	HHCS 1/2X3/4	O-RING 130
DLR2-36M-L56M	SHCS 1/2X3/4	O-RING 133
DLR3-36M-L59M	SHCS 1/2X3/4	O-RING 224
DLR2-42M-L57M	HHCS 5/8X1	O-RING 139
DLR2-43M-L57M	HHCS 5/8X1	O-RING 139
DLR2-40M-L54M	HHCS 1/2X3/4	O-RING 130
VLR-32F-L43F	SHCS 1/2X3/4	NONE
VLR-30F-L43FXXL	SHCS 1/2X3/4	NONE
VLR-40F-L43F	SHCS 1/2X3/4	NONE
VLR-46F-L43F	SHCS 1/2X3/4	NONE
VLRV-31F-L42F-X	SHCS 3/8X5/8	NONE
VLRV-32F-L43F	SHCS 1/2X3/4	NONE
VLRV-30F-L43F-X	SHCS 1/2X3/4	NONE
VLRV-30FL43FXXL	SHCS 1/2X3/4	NONE
VLRV-40F-L43F	SHCS 1/2X3/4	NONE
VLRV-33F-L43F	SHCS 1/2X3/4	NONE
VLRV-46F-L43F	SHCS 1/2X3/4	NONE
VLRV-41F-L43F	SHCS 1/2X3/4	NONE

HOUSING BOLTS

HOUSING	LID BOLT	BLADE BOLTS
1720-HM-09	SHCS 3/8X3/4	SHCS 12X20
1920-HD-09	SHCS 3/8X3/4	SHCS 12X20
3625-HT3-06	SHCS 1/2X3/4	SHCS 3/8X3/4
3625-HT3-13	SHCS 1/2X3/4	SHCS 1/2X1
3627-HT3-13	SHCS 1/2X3/4	SHCS 1/2X1
3627-HT3-14	SHCS 1/2X3/4	SHCS 12X25
3632-HT3-13	SHCS 1/2X1	SHCS 1/2X1
3632-HT3-15	SHCS 1/2X1	SHCS 16X35
3825-HT3-06	SHCS 1/2X3/4	SHCS 3/8X3/4
3925-HD3-14	SHCS 12X20	SHCS 12X25
3927-HD3-14	SHCS 12X20	SHCS 12X25
3932-HD3-15	SHCS 16X25	SHCS 16X35
3935-HD3-15	SHCS 16X25	SHCS 16X35
3625-HT3	SHCS 1/2X3/4	N/A
3627-HT3	SHCS 1/2X3/4	N/A
3632-HT3	SHCS 1/2X1	N/A
3742-HU	SHCS 1/2X1	N/A
3927-HD3	SHCS 12X20	N/A
3932-HD3	SHCS 16X25	N/A
3935-HD3	SHCS 16X25	N/A

BLADE BOLTS

BOLT PATTERN #	BLADE THICKNESS	BOLT
-06	1/2"	SHCS 3/8X3/4
-09	1/2"	SHCS 12X20
-13	3/4"	SHCS 1/2X1
-13	1"	SHCS 1/2X1-1/4
-14	1/2"	SHCS 12X20
-14	3/4"	SHCS 12X25
-15	3/4"	SHCS 16X35
-15	1"	SHCS 16X40
-23	1"	SHCS 5/8X1-1/4
-25	1"	SHCS 20X40
-33	1 1/4"	SHCS 3/4X1-1/2

ADAPTER O-RINGS

ADAPTERS	BOLT	O-RING
21M-H350M	SHCS1/2X3/4	O-RING 221
21M-L300MV3	SHCS3/8X1/2	O-RING 213
21M-L400MV3	SHCS1/2X3/4	O-RING 218
21M-L42M	N/A	O-RING 028
21M-L43M	N/A	O-RING 029
23M-H350M	SHCS1/2X3/4	O-RING 221
23M-L400MV3	SHCS1/2X3/4	O-RING 218
23M-L43M	N/A	O-RING 029
23M-L460MV3	SHCS1/2X1/2	O-RING 323
27M-L43M	N/A	O-RING 029
35M-L43M	N/A	O-RING 029
80M-L43M	N/A	O-RING 029

FLANGE O-RINGS

FLANGES	O-RING
VF-30M-FO	O-RING 225
VF-31M-FO-V	O-RING 225
VF-32M-FO	O-RING 225
VF-32M-FO-V	O-RING 225
VF-40M-FO	O-RING 225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