MOTOR HANDBOOK

GYRODRILL™ PERFORMANCE MOTOR

gyrodata

Gyrodata is an independent supplier and service provider delivering precision wellbore placement and evaluation solutions for drilling, completions and production challenges. Since 1980, we have been partnering with leading organizations to develop innovative technologies to support the most complex Oil & Gas, Unconventional Resources, Civil and Mining projects around the world.

We are proud to be both a global service provider and supplier of directional drilling systems, such as the **GyroDrill™ Performance Motor** to support a wide range of your drilling operations.

Motor Handbook

This Motor Handbook is the latest edition of the technical information and illustrations for the GyroDrill drilling mud motor product line. Included in this handbook are tables, charts and diagrams for the extensive range of motor sizes and configurations available.

Disclaimer

The technical specifications in this handbook are subject to change at any time. Please contact your Gyrodata representative for more information.

Please note the interpretation and utilization of the information contained herein is the responsibility of the user. Gyrodata is not in any way responsible as to the end result of work done based on information obtained from this handbook.

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01 **INTRODUCTION**

01 INTRODUCTION

GyroDrill Performance Motor

Gyrodata's GyroDrill performance motors are designed to withstand the harshest downhole conditions while delivering superior performance in a wide range of drilling applications.

The GyroDrill fleet is managed with a comprehensive serialized component tracking system which greatly extends motor life and ensures consistent reliability.

Design + Performance

- Utilizes high strength alloy motor parts, including high capacity thrust and radial bearings - extending motor life and supporting higher weight on bit (WOB)
- Entire fleet outfitted with hard rubber stators and tungsten carbide coated rotors, delivering increased reliability in harsh environments
- Extensive selection of power section options, allowing motors to be tailored to support varying bit speeds, an array of downhole temperatures, fluid types and high torque operations
- Robust design, enabling motor to be run above RSS and MWD systems for added at bit RPM and torque
- Redundant 4 catch system, enabling full recovery of motor system and other expensive RSS & MWD equipment in the event of a back-off/twist-off

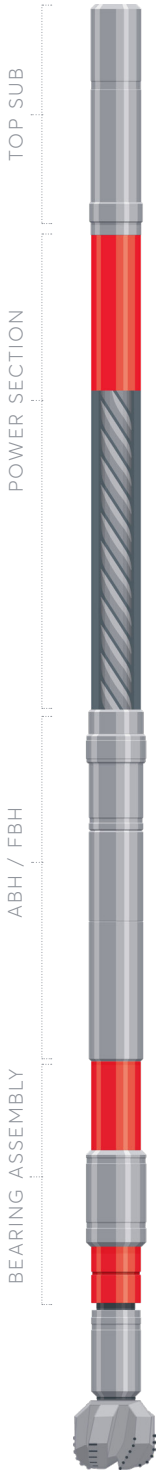
Market + Applications

- Horizontal and Directional Drilling
- Vertical Drilling
- Performance Drilling
- RSS & MWD Assist
- High Torque Operations
- One-Run Applications
- Extended Reach Laterals
- BHA Optimization
- High DLS Curves
- Laminated Formations

Table 1-1
GyroDrill General Specs

MOTOR SIZE (in)	REC. HOLE SIZE (in)	CONFIGURATION		SPEED RATIO (rev/gal)	HOUSING TYPE
		LOBE	STAGE		
4 3/4	6–7 7/8	5/6	8.3	1.00	Adjustable Fixed Short BTB
4 3/4	6–7 7/8	7/8	2.6	0.26	Adjustable Fixed
4 3/4	6–7 7/8	7/8	3.8	0.52	Adjustable Fixed Short BTB
5	6–7 7/8	6/7	8.0	0.81	Adjustable Fixed Short BTB
5	6–7 7/8	6/7	10.0	0.84	Fixed
6 1/2	7 7/8–8 3/4	6/7	5.0	0.29	Adjustable Fixed
6 1/2	7 7/8–8 3/4	7/8	3.3	0.14	Adjustable Fixed
6 3/4	8 1/2–9 7/8	4/5	7.0	0.50	Adjustable Fixed Short BTB
6 3/4	8 1/2–9 7/8	6/7	5.0	0.29	Adjustable Fixed Short BTB
6 3/4	8 1/2–9 7/8	7/8	3.3	0.14	Adjustable Fixed
6 3/4	8 1/2–9 7/8	7/8	5.7	0.24	Adjustable Fixed Short BTB
6 3/4	8 1/2–9 7/8	4/5	7.0		Double Stabilized
6 3/4	8 1/2–9 7/8	6/7	5.0		Double Stabilized
6 3/4	8 1/2–9 7/8	7/8	3.3		Double Stabilized
6 3/4	8 1/2–9 7/8	7/8	5.7		Double Stabilized
7	8 1/2–9 7/8	5/6	8.3	0.38	Fixed
7	8 1/2–9 7/8	6/7	6.5	0.23	Fixed
8	9 7/8–12 1/4	7/8	4.0	0.17	Adjustable Fixed Short BTB
9 5/8 Combo	12 1/4–17 1/2	7/8	3.4	0.09	Fixed
9 5/8 Combo	12 1/4–17 1/2	7/8	5.9	0.17	Fixed

01 INTRODUCTION



01 INTRODUCTION

Gyrodata's Gyrodrill performance motor line adheres strictly to our SQ³ program.

What is SQ³?

SQ³ (Service Quality Cubed) is Gyrodata's proprietary, multi-faceted approach that we have implemented across all of our product lines globally to differentiate us as a supplier and service provider that delivers both precision and accuracy for superior performance on each and every job.

The SQ³ seal is Gyrodata's promise to consistently provide the highest level of reliability and quality service available.

Gyrodata's new SQ³ initiative is both an educational program and a certification requirement for the company's gyroscopic survey operations in the field.

SQ³ highlights three main aspects of Gyrodata's services through Quality Refinement:

- **System Quality -** Precision engineered gyroscopic systems, designed and manufactured in-house
- **Survey Quality -** Enhanced data accuracy through standardized procedures resulting in quality assurance
- **Service Quality -** Exceptional value for our customers through controlled process

02 MOTOR COMPONENTS

Top Sub & Power Section

Top Sub

The top sub is the uppermost portion of the mud motor with an API tool joint box thread. The lower end is a Gyrodata designed thread form that connects to the upper box thread of the stator. All top subs are bored for a float valve.

Rotor Catch

The rotor catch is a standard motor component that is inserted into the top of the rotor and runs inside the top sub. The catch design works with either left or right-hand torque operations. Its main function is to "catch" the rotor, and possibly the entire motor in the event of a broken or backed-off connection below the top sub.

Power Section

The power section is a Moineau pump operated in reverse when drilling fluid pressure is applied. It transforms the hydraulic energy from the drilling fluid pressure to mechanical energy which rotates the articulated driveshaft, in turn rotating the bit.

Stator & Rotor Designs

The power section consists of a helically shaped rotor running inside the stator.

The stator tube has an elastomer liner that is bonded to the ID of the tube. The stator elastomer liner is similar to the shape of the rotor. However, it has an additional lobe which creates adequate clearance enabling the rotor to rotate within the stator.

The rotor forms a continuous seal lengthwise with the stator, creating wedge-shaped cavities. As drilling fluid is applied to these cavities, the rotor is forced to rotate within the stator.

Multi-Lobe Configuration

Gyrodata's power sections utilize a multi-lobe configuration. The motors use a rotor with a multiple lobe cross-section that forms a helix.

The stator has one more lobe and a pitch length longer than the rotor. The stator pitch length can be calculated by dividing the number of stator lobes by the number of rotor lobes.

Rotor/Stator to Lobe Ratio

The rotor/stator configurations are designated by the ratio of their lobes. Generally, as the number of lobes increases, the torque increases and the speed decreases.

Power Section

Stages

Another factor that affects torque is the number of spirals each lobe translates over the rotor's length. One complete stator spiral is referred to as one stage.

Extended power sections offer increased torque without reducing speed by increasing the overall length and number of stages.

Power Section Fit

The power section fit is established by rotor/stator interference or clearance. This is the difference between the stator minor diameter (lobe peak to lobe peak) and the rotor mean diameter (lobe peak to lobe valley).

The power section fit is determined by the bottom hole temperature (BHT), mud type required, etc.

Low BHT: The rotor fit is sized slightly larger than the stator, creating an interference fit. Increasing the rotor/stator interference, in turn, increases the sealing surfaces. This produces larger pressure drops but decreases stator life due to the elevated frictional forces causes by elastomer wear and/or premature chunking.

High BHT**:** In these applications, the rotor/stator fit is decreased. Elevated temperatures require the rotor/stator fit to be reduced to achieve clearance (negative) fits. Clearance fits and/or flush fits (rotor mean diameter and stator minor diameter are the same size) are generally used when downhole temperatures are expected to be above 200°F. These clearances are measured at room temperature.

Increasing Power

Increasing the power output is achieved by extending the length and increasing the number of stages of the power section.

Since rotor/stator power is proportional to the number of stages of a power section, increasing the number of stages thus increases the power delivered. This can be achieved by using an extended length power section. Extended power sections are also used to produce more torque or an equivalent amount of torque at a lower pressure drop, greatly increasing power section life.

02 MOTOR COMPONENTS

Power Section

Factors Affecting Power Section Life

The most common mode of failure in power sections is damage to the stator elastomer, also known as chunking. "Chunks", which consist of pieces of stator lobes, are torn or pulled away. This is caused by frictional forces between the rotor and stator rubber exceeding the tensile strength of the rubber.

Power section life can be lengthened by following the recommendations outlined below:

- Never exceed the recommended maximum operating differential pressures outlined on the motor specification sheets in chapter 4
- Never exceed the recommended maximum flow rate outlined on the motor specification sheets in chapter 4
- Ensure that the appropriate power section fit is selected for the specific drilling application
- When utilizing oil based drilling mud (OBM), consider the bottom hole operating temperatures (BHT) and the aniline point (AP):

  The AP (temperature) of an oil is an indication of its tendency to cause swelling of the stator elastomer, and is a measure of the oil's aromatic content.

  Low AP: The lower the AP, the greater the swelling tendency of the stator elastomer. Generally, stator elastomer or bond degradation increases when the AP is lower than 160. The aniline point gives a measure of the solvent power of a petroleum product for aniline, which is related to its solvent power for many materials.

  High AP: At temperatures higher than the oil's AP, the aromatic portion of the oil tends to penetrate and swell the elastomer, reducing the strength and hardness. As the swelling increases, the interference fit between the rotor and stator also increases. This results in additional heat build-up which leads to rapid degradation of the elastomer.
- Larger power section fits will minimize the potential for premature chunking
- Avoid or minimize motor stalls
- Minimize the amount of trash (metal filings, etc.) in the drilling mud system
- Closely monitor the age and condition of the stator's elastomer, as this can help to reduce failures and determine when relining is required

Rotor Nozzles

Rotor Nozzles

Higher flow rates can be achieved by using tungsten-carbide rotor nozzles. Rotor nozzles enable higher drilling fluid circulation rates by diverting a portion of the drilling fluid through the center of the rotor. They can also be used to reduce the bit speed at these higher flow rates.

When the drilling requirements are within the operating parameters, the rotor is then fitted with a plug.

The following hydraulic equation is used to determine jet size:

$$A = \sqrt{(Q^2 \times W) / (P \times 10{,}858)}$$

Where:

A	=	Nozzle Area (in^2)
Q	=	Flow Rate (gpm)
W	=	Mud Weight (ppg)
P	=	Differential Pressure (psi)

Refer to Table 2-1 for the flow area of a particular jet size and Table 2-2 for the bypass flow for a particular jet size given differential pressure.

Table 2-1
Flow Areas by Nozzle Size

NOZZLE SIZE (in)	FLOW AREA (in^2)
$^{6}/_{32}$	0.028
$^{7}/_{32}$	0.038
$^{8}/_{32}$	0.049
$^{9}/_{32}$	0.062
$^{10}/_{32}$	0.077
$^{11}/_{32}$	0.093
$^{12}/_{32}$	0.110
$^{13}/_{32}$	0.130
$^{14}/_{32}$	0.150
$^{15}/_{32}$	0.172
$^{16}/_{32}$	0.196
$^{18}/_{32}$	0.249
$^{20}/_{32}$	0.306
$^{22}/_{32}$	0.371
$^{24}/_{32}$	0.442
$^{26}/_{32}$	0.518
$^{28}/_{32}$	0.601
$^{30}/_{32}$	0.690

Rotor Nozzles

Table 2-2
Nozzle Size & Bypass Flow by Differential Pressure

NOZZLE (in)	MUD WEIGHT (ppg)	BYPASS FLOW RATES (gpm) BY DIFFERENTIAL PRESSURES (psi)								
		100	200	300	400	500	600	700	800	900
$^{7}/_{32}$	water	14	19	23	27	30	33	36	38	41
	10	12	18	21	25	28	30	33	35	37
	12	11	16	20	23	25	28	30	32	34
	14	10	15	18	21	23	26	28	30	32
$^{8}/_{32}$	water	17	25	31	35	40	43	47	50	53
	10	15	23	28	32	36	40	43	46	48
	12	14	21z	26	29	33	36	39	42	44
	14	13	19	24	27	30	33	36	39	41
$^{10}/_{32}$	water	28	39	48	55	62	68	72	78	83
	10	25	36	44	50	57	62	67	71	75
	12	23	33	40	46	52	56	61	65	69
	14	21	30	37	42	48	52	56	60	64
$^{12}/_{32}$	water	40	56	69	80	89	98	105	113	119
	10	36	51	63	73	81	89	96	103	109
	12	33	47	58	66	74	81	88	94	99
	14	31	43	53	62	69	75	81	87	91
$^{14}/_{32}$	water	54	77	94	108	121	133	144	153	162
	10	50	70	86	99	111	121	131	140	147
	12	45	64	78	90	101	111	120	128	135
	14	42	59	73	84	94	103	111	118	124
$^{16}/_{32}$	water	71	100	123	142	158	174	187	200	212
	10	65	91	112	129	145	158	171	183	193
	12	59	84	102	118	132	145	156	167	175
	14	55	77	95	109	122	134	145	155	162
$^{18}/_{32}$	water	90	127	155	179	200	220	237	254	268
	10	82	116	142	164	183	201	217	232	245
	12	75	106	129	150	167	183	198	211	221
	14	69	98	120	138	155	170	183	196	202

Driveshaft & Bend Housing Options

Driveshaft

The heavy-duty driveshaft assembly is a ball-driven design that converts the eccentric rotation of the rotor into concentric rotation for input into the bearing assembly.

The driveshaft transfers the thrust load from the rotor caused by the pressure drop across it.

Ball drives are capable of withstanding the high torque of extended power sections and still support adjustable bend settings up to 3°.

The driveshaft assembly consists of upper and lower universal joints along with a center driveshaft. The upper universal connects to the lower rotor connection, and the lower universal connects to the bearing assembly. Both universal joints are lubricated, sealed and pressure balanced.

Bend Housing Options

Adjustable Bend Housing

The adjustable bend housing (ABH) connects the lower stator to the bearing assembly. It was engineered to allow the bend angle to be easily adjusted at 13 increments from 0° - 3°. These angle settings are rig adjustable and can produce a wide range of build rates.

Fixed Bend Housing

Gyrodata's GyroDrill performance motors can also be assembled with a fixed bend housing (FBH), which also feature an extensive range of bend angles.

Bearing Assembly

Bearing Assembly

The bearing assembly transfers the rotation of the rotor through the driveshaft to the drill bit.

The bearing assembly carries the following:

- **Compression Thrust Load**
  Created by weight on bit (WOB).
- **Radial and Bending Loads**
  Created while directional or steerable drilling.
- **Tension**
  Created when off-bottom as thrust loads are produced by the pressure drop across the rotor and the drill bit.
- **Any load caused by backreaming**

The bearing mandrel bit box is the lowermost connection of the mud motor and is manufactured with an API tool joint box thread.

Maximum Bearing Assembly Life

Maintaining the proper flow rate and WOB will significantly increase bearing assembly life. Refer to the detailed motor specifications located in chapter 4.

NOTE

- Exceeding maximum flow rate can cause the radial bearings to wash
- Exceeding maximum WOB can cause the thrust bearings to wear prematurely

03 OPERATING PROCEDURES

Equipment Selection & Set Up

Job Preparation

Motor Selection

The motor selection process requires careful evaluation of the following specifications: hydraulics, circulating fluid data, speed, formation characteristics, and motor diameter.

Power Section Selection

The power section should be selected based on the performance requirements for the specific drilling application. By evaluating the relation of the power section output to the bit and formation type, a proper power section can be selected.

Motor Bend Angle

The bend angle is determined by the required build rates in degrees/100 ft. Refer to the motor specification sheets in chapter 4.

Rotor Nozzle Sizing

A rotor nozzle can be utilized to bypass flow should the rate exceed the recommended maximum. The nozzle is fitted in the rotor catch and allows a portion of the fluid to bypass through the ID of the rotor. This option must be selected prior to shipping motors from the service facility. Refer to Table 2-1 and Table 2-2 for nozzle sizing.

Top Sub and Bit Box Connections

It is necessary that the requested top sub and bit box connections match those of the rig.

Stabilizers

It is recommended that the stabilizer be under gauge by no less than 1/8" and not exceed 1/4" . A ring gauge should always be utilized to ensure that the stabilizer is within specification. If a stabilizer is not required and the housing is threaded, a slick sleeve thread protector must be used.

Pre-Run Motor Evaluation and Set Up

Visual Inspection

A visual inspection of the motor is recommended to check for any signs of external damage to the motor.

Adjustable Bend Housing (ABH) Angle

Refer to Figure 3-2 for ABH alignment instructions.

Stabilizers

If the bearing housing is threaded, be sure that a stabilizer or slick sleeve thread protector is used. Refer to Table 4-2 in Chapter 4 for the recommended sleeve torque values.

Bearing Assembly

Bearing Assembly Wear Measurements (Push/Pull)

To determine whether a motor is within acceptable wear limits for new and/or continued operation, follow the steps below both before and after motor runs:

1. Measure the off-bottom or tension gap between the lower housing and bit box when the motor is hanging above the rig floor (Refer to L2 in Figure 3-1)
2. Measure the on-bottom or compression gap when the motor is standing on the rig floor (Refer to L1 in Figure 3-1)
3. Subtract the "new" hanging gap minus the standing gap (L2 - L1)
4. Subtract the "used" hanging gap minus the standing gap (L2 - L1)
5. Lay the motor down if the difference between the hanging and standing gap, new or used, exceeds those in Table 3-1

Formula New/Used L2 – L1 = △

Figure 3-1
Push/Pull Measurements

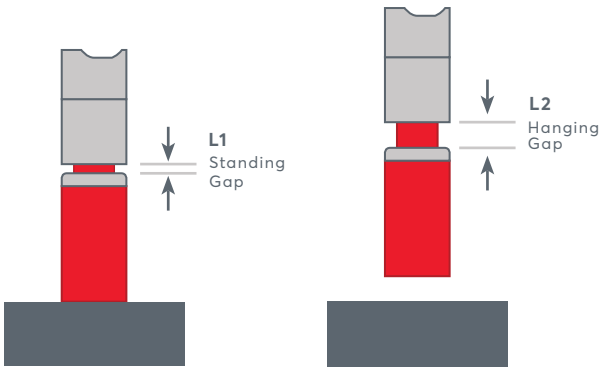


Table 3-1
Push/Pull Measurements

MOTOR SIZE (in)	MAX BEARING WEAR HANGING OR STANDING POSITION (in)
4¾ – 5	0.20
6½	0.20
6¾	0.20
7	0.20
8	0.20
9⅝ Combo	0.25

ABH Alignment

Figure 3-2
ABH Adjusting Procedure

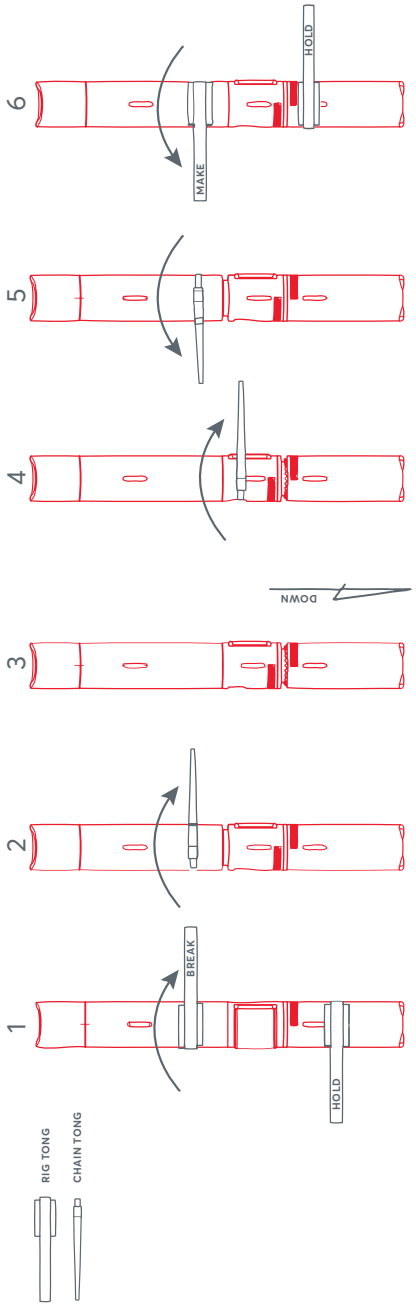


Table 3-2

MOTOR SIZE (in)	TOOL TORQUES (Nm)	ABH MAKE-UP TORQUE (lb-ft)
4¾ – 5	13,600	10,000
6½	27,100	20,000
6¾	32,500	24,000
7	32,500	24,000
8	48,800	36,000
9⅝ Combo	101,700	75,000

ABH Adjustment Procedure

1. Break connection as shown.
2. Chain Tong 3-4 turns – DO NOT USE ROTARY TABLE.
3. Retract the Kick Ring.
4. Chain Tong Kick Ring. Align windows for desired setting.
5. Slide Kick Ring back to engage kick housing and Chain Tong snug.
6. Torque to proper setting per values in Table 3-2.

Standard Operations

Running In

A straight motor can be run in the hole normally.

However, when the motor is set at a non-zero angle, it is advised to trip in the hole at a controlled rate. This should be done when running the drill string through the blowout preventer, casing shoes, liner hangers, ledges, or key seats to ensure that the motor or drill bit does not hang up.

Do not run into bottom or bottom fill, as it could plug the bit or damage the motor.

Starting the Motor

1. Begin circulating the motor off-bottom allowing the bit to turn freely.
2. Continue circulating until the desired flow rate is achieved. Avoid flow rates outside the recommended values to prevent motor damage.
3. Record the off-bottom pressure.

Drilling

1. Slowly lower the motor to bottom, noting that the standpipe pressure will increase as it is fully set (this is the differential pressure).
2. Gradually increase the weight on bit (WOB) until the optimal rate of penetration (ROP) is achieved. Maintaining ideal ROP can be achieved by constantly monitoring differential pressure and incrementally adjusting the WOB as needed.

The standpipe pressure will gradually increase after the hole cleaning due to the hydraulic energy required to lift the cuttings. Therefore, it may become necessary to periodically recheck the off-bottom pressure.

Bit torque is produced while the motor is on-bottom. The torque is directly proportional to the difference between the on-bottom and off-bottom pressure.

- As the WOB increases, the bit torque increases as well.
- As the bit drills off, the WOB, pressure and torque decreases.
- Therefore, the standpipe pressure gauge can be used as a torque indicator.

Standard Operations

Motor Settings Precautions

Rotary RPM

Fatigue loading on the motor can be produced when the bend settings are within recommended values. As such, it is recommended that the rotary speed not exceed the values in Table 3-3, RPM Specs. Doing so will reduce rotational and bending load across the motor which will minimize the possibility of a motor failure.

Table 3-3
RPM Specs

MOTOR BEND ANGLE	MAX RPM VERTICAL/LATERAL SECTION	MAX RPM CURVE/TRANSITION SECTION
	ROTARY SPEED (RPM)	ROTARY SPEED (RPM)
0	80	80
0.39	80	80
0.78	80	80
1.15	80	80
1.25	80	80
1.5	80	80
1.75	80	80
1.83	70	60
2	60	50
2.12	50	40
2.25	40	30
2.38	0	20
2.5	0	0
2.6	0	0
2.77	0	0
2.9	0	0
2.97	0	0
3	0	0

If the customer requires the rotary speed to exceed the values above, then excessive fatigue loads will be produced which can increase the potential for a motor failure.

Standard Operations

Stalling

Stalling occurs when the drill bit is overloaded. The differential pressure increases while the ROP ceases. When a stall occurs, the drilling fluid distorts the stator elastomer and flows through the motor without turning the rotor.

If a stall should occur, the following steps should be taken immediately:

1. Immediately shut down the rotary table.
2. If required, shut the pumps off.
3. Slowly release trapped torque using the rotary table brake.
4. Lift the bit off-bottom.

Following the aforementioned procedure will significantly reduce possible motor damage and connection back-off.

Failure to properly respond to a stall may result in the following:

- Continuous circulation through a stalled motor or repeated stalling can seriously damage the stator elastomer as well as other internal components.
- If a stall occurs and the bit is picked up off-bottom, the torque (which becomes trapped in the drill string) will be released. Thus, possibly causing damage to the BHA or cause connections to back-off.

Bit Pressure Drop

The bit pressure drop should not exceed 1,500 psi, as exceeding this value increases the chance of bearing failure.

Tripping Out of the Hole and Surface Checking

No special procedures are required when tripping out of the hole.

As the motor reaches the surface it is recommended to do a thorough visual inspection to identify any possible external damage to the motor.

Prior to the motor being laid down and bit removed, it should be flushed with water until it is flowing out the bit box. This is especially important when the motor has been run in oil based mud or elevated chloride content applications.

Drilling Fluid

Drilling Fluid Selection

Selecting the appropriate drilling fluid is crucial to extend motor life, but also essential to delivering superior performance to drilling operation overall.

Chlorides

Drilling fluid containing chlorides, especially at elevated temperatures, can cause corrosion that greatly reduces rotor and stator life.

Although Gyrodata's rotors utilize a high-quality coat of tungsten carbide, chlorides can still be detrimental to the rotor's chrome coating. Therefore it is recommended that chloride concentration never to exceed 30,000 PPM when chrome rotors are in use.

Oil Based Mud

The GyroDrill performance motor can be run in oil based mud (OBM), provided the operating temperature is less than the aniline point (AP) of the oil. The AP value gives an approximation of the oil's aromatic content.

Operating above the AP of the oil can cause swelling of stator elastomer. Oil based mud will degrade the stator elastomer making a reline necessary after each run.

EXAMPLE

- If a motor is run in oil based fluids at a temperature above the oil's AP, the aromatic portion of the oil will penetrate the elastomer. The stator elastomer will then swell and reduce in hardness and strength. As the elastomer swells the interference fit between the rotor and stator increases, resulting in the heat buildup and eventual chunking.

As a solution, power sections with less interference or larger clearance can help to limit the effects of swelling.

Mud Density

Drilling mud with a density greater than 16.0 lbs/gal can cause irregular erosion of internal motor components including stator elastomer due to suspended materials in the mud.

Mud material density recommendations:

- Ensure sand content in drilling fluids do not exceed 1%
- Corrected solids should not exceed 18%
- Low gravity solid content should not exceed 6%

Air or 2 - Phase Drilling

Air or 2 - Phase Drilling

Types

- **Mist**
  Occurs when the liquid fraction is greater than 2.5% at downhole operating conditions. This ensures the liquid remains as droplets within the gas.

- **Foam**
  Occurs when the liquid fraction is between 2.5% - 25% at downhole operating conditions. Foam is specified as "% foam quality". This is the volume fraction of the gas. Therefore, 60% foam quality is 60% gas and 40% liquid, by volume.

- **Aerated Mud**
  Occurs when the liquid fraction is greater than 25% at downhole operating conditions. In this circumstance, gas stays as bubbles in the liquid.

Recommended Operations Requirement

- **Air Volume Requirement**
  3 to 4 standard cubic feet per minute (scfm) = 1 gallon per minute (gpm) of drilling fluid.

  EXAMPLE 400 gpm = 1,200 – 1,600 scfm

- **Foam Volume Requirement**
  3½ - 4½ scfm of air plus between 10 - 100 gpm of foam injection is recommended.

- **Pressure Requirement**
  Approximately twice the amount required with normal fluids.

Lubricants

Utilizing dry air can cause friction between the rotor and stator, resulting in short motor runs. As such, it is necessary to ensure the stator elastomer is properly lubricated.

A lubricant created from mixture of soap/gel and water that is injected at ~5% rate by volume at downhole operating conditions is sufficient in most applications.

- **Standard Lubricants**

  Liquid Soap .....½ to 1 gal/barrel of water
  Graphite .....4 to 6 lbs/barrel of water
  Gel .....½ to 1 lb/barrel of water
  Oil .....0.1 to 0.6 gal/hour

Drilling with Air

Motor Selection

Sealed bearing assembly motors are traditionally preferred, as air does not conduct heat as well as fluids. Mud lubricated bearing assemblies are susceptible to seizing due to overheating. However, this may not be an issue in aerated muds. The main factor, when selecting a motor in an air or 2 - phase application, is minimizing the temperature generated within the stator elastomer.

The following is recommended:

- Select a stator that ensures a loose power section fit versus one that would be run in fluid at a similar temperature
- Utilize the highest amount of liquid and lowest form quality possible
- Minimize the RPM
- Maximize the allowable amount of time to circulate through the motor

Drilling with Nitrogen (N_2)

Air consists of 78% nitrogen. The density of nitrogen is about 3% less than that of air at standard temperature and pressure. The motor will operate the same on nitrogen as air.

NOTE

Nitrogen is an inert gas. The nitrile sealing components within the motor (i.e., stator elastomer) are not typically affected by nitrogen. However, the sealing compounds will absorb nitrogen and other gases while under pressure. If the pressure has been applied for an extended period of time and is released too soon, the gas does not have enough time to exit from the nitrile. This can result in explosive decompression, leading to blistering of the stator elastomer. Normally, this is not a problem with continuous pressure drops of 400 psi or less across the motor.

Motor Operation On Air

When drilling with air, the motor will:

- Be more weight sensitive than in fluids
- Stall out at lower pressure
- Require less weight on bit to drill

When drilling is completed, let the motor drill off as the compressors and boosters are being shut down. Picking the motor up off-bottom before the pressure is equalized can cause the air compressed in the drill string to expand. This can lead to high motor speeds, possibly causing damage to the motor, including internal motor connections to back-off.

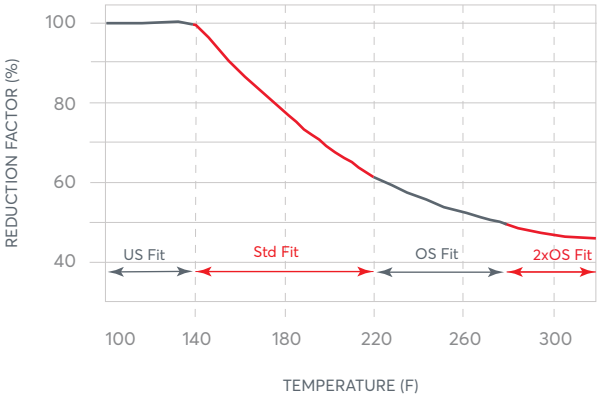
Downhole Temperature

Downhole Temperature

A reduction of stator elastomer strength can be caused by an increase of the downhole circulating temperature. Therefore, a reduction of the maximum recommended differential pressure drop across the power section should be made to avoid premature stator elastomer failure.

As illustrated in Figure 3-3, it is not required to reduce the pressure drop if the temperature is at or below 140° F. However, if the temperature is above 140° F, then the maximum rated differential pressure obtained from the performance curves (shown in chapter 4) should be multiplied by the differential pressure reduction factor (shown in Figure 3-3).

Figure 3-3
Maximum Differential Pressure De-Rating for Power Sections



The fit sections at the bottom of the Figure 3-3 - indicated as "Std Fit", "OS Fit" and "2xOS Fit"- reflect the recommended stator sizes that can be used at temperature.

While a standard fit stator can be used at temperatures higher than 220°F, it is susceptible to premature failure due to excessive interference fit, resulting in additional frictional heat.

Likewise, an oversized fit can be used at temperatures below 220°F, but may not perform as expected due to the looser fit. This enables fluid leakage at the seal lines of the rotor and stator, resulting in stalling and the motor to become weak.

EXAMPLE

- If the maximum differential pressure is 900 psi and the downhole circulating temperature is 180° F, the operating full load pressure is calculated by multiplying 900 psi by a differential reduction factor of 77%, yielding 693 psi.

03 OPERATING PROCEDURES

Downhole Temperature

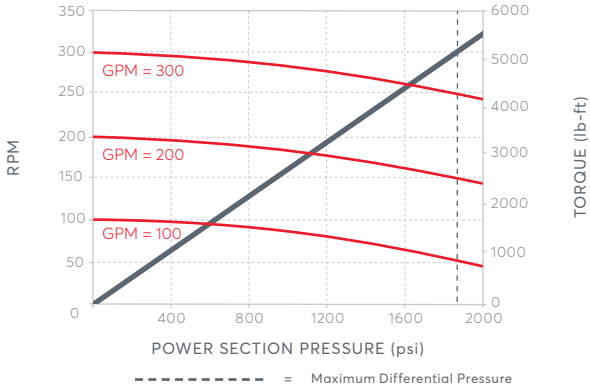
NOTE

Gyrodata power sections are assembled to actual fits based on proposed downhole temperature and mud type. Simply using a standard fit stator for a low temperature application is not considered good practice. The practice of assembling power sections by fit is primarily due to the tolerance swing of stator elastomer during the manufacturing process. Elastomer tolerances can range from +/- .010" to +/- .015" depending on the stator vendor resulting in a .020" - .030" measurement swing. This could produce a power section that is too tight or too loose - resulting in premature stator failure or excessive stalling causing the motor to be weak.

04 MOTOR SPECIFICATIONS

4¾" 5/6 8.3 Adjustable Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (ABH)	58.25"	Bit Sizes	6" - 7⅞"
Wear Pad OD	5.5"	Std Bit Connection	3½ Reg box
Nominal Length	29'	Std Top Connection*	3½ IF box
Weight	1,100 lbs	Max WOB w/ Flow	56,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	261,400 lbs
Bit Speed (No Load)	100-300 rpm	Max Bit Pull w/o Damage	261,400 lbs
Flow Range	100-300 gpm	Max Bit Pull w/ Damage**	310,000 lbs
Revolutions Per Gallon	1.0 rev/gal	Max Body Pull w/ Damage**	494,000 lbs
Max Differential Pressure	1,870 psi		
Off Bottom Pressure Loss	116 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Max Operating Torque	4,810 lb-ft		
Stall Torque	7,220 lb-ft		

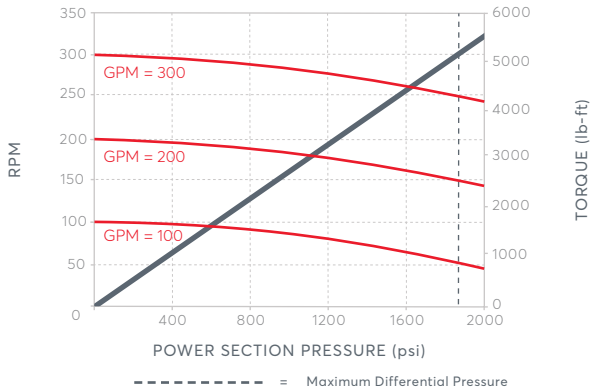
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE				HOLE SIZE (in) - STABILIZED			
Deg.	6	6⅛	6¾	7⅞	6	6⅛	6¾	7⅞
0.39					2.10	2.19	2.61	3.37
0.78	0.70	0.30			4.52	4.61	5.03	5.79
1.15	3.30	2.80	0.50		6.82	6.91	7.33	8.09
1.50	5.71	5.23	2.93	1.27	9.00	9.08	9.50	10.26
1.83	9.16	8.67	6.37	2.18	11.05	11.13	11.55	12.32
2.12	9.98	9.50	7.20	3.01	12.10	12.19	12.61	13.37
2.38	11.78	11.29	8.99	4.80	14.46	14.55	14.97	15.73
2.60	13.29	12.81	10.51	6.32	15.83	15.92	16.34	17.10
2.77	14.47	13.98	11.68	7.49	16.89	16.98	17.39	18.16
2.90	15.36	14.88	12.58	8.39	17.70	17.78	18.20	18.96
2.97	15.84	15.36	13.06	8.87	18.13	18.22	18.64	19.40
3.00	16.05	15.57	13.27	9.08	18.32	18.40	18.82	19.59

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

4¾" 5/6 8.3 Fixed Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	53.25"	Bit Sizes	6" - 7⅞"
Wear Pad OD	5.5"	Std Bit Connection	3½ Reg box
Nominal Length	29'	Std Top Connection*	3½ IF box
Weight	1,100 lbs	Max WOB w/ Flow	56,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	261,400 lbs
Bit Speed (No Load)	100-300 rpm	Max Bit Pull w/o Damage	261,400 lbs
Flow Range	100-300 gpm	Max Bit Pull w/ Damage**	310,000 lbs
Revolutions Per Gallon	1.0 rev/gal	Max Body Pull w/ Damage**	494,000 lbs
Max Differential Pressure	1,870 psi		
Off Bottom Pressure Loss	116 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Max Operating Torque	4,810 lb-ft		
Stall Torque	7,220 lb-ft		

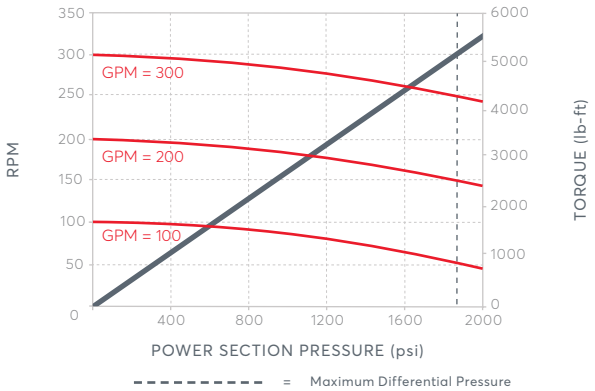
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE				HOLE SIZE (in) - STABILIZED			
Deg.	6	6⅛	6¾	7⅞	6	6⅛	6¾	7⅞
0.39					2.19	2.28	2.71	3.50
0.78	1.10	0.70			4.69	4.78	5.21	6.00
1.15	3.70	3.30	1.10		7.06	7.15	7.58	8.37
1.50	6.11	5.67	3.56		9.30	9.39	9.82	10.61
1.83	9.55	9.11	7.01	3.18	11.42	11.51	11.94	12.73
2.12	10.38	9.94	7.84	4.01	12.51	12.60	13.03	13.82
2.38	12.17	11.73	9.63	5.80	14.94	15.03	15.47	16.25
2.60	13.69	13.25	11.15	7.32	16.35	16.45	16.88	17.66
2.77	14.86	14.42	12.32	8.49	17.44	17.54	17.97	18.75
2.90	15.76	15.32	13.22	9.39	18.28	18.37	18.80	19.59
2.97	16.24	15.80	13.70	9.87	18.73	18.82	19.25	20.04
3.00	16.45	16.01	13.91	10.08	18.92	19.01	19.44	20.23

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

4¾" 5/6 8.3 Short Bit to Bend - Fixed

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	47"	Bit Sizes	6" - 7⅞"
Wear Pad OD	5.5"	Std Bit Connection	3½ Reg box
Nominal Length	28½'	Std Top Connection*	3½ IF box
Weight	1,085 lbs	Max WOB w/ Flow	38,400 lbs
PERFORMANCE DATA		Max WOB w/o Flow	261,400 lbs
Bit Speed (No Load)	100-300 rpm	Max Bit Pull w/o Damage	261,400 lbs
Flow Range	100-300 gpm	Max Bit Pull w/ Damage**	310,000 lbs
Revolutions Per Gallon	1.0 rev/gal	Max Body Pull w/ Damage**	494,000 lbs
Max Differential Pressure	1,870 psi		
Off Bottom Pressure Loss	116 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Max Operating Torque	4,810 lb-ft		
Stall Torque	7,220 lb-ft		

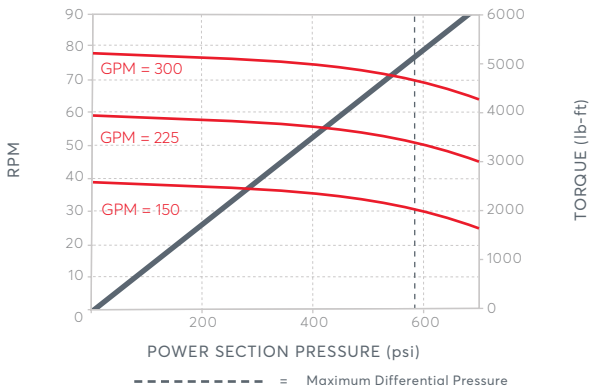
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE				HOLE SIZE (in) - STABILIZED			
Deg.	6	6⅛	6¾	7⅞	6	6⅛	6¾	7⅞
0.39					2.43	2.53	3.00	3.88
0.78	1.12	0.71			5.19	5.29	5.77	6.65
1.15	3.76	3.36	1.12		7.82	7.92	8.39	9.27
1.50	6.22	5.77	3.62		10.30	10.40	10.88	11.75
1.83	9.72	9.27	7.13	3.24	12.65	12.75	13.22	14.10
2.12	10.56	10.11	7.98	4.08	13.85	13.95	14.43	15.31
2.38	12.38	11.94	9.80	5.90	16.55	16.65	17.13	18.00
2.60	13.93	13.48	11.35	7.45	18.11	18.22	18.69	19.56
2.77	15.12	14.67	12.54	8.64	19.31	19.43	19.90	20.77
2.90	16.04	15.59	13.45	9.55	20.25	20.34	20.82	21.70
2.97	16.52	16.08	13.94	10.04	20.74	20.84	21.32	22.19
3.00	16.74	16.29	14.15	10.26	20.95	21.05	21.53	22.40

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

4¾" 7/8 2.6 Adjustable Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (ABH)	58.25"	Bit Sizes	6" - 7⅞"
Wear Pad OD	5.5"	Std Bit Connection	3½ Reg Box
Nominal Length	29'	Std Top Connection*	3½ IF Box
Weight	1,100 lbs	Max WOB w/ Flow	56,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	261,400 lbs
Bit Speed (No Load)	39-79 rpm	Max Bit Pull w/o Damage	261,400 lbs
Flow Range	150-300 gpm	Max Bit Pull w/ Damage**	310,000 lbs
Revolutions Per Gallon	0.26 rev/gal	Max Body Pull w/ Damage**	494,000 lbs
Max Differential Pressure	590 psi		
Off Bottom Pressure Loss	46 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Max Operating Torque	5,250 lb-ft		
Stall Torque	7,880 lb-ft		

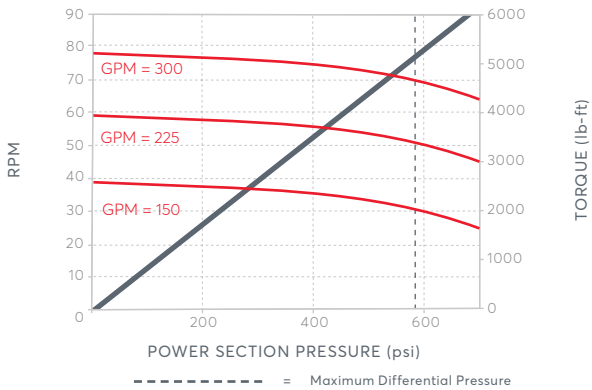
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE				HOLE SIZE (in) - STABILIZED			
Deg.	6	6⅛	6¾	7⅞	6	6⅛	6¾	7⅞
0.39					1.93	2.02	2.49	3.33
0.78	1.20	0.80			4.44	4.54	5.00	5.84
1.15	3.80	3.68	1.30		6.83	6.92	7.39	8.23
1.50	6.20	5.76	3.69	0.09	9.08	9.18	9.64	10.49
1.83	9.71	9.42	7.62	2.19	11.21	11.31	11.77	12.61
2.12	10.49	10.05	7.98	4.20	12.31	12.40	12.87	13.71
2.38	12.29	11.85	9.78	6.00	14.76	14.85	15.32	16.16
2.60	13.81	13.37	11.30	7.52	16.18	16.27	16.74	17.58
2.77	14.98	14.55	12.48	8.70	17.27	17.37	17.83	18.68
2.90	15.88	15.45	13.37	9.60	18.11	18.21	18.67	19.52
2.97	16.37	15.93	13.86	10.08	18.56	18.66	19.12	19.97
3.00	16.57	16.14	14.07	10.29	18.76	18.85	19.32	20.16

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

4¾" 7/8 2.6 Fixed Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	53.25"	Bit Sizes	6" - 7⅞"
Wear Pad OD	5.5"	Std Bit Connection	3½ Reg Box
Nominal Length	29'	Std Top Connection*	3½ IF Box
Weight	1,100 lbs	Max WOB w/ Flow	56,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	261,400 lbs
Bit Speed (No Load)	39-79 rpm	Max Bit Pull w/o Damage	261,400 lbs
Flow Range	150-300 gpm	Max Bit Pull w/ Damage**	310,000 lbs
Revolutions Per Gallon	0.26 rev/gal	Max Body Pull w/ Damage**	494,000 lbs
Max Differential Pressure	590 psi		
Off Bottom Pressure Loss	46 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Max Operating Torque	5,250 lb-ft		
Stall Torque	7,880 lb-ft		

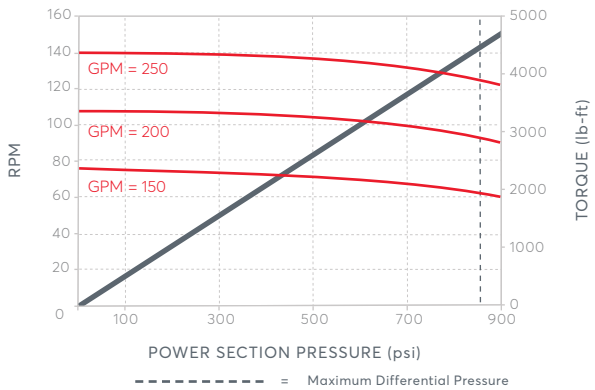
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE				HOLE SIZE (in) - STABILIZED			
Deg.	6	6⅛	6¾	7⅞	6	6⅛	6¾	7⅞
0.39	1.10				1.98	2.07	2.54	3.38
0.78	1.50	1.10	0.80		4.54	4.64	5.10	5.94
1.15	4.00	3.81	1.80		6.98	7.07	7.53	8.38
1.50	6.43	6.03	4.15	1.98	9.28	9.37	9.84	10.68
1.83	10.02	9.67	7.78	2.96	11.45	11.55	12.01	12.85
2.12	10.66	10.26	8.38	4.94	12.57	12.66	13.13	13.97
2.38	12.43	12.04	10.15	6.72	15.07	15.16	15.63	16.47
2.60	13.93	13.54	11.65	8.22	16.51	16.61	17.07	17.92
2.77	15.09	14.70	12.81	9.38	17.63	17.73	18.19	19.04
2.90	15.98	15.58	13.70	10.26	18.49	18.59	19.05	19.89
2.97	16.46	16.06	14.18	10.74	18.95	19.05	19.51	20.35
3.00	16.66	16.26	14.38	10.94	19.15	19.24	19.71	20.55

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

4¾" 7/8 3.8 Adjustable Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (ABH)	58.25"	Bit Sizes	6" - 7⅞"
Wear Pad OD	5.5"	Std Bit Connection	3½ Reg Box
Nominal Length	24'	Std Top Connection*	3½ IF Box
Weight	990lbs	Max WOB w/ Flow	56,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	261,400 lbs
Bit Speed (No Load)	78-140 rpm	Max Bit Pull w/o Damage	261,400 lbs
Flow Range	150-250 gpm	Max Bit Pull w/ Damage**	310,000 lbs
Revolutions Per Gallon	0.52 rev/gal	Max Body Pull w/ Damage**	494,000 lbs
Max Differential Pressure	860 psi		
Off Bottom Pressure Loss	64 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Max Operating Torque	4,450 lb-ft		
Stall Torque	6,670 lb-ft		

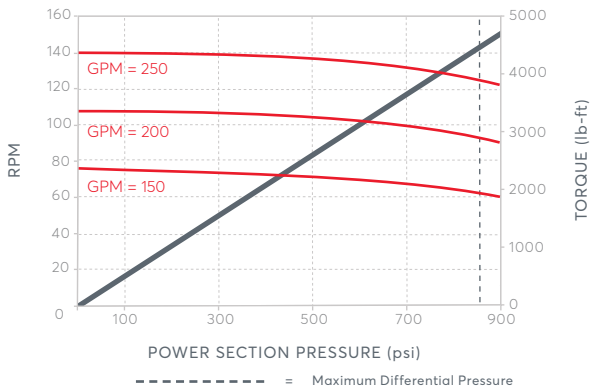
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE				HOLE SIZE (in) - STABILIZED			
Deg.	6	6⅛	6¾	7⅞	6	6⅛	6¾	7⅞
0.39					2.62	2.75	3.36	4.48
0.78	0.90	0.30			5.42	5.55	6.17	7.28
1.15	3.90	3.30	0.60		8.08	8.21	8.83	9.94
1.50	6.79	6.22	3.48	1.51	10.60	10.73	11.34	12.46
1.83	10.90	10.32	7.59	2.60	12.97	13.10	13.72	14.84
2.12	11.88	11.31	8.57	3.58	14.20	14.33	14.94	16.06
2.38	14.02	13.44	10.71	5.72	16.93	17.06	17.67	18.79
2.60	15.82	15.25	12.51	7.52	18.51	18.64	19.26	20.37
2.77	17.22	16.64	13.91	8.92	19.74	19.86	20.48	21.60
2.90	18.28	17.71	14.97	9.99	20.67	20.80	21.41	22.53
2.97	18.86	18.28	15.55	10.56	21.18	21.30	21.92	23.04
3.00	19.10	18.53	15.79	10.81	21.39	21.52	22.13	23.25

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

4¾" 7/8 3.8 Fixed Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	53.25"	Bit Sizes	6" - 7⅞"
Wear Pad OD	5.5"	Std Bit Connection	3½ Reg Box
Nominal Length	24'	Std Top Connection*	3½ IF Box
Weight	990lbs	Max WOB w/ Flow	56,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	261,400 lbs
Bit Speed (No Load)	78-140 rpm	Max Bit Pull w/o Damage	261,400 lbs
Flow Range	150-250 gpm	Max Bit Pull w/ Damage**	310,000 lbs
Revolutions Per Gallon	0.52 rev/gal	Max Body Pull w/ Damage**	494,000 lbs
Max Differential Pressure	860 psi		
Off Bottom Pressure Loss	64 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Max Operating Torque	4,450 lb-ft		
Stall Torque	6,670 lb-ft		

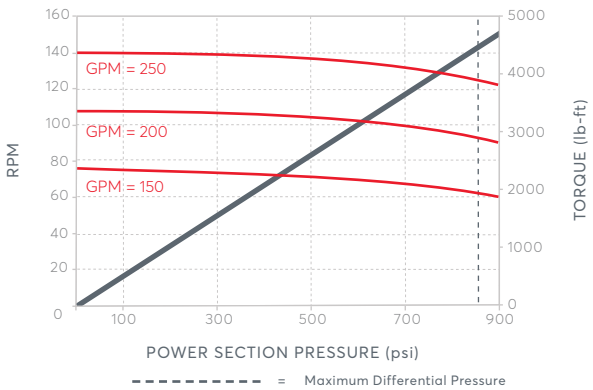
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE				HOLE SIZE (in) - STABILIZED			
Deg.	6	6⅛	6¾	7⅞	6	6⅛	6¾	7⅞
0.39					2.69	2.82	3.43	4.55
0.78	1.40	0.80			5.56	5.69	6.30	7.42
1.15	4.40	3.90	1.40		8.28	8.41	9.02	10.14
1.50	7.27	6.74	4.24		10.86	10.99	11.60	12.72
1.83	11.37	10.85	8.34	3.78	13.29	13.42	14.03	15.15
2.12	12.36	11.83	9.33	4.77	14.54	14.67	15.28	16.40
2.38	14.49	13.97	11.46	6.90	17.34	17.47	18.08	19.20
2.60	16.30	15.77	13.27	8.71	18.96	19.09	19.70	20.82
2.77	17.69	17.17	14.66	10.10	20.21	20.34	20.96	22.08
2.90	18.76	18.23	15.73	11.17	21.17	21.30	21.91	23.03
2.97	19.33	18.81	16.31	11.75	21.69	21.82	22.43	23.55
3.00	19.58	19.05	16.55	11.99	21.91	22.04	22.65	23.77

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

4¾" 7/8 3.8 Short Bit to Bend - Fixed

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	47"	Bit Sizes	6" - 7⅞"
Wear Pad OD	5.5"	Std Bit Connection	3½ Reg Box
Nominal Length	23½'	Std Top Connection*	3½ IF Box
Weight	975 lbs	Max WOB w/ Flow	38,400 lbs
PERFORMANCE DATA		Max WOB w/o Flow	261,400 lbs
Bit Speed (No Load)	78-140 rpm	Max Bit Pull w/o Damage	261,400 lbs
Flow Range	150-250 gpm	Max Bit Pull w/ Damage**	310,000 lbs
Revolutions Per Gallon	0.52 rev/gal	Max Body Pull w/ Damage**	494,000 lbs
Max Differential Pressure	860 psi		
Off Bottom Pressure Loss	64 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Max Operating Torque	4,450 lb-ft		
Stall Torque	6,670 lb-ft		

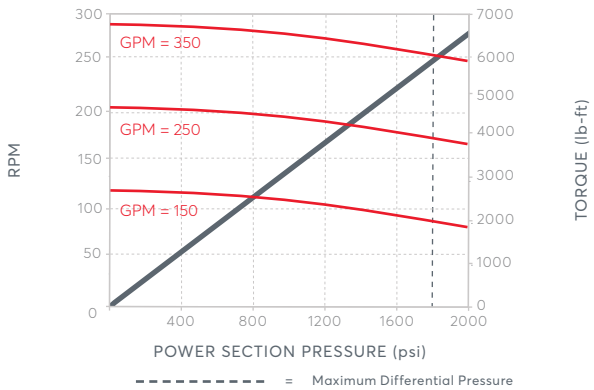
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE				HOLE SIZE (in) - STABILIZED			
Deg.	6	6⅛	6¾	7⅞	6	6⅛	6¾	7⅞
0.39					2.91	3.04	3.67	4.82
0.78	1.57	0.90			5.91	6.04	6.67	7.82
1.15	4.93	4.37	1.57		8.75	8.89	9.52	10.66
1.50	8.14	7.55	4.75		11.44	11.58	12.21	13.35
1.83	12.73	12.15	9.34	4.23	13.98	14.11	14.74	15.89
2.12	13.84	13.25	10.45	5.34	16.21	16.34	16.97	18.12
2.38	16.23	15.65	12.84	7.73	18.21	18.34	18.97	20.12
2.60	18.26	17.66	14.86	9.76	19.90	20.03	20.66	21.81
2.77	19.81	19.23	16.42	11.31	21.21	21.34	21.97	23.12
2.90	21.01	20.42	17.62	12.51	22.21	22.34	22.97	24.12
2.97	21.65	21.07	18.27	13.16	22.75	22.88	23.51	24.66
3.00	21.93	21.34	18.54	13.43	22.98	23.11	23.74	24.89

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

5" 6/7 8.0 Adjustable Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (ABH)	60.25"	Bit Sizes	6" - 7⅞"
Wear Pad OD	5.5"	Std Bit Connection	3½ Reg Box
Nominal Length	29½'	Std Top Connection*	3½ IF Box
Weight	1,100 lbs	Max WOB w/ Flow	56,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	261,400 lbs
Bit Speed (No Load)	121-290 rpm	Max Bit Pull w/o Damage	261,400 lbs
Flow Range	150-350 gpm	Max Bit Pull w/ Damage**	310,000 lbs
Revolutions Per Gallon	0.81 rev/gal	Max Body Pull w/ Damage**	494,000 lbs
Max Differential Pressure	1,800 psi		
Off Bottom Pressure Loss	122 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Max Operating Torque	5,720 lb-ft		
Stall Torque	8,580 lb-ft		

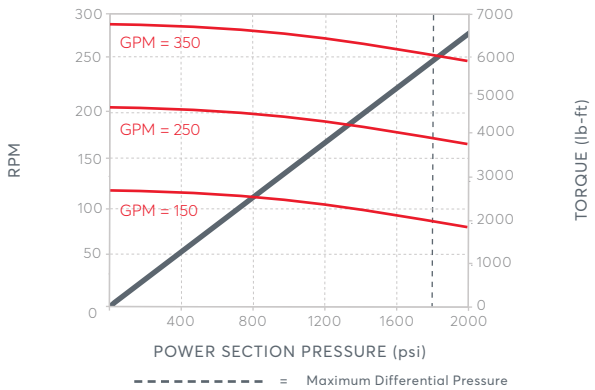
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE				HOLE SIZE (in) - STABILIZED			
Deg.	6	6⅛	6¾	7⅞	6	6⅛	6¾	7⅞
0.39					1.79	1.87	2.28	3.02
0.78	1.20	0.80			4.18	4.26	4.67	5.41
1.15	3.60	3.20	1.20		6.44	6.53	6.94	7.68
1.50	5.97	5.55	3.55	0.09	8.59	8.67	9.08	9.82
1.83	8.17	7.75	5.75	2.11	10.61	10.70	11.10	11.84
2.12	10.10	9.68	7.68	4.04	11.65	11.74	12.15	12.89
2.38	11.83	11.41	9.42	5.78	13.98	14.07	14.48	15.22
2.60	13.30	12.88	10.88	7.24	15.33	15.42	15.82	16.57
2.77	14.43	14.01	12.01	8.38	16.37	16.46	16.87	17.61
2.90	15.30	14.88	12.88	9.24	17.17	17.26	17.66	18.40
2.97	15.76	15.34	13.35	9.71	17.60	17.69	18.09	18.83
3.00	15.96	15.54	13.55	9.91	17.78	18.28	18.28	19.02

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

5" 6/7 8.0 Fixed Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	55.25"	Bit Sizes	6" - 7⅞"
Wear Pad OD	5.5"	Std Bit Connection	3½ Reg Box
Nominal Length	29½'	Std Top Connection*	3½ IF Box
Weight	1,100 lbs	Max WOB w/ Flow	56,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	261,400 lbs
Bit Speed (No Load)	121-290 rpm	Max Bit Pull w/o Damage	261,400 lbs
Flow Range	150-350 gpm	Max Bit Pull w/ Damage**	310,000 lbs
Revolutions Per Gallon	0.81 rev/gal	Max Body Pull w/ Damage**	494,000 lbs
Max Differential Pressure	1,800 psi		
Off Bottom Pressure Loss	122 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Max Operating Torque	5,720 lb-ft		
Stall Torque	8,580 lb-ft		

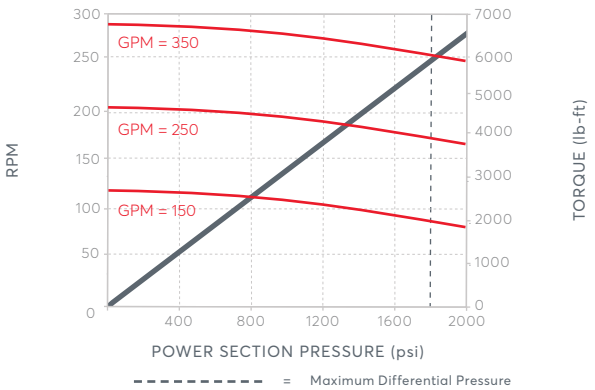
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE				HOLE SIZE (in) - STABILIZED			
Deg.	6	6⅛	6¾	7⅞	6	6⅛	6¾	7⅞
0.39					1.83	1.92	2.32	3.05
0.78	1.50	1.10	0.70		4.27	4.35	4.76	5.50
1.15	3.90	3.60	1.70		6.58	6.66	7.07	7.81
1.50	6.28	5.90	4.05	0.70	8.76	8.85	9.25	9.99
1.83	8.48	8.09	6.25	2.90	10.82	10.91	11.31	12.05
2.12	10.41	10.03	8.19	4.83	11.88	11.97	12.37	13.12
2.38	12.15	11.76	9.92	6.56	14.26	14.34	14.75	15.49
2.60	13.61	13.22	11.38	8.03	15.63	15.71	16.12	16.86
2.77	14.74	14.36	15.52	9.16	16.69	16.78	17.18	17.92
2.90	15.61	15.22	13.38	10.03	17.50	17.59	18.00	18.74
2.97	16.08	15.69	13.85	10.49	17.94	18.03	18.43	19.17
3.00	16.28	15.89	14.05	10.69	18.13	18.21	18.62	19.36

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

5" 6/7 8.0 Short Bit to Bend - Fixed

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	49"	Bit Sizes	6" - 7⅞"
Wear Pad OD	5.5"	Std Bit Connection	3½ Reg Box
Nominal Length	29¼'	Std Top Connection*	3½ IF Box
Weight	1,085 lbs	Max WOB w/ Flow	38,400 lbs
PERFORMANCE DATA		Max WOB w/o Flow	261,400 lbs
Bit Speed (No Load)	121-290 rpm	Max Bit Pull w/o Damage	261,400 lbs
Flow Range	150-350 gpm	Max Bit Pull w/ Damage**	310,000 lbs
Revolutions Per Gallon	0.81 rev/gal	Max Body Pull w/ Damage**	494,000 lbs
Max Differential Pressure	1,800 psi		
Off Bottom Pressure Loss	122 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Max Operating Torque	5,720 lb-ft		
Stall Torque	8,580 lb-ft		

Predicted Build Rates - Deg/100 ft

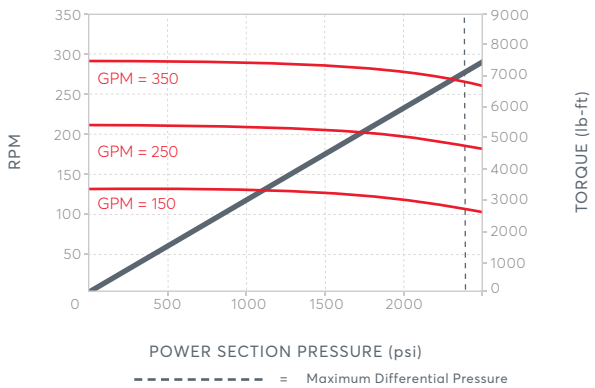
ANGLE	HOLE SIZE (in) - SLICK SLEEVE				HOLE SIZE (in) - STABILIZED			
Deg.	6	6⅛	6¾	7⅞	6	6⅛	6¾	7⅞
0.39					1.92	2.01	2.43	3.19
0.78	1.57	1.15	0.73		4.47	4.55	4.98	5.76
1.15	4.08	3.77	1.78		6.89	6.97	7.40	8.17
1.50	6.57	6.18	4.24	0.73	9.17	9.26	9.68	10.46
1.83	8.88	8.47	6.54	3.04	11.32	11.42	11.84	12.61
2.12	10.90	10.50	8.57	5.06	12.43	12.53	12.95	13.73
2.25	11.81	11.37	9.29	5.48	13.47	13.57	14.03	14.88
2.38	12.72	12.31	10.38	6.87	14.93	15.01	15.44	16.21
2.60	14.25	13.84	11.91	8.40	16.36	16.44	16.87	17.65
2.77	15.43	15.03	16.24	9.59	17.47	17.56	17.98	18.76
2.90	16.34	15.93	14.00	10.50	18.32	18.41	18.84	19.61
2.97	16.83	16.42	14.50	10.98	18.78	18.87	19.29	20.06
3.00	17.04	16.63	14.71	11.19	18.98	19.06	19.49	20.26

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

04 MOTOR SPECIFICATIONS

5" 6/7 10.0 Fixed Bend Housing

Performance Curves



POWER SECTION PRESSURE (psi)

= Maximum Differential Pressure

PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	53.25"	Bit Sizes	6" - 7⅞"
Wear Pad OD	5.5"	Std Bit Connection	3½ Reg Box
Nominal Length	31¾'	Std Top Connection*	3½ IF Box
Weight	1,158 lbs	Max WOB w/ Flow	56,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	261,400 lbs
Bit Speed (No Load)	130-290 rpm	Max Bit Pull w/o Damage	261,400 lbs
Flow Range	150-350 gpm	Max Bit Pull w/ Damage**	310,000 lbs
Revolutions Per Gallon	0.84 rev/gal	Max Body Pull w/ Damage**	494,000 lbs
Max Differential Pressure	2,350 psi		
Off Bottom Pressure Loss	130 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Max Operating Torque	6,940 lb-ft		
Stall Torque	10,920 lb-ft		

Predicted Build Rates - Deg/100 ft

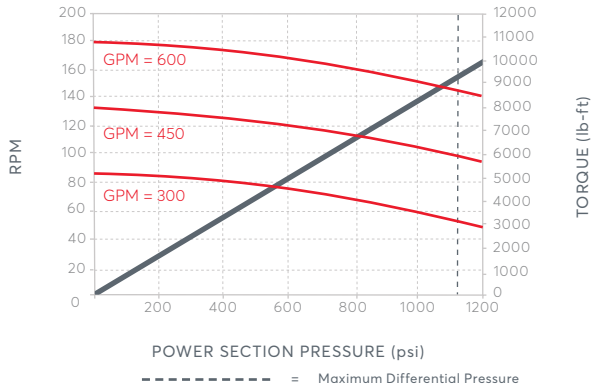
ANGLE	HOLE SIZE (in) - SLICK SLEEVE				HOLE SIZE (in) - STABILIZED			
Deg.	6	6⅛	6¾	7⅞	6	6⅛	6¾	7⅞
0.39	0.90	1.40			1.52	1.59	1.93	2.56
0.78	1.50	1.10	1.00		3.79	3.86	4.20	4.83
1.15	3.80	3.40	1.30		5.94	6.01	6.35	6.98
1.50	6.03	5.59	3.50	0.31	7.98	8.05	8.39	9.01
1.83	8.10	7.66	5.57	1.76	9.90	9.97	10.31	10.93
2.12	9.91	9.47	7.39	3.58	11.58	11.65	12.00	12.62
2.38	11.54	11.10	9.01	5.21	13.10	13.17	13.51	14.13
2.60	12.92	12.48	10.39	6.59	14.38	14.45	14.79	15.41
2.77	13.98	13.55	11.46	7.65	15.37	15.44	15.78	16.40
2.90	14.80	14.36	12.27	8.46	16.12	16.19	16.54	17.16
2.97	15.24	14.80	12.71	8.90	16.53	16.60	16.94	17.57
3.00	15.42	14.99	12.90	9.09	16.70	16.78	17.12	17.74

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

04 MOTOR SPECIFICATIONS

6½" 6/7 5.0 Adjustable Bend Housing

Performance Curves



POWER SECTION PRESSURE (psi)

= Maximum Differential Pressure

PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (ABH)	64"	Bit Sizes	7⅞" - 8¾"
Wear Pad OD	7.32"	Std Bit Connection	4½ Reg Box
Nominal Length	25'	Std Top Connection*	4½ XH Box
Weight	2,105 lbs	Max WOB w/ Flow	90,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	433,500 lbs
Bit Speed (No Load)	87-180 rpm	Max Bit Pull w/o Damage	433,500 lbs
Flow Range	300-600gpm	Max Bit Pull w/ Damage**	560,000 lbs
Revolutions Per Gallon	0.29 rev/gal	Max Body Pull w/ Damage**	918,000 lbs
Max Differential Pressure	1,130 psi		
Off Bottom Pressure Loss	110 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Max Operating Torque	9,350 lb-ft		
Stall Torque	14,030 lb-ft		

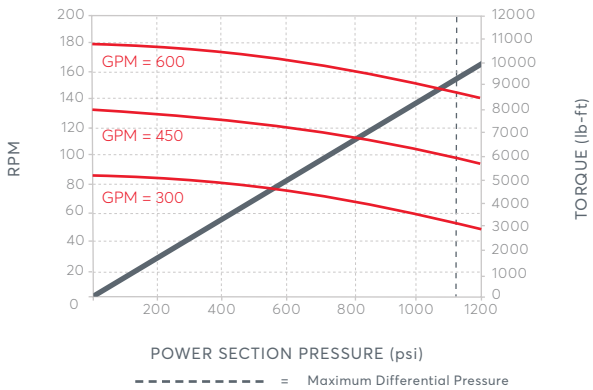
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE			HOLE SIZE (in) - STABILIZED		
Deg.	7⅞	8½	8¾	7⅞	8½	8¾
0.39				1.93	2.42	2.47
0.78	1.40	0.70		4.22	4.77	4.77
1.15	4.40	2.30	1.40	6.40	7.00	6.95
1.50	7.21	5.06	4.19	8.46	9.12	9.01
1.83	9.85	7.70	6.83	10.40	11.11	10.95
2.12	12.17	10.01	9.15	12.41	12.86	12.66
2.38	14.25	12.09	11.23	14.54	14.43	14.19
2.60	16.01	13.85	12.99	16.33	15.76	15.49
2.77	17.37	15.21	14.35	17.72	16.78	16.49
2.90	18.41	16.25	15.39	18.78	17.57	17.25
2.97	18.97	16.81	15.95	19.35	17.99	17.67
3.00	19.21	17.05	16.19	19.59	18.17	17.84

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

6½" 6/7 5.0 Fixed Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	54"	Bit Sizes	7⅞" - 8¾"
Wear Pad OD	7.32"	Std Bit Connection	4½ Reg Box
Nominal Length	25'	Std Top Connection*	4½ XH Box
Weight	2,105 lbs	Max WOB w/ Flow	90,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	433,500 lbs
Bit Speed (No Load)	87-180 rpm	Max Bit Pull w/o Damage	433,500 lbs
Flow Range	300-600gpm	Max Bit Pull w/ Damage**	560,000 lbs
Revolutions Per Gallon	0.29 rev/gal	Max Body Pull w/ Damage**	918,000 lbs
Max Differential Pressure	1,130 psi		
Off Bottom Pressure Loss	110 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Max Operating Torque	9,350 lb-ft		
Stall Torque	14,030 lb-ft		

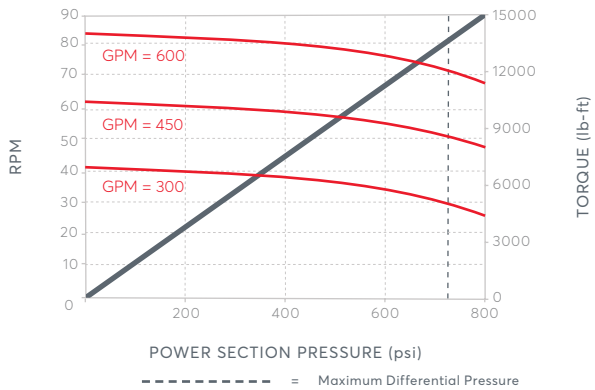
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE			HOLE SIZE (in) - STABILIZED		
Deg.	7⅞	8½	8¾	7⅞	8½	8¾
0.39	1.00			2.01	2.51	2.56
0.78	2.10	0.20	0.06	4.39	4.95	4.94
1.15	5.00	3.20	2.29	6.65	7.27	7.20
1.50	7.84	5.97	4.95	8.79	9.47	9.34
1.83	10.48	8.61	7.46	10.81	11.54	11.35
2.12	12.80	10.93	9.67	13.06	13.35	13.12
2.38	14.88	13.01	11.64	15.18	14.98	14.71
2.60	16.64	14.77	13.31	16.97	16.36	16.06
2.77	18.00	16.13	14.61	18.36	17.43	17.10
2.90	19.04	17.17	15.59	19.42	18.25	17.89
2.97	19.60	17.79	16.12	19.99	18.68	18.32
3.00	19.84	17.97	16.35	20.24	18.87	18.50

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

6½" 7/8 3.3 Adjustable Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (ABH)	64"	Bit Sizes	7⅞" - 8¾"
Wear Pad OD	7.32"	Std Bit Connection	4½ Reg Box
Nominal Length	30'	Std Top Connection*	4½ XH Box
Weight	2,600 lbs	Max WOB w/ Flow	90,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	433,500 lbs
Bit Speed (No Load)	42-84 rpm	Max Bit Pull w/o Damage	433,500 lbs
Flow Range	300-600gpm	Max Bit Pull w/ Damage**	560,000 lbs
Revolutions Per Gallon	0.14 rev/gal	Max Body Pull w/ Damage**	918,000 lbs
Max Differential Pressure	740 psi		
Off Bottom Pressure Loss	150 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Max Operating Torque	14,110 lb-ft		
Stall Torque	21,160 lb-ft		

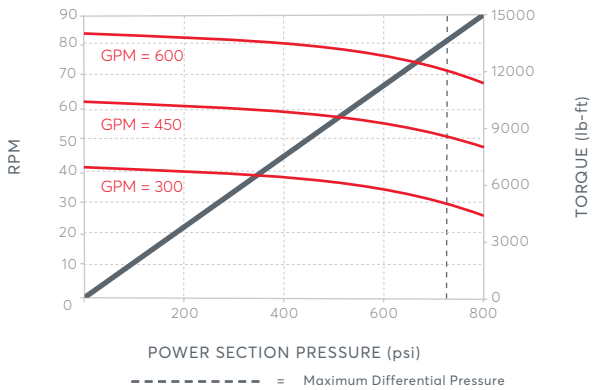
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE			HOLE SIZE (in) - STABILIZED		
Deg.	7⅞	8½	8¾	7⅞	8½	8¾
0.39				1.67	1.97	2.09
0.78	1.20	0.56		3.74	4.04	4.17
1.15	3.70	1.79	0.68	5.71	6.02	6.14
1.50	6.01	4.21	3.16	7.58	7.88	8.00
1.83	8.21	6.41	5.69	9.33	9.64	9.76
2.12	10.14	8.35	7.62	10.88	11.18	11.30
2.38	11.87	10.08	9.36	12.26	12.57	12.69
2.60	13.34	11.55	10.82	13.44	13.74	13.86
2.77	14.47	12.68	11.96	14.75	14.64	14.77
2.90	15.34	13.54	12.82	15.63	15.34	15.46
2.97	15.80	14.01	13.29	16.10	15.71	15.83
3.00	16.00	14.21	13.49	16.31	15.87	15.99

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

6½" 7/8 3.3 Fixed Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	54"	Bit Sizes	7⅞" - 8¾"
Wear Pad OD	7.32"	Std Bit Connection	4½ Reg Box
Nominal Length	30'	Std Top Connection*	4½ XH Box
Weight	2,600 lbs	Max WOB w/ Flow	90,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	433,500 lbs
Bit Speed (No Load)	42-84 rpm	Max Bit Pull w/o Damage	433,500 lbs
Flow Range	300-600gpm	Max Bit Pull w/ Damage**	560,000 lbs
Revolutions Per Gallon	0.14 rev/gal	Max Body Pull w/ Damage**	918,000 lbs
Max Differential Pressure	740 psi		
Off Bottom Pressure Loss	150 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Max Operating Torque	14,110 lb-ft		
Stall Torque	21,160 lb-ft		

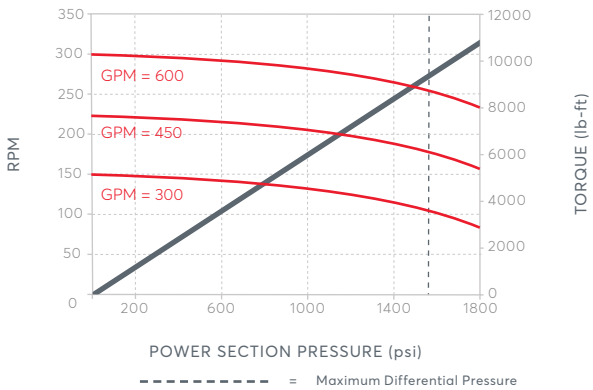
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE			HOLE SIZE (in) - STABILIZED		
Deg.	7⅞	8½	8¾	7⅞	8½	8¾
0.39				1.73	2.03	2.16
0.78	1.70	0.60		3.88	4.18	4.30
1.15	4.20	2.60	1.02	5.91	6.21	6.33
1.50	6.53	4.97	4.35	7.83	8.13	8.26
1.83	8.73	7.17	6.55	9.65	9.95	10.07
2.12	10.66	9.11	8.48	11.24	11.54	11.66
2.38	12.40	10.84	10.21	12.67	12.97	13.09
2.60	13.86	12.31	11.68	14.13	14.18	14.30
2.77	15.00	13.44	12.81	15.29	15.12	15.24
2.90	15.86	14.31	13.68	16.17	15.83	15.95
2.97	16.33	14.77	14.14	16.61	16.21	16.34
3.00	16.53	14.97	14.34	16.84	16.38	16.50

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

6¾" 4/5 7.0 Adjustable Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (ABH)	64"	Bit Sizes	8½" - 9⅞"
Wear Pad OD	7.5"	Std Bit Connection	4½ Reg Box
Nominal Length	25½'	Std Top Connection*	4½ XH Box
Weight	2,050 lbs	Max WOB with Flow	90,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	433,500 lbs
Bit Speed (No Load)	149-300 rpm	Max Bit Pull w/o Damage	433,500 lbs
Flow Range	300-600 gpm	Max Bit Pull w/ Damage**	560,000 lbs
Revolutions Per Gallon	0.50 rev/gal	Max Body Pull w/ Damage**	1,033,000 lbs
Max Differential Pressure	1,580 psi		
Off Bottom Pressure Loss	184 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Max Operating Torque	9,090 lb-ft		
Stall Torque	13,630 lb-ft		

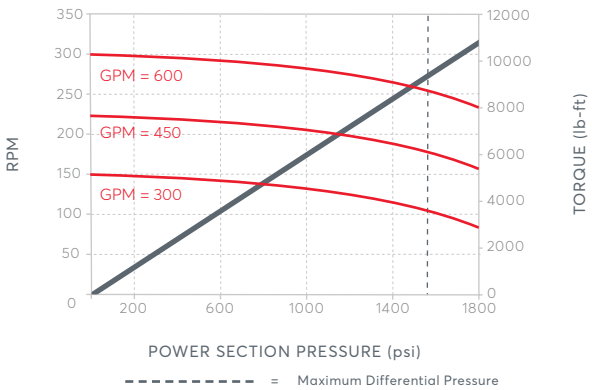
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE			HOLE SIZE (in) - STABILIZED		
Deg.	8½	8¾	9⅞	8½	8¾	9⅞
0.39				2.16	2.32	3.04
0.78				4.46	4.62	5.33
1.15	2.90	2.10		6.64	6.80	7.51
1.50	5.70	4.83	0.87	8.71	8.87	9.58
1.83	8.30	7.30	3.47	10.65	10.81	11.52
2.12	10.59	9.72	5.76	12.36	12.52	13.23
2.38	12.63	11.55	7.63	13.90	14.05	14.77
2.60	14.26	13.42	9.45	15.19	15.35	16.06
2.77	15.52	14.81	10.79	16.20	16.35	17.07
2.90	16.48	15.77	11.82	16.96	17.12	17.83
2.97	17.00	16.29	12.38	17.38	17.53	18.25
3.00	17.22	16.51	12.59	17.55	17.71	18.42

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

6¾" 4/5 7.0 Fixed Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	54"	Bit Sizes	8½" - 9⅞"
Wear Pad OD	7.5"	Std Bit Connection	4½ Reg Box
Nominal Length	25½'	Std Top Connection*	4½ XH Box
Weight	2,050 lbs	Max WOB w/ Flow	90,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	433,500 lbs
Bit Speed (No Load)	149-300 rpm	Max Bit Pull w/o Damage	433,500 lbs
Flow Range	300-600 gpm	Max Bit Pull w/ Damage**	560,000 lbs
Revolutions Per Gallon	0.50 rev/gal	Max Body Pull w/ Damage**	1,033,000 lbs
Max Differential Pressure	1580 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Off Bottom Pressure Loss	184 psi		
Max Operating Torque	9,090 lb-ft		
Stall Torque	13,630 lb-ft		

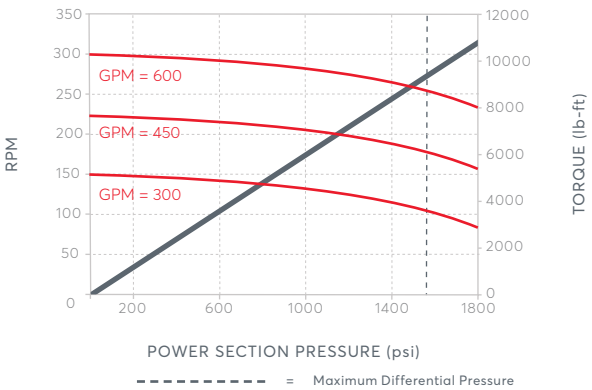
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE			HOLE SIZE (in) - STABILIZED		
Deg.	8½	8¾	9⅞	8½	8¾	9⅞
0.39				2.25	2.41	3.12
0.78	0.83	0.10		4.60	4.79	5.51
1.15	3.71	2.80	0.40	6.90	7.06	7.77
1.50	6.43	5.41	2.20	9.04	9.20	9.91
1.83	8.99	7.85	4.64	11.06	11.21	11.93
2.12	10.71	10.00	6.78	12.83	12.99	13.70
2.38	12.64	11.77	7.81	14.42	14.58	15.29
2.60	14.38	13.50	9.54	15.77	15.92	16.64
2.77	15.72	14.84	10.89	16.81	16.96	17.68
2.90	16.74	15.87	11.91	17.60	17.76	18.47
2.97	17.29	16.42	12.46	18.03	18.19	18.90
3.00	17.53	16.66	12.70	18.21	18.37	19.08

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

6¾" 4/5 7.0 Short Bit to Bend - Fixed

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	47"	Bit Sizes	8½" - 9⅞"
Wear Pad OD	7.5"	Std Bit Connection	4½ Reg Box
Nominal Length	25'	Std Top Connection*	4½ XH Box
Weight	2,025 lbs	Max WOB w/Flow	72,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	433,500 lbs
Bit Speed (No Load)	149-300 rpm	Max Bit Pull (w/o Damage	433,500 lbs
Flow Range	300-600gpm	Max Bit Pull w/ Damage**	560,000 lbs
Revolutions Per Gallon	0.50 rev/gal	Max Body Pull w/ Damage**	1,033,000 lbs
Max Differential Pressure	1,580 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Off Bottom Pressure Loss	184 psi		
Max Operating Torque	9,090 lb-ft		
Stall Torque	13,630 lb-ft		

Predicted Build Rates - Deg/100 ft

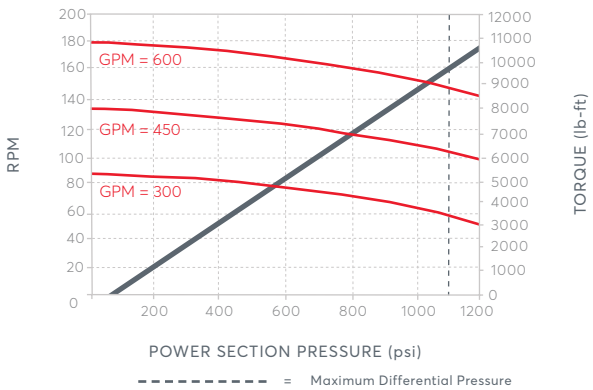
ANGLE	HOLE SIZE (in) - SLICK SLEEVE			HOLE SIZE (in) - STABILIZED		
Deg.	8½	8¾	9⅞	8½	8¾	9⅞
0.39				2.65	2.81	3.55
0.78	0.82	0.10		5.11	5.27	6.00
1.15	3.91	2.96	0.41	7.44	7.60	8.33
1.50	6.76	5.69	2.31	9.65	9.81	10.54
1.83	9.47	8.26	4.89	11.73	11.89	12.62
2.12	11.27	10.53	7.14	13.55	13.72	14.46
2.38	13.33	12.55	9.17	15.20	15.36	16.09
2.60	15.17	14.24	10.87	16.58	16.75	17.47
2.77	16.58	15.66	11.59	17.66	17.82	18.55
2.90	17.66	16.74	12.71	18.47	18.64	19.37
2.97	18.24	17.32	13.43	18.91	19.08	19.82
3.00	18.49	17.56	13.99	19.11	19.27	20.00

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

04 MOTOR SPECIFICATIONS

6¾" 6/7 5.0 Adjustable Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (ABH)	64"	Bit Sizes	8½" - 9⅞"
Wear Pad OD	7.5"	Std Bit Connection	4½ Reg Box
Nominal Length	25'	Std Top Connection*	4½ XH Box
Weight	2,185 lbs	Max WOB w/Flow	90,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	433,500 lbs
Bit Speed (No Load)	87-180 rpm	Max Bit Pull (w/o Damage	433,500 lbs
Flow Range	300-600gpm	Max Bit Pull w/ Damage**	560,000 lbs
Revolutions Per Gallon	0.29 rev/gal	Max Body Pull w/ Damage**	1,033,000 lbs
Max Differential Pressure	1,130 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Off Bottom Pressure Loss	110 psi		
Max Operating Torque	9,350 lb-ft		
Stall Torque	14,030 lb-ft		

Predicted Build Rates - Deg/100 ft

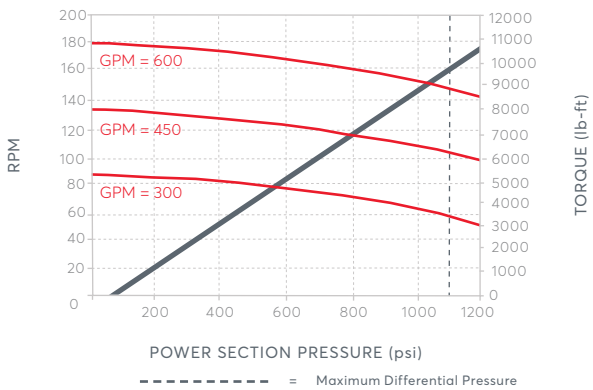
ANGLE	HOLE SIZE (in) - SLICK SLEEVE			HOLE SIZE (in) - STABILIZED		
Deg.	8½	8¾	9⅞	8½	8¾	9⅞
0.39				2.25	2.42	3.18
0.78				4.60	4.77	5.53
1.15	3.00	2.10		6.84	7.00	7.76
1.50	5.90	4.99	0.90	8.95	9.12	9.87
1.83	8.59	7.68	3.59	10.94	11.11	11.87
2.12	10.95	10.05	5.95	12.69	12.86	13.62
2.38	13.04	12.17	8.07	14.26	14.43	15.19
2.60	14.72	13.94	9.87	15.59	15.76	16.51
2.77	16.01	15.28	11.26	16.61	16.78	17.54
2.90	17.01	16.27	12.32	17.40	17.57	18.33
2.97	17.54	16.81	12.89	17.82	17.99	18.75
3.00	17.77	17.04	13.13	18.00	18.17	18.93

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

04 MOTOR SPECIFICATIONS

6¾" 6/7 5.0 Fixed Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	54"	Bit Sizes	8½" - 9⅞"
Wear Pad OD	7.5"	Std Bit Connection	4½ Reg Box
Nominal Length	25'	Std Top Connection*	4½ XH Box
Weight	2,185 lbs	Max WOB with Flow	90,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	433,500 lbs
Bit Speed (No Load)	87-180 rpm	Max Bit Pull w/o Damage	433,500 lbs
Flow Range	300-600 gpm	Max Bit Pull w/ Damage**	560,000 lbs
Revolutions Per Gallon	0.29 rev/gal	Max Body Pull w/ Damage**	1,033,000 lbs
Max Differential Pressure	1,130 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Off Bottom Pressure Loss	110 psi		
Max Operating Torque	9,350 lb-ft		
Stall Torque	14,030 lb-ft		

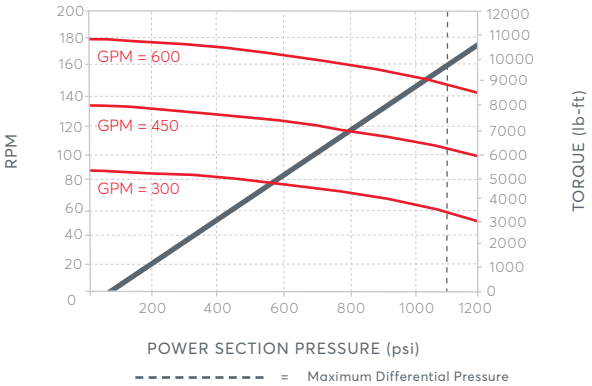
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE			HOLE SIZE (in) - STABILIZED		
Deg.	8½	8¾	9⅞	8½	8¾	9⅞
0.39				2.34	2.51	3.27
0.78	0.80	0.10		4.79	4.95	5.71
1.15	3.83	2.90	0.40	7.10	7.27	8.03
1.50	6.63	5.58	2.26	9.30	9.47	10.22
1.83	9.28	8.10	4.79	11.37	11.54	12.29
2.12	11.05	10.32	7.00	13.19	13.35	14.11
2.38	13.07	12.30	8.99	14.82	14.98	15.74
2.60	14.87	13.96	10.66	16.20	16.36	17.12
2.77	16.25	15.35	11.36	17.26	17.43	18.19
2.90	17.31	16.41	12.46	18.08	18.25	19.00
2.97	17.88	16.98	13.17	18.52	18.68	19.44
3.00	18.13	17.22	13.72	18.70	18.87	19.63

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

6¾" 6/7 5.0 Short Bit to Bend - Fixed

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	47"	Bit Sizes	8½" - 9⅞"
Wear Pad OD	7.5"	Std Bit Connection	4½ Reg Box
Nominal Length	24.5'	Std Top Connection*	4½ XH Box
Weight	2,165 lbs	Max WOB with Flow	72,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	433,500 lbs
Bit Speed (No Load)	87-180 rpm	Max Bit Pull w/o Damage	433,500 lbs
Flow Range	300-600gpm	Max Bit Pull w/ Damage**	560,000 lbs
Revolutions Per Gallon	0.29 rev/gal	Max Body Pull w/ Damage**	1,033,000 lbs
Max Differential Pressure	1,130 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Off Bottom Pressure Loss	110 psi		
Max Operating Torque	9,350 lb-ft		
Stall Torque	14,030 lb-ft		

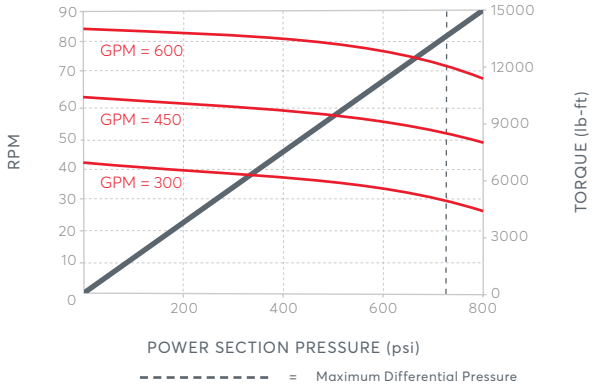
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE			HOLE SIZE (in) - STABILIZED		
Deg.	8½	8¾	9⅞	8½	8¾	9⅞
0.39				2.70	2.87	3.62
0.78	0.85	0.11		5.21	5.38	6.12
1.15	4.06	3.07	0.42	7.59	7.76	8.50
1.50	7.03	5.91	2.40	9.85	10.01	10.76
1.83	9.84	8.59	5.08	11.97	12.13	12.88
2.12	11.71	10.94	7.42	13.83	14.00	14.75
2.38	13.85	13.04	9.53	15.51	15.67	16.42
2.60	15.76	14.80	11.30	16.92	17.09	17.83
2.77	17.23	16.27	12.04	18.02	18.18	18.93
2.90	18.35	17.39	13.21	18.85	19.02	19.77
2.97	18.95	18.00	13.96	19.30	19.47	20.22
3.00	19.22	18.25	14.54	19.50	19.66	20.41

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

6¾" 7/8 3.3 Adjustable Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (ABH)	64"	Bit Sizes	8½" - 9⅞"
Wear Pad OD	7.5"	Std Bit Connection	4½ Reg Box
Nominal Length	30'	Std Top Connection*	4½ XH Box
Weight	2,700 lbs	Max WOB with Flow	90,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	433,500 lbs
Bit Speed (No Load)	42-84 rpm	Max Bit Pull w/o Damage	433,500 lbs
Flow Range	300-600gpm	Max Bit Pull w/ Damage**	560,000 lbs
Revolutions Per Gallon	0.14 rev/gal	Max Body Pull w/ Damage**	1,033,000 lbs
Max Differential Pressure	740 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Off Bottom Pressure Loss	150 psi		
Max Operating Torque	14,110 lb-ft		
Stall Torque	21,160 lb-ft		

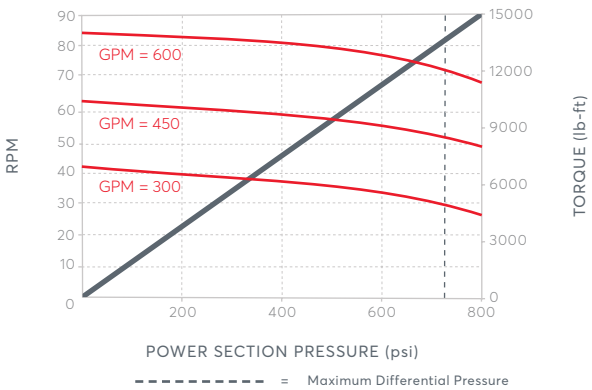
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE			HOLE SIZE (in) - STABILIZED		
Deg.	8½	8¾	9⅞	8½	8¾	9⅞
0.39				1.85	1.97	2.52
0.78				3.92	4.04	4.59
1.15	1.80	0.80		5.89	6.02	6.57
1.50	4.39	3.41	1.03	7.76	7.88	8.43
1.83	7.74	7.16	2.72	9.52	9.64	10.19
2.12	9.05	8.06	3.63	11.06	11.18	11.73
2.38	11.00	10.02	5.58	12.44	12.57	13.12
2.60	12.65	11.67	7.23	13.62	13.74	14.29
2.77	13.93	12.95	8.51	14.52	14.64	15.20
2.90	14.90	13.92	9.48	15.22	15.34	15.89
2.97	15.43	14.45	10.01	15.59	15.71	16.26
3.00	15.66	14.67	10.23	15.75	15.87	16.42

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

6¾" 7/8 3.3 Fixed Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	54"	Bit Sizes	8½" - 9⅞"
Wear Pad OD	7.5"	Std Bit Connection	4½ Reg Box
Nominal Length	30'	Std Top Connection*	4½ XH Box
Weight	2,700 lbs	Max WOB with Flow	90,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	433,500 lbs
Bit Speed (No Load)	42-84 rpm	Max Bit Pull w/o Damage	433,500 lbs
Flow Range	300-600gpm	Max Bit Pull w/ Damage**	560,000 lbs
Revolutions Per Gallon	0.14 rev/gal	Max Body Pull w/ Damage**	1,033,000 lbs
Max Differential Pressure	740 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Off Bottom Pressure Loss	150 psi		
Max Operating Torque	14,110 lb-ft		
Stall Torque	21,160 lb-ft		

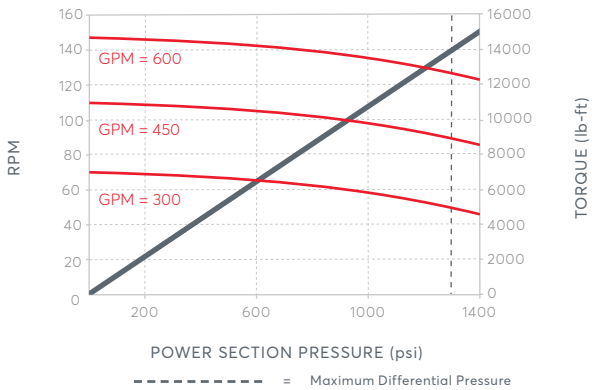
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE			HOLE SIZE (in) - STABILIZED		
Deg.	8½	8¾	9⅞	8½	8¾	9⅞
0.39				1.91	2.03	2.58
0.78	0.70	0.10		4.06	4.18	4.73
1.15	3.30	2.60	0.40	6.09	6.21	6.76
1.50	5.68	5.02	2.04	8.01	8.13	8.68
1.83	7.95	7.29	4.31	9.83	9.95	10.50
2.12	9.94	9.28	6.30	10.76	10.88	11.43
2.38	11.73	11.07	8.08	12.85	12.97	13.52
2.60	13.24	12.58	9.60	14.06	14.18	14.73
2.77	14.41	13.75	10.76	14.99	15.12	15.67
2.90	15.30	14.40	11.66	15.71	15.83	16.38
2.97	15.78	15.12	12.14	16.09	16.21	16.77
3.00	15.99	15.33	12.34	16.26	16.38	16.93

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

6¾" 7/8 5.7 Adjustable Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (ABH)	64"	Bit Sizes	8½" - 9⅞"
Wear Pad OD	7.5"	Std Bit Connection	4½ Reg Box
Nominal Length	31'	Std Top Connection*	4½ IF Box
Weight	2,750 lbs	Max WOB with Flow	90,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	433,500 lbs
Bit Speed (No Load)	72-150 rpm	Max Bit Pull w/o Damage	433,500 lbs
Flow Range	300-600gpm	Max Bit Pull w/ Damage**	560,000 lbs
Revolutions Per Gallon	0.24 rev/gal	Max Body Pull w/ Damage**	1,033,000 lbs
Max Differential Pressure	1,280 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Off Bottom Pressure Loss	106 psi		
Max Operating Torque	13,720 lb-ft		
Stall Torque	20,580 lb-ft		

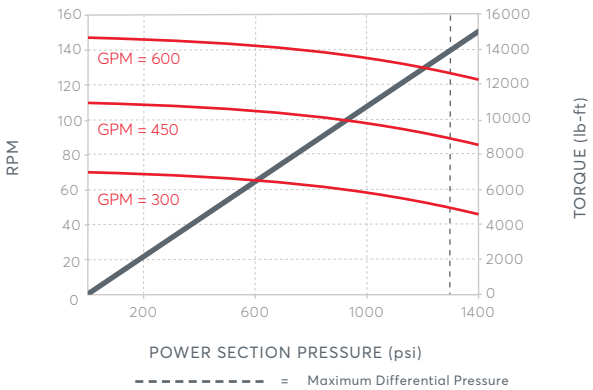
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE			HOLE SIZE (in) - STABILIZED		
Deg.	8½	8¾	9⅞	8½	8¾	9⅞
0.39				1.74	1.86	2.37
0.78				3.69	3.81	4.32
1.15	1.70	0.75		5.55	5.67	6.19
1.50	4.14	3.21	0.97	7.31	7.42	7.94
1.83	7.29	6.74	2.56	8.97	9.08	9.60
2.12	8.53	7.59	3.42	10.42	10.53	11.05
2.38	10.36	9.44	5.26	11.72	11.84	12.36
2.60	11.92	10.99	6.81	12.83	12.94	13.46
2.77	13.12	12.20	8.02	13.68	13.79	14.32
2.90	14.04	13.11	8.93	14.34	14.45	14.97
2.97	14.54	13.61	9.43	14.69	14.80	15.32
3.00	14.75	13.82	9.64	14.84	14.95	15.47

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

6¾" 7/8 5.7 Fixed Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	54"	Bit Sizes	8½" - 9⅞"
Wear Pad OD	7.5"	Std Bit Connection	4½ Reg Box
Nominal Length	31'	Std Top Connection*	4½ IF Box
Weight	2,750 lbs	Max WOB with Flow	90,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	433,500 lbs
Bit Speed (No Load)	72-150 rpm	Max Bit Pull w/o Damage	433,500 lbs
Flow Range	300-600gpm	Max Bit Pull w/ Damage**	560,000 lbs
Revolutions Per Gallon	0.24 rev/gal	Max Body Pull w/ Damage**	1,033,000 lbs
Max Differential Pressure	1,280 psi		
Off Bottom Pressure Loss	106 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Max Operating Torque	13,720 lb-ft		
Stall Torque	20,580 lb-ft		

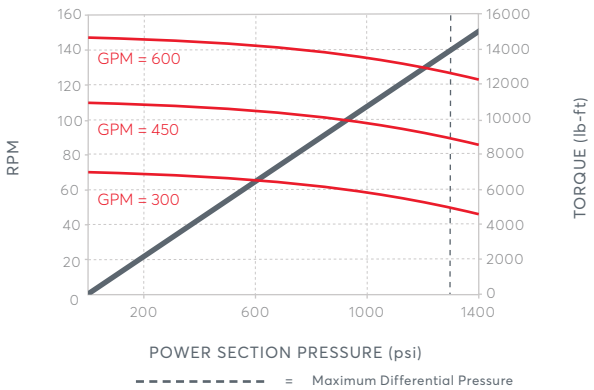
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE			HOLE SIZE (in) - STABILIZED		
Deg.	8½	8¾	9⅞	8½	8¾	9⅞
0.39				1.80	1.91	2.43
0.78	0.66	0.09		3.82	3.94	4.46
1.15	3.11	2.45	0.38	5.74	5.85	6.37
1.50	5.35	4.73	1.92	7.55	7.66	8.18
1.83	7.49	6.87	4.06	9.26	9.37	9.89
2.12	9.36	8.74	5.93	10.14	10.25	10.77
2.38	11.05	10.43	7.61	12.10	12.22	12.74
2.60	12.47	11.85	9.04	13.24	13.36	13.88
2.77	13.57	12.95	10.14	14.12	14.24	14.76
2.90	14.41	13.56	10.98	14.80	14.91	15.43
2.97	14.86	14.24	11.44	15.16	15.27	15.80
3.00	15.06	14.44	11.62	15.32	15.43	15.95

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

6¾" 7/8 5.7 Short Bit to Bend - Fixed

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	47"	Bit Sizes	8½" - 9⅞"
Wear Pad OD	7.5"	Std Bit Connection	4½ Reg Box
Nominal Length	29½'	Std Top Connection*	4½ IF Box
Weight	2,725 lbs	Max WOB with Flow	72,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	433,500 lbs
Bit Speed (No Load)	72-150 rpm	Max Bit Pull w/o Damage	433,500 lbs
Flow Range	300-600gpm	Max Bit Pull w/ Damage**	560,000 lbs
Revolutions Per Gallon	0.24 rev/gal	Max Body Pull w/ Damage**	1,033,000 lbs
Max Differential Pressure	1,280 psi		
Off Bottom Pressure Loss	106 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Max Operating Torque	13,720 lb-ft		
Stall Torque	20,580 lb-ft		

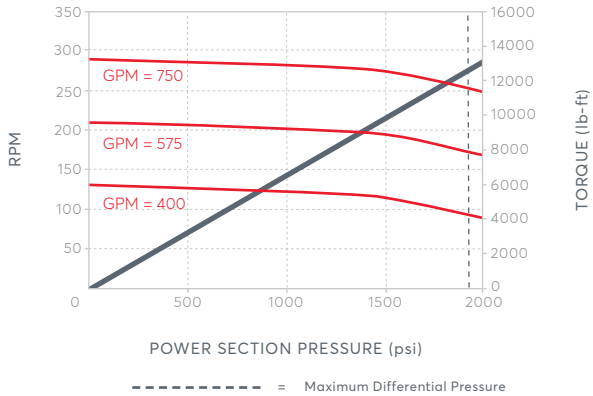
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE			HOLE SIZE (in) - STABILIZED		
Deg.	8½	8¾	9⅞	8½	8¾	9⅞
0.39	0.25	0.23		1.88	2.00	2.51
0.78	0.81	0.50	0.36	4.01	4.13	4.64
1.15	4.06	3.21	1.65	6.03	6.15	6.67
1.50	6.14	5.06	3.02	7.95	8.06	8.58
1.83	8.99	7.89	6.71	9.75	9.86	10.38
2.12	11.91	11.21	8.03	11.34	11.45	11.97
2.38	13.54	12.84	9.67	12.76	12.87	13.39
2.60	14.26	14.01	10.98	13.96	14.07	14.59
2.77	15.99	15.29	12.11	14.89	15.00	15.52
2.90	16.81	16.11	12.93	15.60	15.71	16.23
2.97	17.25	16.55	13.37	15.98	16.10	16.61
3.00	17.44	16.74	13.56	16.14	16.26	16.78

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

7" 5/6 8.3 Fixed Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	55.25"	Bit Sizes	8½" - 9⅞"
Wear Pad OD	7.5"	Std Bit Connection	4½ Reg Box
Nominal Length	31'	Std Top Connection*	4½ IF Box
Weight	2,613 lbs	Max WOB with Flow	90,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	433,500 lbs
Bit Speed (No Load)	130-290 rpm	Max Bit Pull w/o Damage	433,500 lbs
Flow Range	400-750 gpm	Max Bit Pull w/ Damage**	560,000 lbs
Revolutions Per Gallon	0.38 rev/gal	Max Body Pull w/ Damage**	1,033,000 lbs
Max Differential Pressure	1,960 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Off Bottom Pressure Loss	180 psi		
Max Operating Torque	13,030 lb-ft		
Stall Torque	20,530 lb-ft		

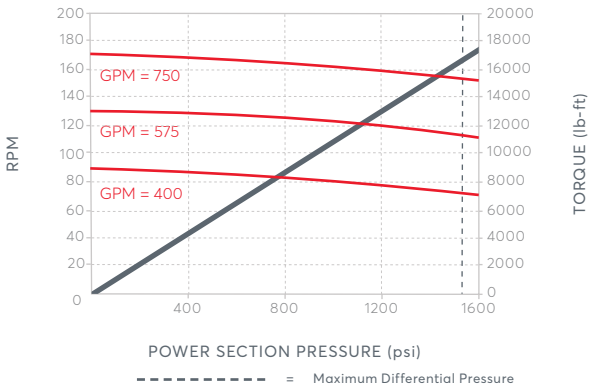
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE			HOLE SIZE (in) - STABILIZED		
Deg.	8½	8¾	9⅞	8½	8¾	9⅞
0.39				1.71	1.83	2.33
0.78				3.82	3.94	4.43
1.15	2.50	1.70		5.83	5.93	6.44
1.50	4.95	4.06	0.05	7.72	7.82	8.33
1.83	7.20	6.32	2.31	9.50	9.61	10.11
2.12	9.19	8.30	4.29	10.30	11.18	11.68
2.38	10.97	10.08	6.07	12.47	12.59	13.08
2.60	12.48	11.59	7.58	13.66	13.78	14.27
2.77	13.64	12.75	8.74	14.58	14.69	15.19
2.90	14.53	13.64	9.63	15.29	15.39	15.90
2.97	15.01	14.12	10.11	15.67	15.77	16.28
3.00	15.21	14.33	10.32	15.82	15.94	16.43

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

7" 6/7 6.5 Fixed Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	55.25"	Bit Sizes	8½" - 9⅞"
Wear Pad OD	7.5"	Std Bit Connection	4½ Reg Box
Nominal Length	32½'	Std Top Connection*	4½ IF Box
Weight	2,810 lbs	Max WOB with Flow	90,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	433,500 lbs
Bit Speed (No Load)	90-170 rpm	Max Bit Pull w/o Damage	433,500 lbs
Flow Range	400-750 gpm	Max Bit Pull w/ Damage**	560,000 lbs
Revolutions Per Gallon	0.23 rev/gal	Max Body Pull w/ Damage**	1,033,000 lbs
Max Differential Pressure	1,530 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Off Bottom Pressure Loss	130 psi		
Max Operating Torque	16,690 lb-ft		
Stall Torque	26,280 lb-ft		

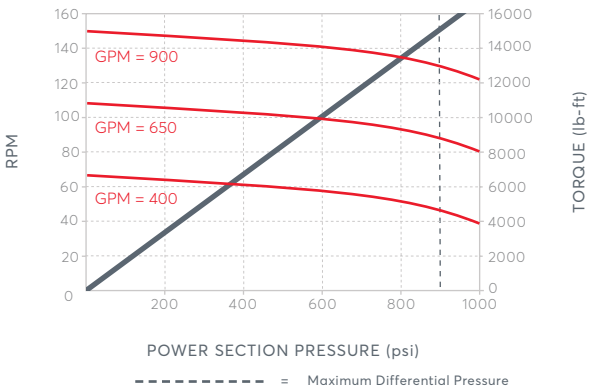
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE			HOLE SIZE (in) - STABILIZED		
(Deg.)	8½	8¾	9⅞	8½	8¾	9⅞
0.39				1.63	1.74	2.22
0.78	0.60			3.64	3.75	4.22
1.15	1.20	1.14		5.55	5.65	6.13
1.50	4.74	3.89	1.37	7.35	7.45	7.93
1.83	6.91	6.06	2.21	9.05	9.15	9.63
2.12	8.81	7.96	4.12	9.81	10.65	11.12
2.38	10.52	9.67	5.82	11.88	11.99	12.46
2.60	11.96	11.11	7.27	13.01	13.12	13.59
2.77	13.08	12.23	8.38	13.89	13.99	14.47
2.90	13.93	13.08	9.24	14.56	14.66	15.14
2.97	14.39	13.54	9.70	14.92	15.02	15.50
3.00	14.59	13.74	9.89	15.07	15.18	15.65

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

8" 7/8 4.0 Adjustable Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (ABH)	85"	Bit Sizes	9⅞" - 12¼"
Wear Pad OD	8.2"	Std Bit Connection	6⅝ Reg Box
Nominal Length	29'	Std Top Connection*	6⅝ Reg Box
Weight	3,600 lbs	Max WOB with Flow	130,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	672,000 lbs
Bit Speed (No Load)	66-150 rpm	Max Bit Pull w/o Damage	672,000 lbs
Flow Range	400-900gpm	Max Bit Pull w/ Damage**	710,000 lbs
Revolutions Per Gallon	0.17 rev/gal	Max Body Pull w/ Damage**	1,512,000 lbs
Max Differential Pressure	900 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Off Bottom Pressure Loss	126 psi		
Max Operating Torque	14,930 lb-ft		
Stall Torque	22,400 lb-ft		

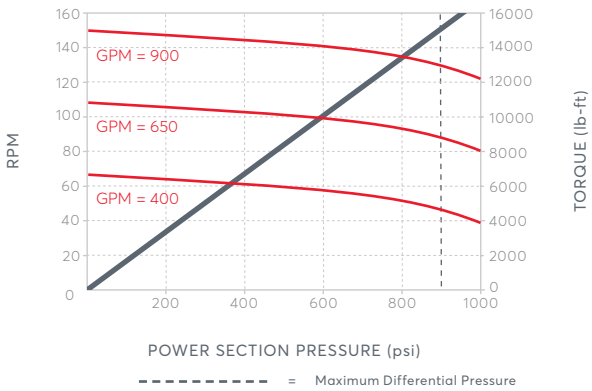
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE			HOLE SIZE (in) - STABILIZED		
Deg.	9⅞	10⅝	12¼	9⅞	10⅝	12¼
0.39	0.80			2.70	3.14	4.09
0.78	1.03	1.00		4.83	5.27	6.22
1.15	1.31	1.23	1.20	6.85	7.29	8.24
1.50	6.14	5.06	2.21	8.76	9.20	10.15
1.83	7.60	6.26	2.74	10.56	11.00	11.96
2.12	9.85	8.18	4.74	11.49	11.93	12.89
2.38	11.58	9.90	7.58	13.56	14.01	14.96
2.60	12.87	11.19	8.05	14.77	15.21	16.16
2.77	14.16	12.49	9.10	15.69	16.14	17.09
2.90	15.02	13.35	9.73	16.40	16.85	17.80
2.97	15.49	13.81	10.19	16.79	17.23	18.18
3.00	15.69	14.01	10.81	16.95	17.39	18.35

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

8" 7/8 4.0 Fixed Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	71"	Bit Sizes	9⅞" - 12¼"
Wear Pad OD	8.2"	Std Bit Connection	6⅝ Reg Box
Nominal Length	29'	Std Top Connection*	6⅝ Reg Box
Weight	3,600 lbs	Max WOB with Flow	130,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	672,000 lbs
Bit Speed (No Load)	66-150 rpm	Max Bit Pull w/o Damage	672,000 lbs
Flow Range	400-900gpm	Max Bit Pull w/ Damage**	710,000 lbs
Revolutions Per Gallon	0.17 rev/gal	Max Body Pull w/ Damage**	1,512,000 lbs
Max Differential Pressure	900 psi	*Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Off Bottom Pressure Loss	126 psi		
Max Operating Torque	14,930 lb-ft		
Stall Torque	22,400 lb-ft		

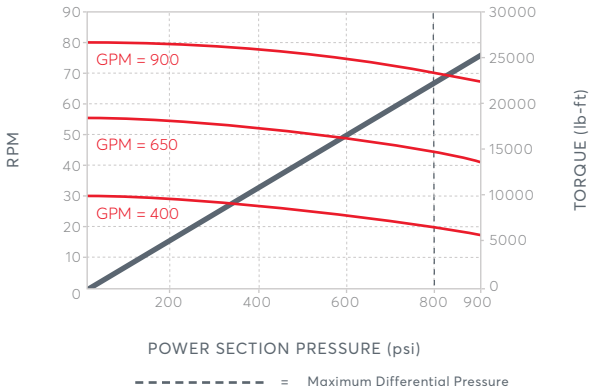
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE			HOLE SIZE (in) - STABILIZED		
Deg.	9⅞	10⅝	12¼	9⅞	10⅝	12¼
0.39	0.96			2.81	3.25	4.21
0.78	1.21	1.20		5.05	5.49	6.45
1.15	1.49	1.47	1.44	7.18	7.62	8.57
1.50	6.37	6.06	2.65	9.19	9.63	10.59
1.83	7.93	7.50	3.28	11.09	11.53	12.48
2.12	9.93	9.80	5.68	12.06	12.51	13.46
2.38	12.02	11.86	9.08	14.25	14.69	15.65
2.60	13.59	13.41	9.64	15.51	15.96	16.91
2.77	15.17	14.96	10.90	16.49	16.93	17.89
2.90	16.21	15.99	11.66	17.24	17.68	18.64
2.97	16.77	16.54	12.21	17.64	18.08	19.04
3.00	17.01	16.78	12.95	17.81	18.26	19.21

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

9⅝" 7/8 3.4 Combo - Fixed Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	76"	Bit Sizes	12¼" - 17½"
Wear Pad OD	10.2"	Std Bit Connection	6⅝ Reg Box
Nominal Length	37½'	Std Top Connection*	6⅝ Reg Box
Weight	6,313 lbs	Max WOB with Flow	174,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	820,000 lbs
Bit Speed (No Load)	30-80 rpm	Max Bit Pull w/o Damage	1,200,000 lbs
Flow Range	400-900gpm	Max Bit Pull w/ Damage**	1,280,000 lbs
Revolutions Per Gallon	0.09 rev/gal	Max Body Pull w/ Damage**	1,512,000 lbs
Max Differential Pressure	800 psi		
Off Bottom Pressure Loss	70 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Max Operating Torque	22,530 lb-ft		
Stall Torque	35,480 lb-ft		

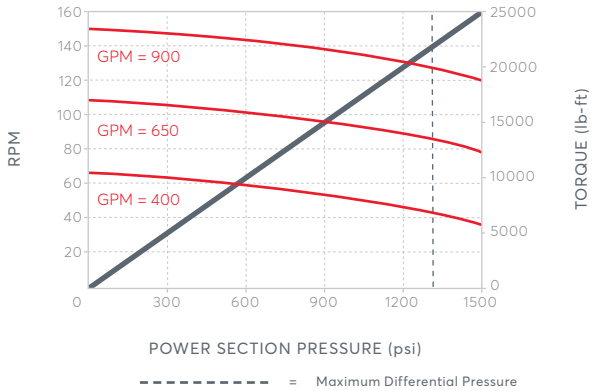
Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE			HOLE SIZE (in) - STABILIZED		
Deg.	12¼	14¾	17½	12¼	14¾	17½
0.39				0.68	1.63	2.58
0.78	1.00			2.44	3.39	4.34
1.15	1.20			4.11	5.06	6.01
1.50	2.74			5.69	6.64	7.59
1.83	4.49			7.18	8.13	9.08
2.12	6.04	1.05		8.49	9.44	10.39
2.38	7.42	2.43		9.67	10.62	11.57
2.60	8.59	3.61		10.66	11.61	12.56
2.77	9.50	4.51		11.43	12.38	13.33
2.90	10.19	5.20		12.02	12.97	13.92
2.97	10.56	5.58		12.33	13.28	14.23
3.00	10.72	5.74		12.47	13.42	14.37

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

9⅝" 7/8 5.9 Combo - Fixed Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	76"	Bit Sizes	12¼" - 17½"
Wear Pad OD	10.2"	Std Bit Connection	6⅝ Reg Box
Nominal Length	37½'	Std Top Connection*	6⅝ Reg Box
Weight	6,388 lbs	Max WOB with Flow	174,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	820,000 lbs
Bit Speed (No Load)	66-150 rpm	Max Bit Pull w/o Damage	1,200,000 lbs
Flow Range	400-900gpm	Max Bit Pull w/ Damage**	1,280,000 lbs
Revolutions Per Gallon	0.17 rev/gal	Max Body Pull w/ Damage**	1,512,000 lbs
Max Differential Pressure	1,330 psi		
Off Bottom Pressure Loss	134 psi	*Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Max Operating Torque	22,020 lb-ft		
Stall Torque	33,030 lb-ft		

Predicted Build Rates - Deg/100 ft

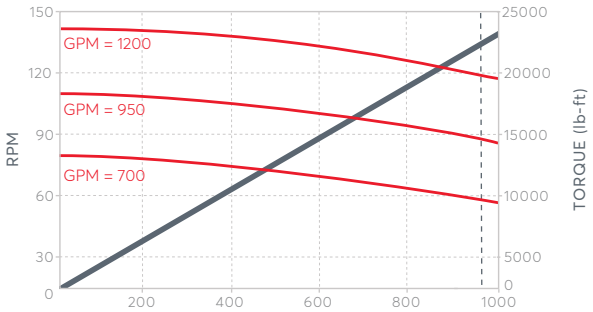
ANGLE	HOLE SIZE (in) - SLICK SLEEVE			HOLE SIZE (in) - STABILIZED		
Deg.	12¼	14¾	17½	12¼	14¾	17½
0.39				0.68	1.63	2.58
0.78	1.00			2.44	3.39	4.34
1.15	1.20			4.11	5.06	6.01
1.50	2.74			5.69	6.64	7.59
1.83	4.49			7.18	8.13	9.08
2.12	6.04	1.05		8.49	9.44	10.39
2.38	7.42	2.43		9.67	10.62	11.57
2.60	8.59	3.61		10.66	11.61	12.56
2.77	9.50	4.51		11.43	12.38	13.33
2.90	10.19	5.20		12.02	12.97	13.92
2.97	10.56	5.58		12.33	13.28	14.23
3.00	10.72	5.74		12.47	13.42	14.37

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

04 MOTOR SPECIFICATIONS

9⅝" 7/8 6.5 - Fixed Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	76"	Bit Sizes	12¼" - 17½"
Wear Pad OD	10.2"	Std Bit Connection	6⅝ or 7⅝ Reg
Nominal Length	38'	Std Top Connection*	6⅝ or 7⅝ Reg
Weight	7,615 lbs	Max WOB with Flow	174,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	820,000 lbs
Bit Speed (No Load)	79-140 rpm	Max Bit Pull w/o Damage	1,200,000 lbs
Flow Range	700-1200gpm	Max Bit Pull w/ Damage**	1,280,000 lbs
Revolutions Per Gallon	0.11 rev/gal	Max Body Pull w/ Damage**	1,512,000 lbs
Max Differential Pressure	980 psi		
Off Bottom Pressure Loss	161 psi	* Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Max Operating Torque	22,500 lb-ft		
Stall Torque	33,750 lb-ft		

Predicted Build Rates - Deg/100 ft

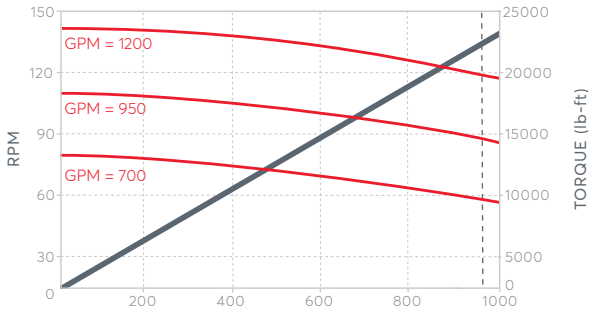
ANGLE	HOLE SIZE (in) - SLICK SLEEVE			HOLE SIZE (in) - STABILIZED		
Deg.	12¼	14¾	17½	12¼	14¾	17½
0.39				1.41	2.26	3.18
0.78				3.16	4.00	4.93
1.15	0.90	0.75	0.63	4.81	5.65	6.58
1.50	2.70	2.24	1.89	6.37	7.20	8.15
1.83	4.44	3.69	3.11	7.85	8.69	9.62
2.12	5.97	4.96	4.18	9.15	9.99	10.92
2.38	7.34	6.09	5.14	10.31	11.15	12.08
2.60	8.49	7.05	5.94	11.29	12.14	13.06
2.77	9.39	7.79	6.57	12.05	12.90	13.83
2.90	10.07	8.36	7.05	12.64	13.48	14.41
2.97	10.44	8.67	7.31	12.95	13.79	14.72
3.00	10.60	8.80	7.42	13.08	13.93	14.85

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

04 MOTOR SPECIFICATIONS

9⅝" 7/8 6.5 Adjustable Bend Housing

Performance Curves



PHYSICAL DATA		GENERAL DATA	
Bit to Bend Length (FBH)	86"	Bit Sizes	12¼" - 17½"
Wear Pad OD	10.13"	Std Bit Connection	6⅝ or 7⅝ Reg
Nominal Length	38'	Std Top Connection*	6⅝ or 7⅝ Reg
Weight	7,615 lbs	Max WOB with Flow	174,000 lbs
PERFORMANCE DATA		Max WOB w/o Flow	820,000 lbs
Bit Speed (No Load)	79-140 rpm	Max Bit Pull w/o Damage	1,200,000 lbs
Flow Range	700-1200gpm	Max Bit Pull w/ Damage**	1,280,000 lbs
Revolutions Per Gallon	0.11 rev/gal	Max Body Pull w/ Damage**	1,760,000 lbs
Max Differential Pressure	980 psi		
Off Bottom Pressure Loss	161 psi	*Other connections available upon request ** Exceeding these values may cause motor components to remain in hole	
Max Operating Torque	22,500 lb-ft		
Stall Torque	33,750 lb-ft		

Predicted Build Rates - Deg/100 ft

ANGLE	HOLE SIZE (in) - SLICK SLEEVE			HOLE SIZE (in) - STABILIZED		
Deg.	12¼	14¾	17½	12¼	14¾	17½
0.39				1.24	1.99	2.80
0.78				2.78	3.52	4.34
1.15	0.79	0.66	0.55	4.23	4.97	5.79
1.50	2.38	1.97	1.66	5.61	6.34	7.17
1.83	3.91	3.25	2.74	6.91	7.65	8.47
2.12	5.25	4.36	3.68	8.05	8.79	9.61
2.38	6.46	5.36	4.52	9.07	9.81	10.63
2.60	7.47	6.20	5.23	9.94	10.68	11.49
2.77	8.26	6.86	5.78	10.60	11.35	12.17
2.90	8.86	7.36	6.20	11.12	11.86	12.68
2.97	9.19	7.63	6.43	11.40	12.14	12.95
3.00	9.33	7.75	6.53	11.51	12.26	13.07

For temperatures exceeding 140° F, the maximum rated differential pressure should be decreased as shown in Figure 3-3.

Table 4-1: Motor Specifications

MOTOR SIZE (in)	MOTOR CONFIG	HOLE SIZE (in)	FLOW RANGE* (gpm)	SPEED NO LOAD* (rpm)	SPEED RATIO (rev/gal)	FULL LOAD TORQUE* (lb-ft)	MAX REC. PRESSURE* (psi)	TOOL WEIGHT (lbs)	LENGTH (ft)	FIXED BIT TO BEND (in)	ADJUSTABLE BIT TO BEND (in)
4¾"	5/6 8.3	6 - 7⅞	100 - 300	100 - 300	1.00	4,810	1,870	1,100	29.00	53.25	58.25
4¾" SBTB **	5/6 8.3	6 - 7⅞	100 - 300	100 - 300	1.00	4,810	1,870	1,085	29.00	47.00	N/A
4¾"	7/8 2.6	6 - 7⅞	150 - 300	39 - 79	0.26	5,250	590	1,100	29.00	53.25	58.25
4¾"	7/8 3.8	6 - 7⅞	150 - 250	78 - 140	0.52	4,450	860	990	24.00	53.25	58.25
4¾" SBTB **	7/8 3.8	6 - 7⅞	150 - 250	78 - 140	0.52	4,450	860	975	24.00	47.00	N/A
5"	6/7 8.0	6 - 7⅞	150 - 350	121-2 90	0.81	5,720	1,800	1,100	29.50	55.25	60.25
5" SBTB**	6/7 8.0	6 - 7⅞	150 - 350	121 - 290	0.81	5,720	1,800	1,085	29.50	49.00	N/A
5"	6/7 10.0	6 - 7⅞	150 - 350	130 - 290	0.84	6,940	2,350	1,158	31.75	53.25	N/A
6½"	6/7 5.0	7⅛ - 8¾	300 - 600	87 - 180	0.29	9,350	1,130	2,105	25.00	54.00	64.00
6½"	7/8 3.3 HTS	7⅛ - 8¾	300 - 600	42 - 84	0.14	14,110	740	2,600	30.00	54.00	64.00
6¾"	4/5 7.0	8½ - 9⅞	300 - 600	149 - 300	0.50	9,090	1,580	2,050	25.50	54.00	64.00
6¾" SBTB**	4/5 7.0	8½ - 9⅞	300 - 600	149 - 300	0.50	9,090	1,580	2,025	25.50	47.00	N/A
6¾"	6/7 5.0	8½ - 9⅞	300 - 600	87 - 180	0.29	9,350	1,130	2,185	25.00	54.00	64.00
6¾" SBTB**	6/7 5.0	8½ - 9⅞	300 - 600	87 - 180	0.29	9,350	1,130	2,160	24.50	47.00	57.00
6¾"	7/8 3.3 HTS	8½ - 9⅞	300 - 600	42 - 84	0.14	14,110	740	2,700	30.00	54.00	64.00
6¾"	7/8 5.7	8½ - 9⅞	300 - 600	72 - 150	0.24	13,720	1,280	2,750	31.00	54.00	64.00
6¾" SBTB**	7/8 5.7	8½ - 9⅞	300 - 600	72 - 150	0.24	13,720	1,280	2,725	31.00	47.00	N/A
7"	5/6 8.3	8½ - 9⅞	400 - 750	130 - 290	0.38	13,030	1,960	2,613	31.00	55.25	N/A
7"	6/7 6.5	8½ - 9⅞	400 - 750	90 - 170	0.23	16,690	1,530	2,810	32.50	55.25	N/A
8"	7/8 4.0	9⅞ - 12¼	400 - 900	66 - 150	0.17	14,930	900	3,600	29.00	71.00	85.00
9⅝" Combo	7/8 3.4	12¼ - 17½	400 - 900	30 - 80	0.09	22,530	800	6,313	37.50	76.00	N/A
9⅝" Combo	7/8 5.9	12¼ - 17½	400 - 900	66 - 150	0.17	22,020	1,330	6,388	37.50	76.00	N/A

* Manufacturer's published power section specifications

Table 4-2: Bearing Stabilizer Torque Values

MOTOR SIZE (in)	MAKE-UP TORQUE (lb-ft)
4¾" – 5"	8,000
6½"	25,000
6¾"	25,000
7"	25,000
8"	38,000
9⅝" x 8" Combo	45,000

05 ENGINEERING DATA

Formulas

HORSEPOWER

Mechanical

$$HP = \frac{T \times N}{5252}$$

HP = Horsepower (hp)
T = Torque (lb-ft)
N = Rotational Speed (rpm)

Hydraulic

$$HP = \frac{P \times Q}{1714}$$

HP = Horsepower (hp)
P = Pressure Drop (psi)
Q = Flow Rate (gpm)

PRESSURE

Across Bit

$$P_b = \frac{Q^2 \times W}{10{,}858 \times A^2}$$

P_b = Bit Pressure Drop (psi)
Q = Flow Rate (gpm)
W = Mud Weight (ppg)
A = Total Flow Area (in^2)

Hydrostatic

$$P = 0.052 \times TVD \times W$$

P = Pressure (psi)
TVD = Total Vertical Depth (ft)
W = Mud Weight (ppg)

VELOCITY

Jet

$$V = \frac{.32086 \times Q}{A}$$

V = Velocity (ft/s)
Q = Flow Rate (gpm)
A = Nozzle Flow Area (in^2)

Annular

$$V = \frac{.4085 \times Q}{D_h^2 - D_p^2}$$

V = Velocity (ft/s)
Q = Flow Rate (gpm)
D_h = Hole Diameter (in)
D_p = Drillstring OD (in)

MOTOR EFFICIENCY

Motor Efficiency %

$$\text{Motor Efficiency \%} = \frac{32.64 \times T \times N}{Q \times P}$$

T = Torque (lb-ft)
N = Rotational Speed (rpm)
Q = Flow Rate (gpm)
P = Pressure Drop (psi)

TOTAL FLOW AREA (TFA)

For a Required Bit Pressure Loss

$$A = \sqrt{(Q^2 \times W) / (P_b \times 10{,}858)}$$

A = Nozzle Area (in^2)
Q = Flow Rate (gpm)
W = Mud Weight (ppg)
P_b = Bit Pressure Drop (psi)

Conversion Tables

	UNITS	MULTIPLY BY	TO OBTAIN
ACCELERATION (via GRAVITY)	ft/sec^2	0.3048	m/sec^2
	32.2 ft/sec^2	0.3084	9.81 m/sec^2
	m/sec^2	3.2808	ft/sec^2
ANGLE	deg (angle)	60	min
	deg (angle)	0.01745	rad
	deg (angle)	3,600	sec
AREA	in^2	6.944 x 10-3	ft^2
	in^2	6.4516	cm^2
	in^2	6.4516	mm^2
	ft^2	0.0929	m^2
	ft^2	144	in^2
	cm^2	0.155	in^2
	mm^2	0.00155	in^2
	m^2	10.764	ft^2
DENSITY	lb/gal	119.82	kg/m^3
	lb/gal	0.11982	g/cm^3
	lb/gal	7.48	lb/ft^3
	lb/ft^3	5.787 x 10-4	lb/in^3
	lb/ft^3	16.02	kg/m^3
	lb/in^3	27679.7	kg/m^3
	lb/in^3	27.6797	g/cm^3
	kg/m^3	8.346 x 10-3	lb/gal^3
	g/cm^3	8.346	lb/gal^3
	kg/m^3	3.61 x 10-5	lb/in^3
	kg/m^3	0.06243	lb/ft^3
	g/cm^3	0.03613	lb/in^3
ENERGY	joule	0.737557	ft-lb
	ft-lb	1.35583	joule
	ft-lb	1.286 x 10-3	Btu
	Btu	777.6	ft-lb

Conversion Tables

	UNITS	MULTIPLY BY	TO OBTAIN
FLOW RATE	bbl/min	42	gpm
	bbl/day	0.02917	gpm
	gpm	0.02381	bbl/min
	gpm	34.286	bbl/day
	gpm	3.785	lpm
	gpm	3.7 x 10-3	m^3/min
	bbl/min	0.158899	m^3/min
	ft^3/min	4.72 x 10-4	m^3/sec
	ft^3/min	0.1247	gal/sec
	ft^3/min	0.472	liters/sec
	ft^3/sec	448.83	gpm
	lpm	0.2642	gpm
	m^3/min	264.2	gpm
	m^3/min	6.2933	bbl/min
	m^3/sec	2118.6	ft^3/min
	gal/sec	8.0515	ft^3/min
	liters/sec	2.1186	ft^3/min
	gpm	0.00228	ft^3/sec
FORCE	lbf	4.448	N
	lbf	4.448 x 10-3	kN
	lbf	0.4536	kgf
	N	0.22481	lbf
	kN	224.82	lbf
	kgf	2.20459	lbf
LENGTH	in	25.4	mm
	in	2.54	cm
	ft	0.30479	m
	ft	5280	mi
	mi	1.609	km
	mm	0.03937	in
	cm	0.3937	in
	m	3.2808	ft
	km	0.6215	mi

Conversion Tables

	UNITS	MULTIPLY BY	TO OBTAIN
MASS	lb	0.453597	kg
	lb	5.535 x 10-4	ton (metric)
	kg	2.2046	lb
NOZZLES	1/32 in	0.79375	mm
	mm	1.2598	1/32 in
POWER	hp	0.7457	kw
	ft-lb/min	2.259 x 10-5	kw
	ft-lb/sec	1.3557	w
	kw	1.34102	hp
	kw	44250	ft-lb/min
	w	0.7376	ft-lb/sec
PRESSURE	psi	6.8948	kPa
	psi	0.0068948	Mpa
	psi	0.0680462	atm
	psi	0.068948	bar
	atm	14.6959	psi
	bar	14.50326	psi
	kPa	0.14504	psi
	Mpa	145.03684	psi
STRESS	psi	0.0068948	Mpa
	psi	0.068948	bar
	psi	0.0068948	N/mm^2
	bar	14.50326	psi
	mPa	145.03684	psi
	N/mm^2	145.03684	psi
TEMPERATURE	°F	(°F - 32) /1.8	°C
	°C	(°C x 1.8) + 32	°F
	°F	°F + 459.69	°R
	°C	°C + 273.16	K
TORQUE	lb-ft	1.35582	Nm
	lb-ft	0.00135582	kNm
	lb-ft	0.1382	kgm
	Nm	0.737561	lb-ft
	kNm	737.561	lb-ft
	kgm	7.23589	lb-ft
VELOCITY	ft/min	0.508	cm/sec
	ft/min	0.01667	ft/sec
	ft/min	0.01829	km/hr
	ft/min	0.3048	m/min
	ft/min	0.01136	mi/hr
	cm/sec	1.9685	ft/min
	ft/sec	59.988	ft/min
	km/hr	54.67	ft/min
	m/min	3.281	ft/min
	mi/hr	88.028	ft/min
VOLUME	gal(US)	3.785	l
	gal(US)	0.003785	m^3
	ft^3	0.02831	m^3
	bbl	0.1589	m^3

Buoyancy Factors for Steel Drill Collars

MUD WEIGHT (lbs/gal)	MUD WEIGHT (kgf/l)	BUOYANCY FACTOR
8.5	1.02	0.870
9.0	1.06	0.862
9.5	1.14	0.855
10.0	1.20	0.847
10.5	1.26	0.839
11.0	1.32	0.832
11.5	1.36	0.824
12.0	1.44	0.816
12.5	1.50	0.809
13.0	1.56	0.801
13.5	1.62	0.793
14.0	1.68	0.786
14.5	1.74	0.778
15.0	1.80	0.771
15.5	1.86	0.763
16.0	1.92	0.755
16.5	1.96	0.748
17.0	2.04	0.740
17.5	2.10	0.732
18.0	2.16	0.725

EXAMPLE

$$BF = \frac{1 - MW_1}{65.37}$$

BF = Buoyancy Factor
MW_1 = Mud Weight (lb/gal)

$$BF = \frac{1 - MW_2}{7.83}$$

BF = Buoyancy Factor
MW_2 = Mud Weight (kgf/l)

Note: lb/gal x 0.11983 = kgf/l

Collar Weights in Pounds Per Foot

OD OF DRILL COLLAR (in)	BORE OF DRILL COLLAR (in)												
	1	1 ¼	1 ½	1 ¾	2	2 ¼	2 ½	1 13/16	3	3 ¼	3 ½	3 ¾	4
2 ⅞	19	18	16										
3	21	20	18										
3 ⅛	22	22	20										
3 ¼	16	26	22										
3 ½	30	29	27										
3 ¾	35	33	32										
4	40	39	37	35	32	29							
4 ⅛	43	41	39	37	35	32							
4 ¼	46	44	42	40	38	35							
4 ½	51	50	48	46	43	41							
4 ¾			54	52	50	47	44						
5			61	59	56	53	50						
5 ¼			68	66	63	60	57						
5 ½			75	73	70	67	64	60					
5 ¾			82	80	78	75	72	67	64	60			
6			90	88	85	83	79	75	72	68			
6 ¼			98	96	94	91	88	83	80	76	72		
6 ½			107	105	102	99	96	91	89	85	80		
6 ¾			116	114	111	108	105	100	98	93	89		
7			125	123	120	117	114	110	107	103	98	93	84
7 ¼			134	132	130	127	124	119	116	112	108	103	93
7 ½			144	142	139	137	133	129	126	122	117	113	102
7 ¾			154	152	150	147	144	139	136	132	128	123	112
8			165	163	160	157	154	150	147	143	138	133	122
8 ¼			176	174	171	168	165	160	158	154	149	144	133
8 ½			187	185	182	179	176	172	169	165	160	155	150
9			210	208	206	203	200	195	192	188	184	179	174
9 ½			234	232	230	227	224	220	216	212	209	206	198
9 ¾			248	245	243	240	237	232	229	225	221	216	211
10			261	259	257	254	251	246	243	239	235	230	225
11			317	315	313	310	307	302	299	295	291	286	281
12			379	377	374	371	368	364	361	357	352	347	342

Drill Collar Connection Make-Up Torque

CONNECTION TYPE			MINIMUM MAKE-UP TORQUE[2] lb-ft BORE OF DRILL COLLAR (in)							
SIZE	TYPE	OD (in)	1	1 ¼	1 ½	1 ¾	2	2 ¼	2 ½	2 13/16
API	NC 23	3	*2,508	*2,508	*2,508					
		3 ⅛	*3,330	*3,330	2,647					
		3 ¼	4,000	3,387	2,647					
2 ⅜	Regular	3		*2,241	*2,241	1,749				
		3 ⅛		*3,028	2,574	1,749				
		3 ¼		3,285	2,574	1,749				
2 ⅞	PAC[3]	3		*3,797	*3,797	2,926				
		3 ⅛		*4,966	4,151	2,926				
		3 ¼		5,206	4,151	2,926				
2 ⅞	API IF	3 ½		*4,606	*4,606	*4,606				
API	NC	3 ¾		5,501	4,668	3,697				
2 ⅞	Slim Hole									

CONNECTION TYPE			MINIMUM MAKE-UP TORQUE[2] lb-ft BORE OF DRILL COLLAR (in)							
SIZE	TYPE	OD (in)	1	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	2 13/16
2 7/8	Regular	3 1/2		*3,838	*3,383	*3,383				
		3 3/4		5,766	4,951	4,002				
		3 7/8		5,766	4,951	4,002				
2 7/8	X-Hole	3 3/4		*4,089	*4,089	*4,089				
3 1/2	Dbl Streamline	3 7/8		*5,352	*5,352	*5,352				
2 7/8	Mod Open	4 1/8		*8,059	*8,059	7,433				
2 7/8	API IF	3 7/8		*4,640	*4,640	*4,640	*4,640			
API	NC31	4 1/8		*7,390	*7,390	*7,390	6,853			
3 1/2	Regular	4 1/8		*6,466	*6,466	*6,466	*6,466	5,685		
		4 1/4		*7,886	*7,886	*7,886	7,115	5,685		
		4 1/2		10,471	9,307	8,161	7,115	5,685		

CONNECTION TYPE			MINIMUM MAKE-UP TORQUE[2] lb-ft BORE OF DRILL COLLAR (in)							
SIZE	TYPE	OD (in)	1	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	2 13/16
3 1/2	Slim Hole	4 1/4		*8,858	*8,858	8,161	6,853	5,391		
		4 1/2		10,286	9,307	8,161	6,853	5,391		
API	NC35	4 1/2				*9,038	*9,038	*9,038	7,411	
		4 3/4				12,300	10,800	9,200	7,411	
		5				12,300	10,800	9,200	7,411	
3 1/2	X-Hole	4 1/4				*5,161	*5,161	*5,161	*5,161	
4	Slim Hole	4 1/2				*8,497	*8,497	*8,497	8,311	
3 1/2	Mod Open	4 3/4				*12,074	11,803	10,144	8,311	
		5				13,283	11,803	10,144	8,311	
		5 1/4				13,283	11,803	10,144	8,311	

CONNECTION TYPE			MINIMUM MAKE-UP TORQUE[2] lb-ft BORE OF DRILL COLLAR (in)							
SIZE	TYPE	OD (in)	1	1 ¼	1 ½	1 ¾	2	2 ¼	2 ½	2 13/16
3½	API IF	4¾				*9,986	*9,986	*9,986	*9,986	8,315
API	NC38	5				*13,949	*13,949	12,907	10,997	8,315
4½	Slim Hole	5¼				16,207	14,643	12,907	10,997	8,315
		5½				16207	14,643	12,907	10,997	8,315
3½	H-90[4]	4¾				*8,786	*8,786	*8,786	*8,786	*8,786
		5				*12,794	*12,794	*12,794	12,794	10,408
		5¼				*17,094	16,929	15,137	13,151	10,408
		5½				18,522	16,929	15,137	13,151	10,408
4	Full Hole	5				*10,910	*10,910	*10,910	*10,910	*10,910
API	NC40	5¼				*15,290	*15,290	*15,290	14,969	12,125
4	Mod Open	5½				*19,985	18,886	17,028	14,969	12,125
4½	Dbl Streamline	5¾				20,539	18,886	17,028	14,969	12,125
		6				20,539	18,886	17,028	14,969	12,125

CONNECTION TYPE			MINIMUM MAKE-UP TORQUE[2] lb-ft BORE OF DRILL COLLAR (in)							
SIZE	TYPE	OD (in)	1 ½	1 ¾	2	2 ¼	2 ½	2 13/16	3	3 ¼
4	H-90[4]	5¼		*12,590	*12,590	*12,590	*12,590	*12,590		
		5½		*17,401	*17,401	*17,401	*17,401	16,536		
		5¾		*22,531	*22,531	21,714	19,543	16,536		
		6		25,408	23,671	21,714	19,543	16,536		
		6¼		25,408	23,671	21,714	19,543	16,536		
4½	API Regular	5½		*15,576	*15,576	*15,576	*15,576	*15,576		
		5¾		*20,609	*20,609	*20,609	19,601	16,629		
		6		25,407	23,686	21,749	19,601	16,629		
		6¼		25,407	23,686	21,749	19,601	16,629		
API	NC44	5¾		*20,895	*20,895	*20,895	*20,895	18,161		
		6		*26,453	25,510	23,493	21,257	18,161		
		6¼		27,300	25,510	23,493	21,257	18,161		
		6½		27,300	25,510	23,493	21,257	18,161		

CONNECTION TYPE			MINIMUM MAKE-UP TORQUE[2] lb-ft BORE OF DRILL COLLAR (in)							
SIZE	TYPE	OD (in)	2	2 1/4	2 1/2	2 13/16	3	3 1/4	3 1/2	3 3/4
4 1/2	API Full Hole	5 1/2	*12,973	*12,973	*12,973	*12,973	*12,973			
		5 3/4	*18,119	*18,119	*18,119	*18,119	17,900			
		6	*23,605	*23,605	23,028	19,921	17,900			
		6 1/4	27,294	25,272	23,028	19,921	17,900			
		6 1/2	27,294	25,272	23,028	19,921	17,900			
4 1/2	X-Hole	5 3/4		*17,738	*17,738	*17,738	*17,738			
API	NC46	6		*23,422	*23,422	22,426	20,311			
4	API IF	6 1/4		28,021	25,676	22,426	20,311			
4 1/2	Semi IF	6 1/2		28,021	25,676	22,426	20,311			
5	Dbl Streamline	6 3/4		28,021	25,676	22,426	20,311			
4 1/2	Mod Open									
4 1/2	H-90[4]	5 3/4		*18,019	*18,019	*18,019	*18,019			
		6		*23,681	*23,681	23,159	21,051			
		6 1/4		28,732	26,397	23,159	21,051			
		6 1/2		28,732	26,397	23,159	21,051			
		6 3/4		28,732	26,397	23,159	21,051			

CONNECTION TYPE			MINIMUM MAKE-UP TORQUE[2] lb-ft BORE OF DRILL COLLAR (in)							
SIZE	TYPE	OD (in)	2	2 1/4	2 1/2	2 13/16	3	3 1/4	3 1/2	3 3/4
5	H-90[4]	6 1/4		*25,360	*25,360	*25,360	*25,360	23,988		
		6 1/2		*31,895	*31,895	29,400	27,167	23,988		
		6 3/4		35,292	32,825	29,400	27,167	23,988		
		7		35,292	32,825	29,400	27,167	23,988		
4 1/2	API IF	6 1/4		*23,004	*23,004	*23,004	*23,004	*23,004		
API	NC50	6 1/2		*29,679	*29,679	*29,679	*29,679	26,675		
5	X-Hole	6 3/4		*36,742	35,824	32,277	29,966	26,675		
5	Mod Open	7		38,397	35,824	32,277	29,966	26,675		
5 1/2	Dbl treamline	7 1/4		38,397	35,824	32,277	29,966	26,675		
5	Semi IF	7 1/2		38,397	35,824	32,277	29,966	26,675		
5 1/2	H-90[4]	6 3/4		*34,508	*34,508	*34,508	34,142	30,781		
		7		*41,993	40,117	36,501	34,142	30,781		
		7 1/4		42,719	40,117	36,501	34,142	30,781		
		7 1/2		42,719	40,117	36,501	34,142	30,781		

CONNECTION TYPE			MINIMUM MAKE-UP TORQUE[2] lb-ft BORE OF DRILL COLLAR (in)							
SIZE	TYPE	OD (in)	2	2 1/4	2 1/2	2 13/16	3	3 1/4	3 1/2	3 3/4
5 1/2	API Regular	6 3/4		*31,941	*31,941	*31,941	*31,941	30,495		
		7		*39,419	*39,419	36,235	33,868	30,495		
		7 1/4		42,481	39,866	36,235	33,868	30,495		
		7 1/2		42,481	39,866	36,235	33,868	30,495		
5 1/2	API Full Hole	7		*32,762	*32,762	*32,762	*32,762	*32,762		
		7 1/4		*40,998	*40,998	*40,998	*40,998	*40,998		
		7 1/2		*49,661	*49,661	47,756	45,190	41,533		
		7 3/4		54,515	51,687	47,756	45,190	41,533		
API	NC56	7 1/4			*40,498	*40,498	*40,498	*40,498		
		7 1/2			*49,060	48,221	45,680	42,058		
		7 3/4			52,115	48,221	45,680	42,058		
		8			52,115	48,221	45,680	42,058		

CONNECTION TYPE			MINIMUM MAKE-UP TORQUE[2] lb-ft BORE OF DRILL COLLAR (in)							
SIZE	TYPE	OD (in)	2	2 1/4	2 1/2	2 13/16	3	3 1/4	3 1/2	3 3/4
6 5/8	API Regular	7 1/2			*46,399	*46,399	*46,399	*46,399		
		7 3/4			*55,627	*53,346	50,704	46,936		
		8			57,393	53,346	50,704	46,936		
		8 1/4			57,393	53,346	50,704	46,936		
6 5/8	H-90[4]	7 1/2			*46,509	*46,509	*46,509	*46,509		
		7 3/4			*55,708	*55,708	53,629	49,855		
		8			60,321	56,273	53,629	49,855		
		8 1/4			60,321	56,273	53,629	49,855		
API	NC61	8			*55,131	*55,131	*55,131	*55,131		
		8 1/4			*65,438	*65,438	*65,438	61,624		
		8 1/2			72,670	68,398	65,607	61,624		
		8 3/4			72,670	68,398	65,607	61,624		
		9			72,670	68,398	65,607	61,624		

CONNECTION TYPE			MINIMUM MAKE-UP TORQUE[2] lb-ft BORE OF DRILL COLLAR (in)							
SIZE	TYPE	OD (in)	2	2 1/4	2 1/2	2 13/16	3	3 1/4	3 1/2	3 3/4
5 1/2	API IF	8			*56,641	*56,641	*56,641	*56,641	*56,641	
		8 1/4			*67,133	*67,133	*67,133	63,381	59,027	
		8 1/2			74,626	70,277	67,436	63,381	59,027	
		8 3/4			74,626	70,277	67,436	63,381	59,027	
		9			74,626	70,277	67,436	63,381	59,027	
		9 1/4			74,626	70,277	67,436	63,381	59,027	
6 5/8	API Full Hole	8 1/2			*67,789	*67,789	*67,789	*67,789	*67,789	67,184
		8 3/4			*79,544	*79,544	*79,544	76,706	72,102	67,184
		9			88,852	83,992	80,991	76,706	72,102	67,184
		9 1/4			88,852	83,992	80,991	76,706	72,102	67,184
		9 1/2			88,852	83,992	80,991	76,706	72,102	67,184
API NC70		9			*75,781	*75,781	*75,781	*75,781	*75,781	*75,781
		9 1/4			*88,802	*88,802	*88,802	*88,802	*88,802	*88,802
		9 1/2			*102,354	*102,354	*102,354	101,107	92,214	90,984
		9 3/4			113,710	108,841	105,657	101,107	92,214	90,984
		10			113,710	108,841	105,657	101,107	92,214	90,984
		10 1/4			113,710	108,841	105,657	101,107	92,214	90,984

CONNECTION TYPE			MINIMUM MAKE-UP TORQUE[2] lb-ft BORE OF DRILL COLLAR (in)							
SIZE	TYPE	OD (in)	2	2 1/4	2 1/2	2 13/16	3	3 1/4	3 1/2	3 3/4
API	NC77	10			*108,194	*108,194	*108,194	*108,194	*108,194	*108,194
		10 1/4			*124,051	*124,051	*124,051	*124,051	*124,051	*124,051
		10 1/2			*140,491	*140,491	*140,491	140,488	135,119	129,375
		10 3/4			154,297	148,965	145,476	140,488	135,119	129,375
		11			154,297	148,965	145,476	140,488	135,119	129,375
7	H-90[4]	8			*53,454	*53,454	*53,454	*53,454	*53,454	*53,454
		8 1/4			*63,738	*63,738	*63,738	*63,738	60,971	56,382
		8 1/2			*74,478	72,066	69,265	65,267	60,971	56,382
7 5/8	Regular	8 1/2			*60,402	*60,402	*60,402	*60,402	*60,402	*60,402
		8 3/4			*72,169	*72,169	*72,169	*72,169	*72,169	*72,169
		9			*84,442	*84,442	*84,442	84,221	79,536	74,529
		9 1/4			96,301	91,633	88,580	84,421	79,536	74,529
		9 1/2			96,301	91,633	88,580	84,221	79,536	74,529
7 5/8	H-90[4]	9			*73,017	*73,017	*73,017	*73,017	*73,017	*73,017
		9 1/4			*86,006	*86,006	*86,006	*86,006	*86,006	*86,006
		9 1/2			*99,508	*99,508	*99,508	*99,508	*99,508	96,285

CONNECTION TYPE			MINIMUM MAKE-UP TORQUE[2] lb-ft BORE OF DRILL COLLAR (in)							
SIZE	TYPE	OD (in)	2	2 1/4	2 1/2	2 13/16	3	3 1/4	3 1/2	3 3/4
8 5/8	API Regular	10			*109,345	*109,345	*109,345	*109,345	*109,345	*109,345
		10 1/4			*125,263	*125,263	*125,263	*125,263	*125,263	125,034
		10 1/2			*141,767	*141,767	141,134	136,146	130,777	125,034
8 5/8	H-90[4]	10 1/4			*113,482	*113,482	*113,482	*113,482	*113,482	*113,482
		10 1/2			*130,063	*130,063	*130,063	*130,063	*130,063	*130,063
7	H-90[4]	8 3/4				*68,061	*68,061	67,257	62,845	58,131
	with low torque face	9				74,235	71,361	67,257	62,845	58,131

CONNECTION TYPE			MINIMUM MAKE-UP TORQUE[2] lb-ft BORE OF DRILL COLLAR (in)							
SIZE	TYPE	OD (in)	2	2 1/4	2 1/2	2 13/16	3	3 1/4	3 1/2	3 3/4
7 5/8	API Regular	9 1/4					*73,099	*73,099	*73,099	*73,099
	with low torque face	9 1/2					*86,463	*86,463	82,457	77,289
		9 3/4					91,789	87,292	82,457	77,289
		10					91,789	87,292	82,457	77,289
7 5/8	H-90[4]	9 3/4				*91,667	*91,667	*91,667	*91,667	*91,667
	with low torque face	10				*106,260	*106,260	*106,260	104,171	98,804
		10 1/4				117,112	113,851	109,188	104,171	98,804
		10 1/2				117,112	113,851	109,188	104,171	98,804
8 5/8	API Regular	10 3/4					*112,883	*112,883	*112,883	*112,883
	with low torque face	11					*130,672	*130,672	*130,672	*130,672
		11 1/4					147,616	142,430	136,846	130,871
8 5/8	H-90[4]	10 3/4					*92,960	*92,960	*92,960	*92,960
	with low torque face	11					*110,781	*110,781	*110,781	*110,781
		11 1/4					*129,203	*129,203	*129,203	*129,203

Drill Collar Connection Make-Up Torque

Recommended Make-Up Torque[1] for Rotary Shouldered Drill Collar Connections.

NOTES

3. Torque values preceded by an asterisk (*) indicates the weaker member and its corresponding outside diameter (OD) and bore, called the box thread. For all other torque values, the weaker connection is the pin thread.

3. Torque values are defined by the output of each connection size and type relative to its corresponding drill collar OD and bore size.

   For example, when the 2⅜" API IF, API NC26, and 2⅞" Slim Hole connections are paired respectively with the 3½" x 1¼" drill collar, the individual output equals a minimum make-up torque value of 4,600 lb-ft and the box as the weakest connection.

3. Stress relief features are disregarded for make-up torque.

FOOTNOTES

1. The basis of calculations for recommended make-up torque assumes a thread compound containing 40-60% by weight of finely powdered metallic zinc or 60% by weight of finely powdered metallic lead; that is not to exceed 0.3% total active sulfur applied thoroughly to all threads and shoulders. Calculations apply the "modified screw jack formula" found in API RP7G (16th edition) Appendix A, paragraph A.8, and a unit stress of 62,500 psi in the box or pin - whichever is weaker.

2. Normal torque range is defined as tabulated value plus 10%. Higher torque values may be used under extreme conditions.

3. Make-up torque for 2⅞ PAC connection is based on 87,500 psi stress and other factors listed in footnote 1.

4. Make-up torque for H-90 connection is based on 56,200 psi stress and other factors listed in footnote 1.

5. Source: API Recommended Practice 7G, Sixteenth Edition, December 1, 1998.

Properties of Drill Pipe and Tool Joints

DRILL PIPE			NEW TOOL JOINT DATA					PREMIUM CLASS			CLASS 2		
NOM SIZE (in)	NOM WEIGHT (lb/ft)	TYPE UPSET & GRADE	CONNECTION	NEW OD (in)	NEW ID (in)	MAKE-UP TORQUE (lb-ft)		MIN OD TOOL JOINT (in)	MIN BOX SHOULDER/ ECCENTRIC WEAR (in)	MAKE-UP TORQUE FOR MIN OD TOOL JOINT (lb-ft)	MIN OD TOOL JOINT (in)	MIN BOX SHOULDER/ ECCENTRIC WEAR (in)	MAKE-UP TORQUE FOR MIN OD TOOL JOINT (lb-ft)
3½	15.50	EU-E75	NC38	5	2 9/16	12,196	P	4 17/32	3/16	7,785	4 15/32	5/32	6,769
3½	15.50	EU-X95	NC38	5	2 7/16	13,328	P	4 21/32	1/4	9,879	4 19/32	7/32	8,822
3½	15.50	EU-G105	NC38	5	2 1/8	15,909	P	4 23/32	9/32	10,957	4 5/8	15/64	9,348
	15.50	EU-G105	NC40	5 1/4	2 9/16	16,656	P	4 15/16	1/4	11,363	4 27/32	13/64	9,595
3½	15.50	EU-S135	NC40	5 1/2	2 1/4	19,766	P	5 3/32	21/64	14,419	4 31/32	17/64	11,963
4	11.85	EU-E75	NC46	6	3 1/4	20,175	P	5 7/32	7/64	7,843	5 5/32	5/64	6,476
	11.85	EU-E75	4 WO	5 3/4	3 7/16	17,285	P	5 7/32	7/64	7,843	5 5/32	5/64	6,476
	11.85	EU-E75	4 OHLW	5 1/4	3 15/32	13,186	P	5	9/64	7,866	4 15/16	7/64	6,593
	11.85	IU-E75	4 H90	5 1/2	2 13/16	21,224	P	4 7/8	7/64	7,630	4 27/32	3/32	6,962

DRILL PIPE			NEW TOOL JOINT DATA				PREMIUM CLASS			CLASS 2		
NOM SIZE (in)	NOM WEIGHT (lb/ft)	TYPE UPSET & GRADE	CONNECTION	NEW OD (in)	NEW ID (in)	MAKE-UP TORQUE (lb-ft)	MIN OD TOOL JOINT (in)	MIN BOX SHOULDER/ ECCENTRIC WEAR (in)	MAKE-UP TORQUE FOR MIN OD TOOL JOINT (lb-ft)	MIN OD TOOL JOINT (in)	MIN BOX SHOULDER/ ECCENTRIC WEAR (in)	MAKE-UP TORQUE FOR MIN OD TOOL JOINT (lb-ft)
4	14.00	IU-E75	NC40	5 1/4	2 13/16	14,092 P	4 13/16	3/16	9,017	4 3/4	5/32	7,877
	14.00	EU-E75	NC46	6	3 1/4	20,175 P	5 9/32	9/64	9,233	5 7/32	7/64	7,843
	14.00	IU-E75	4 SH2	4 5/8	2 9/16	9,102 P	4 7/16	15/64	8,782	4 3/8	1/4	7,817
	14.00	EU-E75	4 OHSW	5 1/2	3 1/4	16,320 P	5 1/16	11/64	9,131	5	9/64	7,839
	14.00	IU-E75	4 H90	5 1/2	2 13/16	21,224 P	4 15/16	9/64	8,986	4 7/8	7/64	7,630
4	14.00	IU-X95	NC40	5 1/4	2 11/16	15,404 P	4 15/16	1/4	11,363	4 27/32	13/64	9,595
	14.00	EU-X95	NC46	6	3 1/4	20,175 P	5 3/8	3/16	11,363	5 5/16	5/32	9,937
	14.00	IU-X95	4 H90	5 1/2	2 13/16	21,224 P	5 1/32	3/16	11,065	4 31/32	5/32	9,673
4	14.00	IU-G105	NC40	5 1/2	2 7/16	18,068 P	5	9/32	12,569	4 29/32	15/64	10,768
	14.00	EU-G105	NC46	6	3 1/4	20,175 P	5 7/16	7/32	12,813	5 11/32	11/64	10,647
	14.00	IU-G105	4 H90	5 1/2	2 13/16	21,224 P	5 3/32	7/32	12,481	5 1/32	3/16	11,065

DRILL PIPE			NEW TOOL JOINT DATA				PREMIUM CLASS			CLASS 2		
NOM SIZE (in)	NOM WEIGHT (lb/ft)	TYPE UPSET & GRADE	CONNECTION	NEW OD (in)	NEW ID (in)	MAKE-UP TORQUE (lb-ft)	MIN OD TOOL JOINT (in)	MIN BOX SHOULDER/ ECCENTRIC WEAR (in)	MAKE-UP TORQUE FOR MIN OD TOOL JOINT (lb-ft)	MIN OD TOOL JOINT (in)	MIN BOX SHOULDER/ ECCENTRIC WEAR (in)	MAKE-UP TORQUE FOR MIN OD TOOL JOINT (lb-ft)
4	14.00	EU-S135	NC46	6	3	23,538 P	5 9/16	9/32	15,787	5 1/2	1/4	14,288
4	15.70	IU-E75	NC40	5 1/4	2 11/16	15,404 P	4 7/8	7/32	10,179	4 25/32	11/64	8,444
	15.70	EU-E75	NC46	6	3 1/4	20,175 P	5 5/16	5/32	9,937	5 1/4	1/8	8,535
	15.70	IU-E75	4 H90	5 1/2	2 13/16	21,224 P	4 31/32	5/32	9,673	4 29/32	1/8	8,305
4	15.70	IU-X95	NC40	5 1/2	2 7/16	18,068 P	5	9/32	12,569	4 29/32	15/64	10,768
	15.70	EU-X95	NC46	6	3	23,538 P	5 7/16	7/32	12,813	5 11/32	11/64	10,647
	15.70	IU-X95	4 H90	5 1/2	2 13/16	21,224 P	5 3/32	7/32	12,481	5 1/32	3/16	11,065
4	15.70	EU-G105	NC46	6	3	23,538 P	5 15/32	15/64	13,547	5 13/32	13/64	12,085
	15.70	IU-G105	4 H90	5 1/2	1 13/16	21,224 P	5 5/32	1/4	13,922	5 1/16	13/64	11,770

DRILL PIPE			NEW TOOL JOINT DATA				PREMIUM CLASS			CLASS 2		
NOM SIZE (in)	NOM WEIGHT (lb/ft)	TYPE UPSET & GRADE	CONNECTION	NEW OD (in)	NEW ID (in)	MAKE-UP TORQUE (lb-ft)	MIN OD TOOL JOINT (in)	MIN BOX SHOULDER/ ECCENTRIC WEAR (in)	MAKE-UP TORQUE FOR MIN OD TOOL JOINT (lb-ft)	MIN OD TOOL JOINT (in)	MIN BOX SHOULDER/ ECCENTRIC WEAR (in)	MAKE-UP TORQUE FOR MIN OD TOOL JOINT (lb-ft)
4	15.70	IU-S135	NC46	6	2 5/8	26,982 B	5 21/32	21/64	18,083	5 17/32	17/64	15,035
	15.00	EU-S135	CN46	6	2 7/8	25,118 P	5 21/32	21/64	18,083	5 17/32	17/64	15,035
4 1/2	16.60	IEU-E75	4 1/2 FH	6	3	20,868 P	5 3/8	13/64	12,125	5 9/32	5/32	10,072
	16.60	IEU-E75	NC46	6 1/4	3 1/4	20,396 P	5 13/32	13/64	12,085	5 11/32	11/64	10,647
	16.60	IEU-E75	4 1/2 OHSW	5 7/8	3 3/4	16,346 P	5 7/16	13/64	11,862	5 3/8	11/64	10,375
	16.60	IEU-E75	NC50	6 5/8	3 3/4	22,836 P	5 23/32	5/32	11,590	5 11/16	9/64	10,773
	16.60	IEU-E75	4 1/2 H90	6	3 1/4	23,355 P	5 11/32	3/16	12,215	5 9/32	5/32	10,642
4 1/2	16.60	IEU-X95	4 1/2 FH	6	2 3/4	23,843 P	5 1/2	17/64	14,945	5 13/32	7/32	12,821
	16.60	IEU-X95	NC46	6 1/4	3 1/4	20,396 P	5 17/32	17/64	15,035	5 7/16	7/32	12,813
	16.60	EU-X95	NC50	6 5/8	3 3/4	22,836 P	5 27/32	7/32	14,926	5 25/32	3/16	13,245
	16.60	IEU-X95	4 1/2 H90	6	3	27,091 P	5 15/32	1/4	15,441	5 3/8	13/64	13,102

DRILL PIPE			NEW TOOL JOINT DATA				PREMIUM CLASS			CLASS 2		
NOM SIZE (in)	NOM WEIGHT (lb/ft)	TYPE UPSET & GRADE	CONNECTION	NEW OD (in)	NEW ID (in)	MAKE-UP TORQUE (lb-ft)	MIN OD TOOL JOINT (in)	MIN BOX SHOULDER/ ECCENTRIC WEAR (in)	MAKE-UP TORQUE FOR MIN OD TOOL JOINT (lb-ft)	MIN OD TOOL JOINT (in)	MIN BOX SHOULDER/ ECCENTRIC WEAR (in)	MAKE-UP TORQUE FOR MIN OD TOOL JOINT (lb-ft)
4 1/2	16.60	IEU-G105	4 1/2 FH	6	2 3/4	23,843 P	5 9/16	19/64	16,391	5 15/32	1/4	14,231
	16.60	IEU-G105	NC46	6 1/4	3	23,795 P	5 19/32	19/64	16,546	5 1/2	1/4	14,288
	16.60	EU-G105	NC50	6 5/8	3 3/4	22,836 P	5 29/32	1/4	16,633	5 13/16	13/64	14,082
	16.60	IEU-G105	4 1/2 H90	6	3	27,091 P	5 1/2	17/64	16,264	5 7/16	15/64	14,625
4 1/2	16.60	IEU-S135	NC46	6 1/4	2 3/4	26,923 P	5 25/32	25/64	21,230	5 21/32	21/64	18,083
	16.60	EU-S135	NC50	6 5/8	3 1/2	27,076 P	6 1/16	21/64	21,017	5 31/32	9/32	18,367
4 1/2	20.00	IEU-G105	4 1/2 FH	6	3	20,868 P	5 15/32	1/4	14,231	5 3/8	13/64	12,125
	20.00	IEU-G105	NC46	6 1/4	3	23,795 P	5 1/2	1/4	14,288	5 13/32	13/64	12,085
	20.00	EU-G105	NC50	6 5/8	3 5/8	24,993 P	5 13/16	13/64	14,082	5 3/4	3/16	12,415
	20.00	IEU-G105	4 1/2 H90	6	3	27,091 P	5 13/32	7/32	13,815	5 11/32	3/16	12,215

DRILL PIPE			NEW TOOL JOINT DATA				PREMIUM CLASS			CLASS 2		
NOM SIZE (in)	NOM WEIGHT (lb/ft)	TYPE UPSET & GRADE	CONNECTION	NEW OD (in)	NEW ID (in)	MAKE-UP TORQUE (lb-ft)	MIN OD TOOL JOINT (in)	MIN BOX SHOULDER/ ECCENTRIC WEAR (in)	MAKE-UP TORQUE FOR MIN OD TOOL JOINT (lb-ft)	MIN OD TOOL JOINT (in)	MIN BOX SHOULDER/ ECCENTRIC WEAR (in)	MAKE-UP TORQUE FOR MIN OD TOOL JOINT (lb-ft)
4 1/2	20.00	IEU-X95	4 1/2 FH	6	2 1/2	29,778 P	5 5/8	21/64	17,861	5 17/32	9/32	15,665
	20.00	IEU-X95	NC46	6 1/4	2 3/4	26,923 P	5 21/32	21/64	18,083	5 9/16	9/32	15,787
	20.00	EU-X95	NC50	6 5/8	3 1/2	27,076 P	5 15/16	17/64	17,497	5 7/8	15/64	15,776
	20.00	IEU-X95	4 1/2 H90	6	3	27,091 P	5 9/16	19/64	17,929	5 15/32	1/4	15,441
4 1/2	20.00	IEU-G105	NC46	6 1/4	2 1/2	29,778 P	5 23/32	23/64	19,644	5 5/8	5/16	17,311
	20.00	EU-G105	NC50	6 5/8	3 1/2	27,076 P	6 1/32	5/16	20,127	5 29/32	1/4	16,633
4 1/2	20.00	EU-S135	NC50	6 5/8	2 7/8	36,398 P	6 7/32	13/32	25,569	6 3/32	11/32	21,914
5	19.50	IEU-E75	NC50	6 5/8	3 3/4	22,836 P	5 7/8	15/64	15,776	5 13/16	13/64	14,082
5	19.50	IEU-X95	NC50	6 5/8	3 1/2	27,076 P	6 1/32	5/16	20,127	5 15/16	17/64	17,497
	19.50	IEU-X95	5 H90	6 1/2	3 1/4	31,084 P	5 27/32	19/64	19,862	5 3/4	1/4	17,116

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DRILL PIPE			NEW TOOL JOINT DATA				PREMIUM CLASS			CLASS 2		
NOM SIZE (in)	NOM WEIGHT (lb/ft)	TYPE UPSET & GRADE	CONNECTION	NEW OD (in)	NEW ID (in)	MAKE-UP TORQUE (lb-ft)	MIN OD TOOL JOINT (in)	MIN BOX SHOULDER/ ECCENTRIC WEAR (in)	MAKE-UP TORQUE FOR MIN OD TOOL JOINT (lb-ft)	MIN OD TOOL JOINT (in)	MIN BOX SHOULDER/ ECCENTRIC WEAR (in)	MAKE-UP TORQUE FOR MIN OD TOOL JOINT (lb-ft)
5	19.50	IEU-G105	NC50	6 5/8	3 1/4	31,025 P	6 3/32	11/32	21,914	6	19/64	19,244
	19.50	IEU-G105	5 H90	6 1/2	3 1/2	35,039 P	5 29/32	21/64	21,727	5 13/16	9/32	18,940
5	19.50	IEU-S135	NC50	6 5/8	2 3/4	38,044 P	6 5/16	29/64	28,381	6 3/16	25/64	24,645
	19.50	IEU-S135	5 1/2 FH	7 1/4	3 1/2	43,490 P	6 3/4	3/8	28,737	6 5/8	5/16	24,412
5	25.60	IEU-E75	NC 50	6 5/8	3 1/2	27,076P	6 1/32	5/16	20,127	5 15/16	17/64	17,497
	25.60	IEU-E75	5 1/2 FH	7	3 1/2	37,742 B	6 1/2	1/4	20,205	6 13/32	13/64	17,127
5	25.60	IEU-X95	NC50	6 5/8	3	34,680 P	6 7/32	13/32	25,569	6 3/32	11/32	21,914
	25.60	IEU-X95	5 1/2 FH	7	3 1/2	37,742 B	6 21/32	21/64	25,483	6 9/16	9/32	22,294
5	25.60	IEU-G105	NC50	6 5/8	2 3/4	38,044 P	6 9/32	7/16	27,437	6 5/32	3/8	23,728
	25.60	IEU-G105	5 1/2 FH	7 1/4	3 1/2	43,490 P	6 23/32	23/64	27,645	6 5/8	5/16	24,412

DRILL PIPE			NEW TOOL JOINT DATA				PREMIUM CLASS			CLASS 2		
NOM SIZE (in)	NOM WEIGHT (lb/ft)	TYPE UPSET & GRADE	CONNECTION	NEW OD (in)	NEW ID (in)	MAKE-UP TORQUE (lb-ft)	MIN OD TOOL JOINT (in)	MIN BOX SHOULDER/ ECCENTRIC WEAR (in)	MAKE-UP TORQUE FOR MIN OD TOOL JOINT (lb-ft)	MIN OD TOOL JOINT (in)	MIN BOX SHOULDER/ ECCENTRIC WEAR (in)	MAKE-UP TORQUE FOR MIN OD TOOL JOINT (lb-ft)
5	25.60	IEU-S135	5 1/2 FH	7 1/4	3 1/4	47,230 B	6 5/16	15/32	35,446	6 13/16	13/32	30,943
5 1/2	21.90	IEU-E75	5 1/2 FH	7	4	33,560 P	6 15/32	15/64	19,172	6 13/32	13/64	17,127
5 1/2	21.90	IEU-X95	5 1/2 FH	7	3 3/4	34,742 B	6 5/8	5/16	24,412	6 17/32	17/64	21,246
	21.90	IEU-X95	5 1/2 H90	7	3 1/2	35,454 P	6 13/16	21/64	24,414	6 3/32	9/32	21,349
5 1/2	21.90	IEU-G105	5 1/2 FH	7 1/4	3 1/2	43,490 P	6 23/32	23/64	27,645	6 19/32	19/64	23,350
5 1/2	21.90	IEU-S135	5 1/2 FH	7 1/2	3	53,302 P	6 15/16	15/32	35,446	6 13/16	13/32	30,943
5 1/2	24.70	IEU-E75	5 1/2 FH	7	4	33,560 P	6 9/16	9/32	22,294	6 15/32	15/64	19,172
5 1/2	24.70	IEU-X95	5 1/2 FH	7 1/4	3 1/2	43,490 P	6 23/32	23/64	27,645	6 19/32	19/64	23,350

DRILL PIPE			NEW TOOL JOINT DATA				PREMIUM CLASS			CLASS 2		
NOM SIZE (in)	NOM WEIGHT (lb/ft)	TYPE UPSET & GRADE	CONNECTION	NEW OD (in)	NEW ID (in)	MAKE-UP TORQUE (lb-ft)	MIN OD TOOL JOINT (in)	MIN BOX SHOULDER/ ECCENTRIC WEAR (in)	MAKE-UP TORQUE FOR MIN OD TOOL JOINT (lb-ft)	MIN OD TOOL JOINT (in)	MIN BOX SHOULDER/ ECCENTRIC WEAR (in)	MAKE-UP TORQUE FOR MIN OD TOOL JOINT (lb-ft)
5 1/2	24.70	IEU-G105	5 1/2 FH	7 1/4	3 1/2	43,490 P	6 25/32	25/64	29,836	6 11/16	11/32	26,560
5 1/2	24.70	IEU-S135	5 1/2 FH	7 1/2	3	52,302 P	7 1/32	33/64	38,901	6 7/8	7/16	33,180
6 5/8	25.20	IEU-E75	6 5/8 FH	8	5	44,196 P	7 7/16	1/4	26,810	7 3/8	7/32	24,100
	25.20	IEU-X95	6 5/8 FH	8	5	44,196 P	7 5/8	11/32	35,139	7 1/2	9/32	29,552
	25.20	IEU-G105	6 5/8 FH	8 1/4	4 3/4	51,742 P	7 11/16	5/8	37,983	7 19/32	21/64	33,730
	25.20	IEU-S135	6 5/8 FH	8 1/2	4 1/4	65,535 P	7 29/32	31/64	48,204	7 25/32	27/64	42,312
6 5/8	27.70	IEU-E75	6 5/8 FH	8	5	44,196 P	7 1/2	9/32	29,552	7 13/32	15/64	25,451
	27.70	IEU-X95	6 5/8 FH	8 1/4	4 3/4	51,742 P	7 11/16	3/8	37,983	7 9/16	5/16	32,329
	27.70	IEU-G105	6 5/8 FH	8 1/4	4 3/4	51,742 P	7 3/4	13/32	40,860	7 21/32	23/64	36,556
	27.70	IEU-S135	6 5/8 FH	8 1/2	4 1/4	65,535 P	8	17/32	52,714	7 27/64	29/64	45,241

Properties of Drill Pipe and Tool Joints†

Recommended minimum OD and make-up torque of weld-on type tool joints based on the torsional strength of box and drill pipe.

Tool joint diameters are required to retain torsional strength in the tool joint comparable to the torsional strength of the attached drill pipe; which is typically adequate for all services. Tool joints with torsional strengths considerably below that of the drill pipe may be adequate for most drilling services.

FOOTNOTES

1. The use of outside diameters (OD) smaller than those listed in the table may be acceptable due to special service requirements.

2. Tool joints with dimensions shown have lower torsional yield ration than the 0.80 which is generally used.

3. Recommended make-up torque is based on 72,000 psi stress.

4. In calculation of torsional strengths of tool joints, both new and worn, the bevels of the tool joint shoulders are disregarded. This thickness measurement should be made in the plane of the face from the ID of the counterbore to the outside diameter of the box, disregarding the bevels.

5. Any tool joint with an outside diameter less than API bevel diameter should be provided with a minimum 1/32" depth x 45° bevel on the outside and inside diameter of the box shoulder and outside diameter of the pin shoulder.

6. P = Pin limit. B = Box limit

The information in the above table is taken from API Recommended Practice 7G, Sixteenth Edition, December 1, 1998.

Mechanical Property of Drill Pipe†

SIZE OD (in)	NOMINAL WEIGHT NEW (lb/ft)	CLASS	TORSIONAL DATA TORSIONAL YIELD STRENGTH (lb-ft)				TENSILE DATA MINIMUM YIELD STRENGTH (lb)			
			E75	X95	G105	S135	E75	X95	G105	S135
2 3/8	4.85	New	4,763	6,033	6,668	8,574	97,817	123,902	136,944	176,071
		Premium	3,725	4,719	5,215	6,705	76,893	97,398	107,650	138,407
		Class 2	3,224	4,083	4,513	5,802	66,686	84,469	93,360	120,035
	6.65	New	6,250	7,917	8,751	11,251	138,214	175,072	193,500	248,786
		Premium	4,811	6,093	6,735	8,659	107,616	136,313	150,662	193,709
		Class 2	4,130	5,232	5,782	7,434	92,871	117,636	130,019	167,167
2 7/8	6.85	New	8,083	10,238	11,316	14,549	135,902	172,143	190,263	244,624
		Premium	6,332	8,020	8,865	11,397	106,946	135,465	149,725	192,503
		Class 2	5,484	6,946	7,677	9,871	92,801	117,549	129,922	167,043

SIZE OD (in)	NOMINAL WEIGHT NEW (lb/ft)	CLASS	TORSIONAL DATA TORSIONAL YIELD STRENGTH (lb-ft)				TENSILE DATA MINIMUM YIELD STRENGTH (lb)			
			E75	X95	G105	S135	E75	X95	G105	S135
	10.40	New	11,554	14,635	16,176	20,798	214,344	271,503	300,082	385,820
		Premium	8,858	11,220	12,401	15,945	166,535	210,945	233,149	299,764
		Class 2	7,591	9,615	10,627	13,663	143,557	181,839	200,980	258,403
3½	9.50	New	14,146	17,918	19,805	25,463	194,264	246,068	271,970	349,676
		Premium	11,094	14,052	15,531	19,968	152,979	193,774	214,171	275,363
		Class 2	9,612	12,176	13,457	17,302	132,793	168,204	185,910	239,027
	13.30	New	18,551	23,498	25,972	33,392	271,569	343,988	380,197	477,825
		Premium	14,361	18,191	20,106	25,850	212,150	268,723	297,010	381,870
		Class 2	12,365	15,663	17,312	22,258	183,398	232,304	256,757	330,116

05 ENGINEERING DATA
Mechanical Property of Drill Pipe†

SIZE OD (in)	NOMINAL WEIGHT NEW (lb/ft)	CLASS	TORSIONAL DATA TORSIONAL YIELD STRENGTH (lb-ft)				TENSILE DATA MINIMUM YIELD STRENGTH (lb)			
			E75	X95	G105	S135	E75	X95	G105	S135
	15.50	New	21,086	26,708	29,520	37,954	322,775	408,848	451,885	580,995
		Premium	16,146	20,452	22,605	29,063	250,620	317,452	350,868	451,115
		Class 2	13,828	17,515	19,359	24,890	215,967	273,558	302,354	388,741
4	11.85	New	19,474	24,668	27,264	35,054	230,755	292,290	323,057	415,360
		Premium	15,310	19,392	21,433	27,557	182,016	230,554	254,823	327,630
		Class 2	13,281	16,823	18,594	23,907	158,132	200,301	221,385	284,638
	14.00	New	23,288	29,498	32,603	41,918	285,359	361,454	399,502	513,646
		Premium	18,196	23,048	25,474	32,752	224,182	283,963	313,854	403,527
		Class 2	15,738	19,935	22,034	28,329	194,363	246,193	272,108	349,852

SIZE OD (in)	NOMINAL WEIGHT NEW (lb/ft)	CLASS	TORSIONAL DATA TORSIONAL YIELD STRENGTH (lb-ft)				TENSILE DATA MINIMUM YIELD STRENGTH (lb)			
			E75	X95	G105	S135	E75	X95	G105	S135
	15.70	New	25,810	32,692	36,134	46,458	324,118	410,550	453,765	583,413
		Premium	20,067	25,418	28,094	36,120	253,851	321,544	355,391	456,931
		Class 2	17,315	21,932	24,241	31,166	219,738	278,335	307,633	395,528
4½	13.75	New	25,907	32,816	36,270	46,633	270,034	342,043	378,047	486,061
		Premium	20,403	25,844	28,564	36,725	213,258	270,127	298,561	383,864
		Class 2	17,715	22,439	24,801	31,887	185,389	234,827	259,545	333,701
	16.60	New	30,807	39,022	43,130	55,453	330,558	418,707	462,781	595,004
		Premium	24,139	30,576	33,795	43,450	260,165	329,542	364,231	468,297
		Class 2	20,908	26,483	29,271	37,634	225,771	285,977	316,080	406,388

SIZE OD (in)	NOMINAL WEIGHT NEW (lb/ft)	CLASS	TORSIONAL DATA TORSIONAL YIELD STRENGTH (lb-ft)				TENSILE DATA MINIMUM YIELD STRENGTH (lb)			
			E75	X95	G105	S135	E75	X95	G105	S135
	20.00	New	36,901	46,741	51,661	66,421	412,358	522,320	577,301	742,244
		Premium	28,683	36,332	40,157	51,630	322,916	409,026	452,082	581,248
		Class 2	24,747	31,346	34,645	44,544	279,502	354,035	391,302	503,103
	22.82	New	40,912	51,821	57,276	73,641	471,239	596,903	659,734	848,230
		Premium	31,587	40,010	44,222	56,856	367,566	465,584	514,593	661,620
		Class 2	27,161	34,404	38,026	48,890	317,497	402,163	444,496	571,495
5	16.25	New	35,044	44,389	49,062	63,079	328,073	415,559	459,302	590,531
		Premium	27,607	34,969	38,650	49,693	259,155	328,263	362,817	466,479
		Class 2	23,974	30,368	33,564	43,154	225,316	285,400	315,442	405,568

SIZE OD (in)	NOMINAL WEIGHT NEW (lb/ft)	CLASS	TORSIONAL DATA TORSIONAL YIELD STRENGTH (lb-ft)				TENSILE DATA MINIMUM YIELD STRENGTH (lb)			
			E75	X95	G105	S135	E75	X95	G105	S135
	19.50	New	41,167	52,144	57,633	74,100	395,595	501,087	553,833	712,070
		Premium	32,285	40,895	45,199	58,113	311,535	394,612	436,150	560,764
		Class 2	27,976	35,436	39,166	50,356	270,432	342,548	378,605	486,778
	25.60	New	52,257	66,192	73,159	94,062	530,144	671,515	742,201	954,259
		Premium	40,544	51,356	56,762	72,979	414,690	525,274	580,566	746,443
		Class 2	34,947	44,267	48,926	62,905	358,731	454,392	502,223	645,715
5½	19.20	New	44,074	55,826	61,703	79,332	372,181	471,429	521,053	669,925
		Premium	34,764	44,035	48,670	62,575	294,260	372,730	411,965	529,669
		Class 2	30,208	28,263	42,291	54,374	255,954	324,208	358,335	460,717

SIZE OD (in)	NOMINAL WEIGHT NEW (lb/ft)	CLASS	TORSIONAL DATA TORSIONAL YIELD STRENGTH (lb-ft)				TENSILE DATA MINIMUM YIELD STRENGTH (lb)			
			E75	X95	G105	S135	E75	X95	G105	S135
	21.90	New	50,710	64,233	70,994	91,278	437,116	553,681	611,963	786,809
		Premium	39,863	50,494	55,809	71,754	344,780	436,721	482,692	620,604
		Class 2	34,582	43,804	48,414	62,247	299,533	379,409	419,346	539,160
	24.70	New	56,574	71,660	79,204	101,833	497,222	629,814	696,111	894,999
		Premium	44,320	56,139	62,048	79,776	391,285	495,627	547,799	704,413
		Class 2	38,383	48,619	53,737	69,090	339,533	430,076	475,347	611,160
6⅝	25.20	New	70,580	89,402	98,812	127,044	489,464	619,988	685,250	881,035
		Premium	55,766	71,522	79,050	101,635	387,466	490,790	542,452	697,438
		Class 2	48,497	61,430	67,896	87,295	337,236	427,166	472,131	607,026

Mechanical Property of Drill Pipe†

SIZE OD (in)	NOMINAL WEIGHT NEW (lb/ft)	CLASS	TORSIONAL DATA TORSIONAL YIELD STRENGTH (lb–ft)				TENSILE DATA MINIMUM YIELD STRENGTH (lb)			
			E75	X95	G105	S135	E75	X95	G105	S135
	27.70	New	76,295	96,640	106,813	137,330	534,199	676,651	747,877	961,556
		Premium	60,192	77,312	85,450	109,864	422,419	535,064	591,387	760,354
		Class 2	52,308	66,257	73,231	94,155	367,455	465,443	514,437	661,419

Mechanical Property of Drill Pipe†

† New Drill Pipe Torsional and Tensile Data, Used Drill Pipe Torsional and Tensile Data API Premium Class, and Used Drill Pipe Torsional and Tensile Data API Class 2

FOOTNOTES

1. New weight, nominal with threads and couplings.

NEW DRILL PIPE

2. Based on the shear strength equal to 57.7% of minimum yield strength and nominal wall thickness. Minimum torsional yield strength calculated from equation RP7G, (16th edition) Appendix A, paragraph A.15.

3. Tensile data based on minimum values. Minimum tensile strength calculated from equation in API RP7G, (16th edition) Appendix A, paragraph A.13.

PREMIUM CLASS

4. Based on the shear strength equal to 57.7% of minimum yield strength.

5. Torsional data based on 20% uniform wear on outside diameter.

6. Tensile data based on 20% uniform wear on outside diameter.

CLASS 2

7. Based on the shear strength equal to 57.7% of minimum yield strength.

8. Torsional data based on 30% uniform wear on outside diameter.

9. Tensile data based on 30% uniform wear on outside diameter.

The information in the above table is taken from API Recommended Practice 7G, Sixteenth Edition, December 1, 1998.

Heavy Walled Drill Pipe

NOMINAL SIZE (in)	TUBE	
	ID (in)	WALL THICKNESS (in)
3 1/2	2 1/16	0.719
3 1/2	2 1/4	0.625
4	2 9/16	0.719
4 1/2	2 3/4	0.875
5	3	1.000
5 1/2	3 3/8	1.063
6 5/8	4 1/2	1.063

NOMINAL SIZE (in)	TOOL JOINT		
	CONNECTION SIZE	OD (in)	ID (in)
3 1/2	NC38 (3 1/2 IF)	4 3/4	2 13/16
3 1/2	NC38 (3 1/2 IF)	4 3/4	2 3/8
4	NC40 (4 FH)	5 1/4	2 11/16
4 1/2	NC46 (4 IF)	6 1/4	2 7/8
5	NC50 (4 1/2 IF)	6 5/8	3 1/16
5 1/2	5 1/2 FH	7	3 1/2
6 5/8	6 5/8 FH	8	4 1/2

NOMINAL SIZE (in)	APPROXIMATE WEIGHT (Incl. TUBE & JOINTS)	
	WT/FT (lb)	WT/JT 30FT (lb)
3 1/2	2 1/16	769
3 1/2	2 1/4	695
4	2 9/16	815
4 1/2	2 3/4	1,230
5	3	1,480
5 1/2	3 3/8	1,880
6 5/8	4 1/2	2,290

Drill Bit Sizes

ROTARY PIN CONNECTION	BIT SIZE (in)
2 3/8 REG	3 3/4
	3 7/8
	4 1/8
	4 1/4
	4 3/8
	4 1/2
2 7/8 REG	4 5/8
	4 3/4
	4 7/8
	5
3 1/2 REG	5 1/8
	5 3/8
	5 5/8
	5 3/4
	5 7/8
	6
	6 1/8
	6 1/4
	6 3/8
	6 1/2
	6 5/8
	6 3/4
	7
	7 3/8
4 1/2 REG	7 1/2
	7 5/8
	7 3/4
	7 7/8
	8 1/8
	8 3/8
	8 1/2
	8 5/8
	8 3/4
	9
	9 3/8

ROTARY PIN CONNECTION	BIT SIZE (in)
6 5/8 REG	9 1/2
	9 5/8
	9 3/4
	9 7/8
	10 5/8
	11
	11 1/2
	11 5/8
	11 3/4
	12
	12 1/4
	13 1/2
	13 3/4
	14 3/4
	15
	16
	17
	17 1/2
	18 1/2
7 5/8 REG	14 1/2
	14 3/4
	15
	16
	17
	17 1/2
	18 1/2
	20
	22
	23
	24
	26
8 5/8 REG	18 5/8
	20
	22
	23
	24
	26
	27
	+ larger

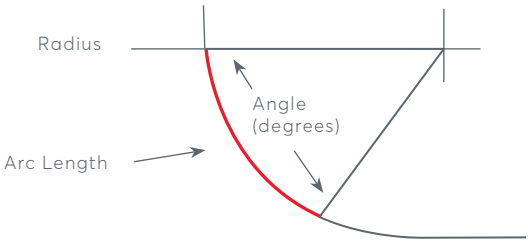
Hole Curvature

BUILD RATE	HOLE RADIUS	
DEG/100 FT (30 m)	R1 FEET	R2 METERS
2	2,865	859
4	1,432	430
6	955	286
8	716	215
10	573	172
12	477	143
14	409	123
16	358	107
18	318	95
20	286	86
22	260	78
24	239	72
26	220	66
28	205	61
30	191	57
32	179	54
34	169	51
36	159	48
38	151	45
40	143	43
42	136	41
44	130	39
46	125	37
48	119	36
50	115	34
52	110	33
54	106	32
56	102	31
58	99	30
60	95	29
62	92	28
64	90	27
66	87	26
68	84	25
70	82	25
72	80	24
74	77	23
76	75	23
78	73	22
80	72	21

BUILD RATE	HOLE RADIUS	
DEG/100 FT (30 m)	R1 FEET	R2 METERS
82	70	21
84	68	20
86	67	20
88	65	20
90	64	19
92	62	19
94	61	18
96	60	18
98	58	18
100	57	17
105	55	16
110	52	16
115	50	15
120	48	14
125	46	14
130	44	13
135	42	13
140	41	12
145	40	12
150	38	11
155	37	11
160	36	11
165	35	10
170	34	10
175	33	10
180	32	10
185	31	9
190	30	9
195	29	9
200	29	9
210	27	8
220	26	8
230	25	7
240	24	7
250	23	7
260	22	7
270	21	6
280	20	6
290	20	6

FORMULA

$$R1 = \frac{\text{Arc Length (ft)}}{0.017453 \times \text{Angle (°)}} \qquad R2 = \frac{\text{Arc Length (m)}}{0.017453 \times \text{Angle (°)}}$$



06 NOZZLE SELECTION

Nozzle Selection Formula

Gyrodata's GyroDrill performance motors can be supplied with a nozzle inserted to the top of the rotor catch to allow a partial fluid bypass of the rotor and stator.

The formula below illustrates the procedure used to properly select the nozzle size.

1. From the motor power curves (shown in chapter 4), specify the flow rate through the motor (Qm) for the required motor RPM and differential pressure.

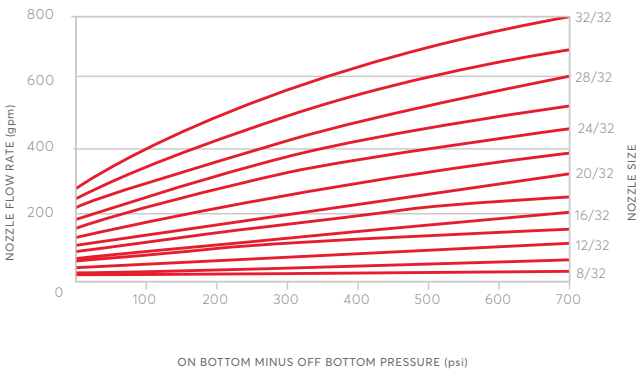
2. Subtract this flow rate from the total required flow rate (Qt) to obtain the required flow rate through the nozzle.

$$Qe = Qn \times 0.35 \times \text{Square Root (Mud Weight)}$$

(gpm) (qpm) (lbs/gal)

Using this comparable nozzle flow rate (Qe) and the optimal motor differential pressure, obtain the required nozzle from the chart in Figure 6-1.

Figure 6-1
Nozzle Selection



Nozzle Selection Example

EXAMPLE

- A total flow of 700 GPM is required using a 6¾" 6/7 lobe, 5.0 stage motor at an on-bottom minus off-bottom pressure of 300 psi. The required speed is 125 RPM and the mud weight is 9 PPG.

  The 6¾" 6/7 lobe, 5.0 stage motor power curve shows that 430 GPM is required to turn the motor at 125 RPM. Subtracting 430 GPM motor flow rate from 700 GPM total flow rate will give the needed nozzle flow rate of 270 GPM.

  Adjusting the nozzle flow rate for 9 PPG mud will give a nozzle flow rate (Qe) of:

  Qe = Qn x .35 x SQRT(PPG)

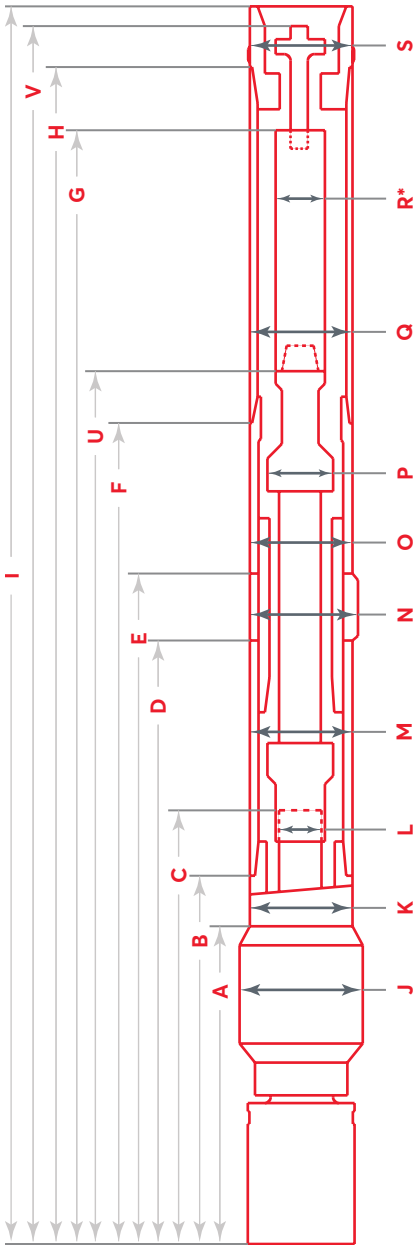
  Qe = 270 GPM x .35 x SQRT (9)

  Qe = 284 GPM

  The above chart indicates that a $^{22}/_{32}$ nozzle is required to bypass 284 GPM at 300 PSI.

07 FISHING DIMENSIONS

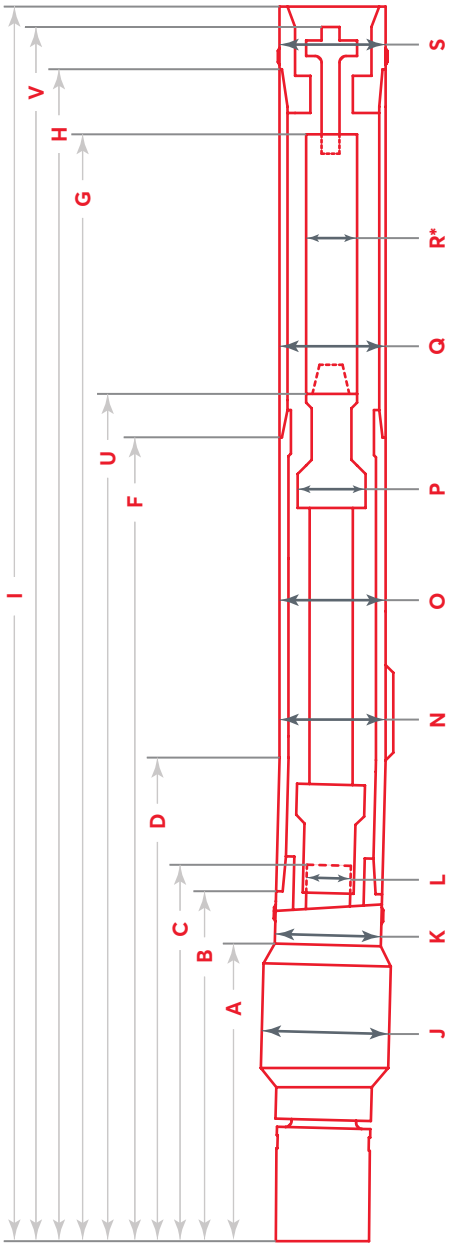
4¾" Adjustable Bend Housing (ABH)



MOTOR	LOBES	STAGES	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R*	S	U	V
4¾	5/6	8.3	28	41	43	58	63	79	316	322	352	5.56	4.88	2.36	4.81	5.19	5.00	3.48	4.75	2.92	4.75	87	331
4¾	7/8	2.6	28	41	43	58	63	79	302	309	339	5.56	4.88	2.36	4.81	5.19	5.00	3.48	4.75	3.10	4.75	87	317
4¾	7/8	3.8	28	41	43	58	63	79	260	266	296	5.56	4.88	2.36	4.81	5.19	5.00	3.48	4.75	2.95	4.75	87	275

R* = All rotors are coated with tungsten carbide.
All values listed are in inches.

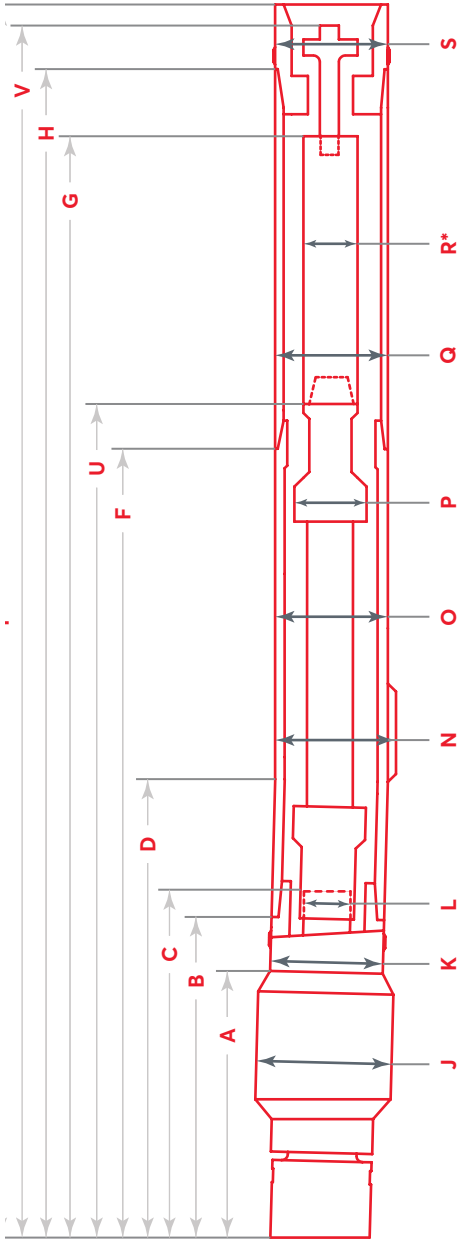
4¾" Fixed Bend Housing (FBH)



MOTOR	LOBES	STAGES	A	B	C	D	F	G	H	I	J	K	L	N	O	P	Q	R*	S	U	V
4¾	5/6	8.3	28	41	43	53	79	316	322	352	5.56	4.88	2.36	5.19	5.00	3.48	4.75	2.92	4.75	87	331
4¾	7/8	2.6	28	41	43	53	79	302	309	339	5.56	4.88	2.36	5.19	5.00	3.48	4.75	3.10	4.75	87	317
4¾	7/8	3.8	28	41	43	53	79	260	266	296	5.56	4.88	2.36	5.19	5.00	3.48	4.75	2.95	4.75	87	275

R* = All rotors are coated with tungsten carbide.
All values listed are in inches.

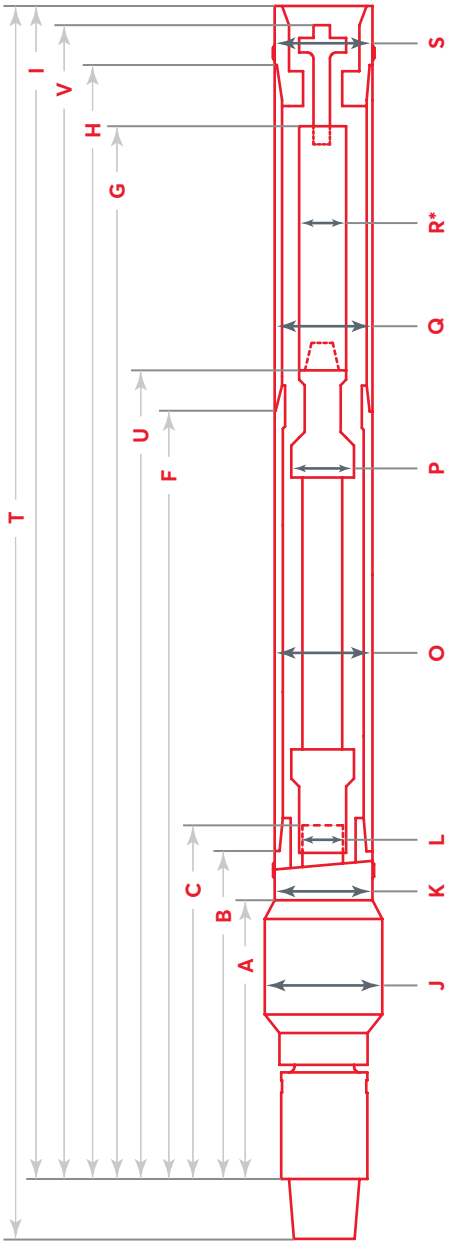
4¾" Short Bit to Bend - Fixed



MOTOR	LOBES	STAGES	A	B	C	D	F	G	H	I	J	K	L	M	N	O	P	Q	R*	S	U	V
4¾	5/6	8.3	23	35	37	47	73	310	316	342	5.56	4.88	2.36	4.81	5.19	5.00	3.48	4.75	2.92	4.75	81	325
4¾	7/8	3.8	23	35	37	47	73	254	260	286	5.56	4.88	2.36	4.81	5.19	5.00	3.48	4.75	2.95	4.75	81	269
4¾	7/8	2.6	23	35	37	47	73	296	302	328	5.56	4.88	2.36	4.81	5.19	5.00	3.48	4.75	3.10	4.75	81	311

R* = All rotors are coated with tungsten carbide.
All values listed are in inches.

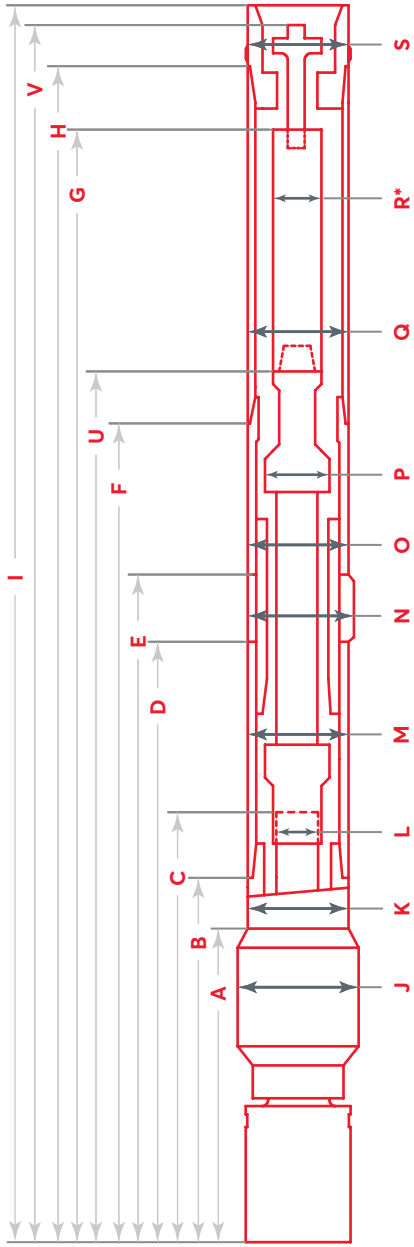
4¾" Rotary Steerable System (RSS)



MOTOR	LOBES	STAGES	A	B	C	F	G	H	I	J	K	L	O	P	Q	R*	S	T	U	V
4¾	7/8	2.6	28	41	43	79	302	309	339	5.56	4.88	2.36	5.00	3.48	4.75	3.10	4.75	343	87	317

R* = All rotors are coated with tungsten carbide.
All values listed are in inches.

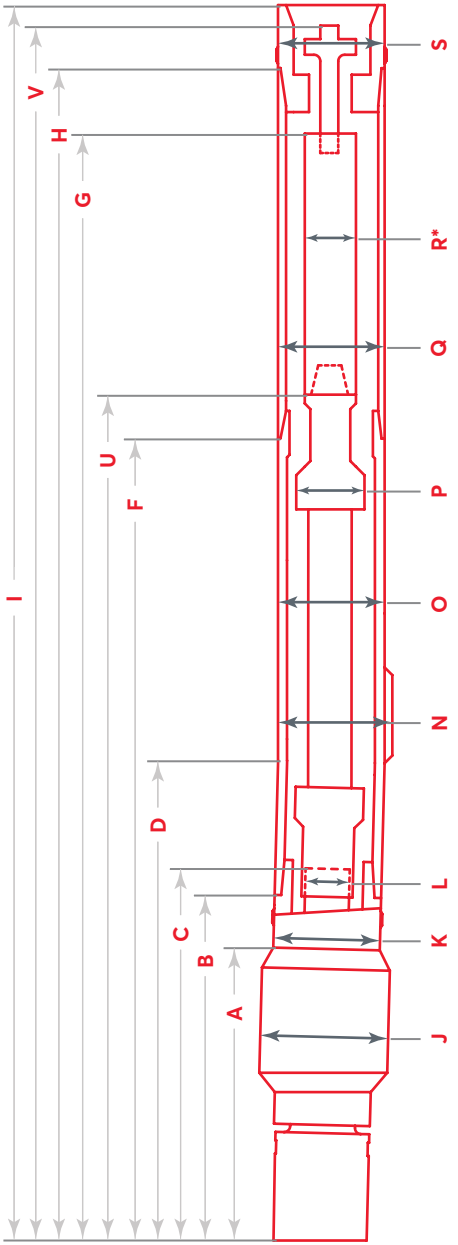
5" Adjustable Bend Housing (ABH)



MOTOR	LOBES	STAGES	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R*	S	U	V
5	6/7	8.0	28	41	43	60	65	81	325	332	362	5.56	4.88	2.36	4.81	4.97	5.00	3.48	5.00	3.02	5.00	89	339

R* = All rotors are coated with tungsten carbide.
All values listed are in inches.

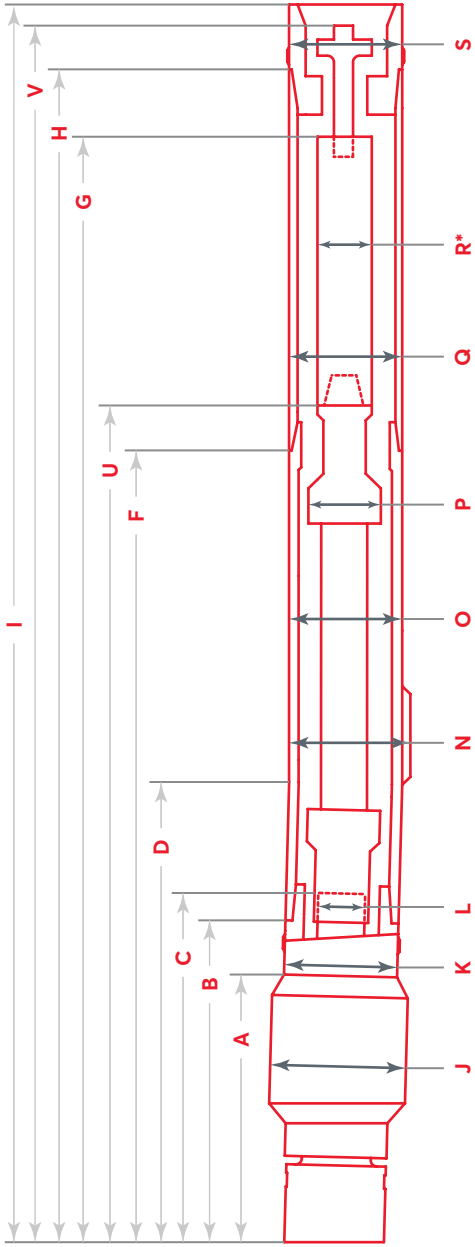
5" Fixed Bend Housing (FBH)



MOTOR	LOBES	STAGES	A	B	C	D	F	G	H	I	J	K	L	N	O	P	Q	R*	S	U	V
5	6/7	8.0	28	41	43	55	81	325	332	362	5.56	4.88	2.36	5.38	5.00	3.48	5.00	3.02	5.00	89	339
5	6/7	10.0	28.4	40.9	42.8	54.5	81.6	350	357	388	5.56	4.88	2.36	5.38	5.00	3.85	5.00	3.26	5.00	81.6	364

R* = All rotors are coated with tungsten carbide.
All values listed are in inches.

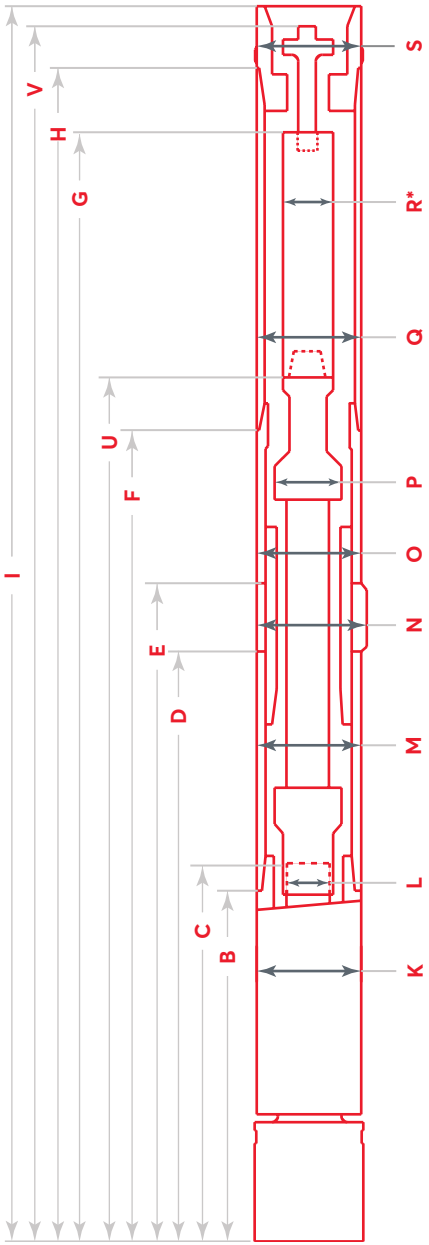
5" Short Bit to Bend - Fixed



MOTOR	LOBES	STAGES	A	B	C	D	F	G	H	I	J	K	L	N	O	P	Q	R*	S	U	V
5	6/7	8.0	23	35	37	49	75	319	326	356	5.56	4.88	2.36	5.38	5.00	3.48	5.00	3.02	5.00	82	333

R* = All rotors are coated with tungsten carbide.
All values listed are in inches.

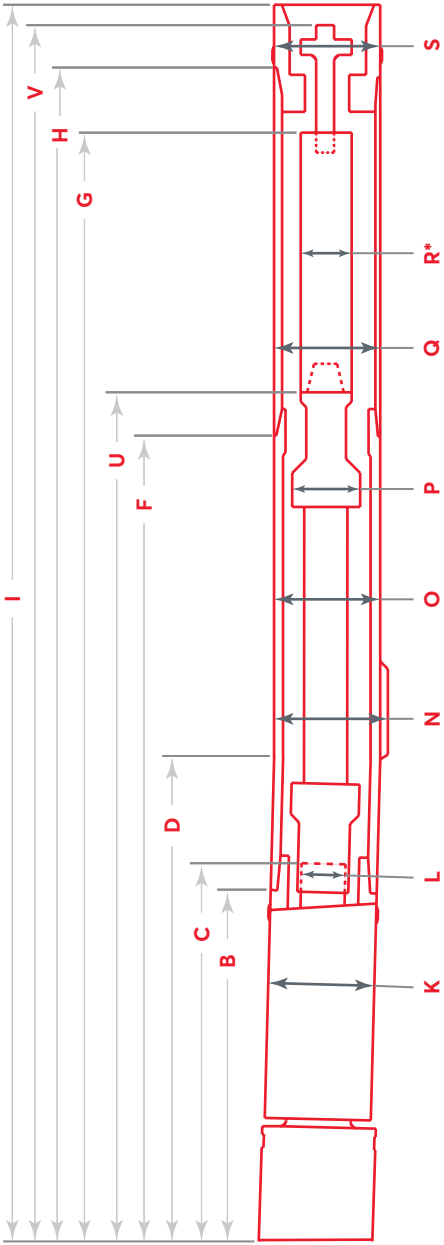
6½" Adjustable Bend Housing (ABH)



MOTOR	LOBES	STAGES	B	C	D	E	F	G	H	I	K	L	M	N	O	P	Q	R*	S	U	V
6½	6/7	5.0	43	47	64	70	89	281	289	319	6.56	3.37	6.56	6.75	6.56	4.55	6.50	4.32	6.50	96	299
6½	7/8	3.3	43	47	64	70	89	326	334	364	6.56	3.37	6.56	6.75	6.56	4.55	6.50	4.50	6.50	96	344

R* = All rotors are coated with tungsten carbide.
All values listed are in inches.

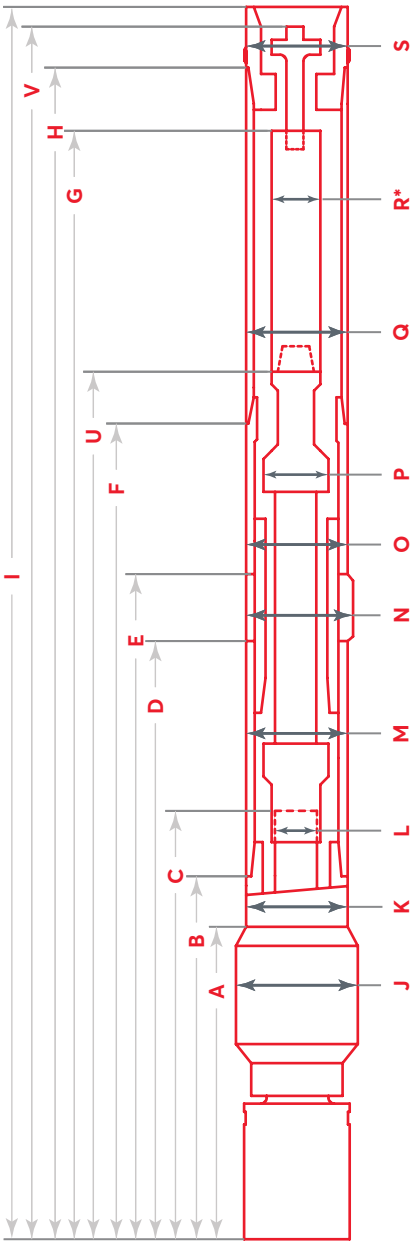
6½" Fixed Bend Housing (FBH)



MOTOR	LOBES	STAGES	B	C	D	F	G	H	I	K	L	N	O	P	Q	R*	S	U	V
6½	6/7	5.0	43	47	54	89	281	289	319	6.56	3.37	6.94	6.56	4.55	6.50	4.32	6.50	96	299
6½	7/8	3.3	43	47	54	89	326	334	364	6.56	3.37	6.94	6.56	4.55	6.50	4.50	6.50	96	344

R* = All rotors are coated with tungsten carbide.
All values listed are in inches.

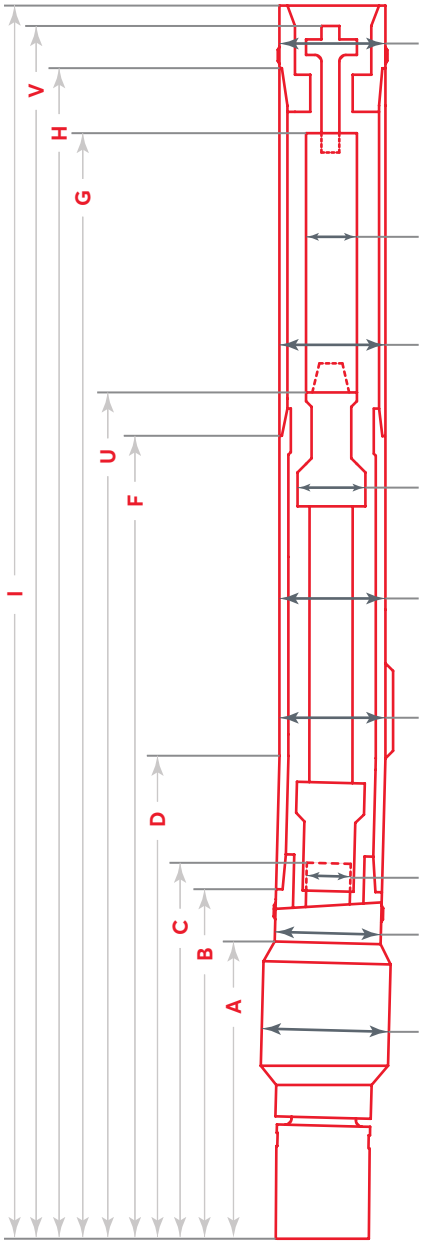
6¾" Adjustable Bend Housing (ABH)



MOTOR	LOBES	STAGES	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R*	S	U	V
6¾	4/5	7.0	31	43	47	64	70	89	291	299	329	7.44	6.75	3.37	6.75	7.00	6.81/7.00	5.00	6.75	4.22	6.75	96	309
6¾	6/7	5.0	31	43	47	64	70	89	281	289	319	7.44	6.75	3.37	6.75	7.00	6.81/7.00	5.00	6.75	4.32	6.75	96	299
6¾	7/8	3.3	31	43	47	64	70	89	326	334	364	7.44	6.75	3.37	6.75	7.00	6.81/7.00	5.00	6.75/7.00	4.50	6.75	96	344
6¾	7/8	5.7	31	43	47	64	70	89	341	349	379	7.44	6.75	3.37	6.75	7.00	6.81/7.00	5.00	6.75	4.64	6.75	96	359

R* = All rotors are coated with tungsten carbide.
All values listed are in inches.

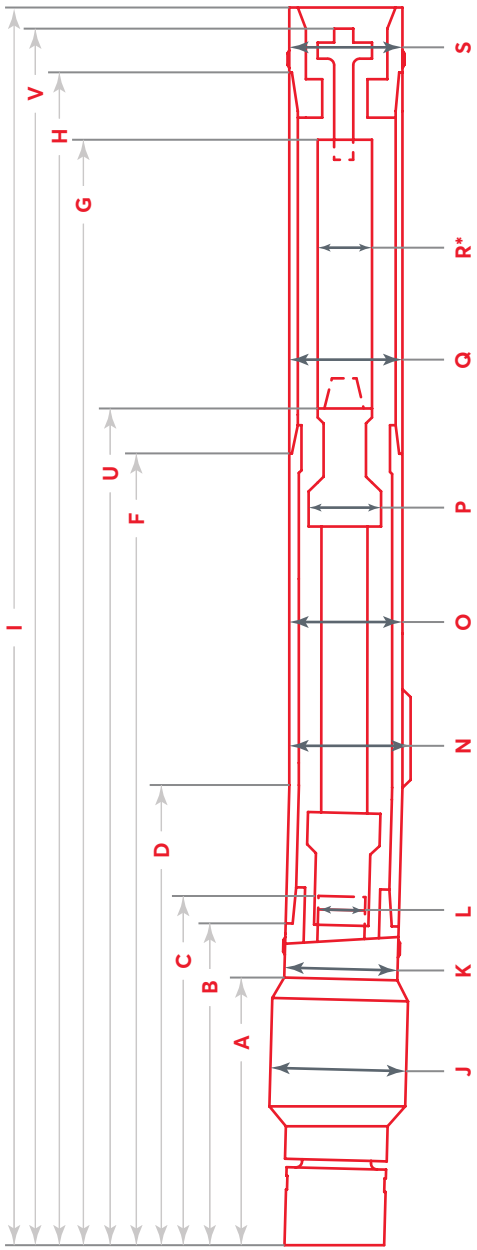
6¾" Fixed Bend Housing (FBH)



MOTOR	LOBES	STAGES	A	B	C	D	F	G	H	I	J	K	L	N	O	P	Q	R*	S	U	V
6¾	4/5	7.0	31	43	47	54	89	291	299	329	7.44	6.75	3.37	7.25	6.88/7.00	5.00	6.75	4.22	6.75	96	309
6¾	6/7	5.0	31	43	47	54	89	281	289	319	7.44	6.75	3.37	7.25	6.88/7.00	5.00	6.75	4.32	6.75	96	299
6¾	7/8	3.3	31	43	47	54	89	326	334	364	7.44	6.75	3.37	7.25	6.88/7.00	5.00	6.75/7.00	4.50	6.75	96	344
6¾	7/8	5.7	31	43	47	54	89	341	349	379	7.44	6.75	3.37	7.25	6.88/7.00	5.00	6.75	4.64	6.75	96	359

R* = All rotors are coated with tungsten carbide.
All values listed are in inches.

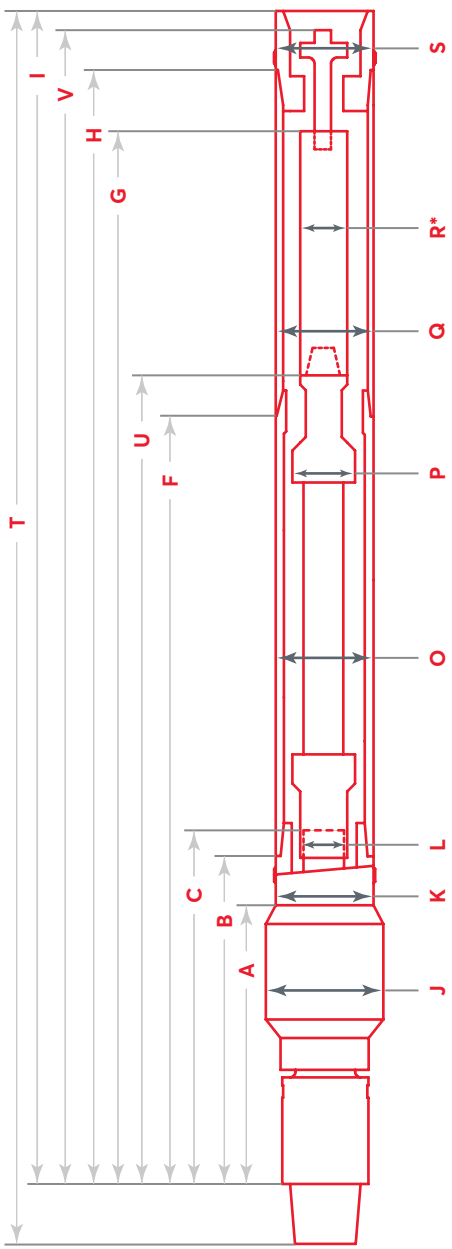
6¾" Short Bit to Bend - Fixed



MOTOR	LOBES	STAGES	A	B	C	D	F	G	H	I	J	K	L	N	O	P	Q	R*	S	U	V
6¾	4/5	7.0	23	36	39	47	82	284	292	322	7.44	6.75	3.37	7.25	6.88/7.00	5.00	6.75	4.22	6.75	89	302
6¾	6/7	5.0	23	36	39	47	82	274	282	312	7.44	6.75	3.37	7.25	6.88/7.00	5.00	6.75	4.32	6.75	89	292
6¾	7/8	5.7	23	36	39	47	82	334	342	372	7.44	6.75	3.37	7.25	6.88/7.00	5.00	6.75	4.64	6.75	89	352

R* = All rotors are coated with tungsten carbide.
All values listed are in inches.

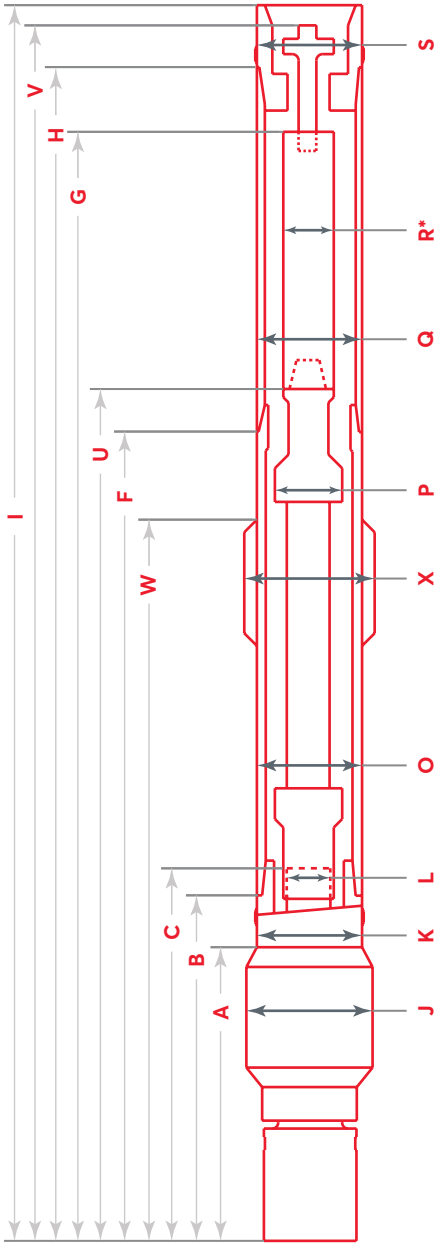
6¾" Rotary Steerable System (RSS)



MOTOR	LOBES	STAGES	A	B	C	F	G	H	I	J	K	L	O	P	Q	R*	S	T	U	V
6¾	7/8	3.3	33	45	48	91	328	336	366	7.44	6.75	3.37	6.88/7.00	5.00	6.75/7.00	4.50	6.75	371	98	346

R* = All rotors are coated with tungsten carbide.
All values listed are in inches.

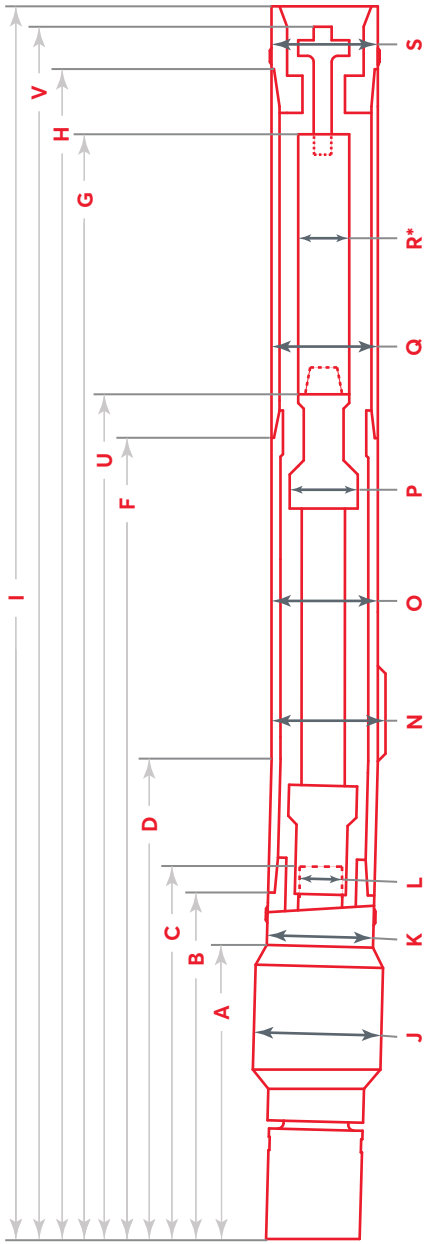
6¾" Double Stabilized



MOTOR	LOBES	STAGES	A	B	C	F	G	H	I	J	K	L	O	P	Q	R*	S	U	V	W	X
6¾	4/5	7.0	32	43	47	104	306	314	344	8.25	6.75	3.37	7.00	5.00	6.75	4.22	6.75	111	324	94	8.69
6¾	6/7	5.0	32	43	47	104	296	304	334	8.25	6.75	3.37	7.00	5.00	6.75	4.32	6.75	111	314	94	8.69
6¾	7/8	3.3	32	43	47	104	341	349	379	8.25	6.75	3.37	7.00	5.00	6.75/7.00	4.50	6.75	111	359	94	8.69
6¾	7/8	5.7	32	43	47	104	356	364	394	8.25	6.75	3.37	7.00	5.00	6.75	4.64	6.75	111	374	94	8.69

R* = All rotors are coated with tungsten carbide.
All values listed are in inches.

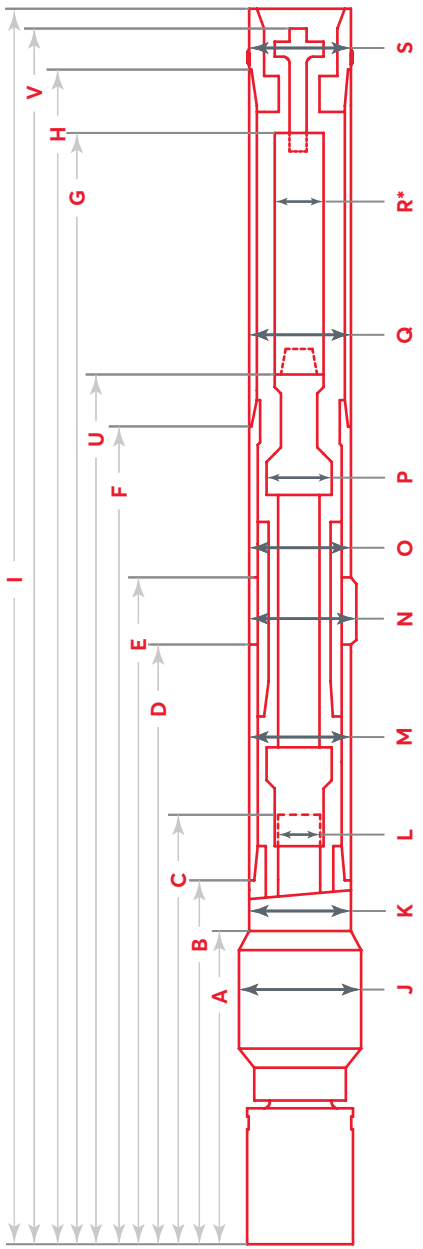
7" Fixed Bend Housing (FBH)



MOTOR	LOBES	STAGES	A	B	C	D	F	G	H	I	J	K	L	N	O	P	Q	R*	S	U	V
7	5/6	8.3	31	43	46	56	91	342	350	380	7.44	6.75	3.37	7.25	7.00	5.00	7.00	4.66	7.00	98	361
7	6/7	6.5	31	43	46	56	91	357	365	395	7.44	6.75	3.37	7.25	7.00	5.00	7.00	4.75	7.00	98	376

R* = All rotors are coated with tungsten carbide.
All values listed are in inches.

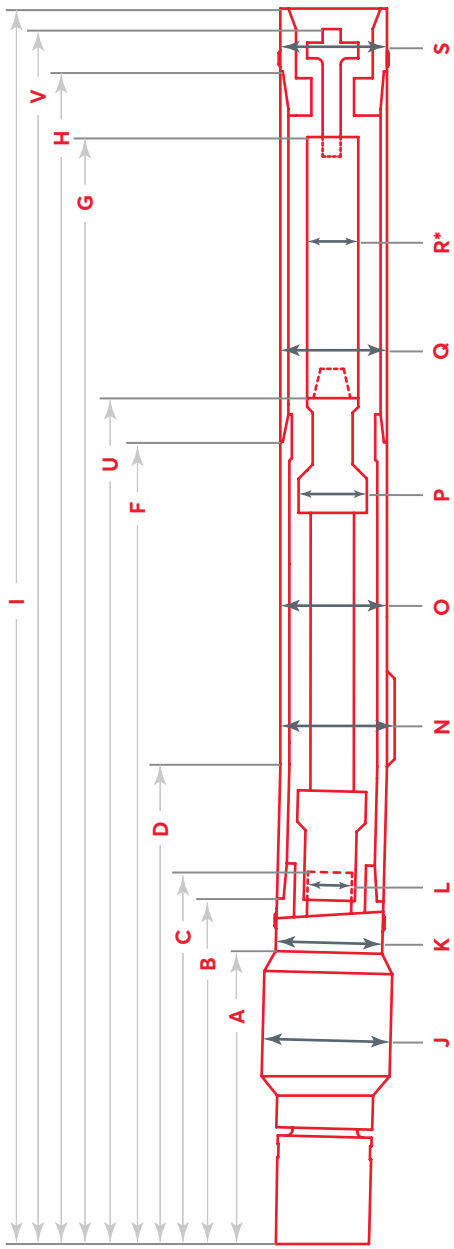
8" Adjustable Bend Housing (ABH)



MOTOR	LOBES	STAGES	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R*	S	U	V
8	7/8	4.0	36	59	63	83	90	111	307	315	348	9.00	8.00	4.00	8.00	8.16	8.00	5.85	8.00	5.19	8.00	120	324

R* = All rotors are coated with tungsten carbide.
All values listed are in inches.

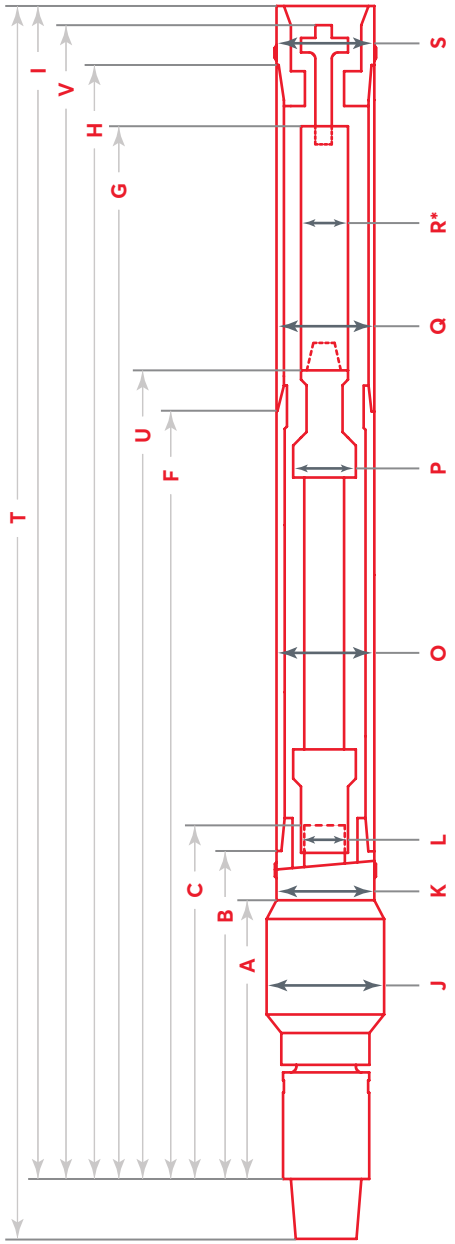
8" Fixed Bend Housing (FBH)



MOTOR	LOBES	STAGES	A	B	C	D	F	G	H	I	J	K	L	N	O	P	Q	R*	S	U	V
8	7/8	4.0	36	59	63	71	111	307	315	348	9.00	8.00	4.00	8.37	8.00	5.85	8.00	5.19	8.00	120	324

R* = All rotors are coated with tungsten carbide.
All values listed are in inches.

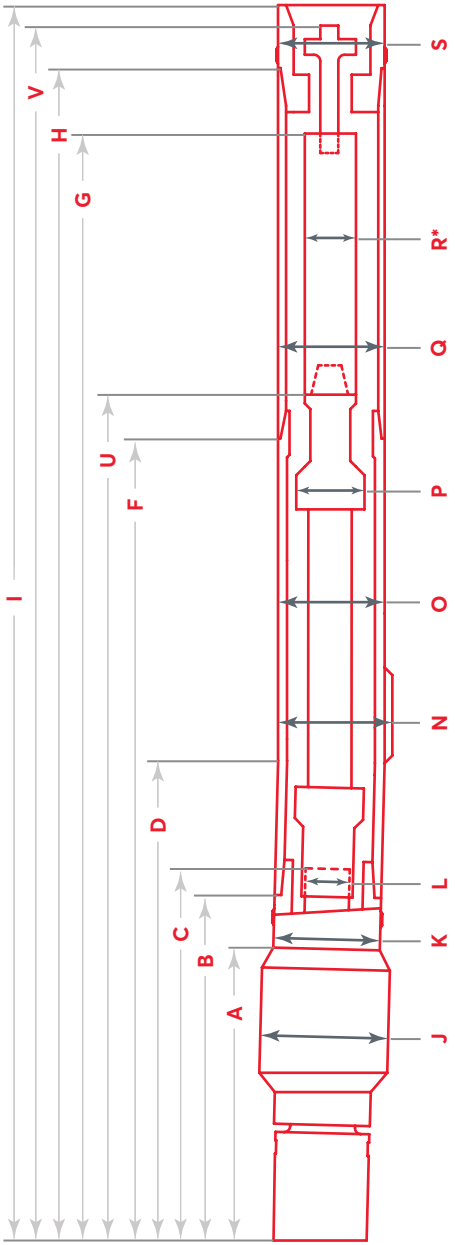
8" Rotary Steerable System (RSS)



MOTOR	LOBES	STAGES	A	B	C	F	G	H	I	J	K	L	O	P	Q	R*	S	T	U	V
8	7/8	4.0	36	59	63	111	307	315	348	9.0	8.00	4.00	8.00	5.85	8.00	5.19	8.00	353	120	324

R* = All rotors are coated with tungsten carbide.
All values listed are in inches.

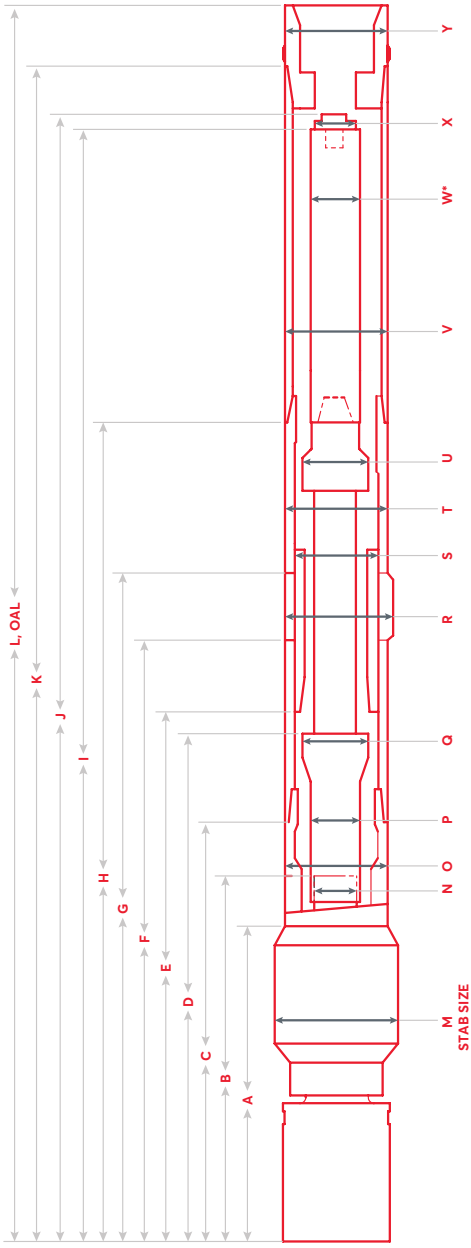
9⅝" Combo - Fixed Bend Housing (FBH)



MOTOR	LOBES	STAGES	A	B	C	D	F	G	H	I	"J" STAB SIZE	K	L	N	O	P	Q	R*	S	U	V
9⅝ Combo	7/8	3.4	25	58	62	76	118	409	418	451	11.75	9.88	6.38	10.26	9.88	6.75	8.00	5.31	8.00	126	427
9⅝ Combo	7/8	5.9	25	58	62	76	118	409	418	451	11.75	9.88	6.38	10.26	9.88	6.75	8.00	5.19	8.00	126	427
											12.00	17.00									

R* = All rotors are coated with tungsten carbide.
All values listed are in inches.

9⅝" Adjustable Bend Housing (ABH)



MOTOR	LOBES	STAGES	A	B	C	D	E	F	G	H	I	J	K	L	"M" STAB SIZE	N	O	P	Q	R	S	T	U	V	W	X	Y
9⅝	7/8	6.5	28	62	57.8	74	79	86.5	94.6	117	403	408	417	454	11.75	12.00	17.00	4.88	9.88	6.38	7.13	10.13	7.23	9.88	7.00	9.63	6.51	6.50	9.63

W*= All rotors are coated with tungsten carbide.
All values listed are in inches.

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