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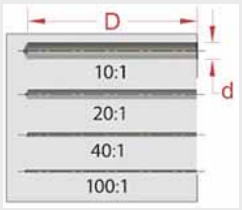
DEEP HOLE DRILLING REFERENCE | OVERVIEW, DEFINITION, DRILL TUBE SIZES

Deep Hole Definition

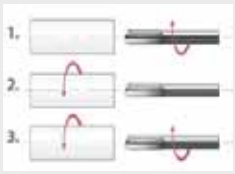


Depth to diameter ratio

HOLE DEPTH : DIAMETER (D:d)

5:1	Common twist drills
10:1	High performance twist drills with through-tool coolant
20:1	Special deep hole drilling tools with through-tool coolant
100:1	Deep hole drilling tools on dedicated deep hole drilling machines
200:1	Gundrilling tools on high performance gundrilling machines
400:1	Extreme drilling range, proprietary processes and equipment required

Drilling Process



Tool and workpiece rotation

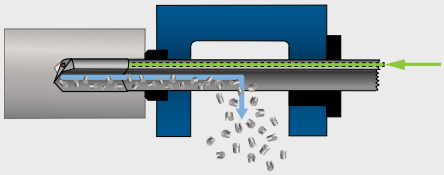
ROTATING TOOL - Typically used for non-symmetrical components, or off-center hole requirements

ROTATING WORKPIECE - Used for round parts with a deep on-center hole, and allows for a reduction in drill drift.

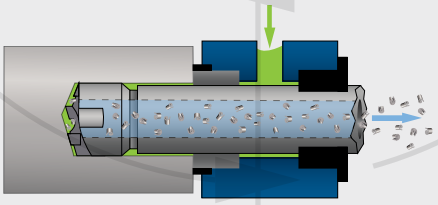
COUNTER-ROTATING TOOL AND WORKPIECE - Used for round parts with a deep on-center hole, provides the best hole straightness and concentricity.

Deep Hole Drilling Systems

GUNDRILL
Internal Coolant Delivery
External Chip Exhaust



BTA
External Coolant Delivery
Internal Chip Exhaust



Deep hole drilling is accomplished productively using a variety of different tools, determined by finished tolerance objectives and starting condition of parts.

In addition to the machine dimensions, power and dynamics, compatibility of these tools with various machines is primarily determined by the fluid delivery and chip exhaust systems. The two most common deep hole drilling systems are Gundrilling and BTA.

Innovations by tooling manufacturers have caused machines to require an array of specialized options to support various fluid delivery and discharge strategies.

UNISIG will provide application advice after reviewing part drawings, tolerance requirements and production volume. Feed and speed recommendations are made by UNISIG based on reputable tooling manufacturer's technical data and our experience drilling many varieties of standard and exotic materials.

Additional deep hole drilling references can be accessed at www.unisig.com, including more detailed information, videos, machines, and applications.

Scan with your smartphone for www.unisig.com

BTA Drill Tube Size and Solid Drill Diameter Standards

BTA Tube Size	Tube OD (mm)	Drilled Hole Diameter (mm)	Drilled Hole Diameter (inch)
794	11	12.6 - 13.6	0.496 - 0.535
795	12	13.6 - 14.6	0.536 - 0.575
796	13	14.6 - 15.6	0.576 - 0.614
797	14	15.6 - 16.7	0.615 - 0.657
798	15	16.7 - 17.7	0.658 - 0.696
799	16	17.7 - 18.9	0.697 - 0.744
800	17	18.9 - 20.0	0.745 - 0.787
801	18	20.0 - 21.8	0.788 - 0.858
802	20	21.8 - 24.1	0.859 - 0.948
803	22	24.1 - 26.4	0.949 - 1.039
804	24	26.4 - 28.7	1.040 - 1.129
805	26	28.7 - 31.0	1.130 - 1.220
806	28	31.0 - 33.3	1.221 - 1.311
807	30	33.3 - 36.2	1.312 - 1.425
808	33	36.2 - 39.6	1.426 - 1.559
809	36	39.6 - 43.0	1.560 - 1.692
810	39	43.0 - 47.0	1.693 - 1.850
811	43	47.0 - 51.7	1.851 - 2.035
812	47	51.7 - 56.2	2.036 - 2.212
813	51	56.2 - 65.0	2.213 - 2.559
813E	56	60.6 - 65.0	2.386 - 2.559
814	56	65.0 - 67.0	2.559 - 2.637
815	62	67.0 - 73.0	2.638 - 2.873
816	68	73.0 - 80.0	2.874 - 3.149
817	75	80.0 - 87.0	3.150 - 3.424
818	82	87.0 - 100.0	3.425 - 3.936
819	94	100.0 - 112.0	3.937 - 4.408
820	106	112.0 - 124.0	4.409 - 4.881
821	118	124.0 - 136.0	4.882 - 5.353
822	130	136.0 - 148.0	5.354 - 5.826
823	142	148.0 - 160.0	5.827 - 6.298
824	154	160.0 - 171.9	6.299 - 6.767
825	166	172.0 - 183.9	6.772 - 7.240
826	178	184.0 - 195.9	7.244 - 7.712
827	190	196.0 - 207.9	7.717 - 8.185
828	202	208.0 - 219.9	8.189 - 8.657
829	214	220.0 - 231.9	8.661 - 9.130
830	226	232.0 - 243.9	9.134 - 9.602
831	238	244.0 - 255.9	9.606 - 10.075
832	250	256.0 - 267.9	10.079 - 10.547
833	262	268.0 - 279.9	10.551 - 11.020
834	274	280.0 - 291.9	11.024 - 11.492
835	286	292.0 - 303.9	11.496 - 11.964
836	298	304.0 - 315.9	11.968 - 12.436
837	310	316.0 - 327.9	12.440 - 12.909

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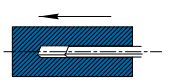
DEEP HOLE DRILLING REFERENCE | TOOLING METHODS, APPLICATIONS, PARAMETERS

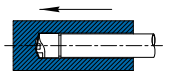
TOOLS FOR CREATING HOLES FROM SOLID

GUN DRILLING
1 - 50 mm
[0.04 -2.00 in]
Internal coolant



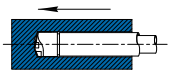
- High-pressure coolant is introduced through the machine spindle and tool center
- Chips are discharged along the v-shaped groove on the outside of the tool body.
- Special forms can be ground in tool tip for form tool operations.
- Brazed shank, solid carbide, and inserted tools are available.

BTA
20 - 630 mm
[0.79 – 24.8 in]
External coolant



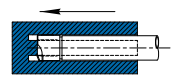
- High-pressure coolant is introduced through the space between the finished hole and the outside of the tool.
- Chips are discharged through the tool center and machine spindle.
- Compared to gun drilling, BTA method provides higher penetration rates (3-5 times faster) and has higher power requirements.

EJECTOR DRILLING
20 - 200 mm
[0.79 – 7.87 in]
Internal and external coolant



- Also called a dual tube system, consists of a drill head, outer tube, and inner tube.
- High-pressure coolant enters through space between inner and outer tubes.
- Chips are discharged through the inside diameter of the inner tube and exhausted through an adapter mounted to the front of the machining spindle.
- Typically used to retrofit lathes or machining centers for deep hole drilling.
- Chip evacuation is less efficient than BTA, due to smaller area for chip/fluid discharge.
- Limited depth to diameter ratio compared to BTA system.

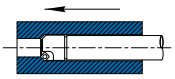
TREPANNING
20 - 500 mm
[0.79 – 20.0 in]
External coolant



- Process performed on blank material without pre-drilled hole. The tool leaves a solid core in the middle of the hole, rather than removing the entire machined area as chips.
- Consumes less power than solid drilling, for the same hole diameter.
- Trepanning in blind hole applications may not be practical due to the difficulty in removing the core.

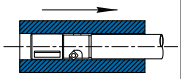
TOOLS FOR SECONDARY MACHINING AND FINISHING

COUNTER BORING/ REAMING
20 - 630 mm
[0.79 – 24.8 in]
External coolant



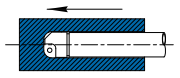
- Counterboring enlarges an existing hole that is drilled or cast.
- Push configuration tools pilot off a finished bore (wear pads supported by finished hole diameter). They can also be designed to pilot off the pre-bore (wear pads supported by pre-bore diameter) for stringent concentricity requirements.
- Multi-cutter counterbore tools are available for high stock removal.
- Reaming performs the same operations as counter boring, but typically, a reduced radial depth and unique geometry are used.

PULL BORING
20 - 630 mm
[0.79 – 24.8 in]
External coolant



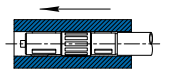
- A special configuration of counterboring, in which the tool enlarges the existing bore as it is pulled back through the workpiece, keeping the boring bar in tension rather than compression for better control over straightness.
- Can be used to straighten a hole with tools designed to follow the center line of the machine by supporting off the finished hole.
- Can also be designed for maintaining uniform wall thickness, with tools made to pilot off existing holes.
- Lantern chuck may be used to align a guide bushing to the centerline of machine.

BOTTOM FORMING
20 - 500 mm
[0.79 – 20.0 in]
External coolant



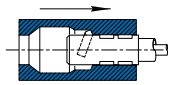
- Bottom forming is essentially a form tooling operation for finishing off the base of a hole.
- After deep hole drilling, the drawing may require a specific form to the hole.
- Bottom forming tools are guided with wear pads along the finished hole diameter, and have very specific designs depending on customer needs.
- Radius, steps, and flat bottom forms are common.

SKIVING AND ROLLER BURNISHING
20 - 500 mm
[0.79 – 20.0 in]
External coolant



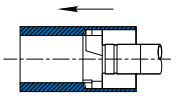
- A skiving tool can be visualized as a modified floating reamer, used to finish the surface when close diameter and roundness tolerances are required.
- Used for rapid stock removal with high penetration rates and low radial engagements.
- A burnishing operation cold works the surface of a workpiece. One or more rollers are pressed against the surface, plasticizing the material's top layer, compressing peaks and filling in valleys.
- In deep hole applications, skiving knives and burnishing rollers are often combined in a single tool to finish the operation in one pass.

BOTTLE BORING
Special application
External coolant



- Bottle boring is also knows as internal profiling or chamber boring.
- The tool is extended and retracted to produce the intended contour inside the workpiece.
- The internal profile is then bigger within the part than at the entry and exit.
- CNC is used to coordinate multiple axes simultaneously to achieve desired profiles.
- Bottle boring tools are typically produced for specific profiles.

TUBE FINISHING LARGE DIAMETER COUNTERBORE
300 - 1200 mm
[12.0 - 4 8.0 in]
Internal coolant



- Tube finishing for extremely large diameters requires specially configured counter boring tools.
- This process can be visualized as a push counter boring operation with a gun drilling type (internal) coolant supply, and BTA type indexable tooling.
- Extreme diameters need extreme amounts of coolant flow, which necessitates a design change in coolant induction and exhaust strategy.

DEEP HOLE DRILLING APPLICATIONS BY OBJECTIVES

Solid drilling application	Used for large stock removal
Counter-boring/Reaming application	Used for large stock removal. May be used for finishing operations
Trepanning application	Used for large stock removal at lower horsepower. Core-slug left after the operation is reusable
Pull counter boring application	Used to straighten the hole or to achieve uniform wall thickness
Skiving application	Used to make a geometrically true round hole
Roller burnishing application	Used to create a mirror surface finish or to impart desired surface qualities
Skive-burnishing application	Used to increase productivity compared to individual skiving + burnishing applications
Honing application	Used to eliminate the residual stress layer left by machining process and to control the hole diameter

TOLERANCE AND SURFACE FINISH BY PROCESS

PROCESS	CONFIGURATION	HOLE SIZE	HOLE STRAIGHTNESS		SURFACE FINISH	
			(inch/foot)	(mm/meter)	µ-inch Ra	µ-m Ra
Gun drilling	Tool rotate-Work rotate	IT6-IT11 (heavily influenced by work material)	0.001-0.004	0.08-0.33	8-248	0.2-6.3
	Tool stationary-Work rotate		0.002-0.006	0.16-0.5		
	Tool rotate-Work stationary		0.012	1.00		
BTA • Solid drilling • Trepanning • Counter-boring	Tool rotate – Work rotate	IT8-IT10	0.001-0.003	0.08-0.25	60-125	1.5-3.2
	Tool stationary – Work rotate		0.003-0.005	0.25-0.42		
	Tool rotate – Work stationary		0.012	1.00		
Pull boring	Tool rotate-Work rotate	IT7-IT9	0.001	0.08	32-125	0.8-3.2
Skive-burnishing	Tool rotate-Work stationary	IT8-IT9	as received	as received	< 8.0	< 0.2

ISO – IT GRADE TOLERANCES FOR COMMON DIAMETERS

DIAMETER RANGE	IT-6	IT-7	IT-8	IT9	IT10
0 - 3 mm (0 - 1.118 in)	0.006 mm (0.0002 in)	0.010 mm (0.0004 in)	0.014 mm (0.0006 in)	0.025 mm (0.0010 in)	0.040 mm (0.0016 in)
3 - 6 mm (0.118 - 0.236 in)	0.008 mm (0.0003 in)	0.012 mm (0.0005 in)	0.018 mm (0.0007 in)	0.030 mm (0.0012 in)	0.048 mm (0.0019 in)
6 - 10 mm (0.236 - 0.394 in)	0.009 mm (0.0004 in)	0.015 mm (0.0006 in)	0.022 mm (0.0009 in)	0.036 mm (0.0014 in)	0.058 mm (0.0023 in)
10 - 18 mm (0.394 - 0.709 in)	0.011 mm (0.0004 in)	0.018 mm (0.0007 in)	0.027 mm (0.0011 in)	0.043 mm (0.0017 in)	0.070 mm (0.0028 in)
18 - 30 mm (0.709 - 1.181 in)	0.013 mm (0.0005 in)	0.021 mm (0.0008 in)	0.033 mm (0.0013 in)	0.052 mm (0.0020 in)	0.084 mm (0.0033 in)
30 - 50 mm (1.181 - 1.969 in)	0.016 mm (0.0006 in)	0.025 mm (0.0009 in)	0.039 mm (0.0015 in)	0.062 mm (0.0024 in)	0.100 mm (0.0039 in)
50 - 80 mm (1.969 - 3.150 in)	0.019 mm (0.0007 in)	0.030 mm (0.0012 in)	0.046 mm (0.0018 in)	0.074 mm (0.0029 in)	0.120 mm (0.0047 in)
80 - 120 mm (3.150 - 4.724 in)	0.022 mm (0.0009 in)	0.035 mm (0.0013 in)	0.054 mm (0.0021 in)	0.087 mm (0.0034 in)	0.140 mm (0.0055 in)
120 - 180 mm (4.724 - 7.086 in)	0.025 mm (0.0010 in)	0.040 mm (0.0015 in)	0.063 mm (0.0025 in)	0.100 mm (0.0039 in)	0.160 mm (0.0063 in)
180 - 250 mm (7.086 - 9.843 in)	0.029 mm (0.0011 in)	0.046 mm (0.0018 in)	0.072 mm (0.0028 in)	0.115 mm (0.0045 in)	0.185 mm (0.0073 in)
250 - 315 mm (9.843 - 12.402 in)	0.032 mm (0.0013 in)	0.052 mm (0.0020 in)	0.081 mm (0.0032 in)	0.130 mm (0.0051 in)	0.210 mm (0.0083 in)
315 - 400 mm (12.402 - 15.748 in)	0.036 mm (0.0014 in)	0.057 mm (0.0022 in)	0.089 mm (0.0035 in)	0.140 mm (0.0055 in)	0.230 mm (0.0091 in)
400 - 500 mm (15.748 - 19.685 in)	0.040 mm (0.0016 in)	0.063 mm (0.0024 in)	0.097 mm (0.0038 in)	0.155 mm (0.0061 in)	0.250 mm (0.0098 in)

DEEP HOLE DRILLING PROCESS PARAMETERS

Cutting Speed (M/min or SFM) Chip Load (mm/rev or in/rev)	Determined by material type, hardness, condition, tool type, substrate, and coating. Use tool manufacturer, or UNISIG engineering recommendations.

Spindle Speed (rev/min)	Calculated by machine or operator using cutting speed and tool diameter
M/min	= RPM x 0.00314 x DIAMETER (mm)
RPM	= M/min x 318 / DIAMETER (mm)
SFM	= RPM x 0.262 x DIAMETER (inches)
RPM	= FPM x 3.820 / DIAMETER (inches)
FPM	= M/min x 3.281
M/min	= FPM x 0.305

Feed Rate (mm/min or in/min)	Calculated by machine or operator using spindle speed and chip load
mm/min	= mm/rev x RPM
in/min	= in/rev x RPM
mm/min	= in/min x 25.4
in/min	= mm/min / 25.4

Cutting Fluid Flow Rate (L/min or gpm)	The amount of cutting fluid that passes through the tool, and carries chips and heat from the process. Parameter values change by tooling type.
Approximate starting values	3.7 - 4.5 L/min per mm of tool diameter 25 - 30 gal/min per inch of tool diameter
Cutting Fluid Pressure (bar or PSI)	Pressure is developed due to the restriction of flow through process. Pressure is typically monitored for safety and tool condition and programmed for a maximum value. Coolant flow is of primary importance.

The tolerances provided are estimates, commonly quoted by tool manufacturers for applications with depth to diameter ratio up to 100:1 and under optimal conditions. As with any machining process, achieved tolerances depend on several factors; process parameters, workpiece condition or dimensions, tool geometry, desired trade-offs between productivity and tool life, cutting oil, etc. Individual results may vary. Diameter ranges beyond the nominal stated may be possible with UNISIG machines. Visit www.unisig.com for more information. Updated September 2011