
GUNDRILLING
WEBINAR
JULY 31ST
SAVE YOUR SEAT

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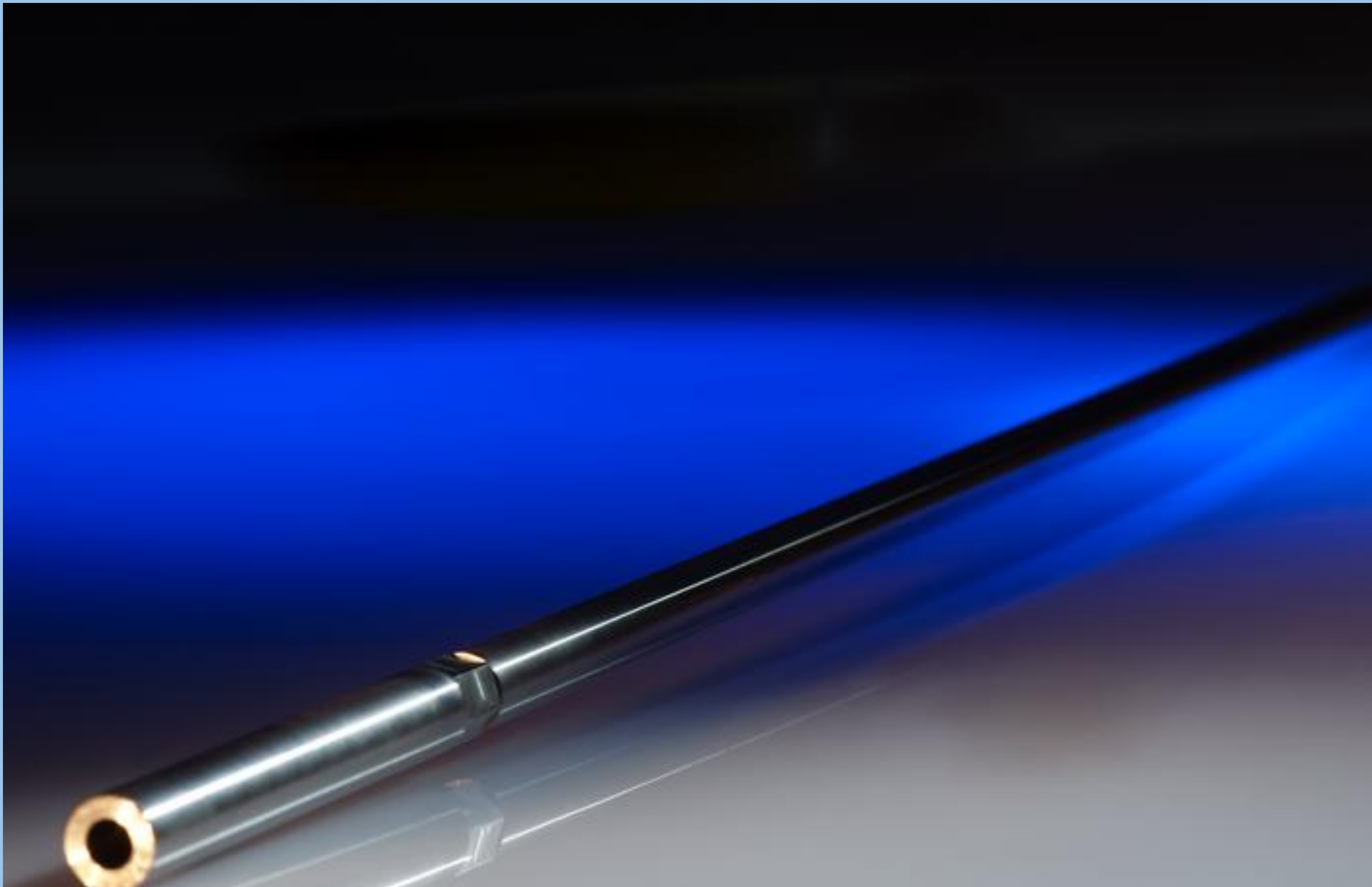
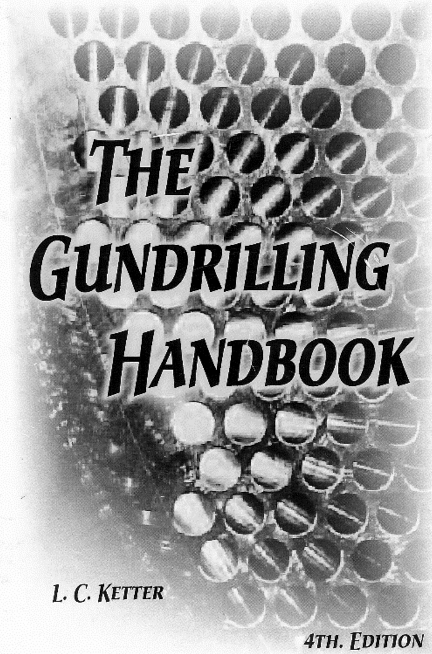
Accuracy Precision Quality



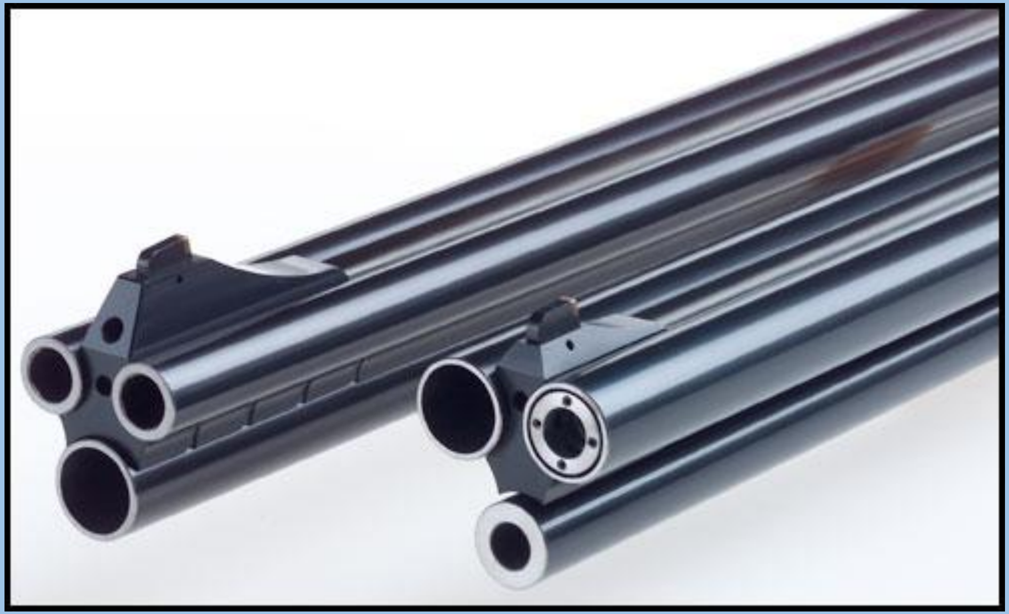
The Gundrilling Handbook



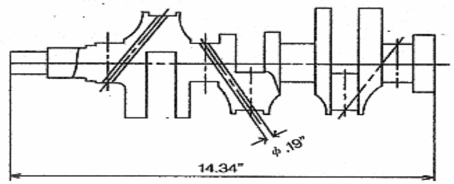
L. C. Ketter

4th. Edition

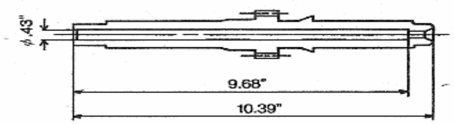
Gundrilled parts



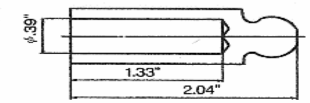
Crank shaft



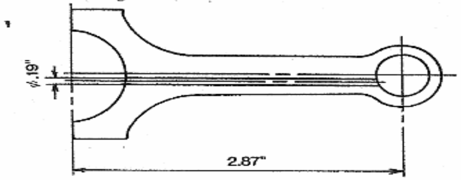
Accelerated main shaft



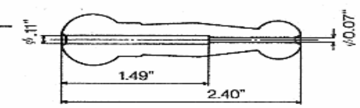
Piston



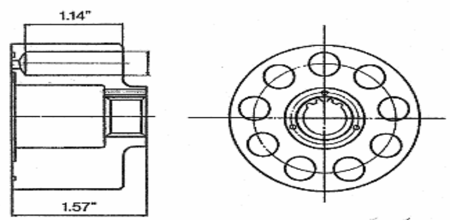
Connecting rod



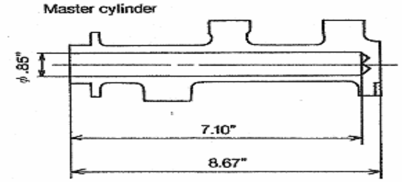
Connecting rod (SCM-21)



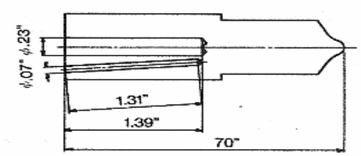
Cylinder block



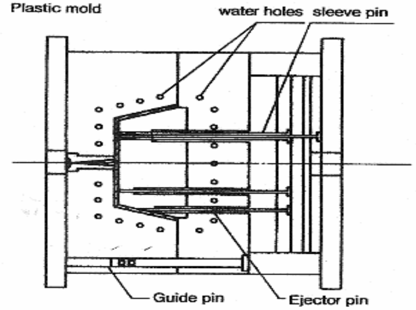
Master cylinder



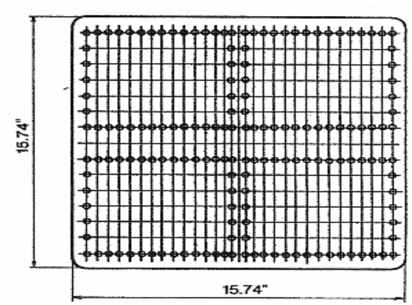
Nozzle



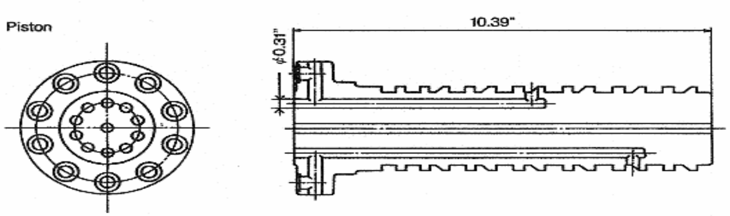
Plastic mold



Heat exchanger (carbon)

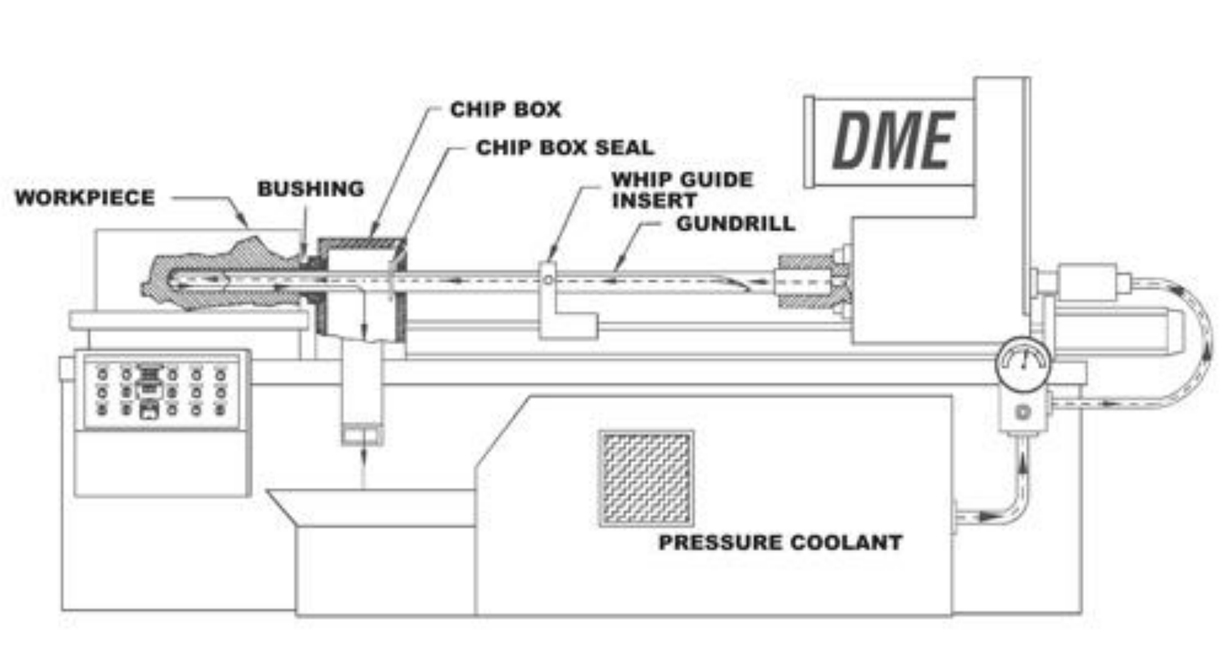


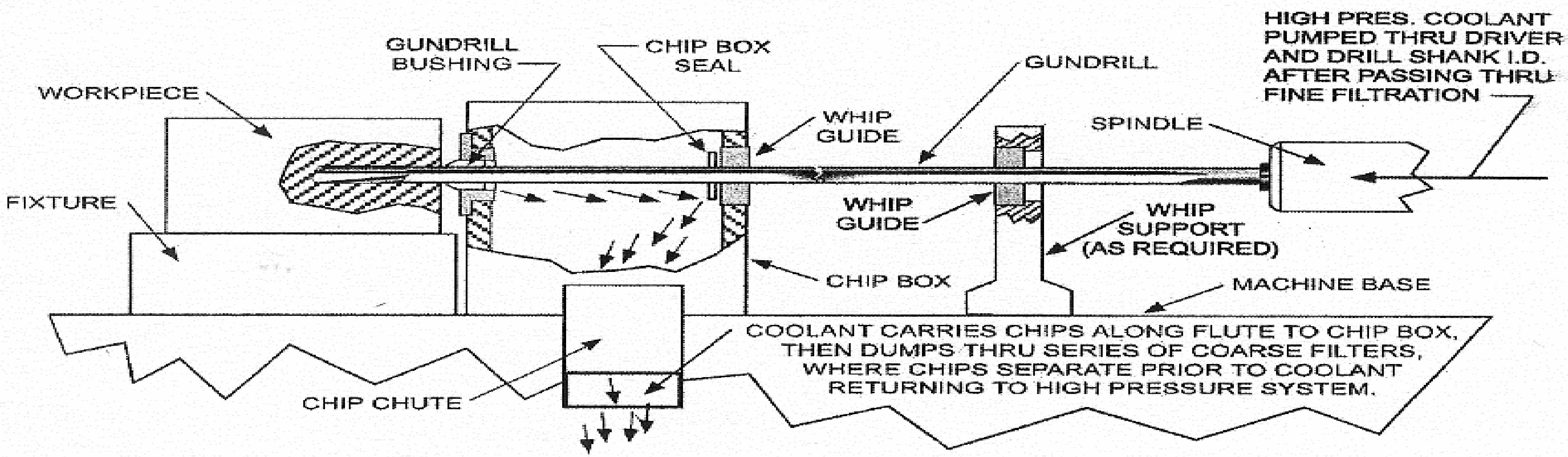
Piston



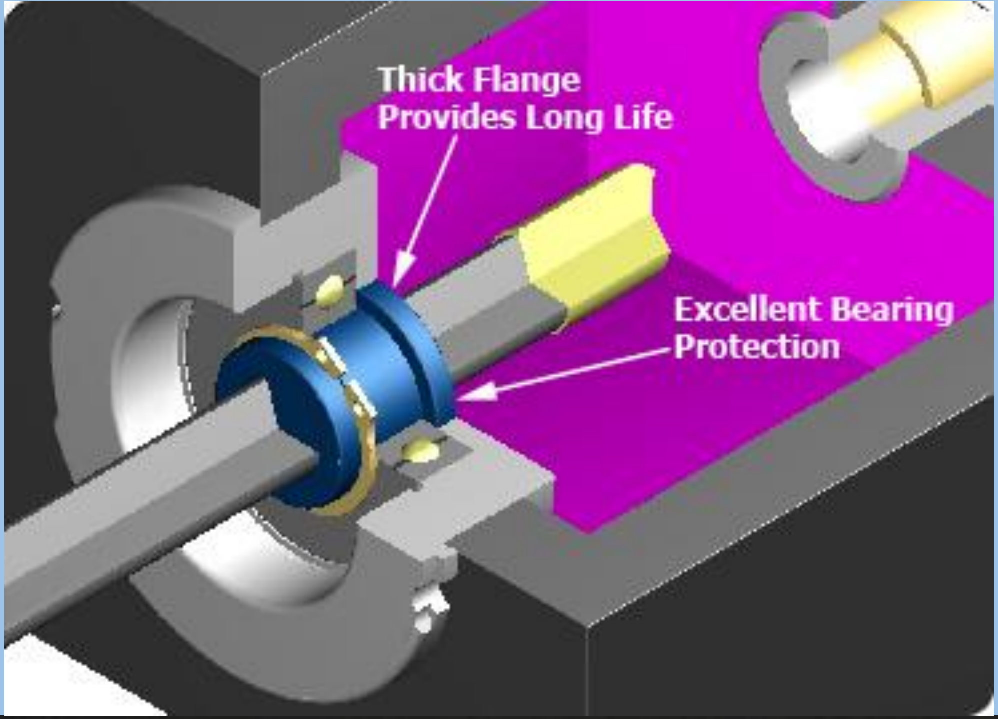
Gundrill Machines

Gundrill Machines are designed to provide optimum conditions for gundrill operation; the gundrilling machine's high pressure pump delivers lubricant to the rear of the drill. The drill can be driven by the spindle or be held stationary if the work piece is rotated. During drilling, the work piece can be advanced or the drill can advance. The gundrill is supported by *anti-whip devices* along the shank and at the rear of the chip box. The chip box contains *chip deflectors* and a front end bushing, which guides the drill into the work piece. The chip box also contains escaping chips and lubricant, which are separated and filtered.

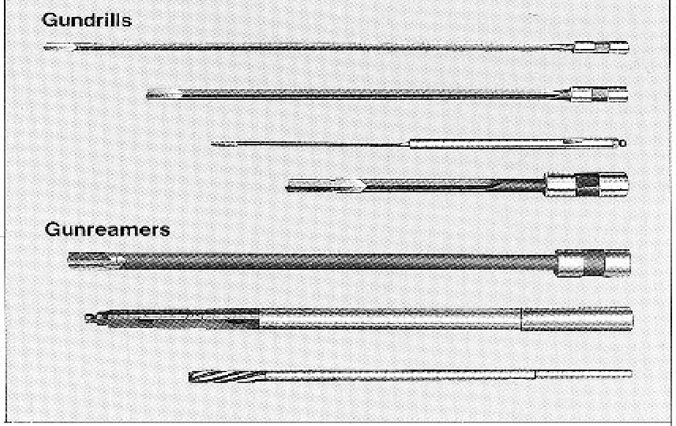




HIGH PRES. COOLANT PUMPED THRU DRIVER AND DRILL SHANK I.D. AFTER PASSING THRU FINE FILTRATION
GUNDRILL BUSHING
CHIP BOX SEAL
GUNDRILL
WORKPIECE
WHIP GUIDE
SPINDLE
FIXTURE
WHIP GUIDE
WHIP SUPPORT (AS REQUIRED)
CHIP BOX
MACHINE BASE
COOLANT CARRIES CHIPS ALONG FLUTE TO CHIP BOX, THEN DUMPS THRU SERIES OF COARSE FILTERS, WHERE CHIPS SEPARATE PRIOR TO COOLANT RETURNING TO HIGH PRESSURE SYSTEM.
CHIP CHUTE

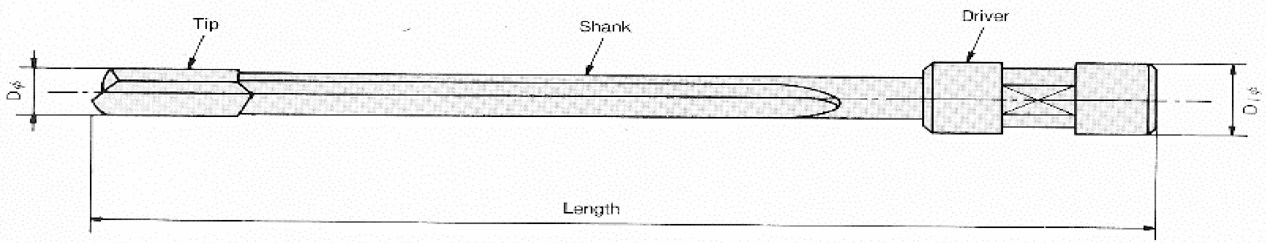

Thick Flange
Provides Long Life
Excellent Bearing
Protection

Tools (Gun drill / Gun reamer)

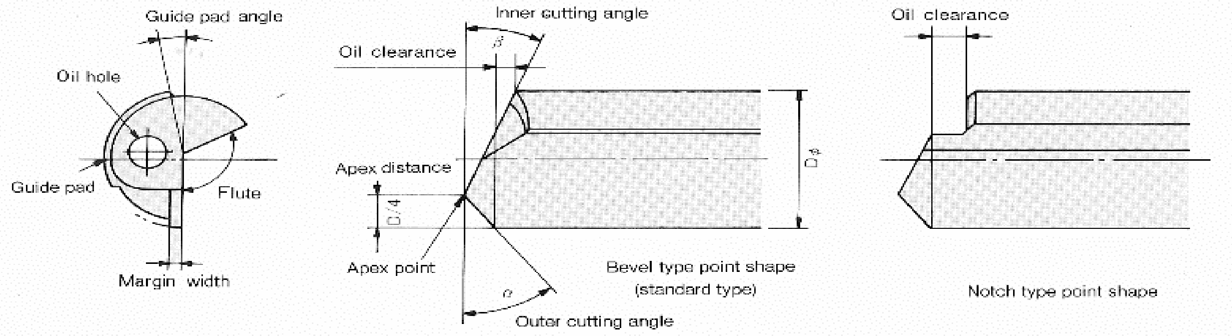


Gun Drills and Gun Reamers
As deep hole drill, ours are highly efficient tools assuring "deeper", "faster", and "more accurate" drilling compared with twist drills.

Specifications of gun drill



Names at the tip of a gundrill

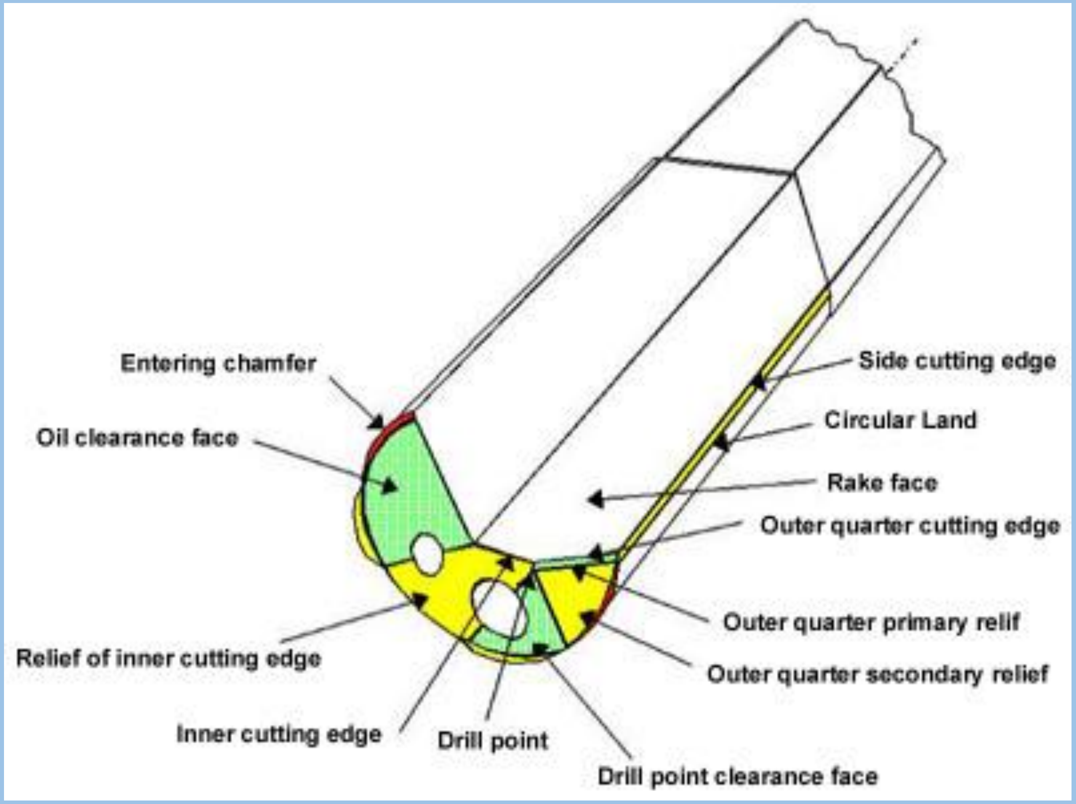


Recommended form of cutting edge

Drilled material	α °	β °	Drilled material	α °	β °
Low carbon steel	30	20	Cast iron	15	20
Carbon steel	30	20	Aluminum alloy	15	20
Alloy steel	30	20	Stainless steel	30	20

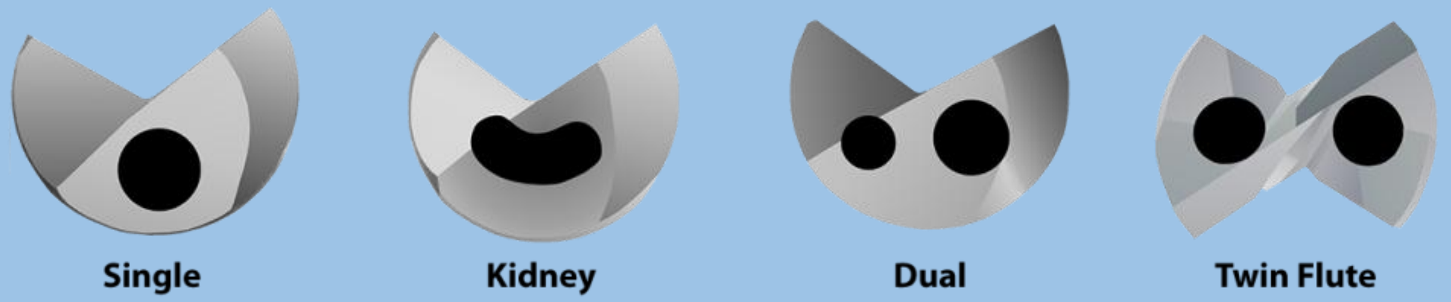
Driver dimensions (inches)

Drill diameter Dφ	D1φ
0.0781 to 0.12	1/2
0.125 to 0.5	3/4
0.5156 to 0.75	1.0
0.7656 to 1.0	1 1/4
1.0625 to 1.5	1 1/2


Entering chamfer
Oil clearance face
Relief of inner cutting edge
Inner cutting edge
Drill point
Drill point clearance face
Outer quarter secondary relief
Outer quarter primary relif
Outer quarter cutting edge
Rake face
Circular Land
Side cutting edge

Coolant Hole Configurations

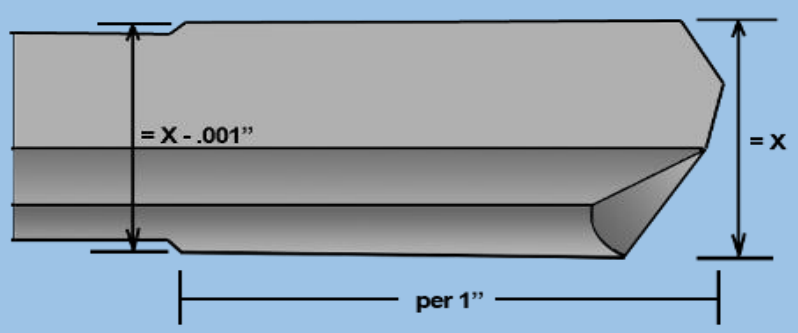
Coolant hole configurations play a critical part in the gundrill selection process. Coolant systems that lack adequate pressure or volume would benefit from the single oil hole. The single orifice allows more PSI with less volume. Systems with ideal PSI and GPM should run either a Kidney (.075″ – .3174″) or Dual (.3108″ – 1.520″) oil holes for greater chip evacuation and coolant to the cutting edge.



Backtapers

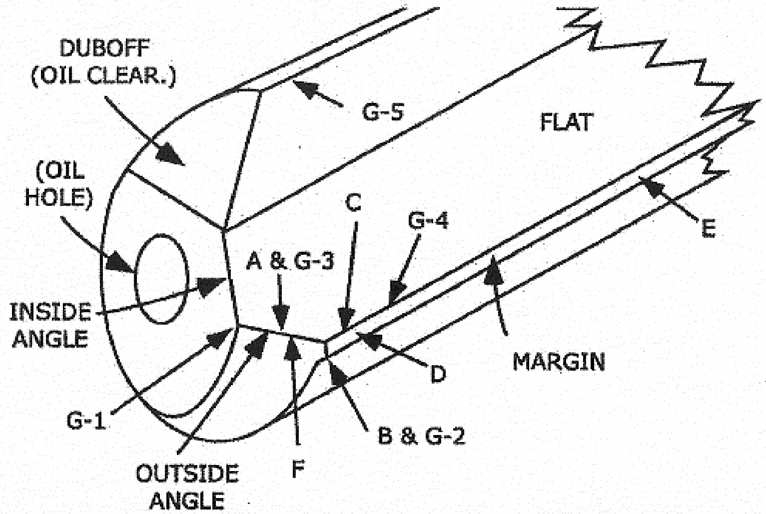
Backtapers are a linear reduction in the tool diameter allowing for clearance and minimal friction. Standard backtaper, .0008″ – .0010″ per inch, is generally used in steel applications where the heat generated by the bearing pads (contours) does not expand and contract the hole during the drilling process. Materials that heat and cool quickly such as aluminums, cast iron, etc. require increased backtaper to prevent the hole from closing in on the gundrill during the retract mode.

DIAMETRICAL BACKTAPER



Objects enhanced for visual representation

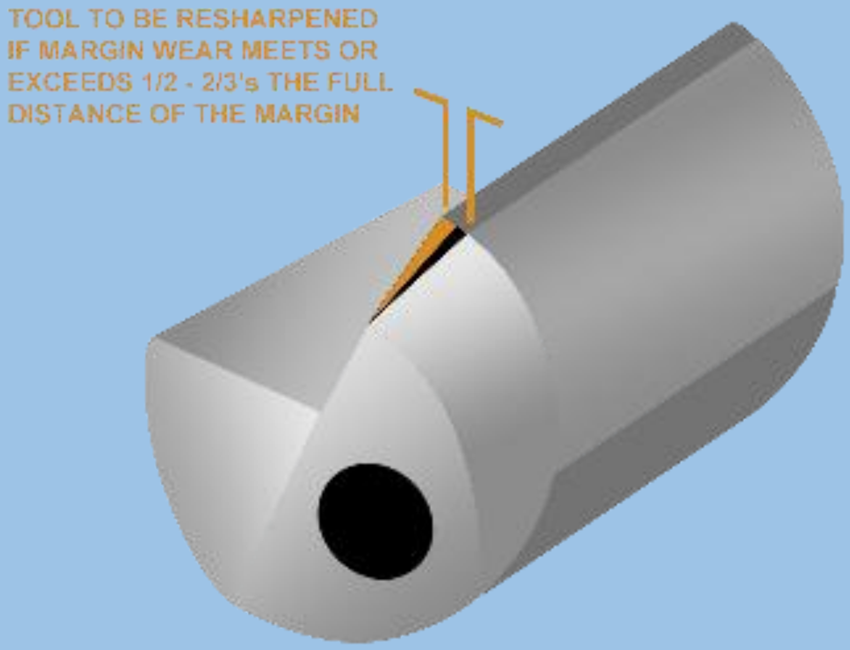
TOOL WEAR GUIDE



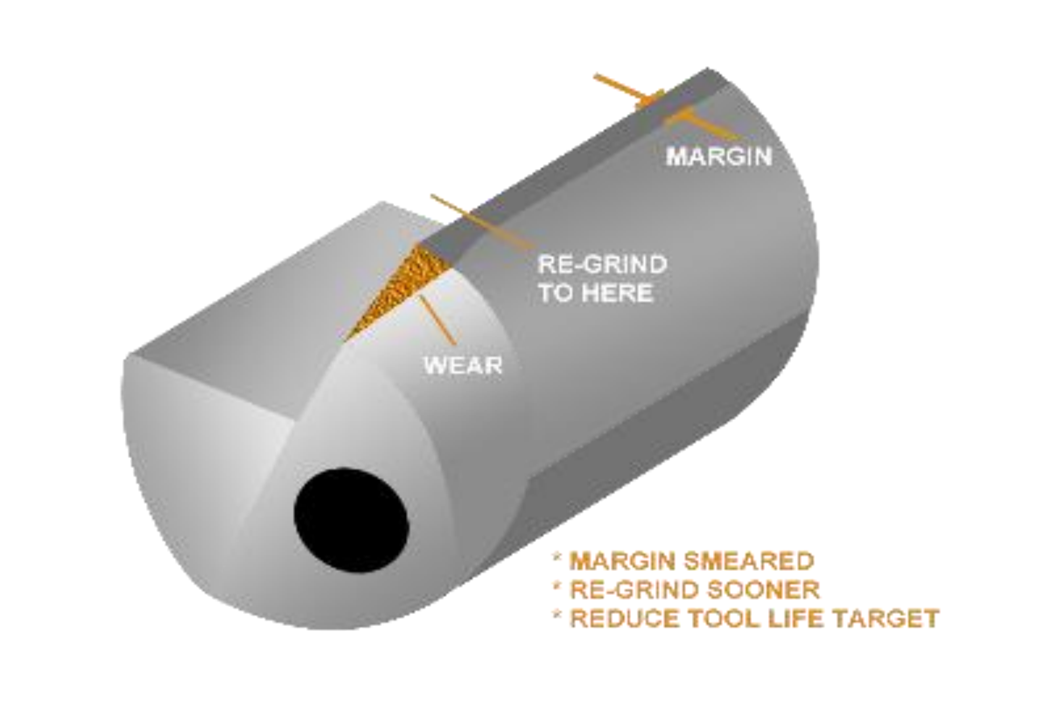
CONDITION	CAUSE
Wear –	
A. Cratering	RPM low or feedrate high
B. Corner breakdown	Heat: RPM high or coolant flow
C. Built up edge	Wrong coolant
D. Pickup on margin	Wrong coolant
E. Wear on margin	Misalignment
F. Burn on outside angle	Too high RPM, coolant flow
G. Chipping–	
G-1 Point	Point bumped
G-2 Outside corner	Bumped, or trapped chip
G-3 Outside angle	High feedrate & end pressure
G-4 Outer edge	Rubbing on tight bushing
G-5 Shoulder	Bumped, or tight bushing

How To Determine If Time To Grind
Determining Time to Re-Grind

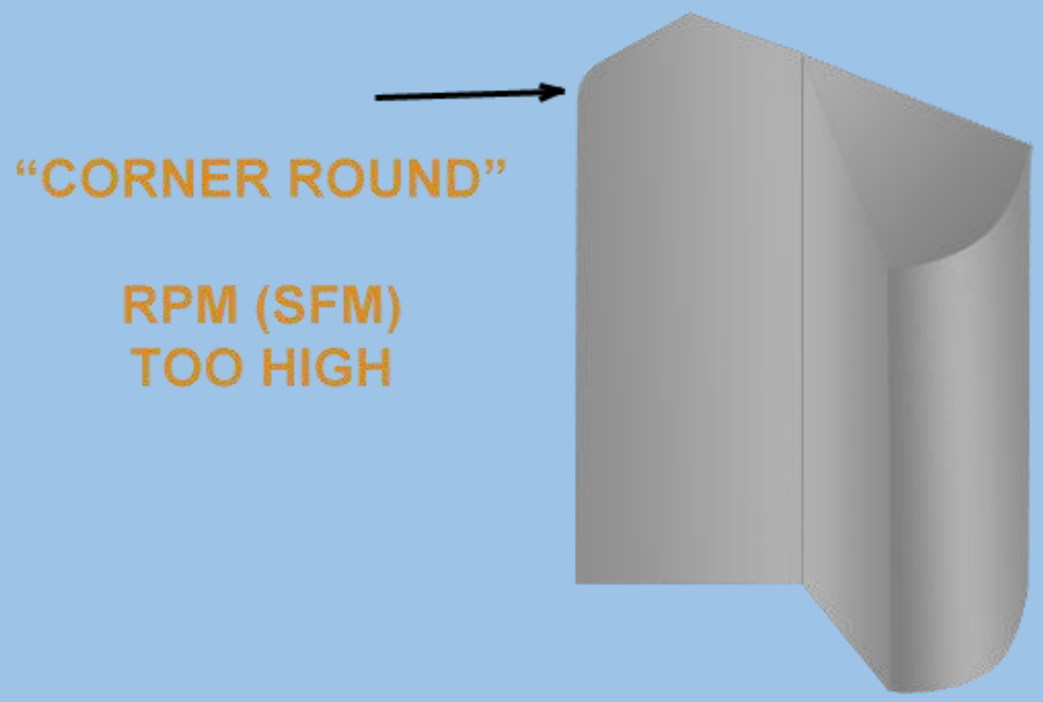
Determining when a tool has reached the point when it's time to re-sharpen takes a visual examination of the cutting edge. Inspecting the cutting edge will determine if the running parameters are adequate for optimal results.



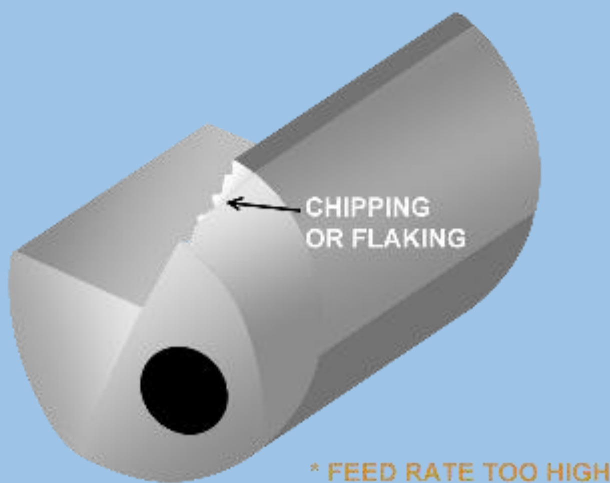
This drawing is an example of when it's time to re-grind a tool. Pay close attention to the margin, smearing, or a need to be cleaned-up during the re-grind process to ensure the tools' repeatability.

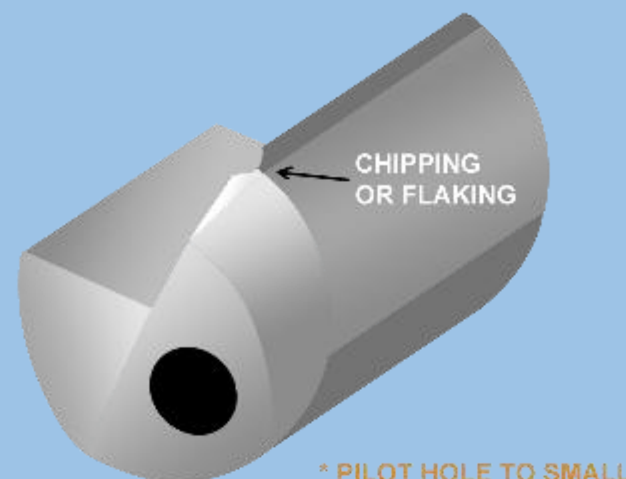


If the outside corner is rounded, it usually means that the SFM is too high and the RPM should be lowered in 10% increments until the wear is along the cutting edge and the corner remains pristine.

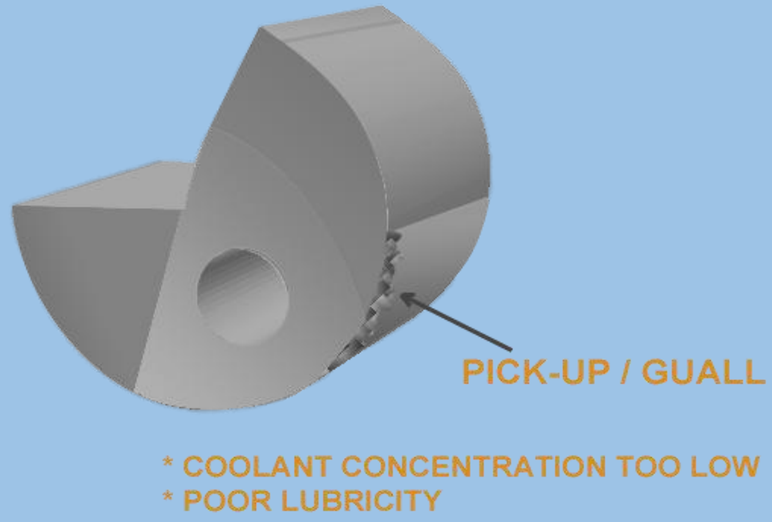


**If there is evidence of chipping or cratering along the cutting edge point,
the feed rate should be lowered.**





If there is build-up on the OD, it is usually a result of too much heat due to low lubricity. Often seen in water soluble applications.



How to troubleshoot gundrilling problems:

A detailed troubleshooting guide, found in the literature of all gundrill and gundrill machine manufacturers, is a great place to start. They are often divided into hole faults or tool faults. Find your problem on the chart and address each area of concern and check and correct any non compliant issues. Most of the remedies from these troubleshooting guides can be attributed to something not correct with the set up and an ignoring of a salient issue which might be causing everything to go wrong. Many times, it is just one thing. Therefore, one adjustment, and you are back to drilling repeatable and predictable outcomes.

Quickly, let's review some of those fundamentals

Machine Requirements for Successful Gundrilling:

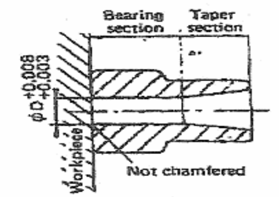
Proper alignment (newer gundrill machines and most all CNC are great) For a gundrill operation to have the best chance for the straightest hole, the deviation between the spindle and the bushing, which is actually between the spindle and back of the chip box should not be more than +.0005”. When using CNC, a pilot hole is produced to within the same tolerance as the gundrill busing, -.0000 + .0002”. This alignment on CNC is assured, however, over time, a gundrill machine may need to be adjusted to return the spindle to a dead center, zero, position.

Information for Use of Gun Drills

Machines and precision

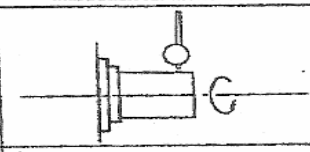
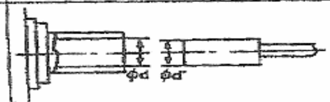
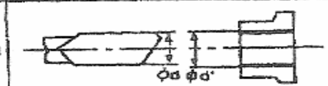
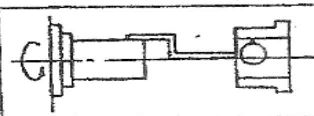
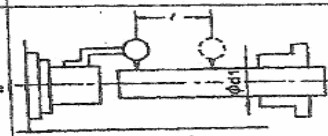
To demonstrate the performance of a gun drill effectively and sufficiently, "precision of the machine and equipments" plays an important role.

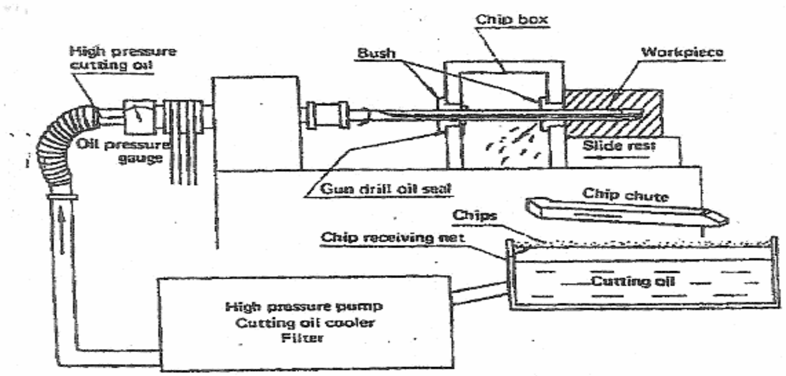
1) A highly rigid special machine with low vibration should be used.
2) High precision should be secured with the machine and the bush, as shown in the table on the right.
3) Irregular feed causes breakage, and automatic mechanical feed is the best for gun drilling.
4) Sufficient power is required to allow high speed rotation.
5) To prevent breakage, a safety device for torque over check must be provided.



Control of bush

In mm

	Check item	Illustration for measurement	Tolerance
a	Deviation of spindle		≦0.005
b	Clearance between spindle hole and driver		(d − d') ≦0.013
c	Clearance between drill bush and drill outer diameter		(d − d') ≦0.015
d	Concentricity between spindle and bush		≦0.013
e	Parallelism between spindle and bush hole in table travel	 δd = ℓ φd indicates the inner diameter of bush	≦0.005/

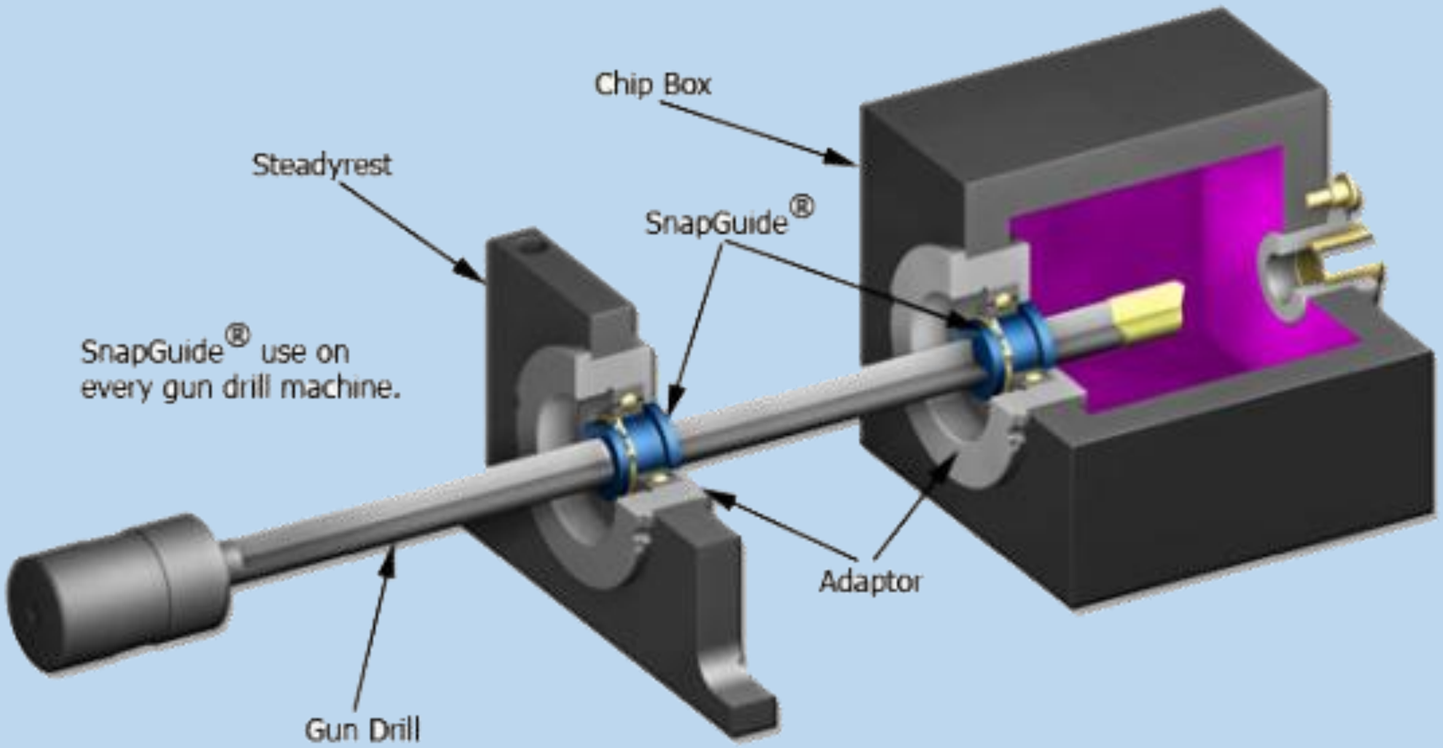


Machine configuration

Proper whip guide placement

Again charts are available to determine the maximum unsupported tool length. RPM’s higher than allowed for the distance where the flute is running unsupported will result in ‘ballooning’ of the flute and drill failure. Proper whip guides, gizmos, drill guides, chip deflectors, all become critical to the stabilization of the precision drill trying to do its job.

Proper whip guide set up.



Proper coolant pressure for the diameter

Coolant pressure requirements are also standard and are on many charts through the industry. It is highly recommended that you adhere to these setting if at all possible. A gundrill machine will be adjustable. A ¼" drill should run at 925 to deliver the required 2.2 GPM for proper lubrication. The same machine needs to be able to also deliver 400 PSI for the ¾" diameter and 8.4 GPM. When PSI does not not changed when diameter changes, trouble.

– STARTING SURFACE FEET PER MINUTE –

LOW & MED. CARBON STEEL

Rc	SFM
12-17	330
17-22	280
22-27	230
27-32	180
32-37	130
37-42	80

ALLOY STEEL
(4000, 5000, 8000 Series)

Rc	SFM
17-22	280
22-27	230
27-32	180
32-37	130
37-42	80

STAINLESS
(300 Ser & PH)

Rc	SFM
12-17	230
17-22	200
22-27	170
27-32	140
32-37	110
37-42	80

STAINLESS
(400 Series)

Rc	SFM
12-17	280
17-22	240
22-27	200
27-32	160
32-37	120
37-42	80

Free Mach: +30%

TOOL STEELS

Rc	SFM
17-22	250
22-27	200
27-32	150
32-37	100

CAST IRON (Grey)

Rc	SFM
12-17	400
17-22	350
22-27	300
27-32	250

(W/Free Carbides: –50%; Ni-Resist: –60%)

CAST IRON
(Nodular)

Rc	SFM
12-17	300
17-22	250
22-27	200
27-32	150
32-37	100

(Ni-Resist & Ductile: –50%)

TITANIUM ALLOY
(Ti6Al4V, etc.)

Rc	SFM
12-17	260
17-22	220
22-27	180
27-32	140
32-37	100
37-42	60

BRASS, BRONZE, MAGNESIUM

Rc	SFM
–	550

HI–TEMP. ALLOYS
(Nickel Based)

Rc	SFM
12-22	120
22-32	90
32-42	60

(Cobalt Base: –40%; Iron Base: +20%)

COPPER (PURE)

Rc	SFM
–	250/275

COPPER ALLOYS
(Beryl, Ni-Based)

Rc	SFM
12-22	200
22-32	130
32-37	60

ALUMINUM, CAST & 2024

Rc	SFM
–	600

ALUMINUM, WROUGHT
(7075, 6061 etc.)

Rc	SFM
–	550

SINTERED MATL, PLASTIC, WOOD, GRAPHITE– See notes, pages 8-4 & 8-5.

COOLANT PRESSURE, FLOW RATES and UNSUPPORTED SHANK LENGTH

Note: Please read important notes following table.

Drill Dia. (In.)	Pressure (PSI)	Flow Rate (GPM)	Max. Unsup. Shank (In.) High SFM	Low SFM
.0550	2000 +	0.2	1	4
.0780	1800	0.3	2	6
.1250	1500	0.7	3	8
.1560	1300	1.1	4	10
.1875	1150	1.5	6	12
.2190	1050	1.9	7	14
.2500	925	2.2	8	16
.2810	850	2.6	9	18
.3125	775	3.0	10	20
.3440	725	3.4	11	22
.3750	675	3.8	12	24
.4375	600	4.5	14	28
.5000	525	5.3	16	32
.5625	500	6.1	18	36
.6250	450	6.8	20	40
.6875	425	7.6	22	44
.7500	400	8.4	24	48
.8750	350	9.9	28	56
1.000	325	11.4	32	64
1.125	300	12.9	36	72
1.250	275	14.5	40	80
1.375	250	16.0	44	88
1.500	225	17.5	48	97

Proper coolant type

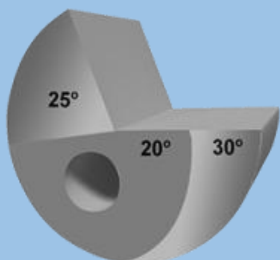
Gundrilling oil is a special blend. The old White and Bagley and the old Eldorado (now Master Chemical and Drill Masters Eldorado) developed together a gundrilling oil formula that is still an industry standard today. Most oil manufactures have the 2190 formula providing you the opportunity to buy your oil from whomever you get the rest of your coolants from. Water soluable is a different subject. Some are better than others but the most effective use is when there is a 10%-12% ratio. Most common problem with water soluable is galling as the lubricity tends to give out or never is enough to begin with.

Proper geometry for the material and the application

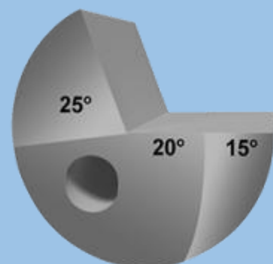
Though the industry standard geometry N8 is used in most applications benefits can be derived by a different set of geometries not only for different materials but also for different results and or complexity of the application. Examples of each might be Aluminum (N4) and cast irons (N73) and again with the N73 for stack material or angle entry.

Nose Grinds

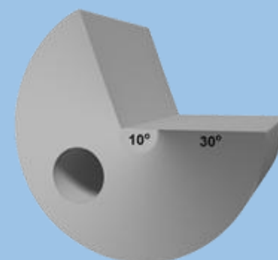
Standard, general purpose nose grinds, N-8 & Facet, are supplied on our stock gundrills. Special grinds are applied to obtain better chip control, bottom forming, and heavy feed rates when drilling Aluminums and Cast Irons in conjunction with special contours.
Some special grinds may be dictated by part pint calling and for corner radius, full spherical radius, flat bottom, step drills, pilot non-cutting step drills, chip breakers, etc.



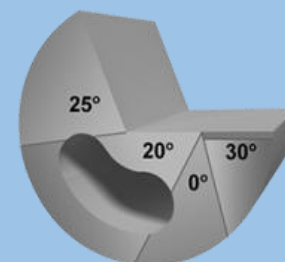
N-8



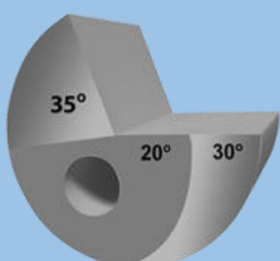
N-4



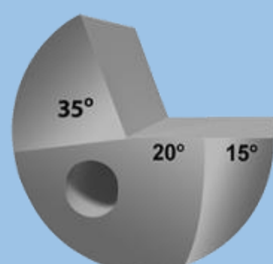
N-73



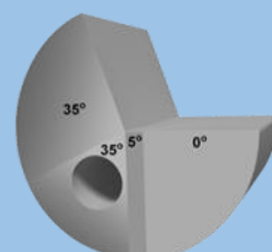
Facet (F-8)



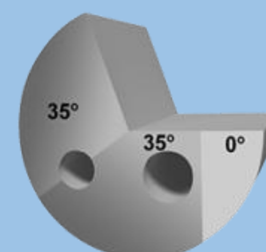
N-8+35



N-4+35



N-126



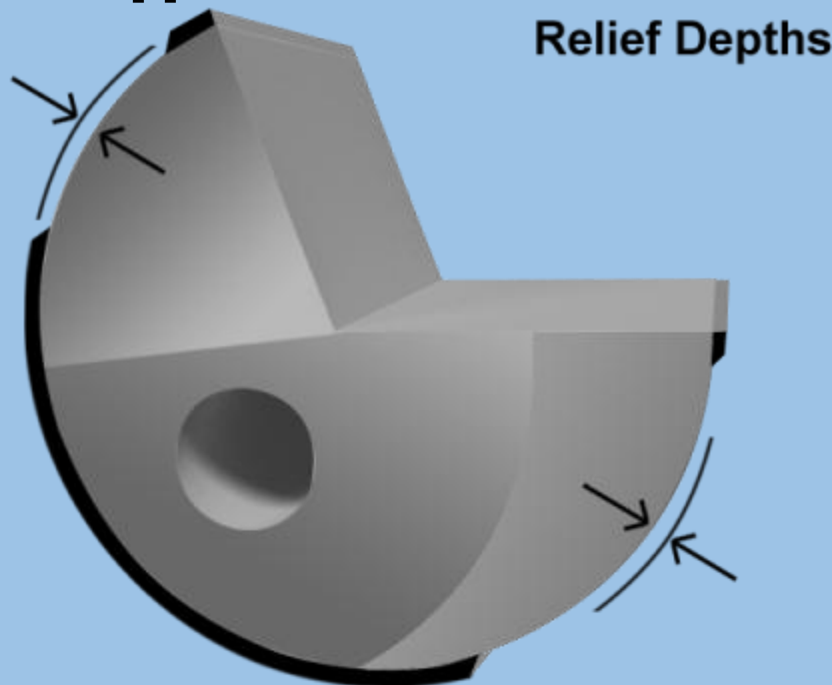
COPPER

Proper filtration of the coolant

No less than a 20 micron final filter but preferably 5. Gundrill machine manufactures employ at least a three stage filtration process, starting with 50-100 then down to 25 and final stage being the 5 micron. Any contaminant smaller than 5 micron will pass between the OD of the drill and the wall of the material being drilled, resulting in no scoring or lapping of material.

Relief Depths

Relief depths are undercuts placed in specified locations to allow coolant to lubricate the bearing pads therefore cooling the tool and obtaining optimal surface finishes. The depths of the reliefs are manufacturing standards and sometimes increased depending on the application.



Objects enhanced for visual representation

Contours

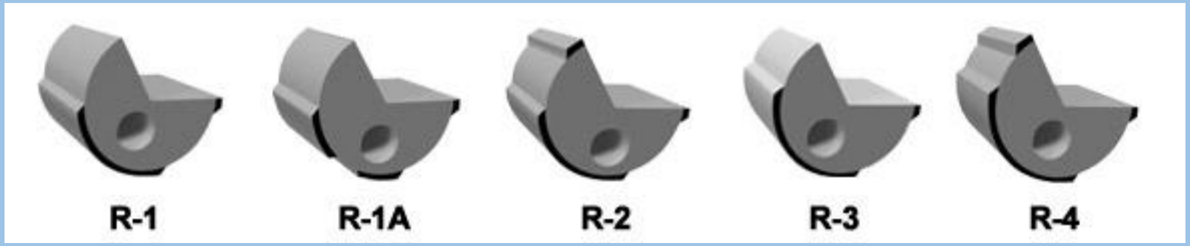
R-1 Standard contour. Non-Micable. Main use is for holes that do not crossover or intersect.

R-1A Pad break allows for more coolant flow is pumping system is not able to produce high pressures.

R-2 The trailing pad adds stability and can improve straightness. Caution, high temp alloys can contract slightly while being drilled.

R-3 Micable. More support and stability than an R1. Better surface finish, less drift. Good for interrupted cuts and cross holes. Nickel alloys do not react well to this contour.

R-4 Cast iron, Aluminum. Good to use when opening a hole.



Proper speed and feed for the material

Again, charts of all kinds are available to give you the starting points for any material. The best ones are charts that correlate SFM to hardness. 40 Rockwell D2 tool Steel must have a slower SFM than the same D2 at 26 Rc. Drill chipping, premature edge wear, or material buildup can occur when the SFM is off by even a few hundred RPM. Materials have speed limits, some more than others. Another chart to attack high temperature alloys is one that relates SFM to the % to a particular element found the metal. The most common of these 'nasty' elements are Chromium and Nickel. Let's look again at the elements chart.

RECOMMENDED FEED AND SPEED CHARTS ASSUME PROPER GUNDRILLING PROCESSES

VALUES BELOW ARE DESIGNED TO YEILD THE MAXIMUM NUMBER OF CYCLES WITH THE HIGHEST QUALITY HOLE

FASTER SPEEDS AND FEEDS ARE ACHIEVABLE, HOWEVER, CYCLES AND HOLE QUALITY MAY BE COMPROMISED

Tool Steels
D,S,M,0,H,P Series

Bhn	Rc	SFM
175-225	< 19	250
225-275	19-28	200
275-325	28-35	150
325-375	35-40	100

Cast Iron - Ductile

Bhn	Rc	SFM
125-175		300
175-225	< 19	250
225-275	19-28	200
275-325	28-35	150
325-375	35-40	100

Ductile Ni Resist -50%

Cast Iron - Grey

Bhn	Rc	SFM
125-175		400
175-225	<19	350
225-275	19-28	300
275-325	28-35	250

With Free Carbides -50%
Ni Resist -60%

Steel, Low, Medium Carbon
C1010-1550

Bhn	Rc	SFM
125-175		450
175-225	< 19	400
225-275	19-28	350
275-325	28-35	300
325-375	35-40	250
375-425	40-45	200

Alloy Steels
4000,5000,8000 Series

Bhn	Rc	SFM
175-225	< 19	350
225-275	19-28	300
275-325	28-35	250
325-375	35-40	200
375-425	40-45	150

Titanium
Most Grades

Bhn	Rc	SFM
125-175		260
175-225	< 19	220
225-275	19-28	180
275-325	28-35	140
325-375	35-40	100
375-425	40-45	60

Stainless Steel*
400 Series

Bhn	Rc	SFM
125-175		280
175-225	< 19	240
225-275	19-28	200
275-325	28-35	160
325-375	35-40	120
375-425	40-45	80

* Free Machining +30%

Stainless Steel*
300 Series + PH

Bhn	Rc	SFM
125-175		230
175-225	< 19	200
225-275	19-28	170
275-325	28-35	140
325-375	35-40	110
375-425	40-45	80

* Free Machining +30%

High Temp Alloy
Nickel Based

Bhn	Rc	SFM
125-225	< 19	120
225-325	19-35	90
325-425	35-45	60

Cobalt Based -40%
Iron Based +20%

Copper Alloys Beryllium,
Nickel Based

Bhn	Rc	SFM
125-225	< 19	200
225-325	19-35	130
325-375	35-40	60

Aluminum Alloys, Free Chipping
Brass, Magnesium, Soft Copper

	SFM
	600-700

CAUTION !

Gundrills must always be piloted or bushed when rotating except at the lowest of speeds.

Please consult your DME application specialist for assistance.

APPROXIMATE FEED RATES (IN/REV)

Diameter mm	Inch	Steel Carbon Low, Med	Steel Alloy Tool, 400 SS	Stainless 300 Series	Copper/ Titanium/ High Temp Alloy	Aluminum FC Cast Iron Grey	Cast Iron Ductile	Aluminum Soft Copper
1	0.039	0.00007	0.00007	0.00007	0.00005	0.00008	0.00008	0.00005
1.9	0.075	0.00011	0.00011	0.00011	0.00008	0.00011	0.00011	0.00008
2.54	0.1	0.00015	0.00015	0.00015	0.0001	0.00015	0.00015	0.0001
4.75	0.187	0.0003	0.0003	0.0003	0.0002	0.0003	0.0003	0.0002
6.35	0.25	0.00045	0.00045	0.00045	0.0003	0.0005	0.0005	0.0003
9.525	0.375	0.0007	0.0006	0.0006	0.0005	0.0013	0.001	0.0005
12.7	0.5	0.0008	0.0007	0.0006	0.0002	0.002	0.0015	0.0007
15.8	0.625	0.001	0.00085	0.0007	0.0007	0.0025	0.002	0.00085
19.05	0.75	0.0013	0.001	0.0008	0.0008	0.003	0.0025	0.001
25.4	1	0.0018	0.0015	0.001	0.001	0.004	0.003	0.0015
31.75	1.25 +	0.0023	0.002	0.0012	0.0012	0.005	0.0035	0.002

Parameters by Chemistry
Single Flute Gundrill

Use these charts when parameters cannot be found in any reference source, but the chemistry of the material is known.

Speed (Surface Ft./Minute)

%	Al	C	(Cb)	(Co)	(Cr)	Cu	Fe	Mg	Mn	(Mo)	(Ni)	Pb	Si	Sn	(Ta)	(Ti)	(V)	(W)	Zn	Zr
0.2	–	375	–	300	300	–	–	600	450	375	–	450	–	600	90	90	300	–	600	*
0.5	–	300	–	300	300	–	–	600	375	300	–	450	–	600	90	90	240	240	600	*
1.0	–	240	120	225	270	–	–	600	300	225	–	450	*	600	90	90	210	210	600	*
2.0	–	195	90	180	240	–	90	600	225	195	225	450	*	450	90	90	150	180	600	*
4.0	150	150	90	150	210	–	105	600	180	150	150	450	*	450	75	90	120	150	600	150
8.0	300	–	75	–	180	150	120	–	150	120	120	600	*	375	75	–	90	90	600	120
10.0	300	–	–	–	120	225	135	–	120	105	105	600	*	300	75	–	75	75	600	–
32.0	450	–	–	–	90	300	150	–	–	90	90	–	–	–	–	–	–	75	600	–
64.0	600	–	–	–	75	600	225	–	–	–	75	–	–	–	–	150	–	–	–	–
100.0	600	–	–	–	–	600	450	–	–	–	75	–	–	–	–	120	–	–	–	–

Legend:
Al= Aluminum **C**= Carbon **Cb**= Columbium **Co**= Cobalt **Cr**= Chromium **Cu**= Copper **Fe**= Iron
Mg= Magnesium **Mn**= Manganese **Mo**= Molybdenum **Ni**= Nickel **Pb**= Lead **Si**= Silicon **Sn**= Tin
Ta= Tantalum **Ti**= Titanium **V**= Vanadium **W**= Tungsten **Zn**= Zinc **Zr**= Zirconium

Note:

1. The starting SFM will be the value from the above chart matching the material's element percentage, then picking the <u>lowest</u> applicable SFM from all the elements. Pay particular attention to the toughest elements, which are bracketed ( ).

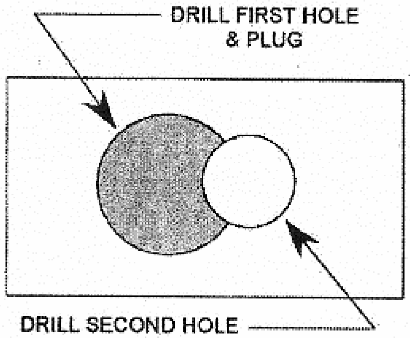
2. Materials around 30 Rc, reduce SFM by 20%; over 30 Rc, reduce SFM by 33%.

Feed (Inches/Rev.)

	Material	
Diameter	With ( )	Without ( )
.125 – .156	.00010 – .00025	.00020 – .00040
.156 – .250	.00025 – .00050	.00040 – .00100
.250 – .500	.00050 – .00100	.00100 – .00150
.500 – .750	.00100 – .00150	.00150 – .00200
.750 – 1.00	.00150 – .00200	.00200 – .00250
1.00 – 1.50	.00200 – .00250	.00250 – .00300

Some of the following tricks may seem obvious. On the other hand, there are sure to be a few that just haven't occurred to you yet.

Siamese holes– Drill the first hole, then plug it with a rod (preferably made from the same material as the workpiece; definitely not from a material which is more difficult to drill).

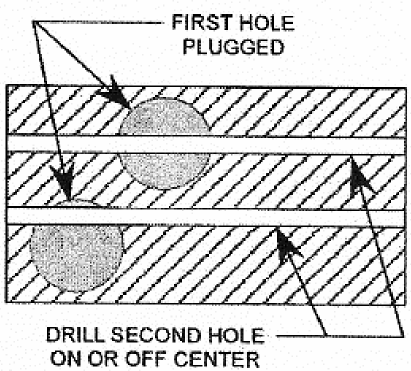


The rod doesn't have to be a press fit, but it should be of a diameter which will drag in the hole as it is being inserted. Sequence of drilling (large hole as opposed to small hole first) is not critical.

The plug can normally be rotated and reused a few to several times depending on fit in the hole as succeeding portions are drilled away.

Intersecting holes–

1. Breaking into a previously drilled hole (on center) with a smaller hole is usually not a problem.



2. If the smaller hole continues into the far wall of the larger hole, plug as described in 'A.' above.

3. In all cases where one hole intersects another off-center, plug the first hole. Even if a large hole is breaking into a previously drilled small hole, the interrupted cut can give you trouble.

Producing chips that do not become so long as to clog the chip box

In some cases the proper feed and speed that produces the most linier inches and the highest quality hole in regard to size and finish will produce chips that become long and even ribbon like. These can clog chip boxes, shutting down spindles with torque meters or breaking drills with those without. 1000 series low carbon steels come to mind. Chip breakers, dwells, or if you are drilling from 1mm to 12mm, incorporating a TriboMAM unit developed by M4 sciences (Nice product placement there) may be an answer.

Proper contour for the desired results

Examples of how the contour burnishes the hole and what the different pads can do on any particular application. At this point we are really tweaking an application finding the best position of these guide pads to achieve or the required tolerance.