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High-Pressure Coolant for Deep-Hole Drilling

A CUTTING TOOL ENGINEERING® webinar

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FEATURED ARTICLE

A FLUID CHOICE

How water-miscible fluid and neat oil stack up when deep-hole drilling with high-pressure coolant.

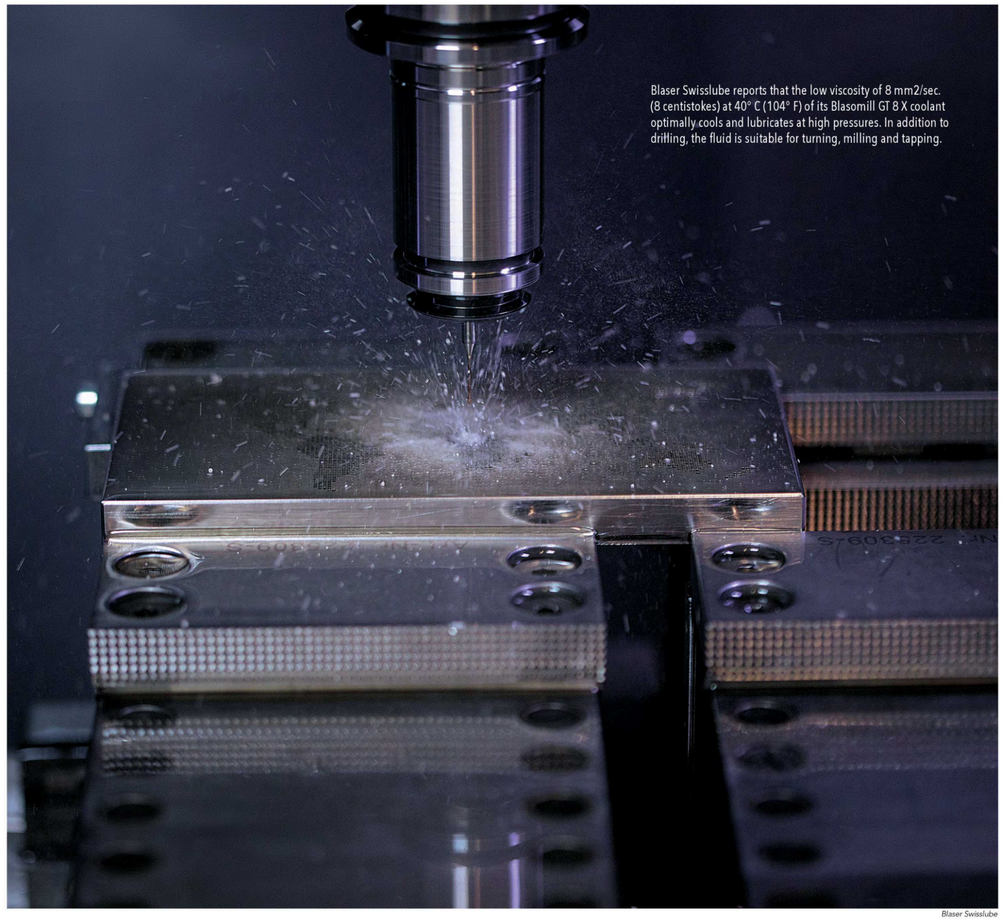
By Alan Richter

When drilling a deep hole with high-pressure fluid, the correct pressure and volume for the cutting tool diameter is a key component, but more critical for successful holemaking in the process itself. That's according to Tim Schneider, vice president of ATS Systems, with locations in Rancho Santa Margarita, California, and Sewickley, Pennsylvania. The company manufactures CoolJet high-pressure coolant delivery systems and distributes Masterall water-soluble, or water-miscible, metalworking fluids from Etna Products Inc. in Chagrin Falls, Ohio. "We know that brand works with high pressure."

He recommends a two-step process, starting with the longest standard drill for the hole diameter being

ATS Systems

Drilling demonstration on 1018 steel. Click image to play video.



Blaser Swisslube reports that the low viscosity of 8 mm2/sec. (8 centistokes) at 40° C (104° F) of its Blasomill GT 8 X coolant optimally cools and lubricates at high pressures. In addition to drilling, the fluid is suitable for turning, milling and tapping.

Blaser Swisslube

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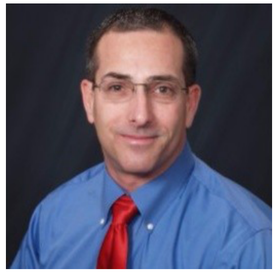
INTRODUCTIONS

Presenters



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Tim Schneider
ATS Systems

High-pressure Cooling for Deep Drilling

Enhancing Precision and Efficiency

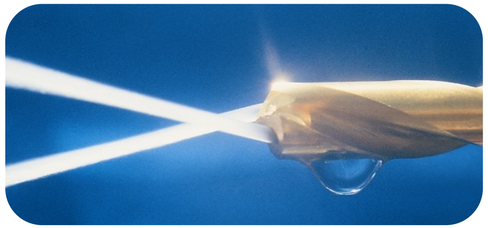
Presented by: Tim Schneider, ATS Systems

Agenda

- Introduction
- Brief Overview of deep-hole drilling
- Importance of high-pressure coolant systems
- Case studies and examples
- Orifice Sizing & Machine Requirements
- Coolant Concentration Recommendations
- High-Pressure Applications
- Q&A session

High-Pressure Coolant In CNC Machining

DRILL FASTER



MILL FASTER

TURN FASTER

Why High-Pressure Coolant

COOLJET SYSTEMS

High-Pressure Applications

High-Pressure Case Studies

Coolant Volume Rules of Thumb

Coolant Concentration Recommendations

Orifice Sizing & Machine Requirements

Recommended Deep Hole Drilling Process

Machine Programming

Cntrl Click the topic to navigate to a specific section

Recommended Deep Hole process

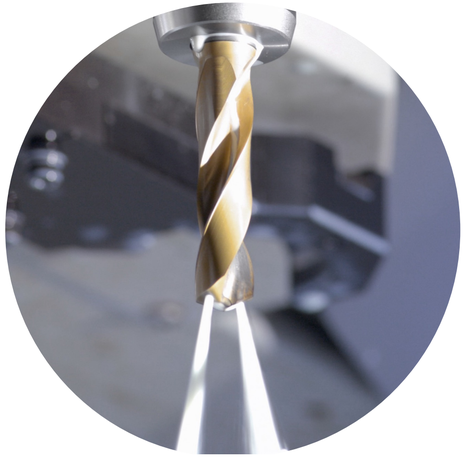
1. Start the hole with the longest stock through coolant solid carbide drill – <u>All drills must be indicated</u>
2. Next using a long drill to finish the hole, (either a twist drill or gun-drill),
   - Start the coolant flow before entering the pilot hole.
   - After you get into the hole start your rotation and continue the process.
   - Note: Both of the drill must have the same point geometry.
3. If you come to a cross hole or a breakthrough you must reduce speed and feed 50%.

Why High-Pressure Coolant?

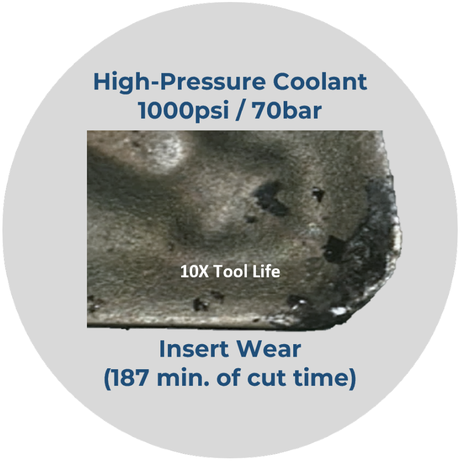
UltraFlex®

Machine tools operating with high-pressure coolant will benefit by experiencing increased efficiency and performance enhancements such as:

✓Faster Cutting



✓Longer Tool Life



✓Controlled Chips

COOLJET SYSTEMS

High-Pressure Coolant

Properly Applied High-pressure Coolant Addresses

- ✓ Heat Damage
- ✓ Chip Damage
- ✓ Poor Lubricity

The Application Of High-Pressure Coolant

- ✓ Gets the proper coolant force at the Chip/Tool Interface
- ✓ Allows tools to wear instead of fail from heat damage
- ✓ Aids in chip breakage (a cold chip will break much easier than a hot chip)
- ✓ Rapidly evacuates all chips from the point of cut
- ✓ Increases tool life
- ✓ Allows Faster Speeds & Feeds

Proper Applied High-Pressure Coolant

Properly Applied High-Pressure Coolant Requires:

1. The proper Volume
2. The proper Pressure
3. The proper Orifice Size(s)
4. The proper Coolant Concentration
5. The proper Filtration

There are five key components to properly applying High-Pressure Coolant.

If you miss just one of these, you will negatively impact your results.

Fixed Flow vs. Variable Flow

Pros

- ✓ Lower cost
- ✓ Ease of installation
- ✓ Ease of trouble shooting

Cons

- ✓ Fixed flow can be either too much or too little
- ✓ Can consume unnecessary energy
- ✓ May generate excess heat due to bypass

Pros

- ✓ Adaptive, system pumps only as much volume as the process requires
- ✓ Maintains optimum pressure
- ✓ Reduces heat build-up in coolant
- ✓ Simple to automate for selectable pressures (i.e. 300, 750, 1000)

Cons

- ✓ Higher purchase cost
- ✓ Specialized knowledge/programming may be required for installation
- ✓ Skill for troubleshooting/support

Force on the Cutting Edge

Tool Orifice Size and aiming point are critical

HIGH ENERGY JET

99% EFFECTIVE

2% EFFECTIVE

STANDARD LOW ENERGY

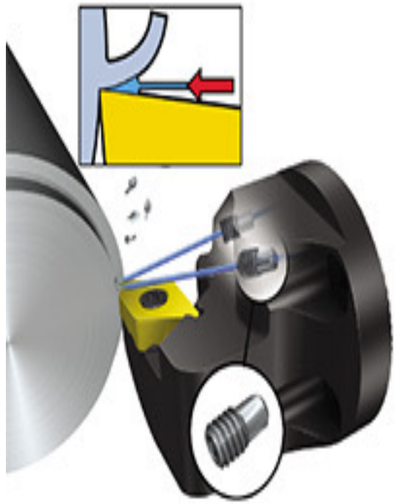
Properly Directed Coolant Flow

- ✓ Direct to the cutting edge
- ✓ 10º angle off the face of the insert
- ✓ No greater than 25º angle
- ✓ 45º or greater forces chip back into the cut

25° Recommended Max

10° Recommended Min.

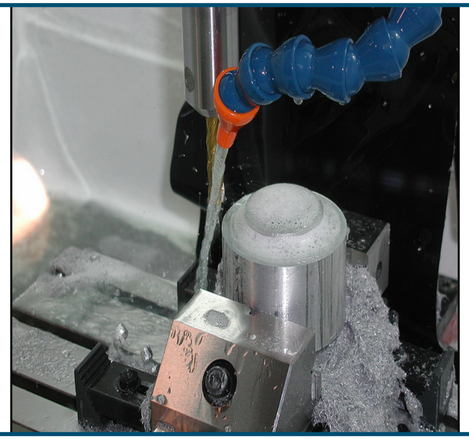
Recommended Angles For Coolant Delivery When Using High-pressure Coolant

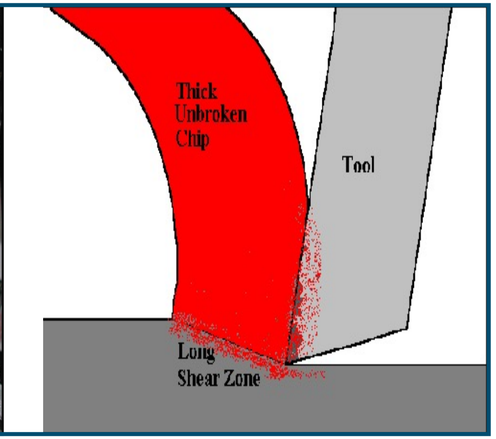


Low-Pressure Coolant vs. High-Pressure Coolant

Low-Pressure Coolant Delivery

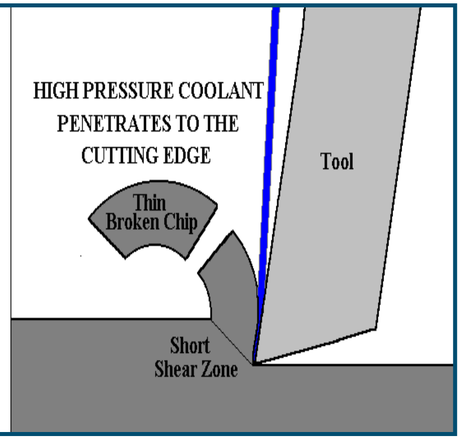
Low-pressure coolant does not have enough force to get to the tooltip, so it provides no benefit to the cutting process.





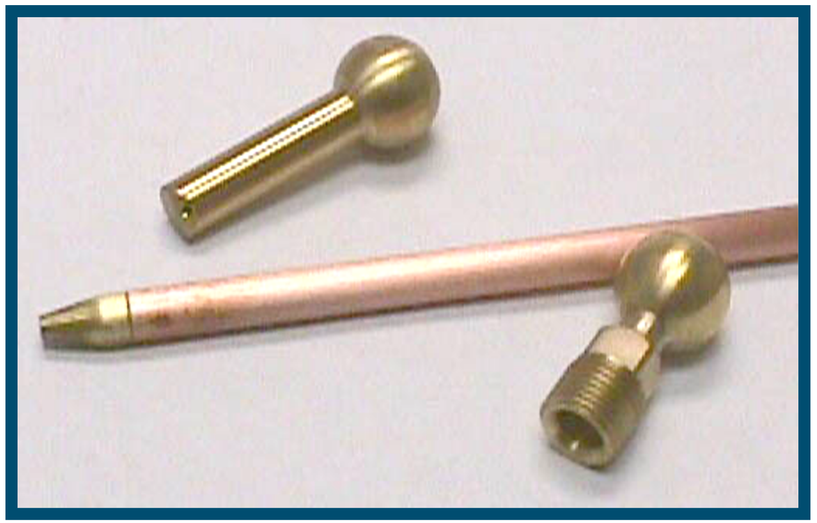
High-Pressure Coolant Delivery

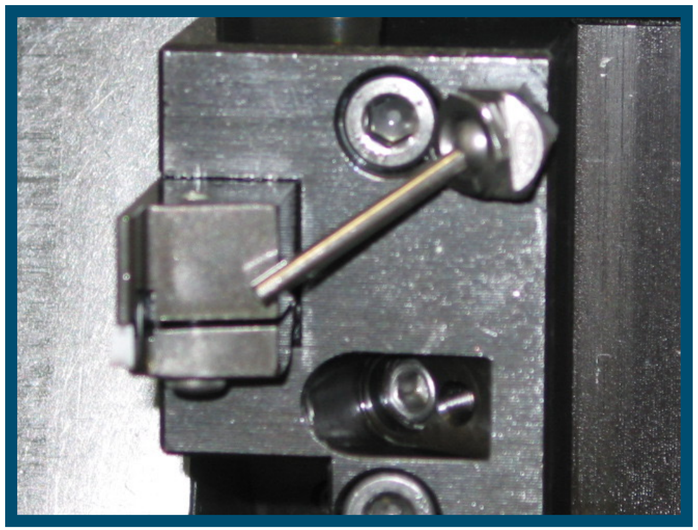
High-pressure coolant reduces friction by getting coolant to the tooltip and takes the heat out of the process. This allows tools to hold their edge longer, as a result, you can run tools faster.



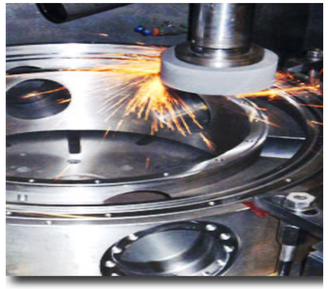
Coolant Nozzles

Nozzle Examples





Volume & Orifice Data

Drilling	Milling	Turning	Grinding
			
Rule	Rule	Rule	Rule
9 gpm per 1” of tool Dia.	1 gpm per Tooth	.5 gpm per 1hp	9 gpm per 1” of wheel Dia.
36 lpm per 25mm of tool Dia.	4 lpm per Tooth	2 lpm per .75kw	36 lpm per 25mm of wheel Dia.

Setting up a Machine for High-Pressure Coolant

Tooling Requirements:

- ✓ Make sure all tooling using high-pressure coolant has the proper orifice size to ensure the high-pressure unit will be able to maintain the proper pressure.
  - The tooling orifice must be appropriately sized to maintain pressure
    1. 9gpm / 36lpm = a maximum tool orifice of .100
    2. 16gpm / 60lpm = a maximum tool orifice of .140
    3. Use an orifice calculator to determine the orifice size required based on the number of turrets and tools that will run simultaneously.

Continued Next Slide

Setting up a Machine for High Pressure Coolant

Machine tool Requirements:

1. Be sure that the machine tool turret(s) is prepped to handle 1,000psi / 70bar coolant.
   - The tool stations need to accept proper plumbing to support High Pressure Through Coolant operations.
2. The machine must have an available M-Code to turn high-pressure coolant on and off.
   - Additional M-Codes are required if multiple pressure settings are desired.

Continued Next Slide

Setting up a Machine for High Pressure Coolant

Unit Sizing Requirements:

1. For Lathes .5 gpm / 2 lpm per hp/kw
2. Minimum flow is 4gpm / 15lpm per turret
3. Unit Type:
   - Fixed Flow is acceptable if
     - All tooling will have the proper orifice size to ensure using all of the available volume to prevent excess heat build-up in the coolant
   - Variable flow should be used if –
     - There will be multiple orifice sizes or multiple pressure settings are desired

Setting up a Machine for High Pressure Coolant

Machine Programming:

1. The machine program should be set to turn high pressure on at the start of the program and then turned off at the end of the program.
2. The coolant unit should be interfaced to accept the Turret Index Signal where the coolant unit goes to Bypass but does not shut off.

Coolant Concentration

Single Point Tools	**5%**	
Drills	**8%**	
Reamers	**10%**	
Taps	**12%**	

Case Study – Tool Life

Productivity Improvements Utilizing High-Pressure
Titanium 6AL4V Material

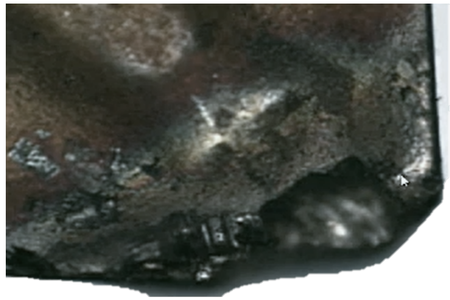
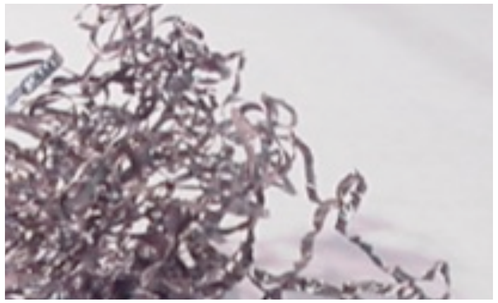
Before High Pressure

Speed	LOC	IPM	# of Pecks	# of Cuts
90 SFM	.630 Inch	2.65	2	100

After High-Pressure = 16x Tool Life

Speed	LOC	IPM	# of Pecks	# of Cuts
116 SFM	.630 Inch	7.9	0	1680

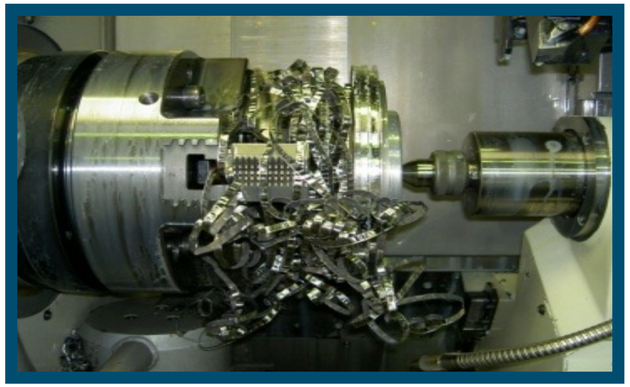
Case Study – Tool Life

718 Inconel	
High-Pressure Coolant 1000psi / 70bar	**Low Pressure Flood Coolant**
Insert wear at 187 min. of cut time 	Insert wear at 18 min. of cut time 
Smaller manageable chips 	Longer stringers 

Case Study – Chip Control

Productivity Improvements Utilizing High-Pressure

Exotics



Pumping Unit	Pressure	Volume
Centrifugal	100 PSI	8 GPM

Superior Chip Control

Pumping Unit	Pressure	Volume
High Pressure	1000 PSI	8 GPM

Case Study – Chip Control

Productivity Improvements Utilizing High Pressure

- ✓ “HPC” is not a chip-breaker, it simply promotes more aggressive cooling
- ✓ Cold chips break much easier than hot chips.
- ✓ After cutting, loose chips are easily flushed away.

Case Study – Increased Speed

Productivity Improvements Utilizing High-Pressure

Drilling 4320 Material

Before High Pressure

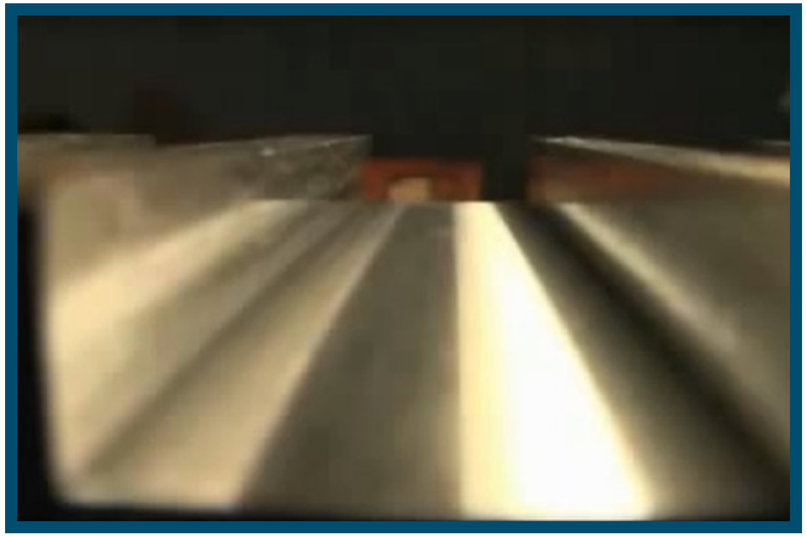
Diameter	SFM	Depth Inch	FPR	IPM
.3906	600	1.25	.008	47

After High-Pressure = 3x Cutting Speed

Diameter	SFM	Depth Inch	FPR	IPM
.3906	1140	1.25	.0125	140

Improved Part Finishes

ATS/CoolJet Quick Product Reference



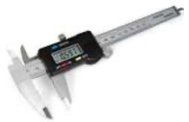
High-Pressure Finish

Low-Pressure Finish

Note:

When drilling with high pressure the hole is typically undersized and has such a good finish that reaming operations to improve the part finish is not required.

High-Pressure Applications

Any Application	Any Material	Any Industry
Drilling 	Aluminum	Automotive 
Turning 	Steel	Aerospace 
Milling 	Brass	Medical 
Grinding 	Titanium	Heavy Equipment 
Gauging 	Plastics	Energy 

Meeting The Machine Tool Industry Needs With High Quality, High Value Accessories

Thank you for your time and attention

Brett Reynolds
Presenter
Blaser Swisslube

Gun drilling and fluid selection

Brett Reynolds, CMFS
Sr. Application Engineer

Blaser. SWISSLUBE

Content

- Deep hole drilling
- Gun drilling
- Gun drilling diameter ratios
- Gun drill types
- Metalworking fluid requirements
- Fluid delivery
- Other considerations
- Common issues with gun drilling
- Case study

Deep hole drilling

What is a deep hole drilling?

- A hole with a depth at least 5 times greater than the diameter.

What type of drills are used for deep holes?

- Twist Drills (Typically on a CNC Machining Center or Turning Center)
- Single Lip Gun Drill
- BTA/STS (Single Tube System)
- Ejector Drill (Double Tube)

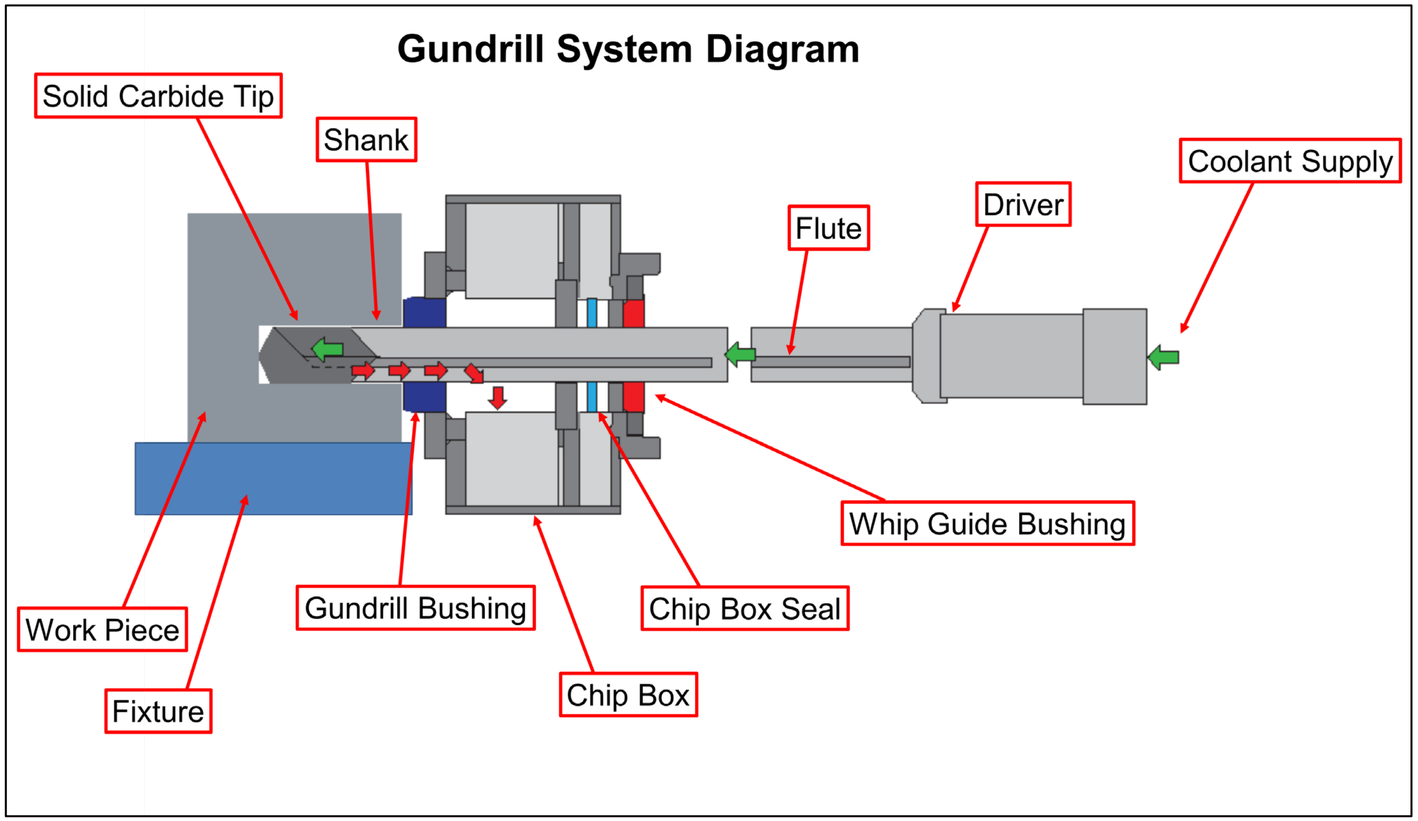
Deep hole drilling

Twist Drills – (Parabolic fluted long length drills) - The design features of this drill with the appropriate cutting parameters, result in chips that are evacuated problem free even from deep holes.

When deep hole machining on CNC machining centers a hole depth of less than 50:1 ratio is recommended.

Gun drilling

Gun Drilling - A method for making deep straight holes. Gun drills are straight fluted drills which allow cutting fluid to be injected through the drill's hollow body to the cutting face. A depth-to-diameter ratio of 300:1 or more is possible.



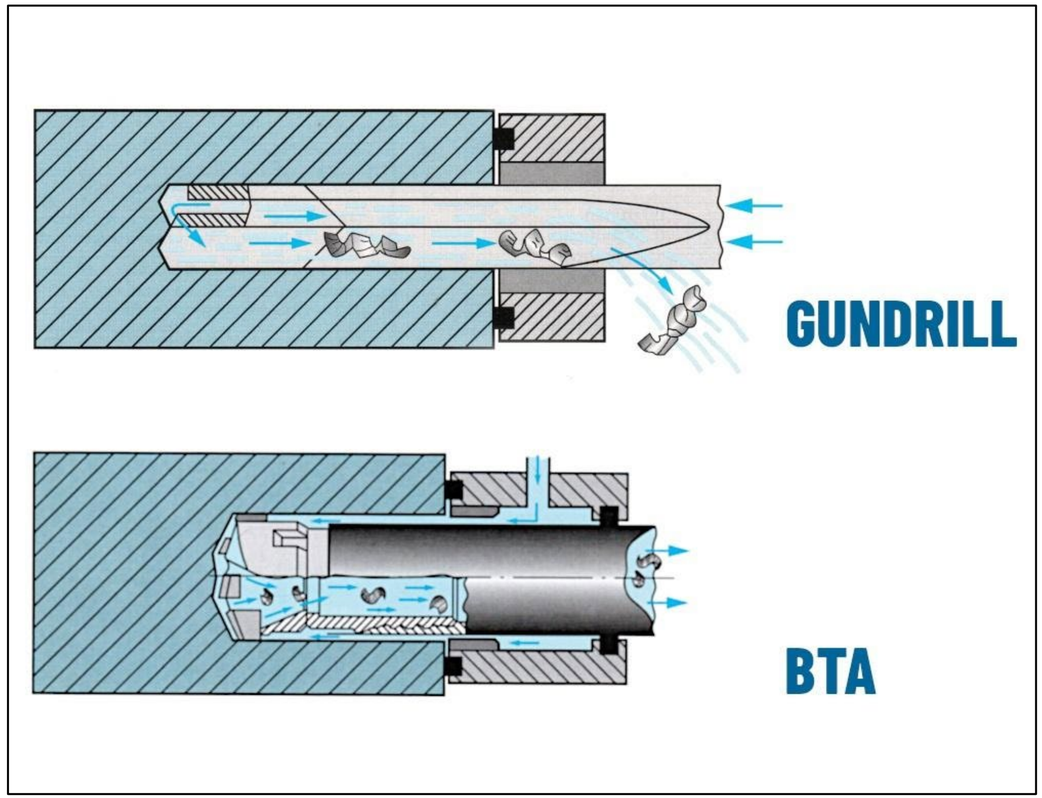
Gun drilling diameter ratios

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	Gun drilling tools on dedicated gun drilling machine
200.1	Gun drilling tools on high performance gun drilling machine
400.1	Extreme drilling range, proprietary processes and equipment required

Gun drill types

Gun Drill (Conventional Single Lip) - The cutting tool is a fluted solid rod that has a hole bored down the center. Fluid is pumped through a hole internal to the drill body. Fluid flows back outside the drill, through the flute, bringing the chips with it. Max diameter 3 inches

BTA / STS (Boring and Trepanning Association / Single Tube System) - The cutting tool is a tube. Fluid is pumped in around the outside of the cutting tool and removes chips through the center tube. Because tubes have minimum sizes, this is only an acceptable technology for holes of over 15.6 mm (0.614”) in diameter.



Metalworking fluid requirements for gun drilling

Gun drilling is a demanding operation which requires a metalworking fluid with high lubrication properties.

Historically, neat oil has been used for gun drilling, but we are now seeing water miscible coolants being utilized as well.

Water miscible coolants allow higher feed rates and faster quenching properties when compared to neat oil, however tool life may decrease when compared to neat oil due to lower lubricity.

Metalworking fluid requirements

Regardless of metalworking fluid type, fluids for gun drilling require high levels of performance additives.

Traditional extreme pressure (EP) additives utilized in gun drilling fluids are:

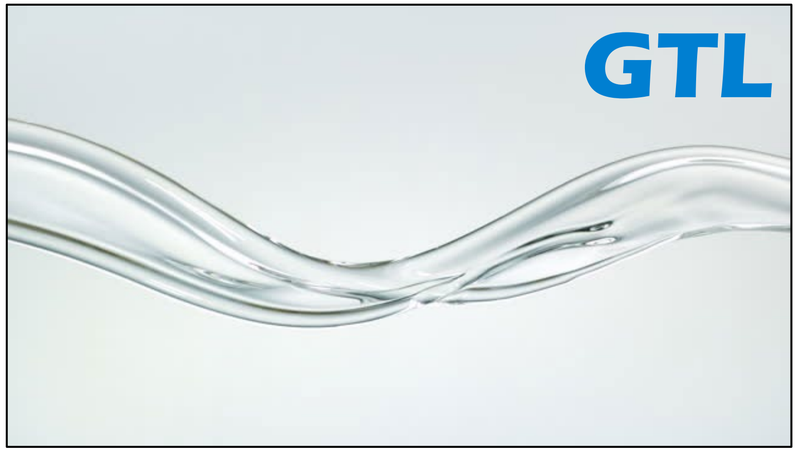
- Sulfur
- Chlorine
- Phosphorous

A combination of the above additives provides a wide temperature range of protection for the cutting tool.

Metalworking fluid requirements

Base oil selection along with proper viscosity, provide additional benefits in the delivery of key EP additives:

- Ester base oils have enhanced boundary lubrication properties due to their unique polar structure. Esters offer a higher viscosity index (HVI) when compared to paraffinic mineral base oils.
- Gas to Liquid (GTL) have faster air release properties and offer high viscosity index (HVI) characteristics, as well as lower cost traditionally associated with full synthetic base oils also know as Polyalphaolefins (PAO).



Fluid delivery

Proper fluid delivery is critical in any hole making operation but especially important in deep hole and gun drilling applications. Its important that the cutting fluid reaches the drill tip to provide optimal cutting performance.

In addition, adequate coolant pressure is needed to ensure that chips are evacuated quickly away from the cutting zone.

Other considerations

- Filtration of the fluid to at least 10 micron or finer if recommended.
- Fluid chiller for adequate temperature regulation. Excessive heat can cause rapid oxidation of neat oils.
- Periodic maintenance of the fluid. This especially applies to water miscible coolants.
- Periodic lab testing to check the various parameters of the metalworking fluid.
- Customer support and technical know how.

Common issues with gun drilling

TOOL PROBLEMS												
Excessive Heat	Flute Packing	Cratering	Built-Up Edge	Pickup/Smearing on Margin	Wear Pad Eroded	Flank Wear	Margin Wear	Tool Breakage	Poor Tool Life	Oversized Holes	Undersized Holes	POSSIBLE CAUSES
•				•		•		•				Insufficent Flow
•		•	•	•	•		•		•			Wrong Product
										•		Pressure too High
	•			•				•	•		•	Pressure too Low
									•			Overheating
	•							•				Pressure Loss

Case study

Customer specialized in the manufacturing of parts for the mining industry

Component	Pins	Operation	Gun Drilling
Material	Alloy Steel	Drill Diameter	7.5 mm
Machine	GSK-928-TE2	Drill Length	450 mm

	Competitor Oil	Blaser Blasomill 10 DM
Feed Rate	25 mm / min	42.5 mm / min
RPM	1800	2150
Tool Life / # of Parts	70	85
Cycle Time	1140 seconds	630 seconds

Result

- Overall machining costs were reduced by 45%
- Tooling costs per component was reduced by 18%

Thank you

Blaser.
SWISSLUBE

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QUESTIONS

- What concentration level are you running at? What is the PSI you recommend for gundrill parts?
- Deep hole drilling 1/16 diameter, very close runout. What do I need to make this work?

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QUESTIONS

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Thank you for watching!

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Ask CTE Contributors: Threading

April 24th, 12pm CST