Technical Data

Stone Code Explanation Chart & Surface Finish Guide

K8 — A 5 7	Abrasive Types	Grit Size	Hardness
Series — **Abrasive Type** — **Grit Size** — **Hard-ness**	**A** - Aluminum Oxide **C, J** - Silicon Carbide **DM, DR, DV** - Diamond **NM, NR** - CBN	**1-** 70 **8-** 400 **2-** 80 **9-** 500 **3-** 100 **0-** 600 **4-** 150 **80-** 800 **5-** 220 **90-** 900 **6-** 280 **10-** 1000 **7-** 320 **00-** 1200	**1-** Soft **3-** **5-** **7-** **9-** **11-** **13-** **15-** Hard

Note: For special abrasive needs, contact your Sunnen Field Engineer.

Approximate Surface Finish in Micrometers (µm)Ra

Material	Abrasive Type	Grit Size 80	100	150	220	280	320	400	500	600	1200
Hard Steel	Aluminum Oxide/ Silicon Carbide	0,65	-	0,50	0,45	0,30	0,25	0,12	0,08	0,03	
	CBN	-	1,40*2,00	1,15	1,00	0,70	-	0,50	-	0,18	0,05
Soft Steel	Aluminum Oxide/ Silicon Carbide	2,00	-	0,90*1,40	0,65	0,50*0,90	0,40	0,18*0,25	0,10*0,20	0,05	
	CBN	-	1,60*2,50	-	1,25*2,00	-	-	0,65	-	0,40	0,12
Cast Iron	Silicon Carbide	2,50	-	0,75*1,00	0,50	0,30	0,25	0,15	0,12	0,08	
	Diamond	-	-	-	2,00	-	-	1,27	-	0,50	0,30
Aluminum, Brass, Bronze	Silicon Carbide	4,30	-	2,00	1,40	0,85	0,70	0,40	0,30	0,05	
Carbide	Diamond	-	-	0,75	0,50	-	-	0,18	-	0,08	0,03
Ceramic	Diamond	-	-	1,27	1,00	-	-	0,50	-	0,40	0,25
Glass	Diamond	-	-	2,40	1,80	-	-	0,75	-	0,40	0,20

Surface Finish Conversions: Millimeter to Inch—To convert one unit of measure to the other use the following formulas.

Micrometer to microinch: Micrometer x 40 = Microinch

Formulas for determining minimum stock removal required on diameter to achieve desired surface finish.

Surface Finish in Micrometers—(µm) R_a

$$\frac{\text{Existing Finish - Desired Finish}}{100} = \text{Required Stock Removal}$$

Example: Existing Finish = 1.25 µm; Desired Finish = 0.25 µm

$$\frac{1.25 - 0.25}{100} = 0.01 \text{ mm}$$

Approximate Surface Finish in Microinches (µ in)Ra

Material	Abrasive Type	Grit Size 80	100	150	220	280	320	400	500	600	1200
Hard Steel	Aluminum Oxide/ Silicon Carbide	25	-	20	18	12	10	5	3	1	
	CBN	-	55*80	45	40	28	-	20	-	7	2
Soft Steel	Aluminum Oxide/ Silicon Carbide	80	-	35*55	25	20*35	16	7*10	4*8	2	
	CBN	-	65*100	-	50*80	-	-	25	-	16	5
Cast Iron	Silicon Carbide	100	-	30*40	20	12	10	6	5	3	
	Diamond	-	-	-	80	-	-	50	-	20	12
Aluminum, Brass, Bronze	Silicon Carbide	170	-	80	55	33	27	16	12	2	
Carbide	Diamond	-	-	30	20	-	-	7	-	3	1
Ceramic	Diamond	-	-	50	40	-	-	20	-	15	10
Glass	Diamond	-	-	95	70	-	-	30	-	15	8

Surface Finish Conversions: Inch to Millimeter—To convert one unit of measure to the other use the following formulas.

Microinch to micrometer: Microinch ÷ 40 = Micrometer

*If two values are shown: the first number is for small parts, honed on machines with one horsepower or less; the second number is for large parts, honed on machines with two or more horsepower.

Formulas for determining minimum stock removal required on diameter to achieve desired surface finish.

Surface Finish in Microinches—(µ") R_a

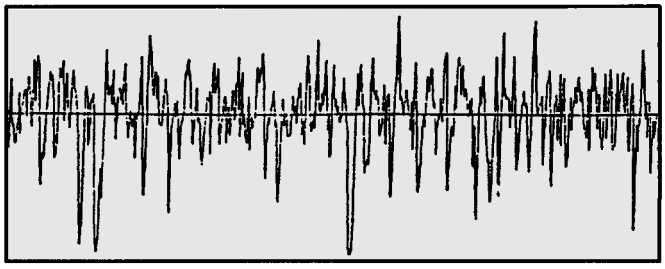
$$\frac{\text{Existing Finish - Desired Finish}}{100{,}000} = \text{Required Stock Removal}$$

Example: Existing Finish = 50 µm"; Desired Finish = 10 µm"

$$\frac{50 - 10}{100{,}000} = 0.0004 \text{ inch}$$

This is what a rough honed surface looks like, magnified 400 times:

But it usually is shown like this:

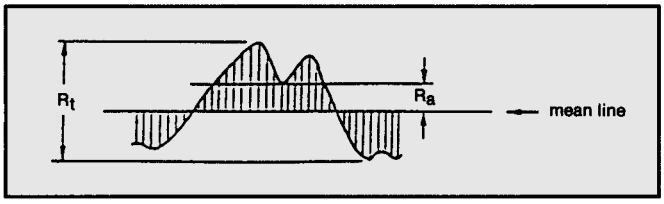


The vertical magnification is now 4000 times, so it can be seen better. The horizontal magnification is now only 40 times, to save paper. Both graphs show the same surface finish.

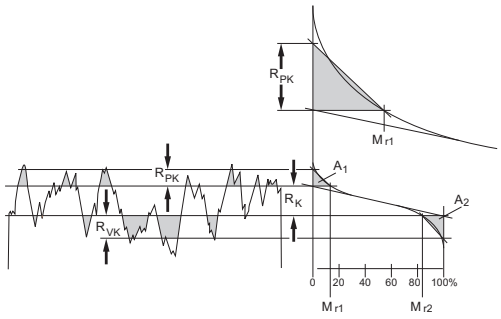
Surface Finish Parameters

Modern surface texture analyzers have the capability of measuring a variety of surface texture parameters. Every parameter has its advantages and limitations. A summary of some of the more commonly used parameters is given below.

Ra is the most widely used description of a surface. If you could level all the peaks to fill in all the valleys you would have a mean line. The arithmetic average of the deviations up and down from this theoretical mean line is Ra.



Rt is the distance from the highest peak to the deepest valley. Rt is rarely specified, but it is useful for detecting honing problems, like pick-up or areas which have not cleaned up. If Rt is much more than 10 times Ra you either have a honing problem or a plateau-honed surface.



CLA (center line average) is used in Britain and is identical to Ra.

Rz DIN, also known as **Rtm** is the same as Rt, but while Rt is established over the entire measuring length, Rz DIN divides the measured length into five equal lengths and then averages the Rt readings of each of the five lengths. Rz DIN is likely to be a slightly smaller number than Rt because one deeper scratch is diminished by the finer finish of the other four values.

Rz ISO (ten point high). The average height difference between the five highest peaks and five deepest valleys. This is the best method for short surfaces.

Rmax (same as Ry or Rma) is the distance of the highest peak to the deepest valley in any of the five sections mentioned in Rz DIN.

Rp (maximum peak height above mean line). The height of the highest peak above the mean line in five sampling distances.

Rpm (mean peak height above mean line). The average of the distances above the mean line of the five highest peaks in the total sampling distance.

RMS, Rq (root mean square). An obsolete definition; same method as Ra, but using a different mathematical principle. Results in a value about 15% higher than Ra.

Rk The main bearing area of a surface, ignoring the highest peaks and deepest valleys. The magnitude of these peaks and valleys can be defined as Rpk and Rvk respectively.

Parameter Conversion Formula*

For a one grit size developed surface finish to convert a known Ra value to a different parameter, use the following formula (These ratios do not apply to composite grit surface finishes - such as "plateau" or surface finishes from other machining processes):
Ra x Parameter Factor = Desired Parameter
Ex: 1.0 micrometer Ra x 8.7 (Rt Factor) = 8.7 micrometer Rt
Ex: 40 microinch Ra x 8.7 (Rt Factor) = 348 microinch Rt

*These conversions are approximate values for general information only and apply only when checking a standard honed finish.

Parameter	Factor
Rt	8.7
Rz	7.2
Rz ISO	7.6
Rmax	8.0
Rp	3.6
RPM	2.9
RMS	1.1

Symbol	Definition
R_k	Core roughness depth
R_{pk}	Reduced peak height
R_{vk}	Reduced valley depth
M_{r1}	Peak material ratio
M_{r2}	Valley material ratio

Technical Data
Alteration of Honing Units

Sunnen honing units have been designed to handle most honing jobs without alteration. However, as tolerances on the job become closer, it becomes more essential that tooling comes closer to meeting the ideal requirement of the bore. Alteration of the stone and guide shoe may be necessary to provide a honing unit for the particular job. One or more of three basic types of alteration to honing units may be required on some applications: (1) for short open holes, (2) for blind holes, or (3) for alignment of tandem bores. All of these alterations can be made quite easily and very quickly in your own shop. For long production runs or repeat jobs it may be advantageous to order altered stones or mandrels from the factory.

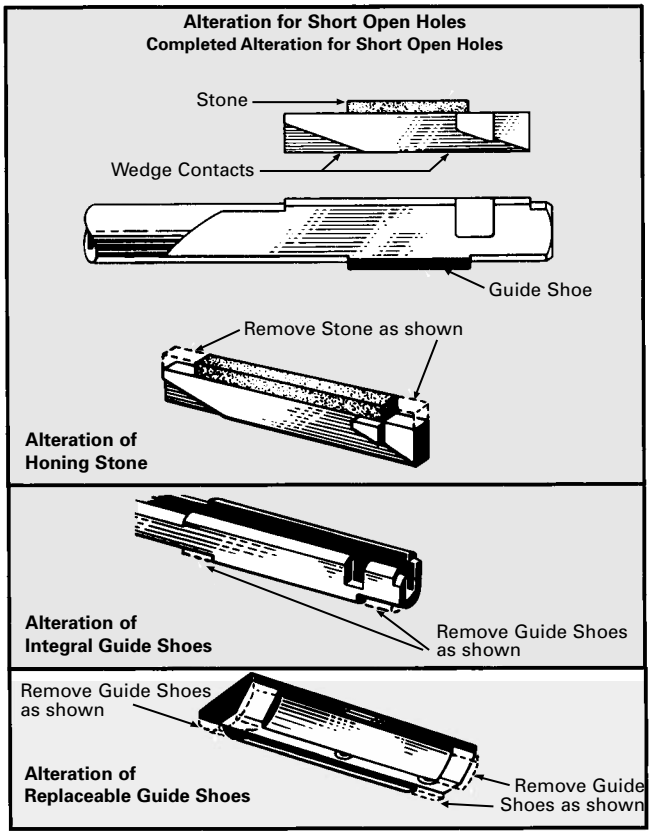
How to Alter Stone, Mandrel, and Guide Shoes

When alteration of the honing tool is necessary use the following procedure:

Conventional Abrasives—Aluminum Oxide (A) and Silicon Carbide (J and C), cut through the abrasive with an old hacksaw blade and break off the unwanted section with a pair of pliers. Avoid breathing dust. Wash dust from hands to prevent skin irritation.

Superabrasives—Diamond (D) and CBN (N). Remove the unwanted section by grinding on a bench grinder. Avoid breathing any mist or dust. Wash dust from hands to prevent skin irritation.

Do not alter the metal stoneholder (except as described under blind hole alterations). Use a file or bench grinder to shorten the mandrel guide shoes. Avoid breathing any metal dust. Wash dust from hands to prevent skin irritation.

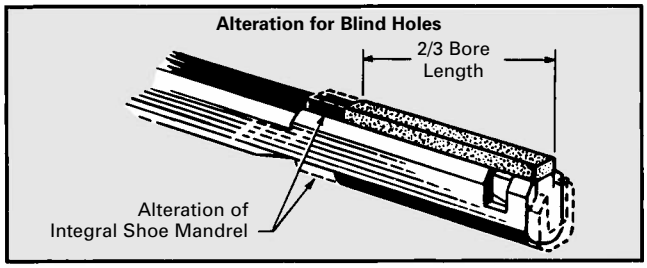


Alterations for Short Open Holes—Always consider the possibility of stacking parts with short bores so that they may be honed as one long bore using standard honing units. Individual parts (if they have at least one flat face) with bore lengths of 1/4 the diameter, or less, can also be honed by holding the parts flat against the face plate of the KKN-100 Honing Fixture (see page 96). For precision sizing of short open holes, THE STONE AND GUIDE SHOE LENGTH SHOULD BE BETWEEN 2/3 AND 1-1/2 TIMES THE BORE LENGTH to be honed. When alteration is necessary, both the stone and guide shoes must be shortened by the same amount. Any alteration of this type should shorten the stone and shoes equally from both ends so that the honing area remaining is centered over the wedge contacts on the stoneholder.

If greater accuracy is required than is obtained after the alteration, refer to the "Honing Guide" in your Honing Machine Operating Instruction Manual. Additional information can also be obtained by contacting the Customer Service Dept. and requesting a copy of Data File 102, "Honing Short Bores."

Alterations for Blind Holes—If at all possible, provide a relief (undercut) at the closed end of the hole to permit the stone to overstroke the honed surface. The relief can be cut to a depth that will actually blend in with the bore when finish honed, but it should be as long as possible, preferably 1/3 the length of the stone.

Sunnen honing units in the K, J-K, AK, J-AK, BL, L, BAL, AL and P28 groups can be utilized for honing bores that have one end closed. In honing blind holes, it is necessary for the stone and guide shoes to extend flush with the tip of the honing unit. If your application utilizes one of the P28 group of honing units, install the blind hole wedge and R28 Honing Stones and move end guide shoe flush with end of mandrel (see page 59). The remaining mandrel groups have a tip which extends slightly beyond the front end of the stone and guide shoes. For blind hole work this tip must be cut off, as illustrated. Mandrels which have been altered in this manner can still be used for honing open holes using a full length stone and guide shoes. P20 and D Honing Unit groups are not adaptable for honing blind holes. Blind Hole Y mandrels are available on a special order basis.

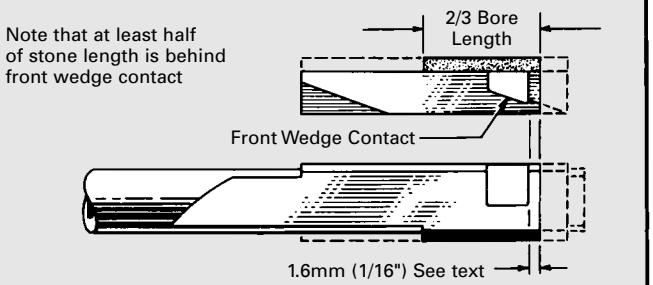


In honing blind holes, the STONE AND GUIDE SHOE LENGTH SHOULD BE BETWEEN 1/2 AND 2/3 THE BLIND HOLE LENGTH. This is necessary to provide for proper stroking. When alteration of the stone and shoe length is necessary, remove material only from the back end as shown.

To maintain stability of the stone in the mandrel, it is important that at least 50% of the stone be behind the forward wedge contact on the stoneholder. Otherwise the stone could rock, causing bore inaccuracies as the work is stroked over the honing unit. To avoid any chance for the stoneholder to "rock" when honing extremely shallow or short blind holes, it may be necessary to cut back the metal stoneholder (as well as the abrasive), mandrel, shoes and wedge tip so that only 1,6 mm (1/16") extends beyond the front wedge contact. Pressure from the wedge is then applied evenly to the stoneholder.

Some improvement can be obtained in honing blind holes where no relief is possible at the blind end by using a "HARD-TIP" stone. The front section of the abrasive has a harder bond than the rest of the stone. This harder abrasive reduces the excessive wear that the stone tip is exposed to when no relief is present. Refer to the Available Stone Sections of this catalog for information on hard-tip stones. Additional information can also be obtained by contacting the Customer Service Dept. and requesting a copy of Data File 103, "How to Hone Blind Holes."

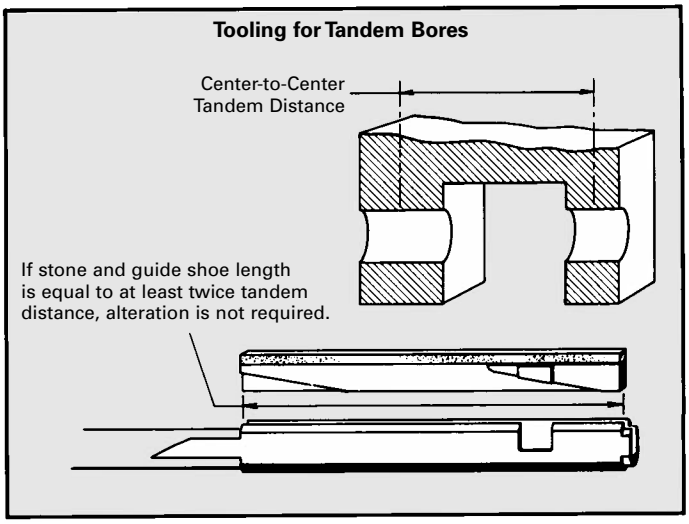
Alteration for Extremely Short Blind Holes



Alterations for Tandem Holes—Sunnen honing units can be used to size two or more "in-line" or tandem bores in perfect alignment. Stone and guide shoes must be of the proper length so that the entire stone surface will contact one or the other of the bores at some time during the honing stroke. To keep the honing unit true during the operation, the STONES AND GUIDE SHOE LENGTH MUST BE AT LEAST TWICE THE CENTER-TO-CENTER TANDEM DISTANCE OF THE BORES (see illustration). When the honing unit meets this requirement, alteration is not required.

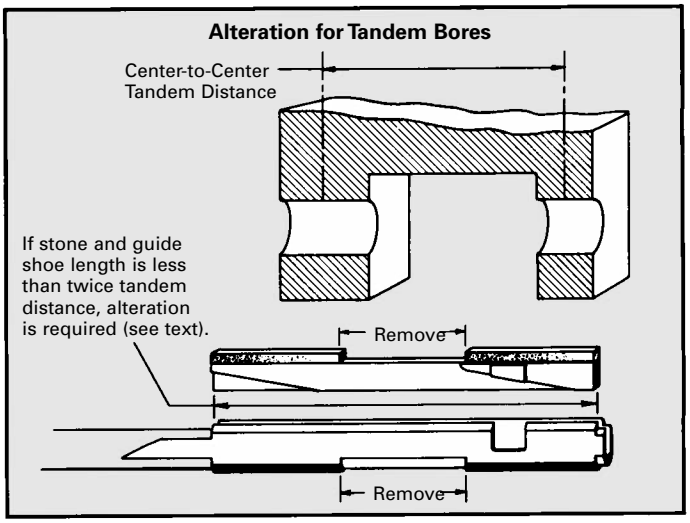
Be sure to reverse the part end for end on the honing unit so that identical bore sizes are obtained. Never stroke either of the tandem bores completely off the stone and guide shoes. Should the stone and guide shoe length be less than twice the tandem distance, the center area of the stone and guide shoes will not wear and a resulting "hump" in the honing unit will bellmouth the inside ends of both bores of the tandem.

Tooling for Tandem Bores



In some tandem applications, it is necessary to alter the honing unit by cutting away the area of stone and guide shoes that would become the "hump." Remove from the center of both the stone and guide shoes an amount equal to the amount they are short of being twice the tandem distance. For example, a part having a 69,9 mm (2¾") tandem spacing would require a 139,7 mm (5½") stone and guide shoes, but the honing unit has a stone and guide length of only 114,3 mm (4½"). This honing unit can be used by removing 25,4 mm (1") from the center of the 114,3 mm (4½") stone and guide shoe length. Multiple stone honing units (P20 and P28) can sometimes be used by setting up the honing unit to leave out the center stones and shoes.

Alteration for Tandem Bores



Additional information can also be obtained by contacting the Customer Service Dept. and requesting a copy of Data File 106, "Honing Tandem Bores."

Technical Data

Guide Shoes • Truing Sleeves • Wedges • Runout Correction • Shims

Guide Shoes-Integral Shoe Mandrels—Mandrels up to 19,0 mm (.750") diameter are solid steel with integral guide shoes — except Keyway (Y) Mandrels, which are solid steel with integral guide shoes up to 25,4 mm (1") diameter. Soft shoe mandrels are recommended for all general honing operations. For honing carbide, ceramic, glass, for extremely rough holes and for some long production jobs, mandrels with hardened steel shoes are recommended.

Where extremely fine finishes are required and 600 or 1200 grit stone is used, solid bronze mandrels with integral shoes are recommended. Occasionally, unusual specifications do not permit the use of sulfur-based honing oil and it may be necessary to use bronze mandrels to reduce the possibility of galling.

Also use a bronze mandrel when a material is very soft or subject to galling.

Production jobs in materials which are prone to galling are best honed by using a bronze guide shoe in which a metal bonded diamond or Borazon stone/stones have been inserted into a bronze guide shoe.

Guide Shoes-Replaceable Shoe Mandrels—The guide shoes supplied as standard with replaceable shoe mandrels have been found to be best for most honing applications. There are cases, however, where "other than standard" guide shoes are more suitable.

When the work being honed is unusually rough or out of round, or has burrs or wire edges, hardened steel guide shoes are usually more economical. The hardened shoes are also more economical when CBN or diamond honing stones are being used.

Important: Guide shoes of different materials should never be mixed on a multi-stone length mandrel. When shoes are removed from a mandrel to be used later, they should be reassembled in their original position.

Proper Use of Truing Sleeves—It is essential that honing tools be kept accurate and true, the same as any other precision tool. The stone and guide shoes must remain parallel to each other and parallel with the axis of the mandrel. It is also important that the stone and guide shoe be radiused to the approximate diameter of the work to be honed. This is especially true when the job being honed requires good surface finish or high accuracy, and for smooth operation in bores containing keyways.

To true a conventional abrasive stone (A or J) and mandrel most quickly, use a truing sleeve. Saturate the stone with honing oil. Hone the sleeve manually as you would during a normal honing operation, but WITHOUT A FLOW OF HONING OIL. Reverse the truing sleeve frequently.

To true superabrasive stones (D or N) true as you would a conventional abrasive stone however, apply a small amount of abrasive grit to the stone and guide shoe before honing. (Using the abrasive slurry found in the work tray is acceptable.)

Because a honing unit must be trued closer to the diameter of the work, excessively worn truing sleeves should be discarded.

Wedges—Wedges are subject to wear, and to assure optimum accuracy they should be replaced when they begin to show wear.

Wedges supplied with all permanent type mandrels (replaceable guide shoes) have long life but should be inspected regularly and replaced if showing any wear. This is especially important in the AK20, BAL20, AL20, and Y32 honing unit groups.

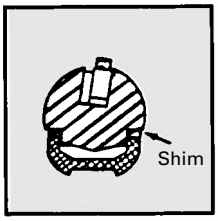
Wedge Plates—High and low wedge plates are supplied with Keyway (Y) Mandrels of 34,7 mm (1.365") size and larger, to provide complete coverage of the mandrel diameter range even when guide shoes and stones are worn. Use the low wedge plate (e.g., Y56L-W) unless the stone cannot be expanded far enough to reach the diameter to be honed (within the range of the honing unit). Use the high wedge plate (e.g., Y56H-W) when necessary to reach the diameter to be honed.

Inserting Mandrel—Do not overtighten set screw in spindle nose or adapter.

Honing Unit Runout Correction—In some cases, due to the weight or shape of the workpiece, the spindle speed, or the requirement of high accuracy, it is desirable to reduce or eliminate eccentric runout of the honing unit.

Since 1950, Sunnen Honing Machines have had an adjustable spindle chuck for runout compensation. Older type machines use an eccentric spindle sleeve — when runout seems excessive, rotate the sleeve one-half turn. In addition, on P28 type honing units, mandrel shims can be inserted under the guide shoes to help reduce runout (see MANDREL SHIMS below).

Mandrel Shims—are furnished with all P28 honing units. They are inserted between the mandrel body and guide shoes when necessary to reach the maximum diameter, especially when the guide shoes are worn. They can also be used to help compensate for mandrel runout.



"How long should it take to hone my part?"

... is one of the most important questions asked by honing machine operators when starting a job. Many operators do not have the luxury of having the number of parts needed to determine the best set up or would like to know if they should be doing better. A good method of estimating cycle time is also necessary when bidding on "new" honing jobs.

Several methods have been developed to assist Sunnen Honing Machine operators in estimating honing times when parts are honed by one of the three following Sunnen systems:

1) ML/EC Series Power Stroked Machines
2) "Hand-Powered" Portable Hones
3) Horizontal Tube Hone with H70 Stone Sets

ML/EC Series Power Stroked Machines

This method of estimating cycle times is most accurate when honing low-alloy steel (hard or soft) using a 220 grit CBN/Borazon stone with Sunnen Industrial Honing Oil.

Honing Time Equation: Finish diameter x part length x stock removal x honing time factor = seconds required to hone.

Workpiece Diameter mm	Honing Time Factor	Workpiece Diameter in	Honing Time Factor
1,5	2.94	0.0625	50000
3,0	1.22	0.125	20000
5,0	0.805	0.1875	12500
6,0	0.590	0.250	8350
7,0	0.50	0.375	5000
8,0	0.415	0.4375	4150
10,0	0.325	0.500	3700
12,0	0.25	0.625	2750
15,0	0.19	0.750	2375
18,0	0.155	0.875	1875
20,0	0.14	1.000	1725
25,0	0.105	1.125	1475
30,0	0.09	1.250	1375
35,0	0.075	1.375	1250
40,0	0.065	1.500	1100
50,0	0.05	1.750	975
60,0	0.045	2.000	820
		2.250	725
		2.500	615

Example: 1" Diameter, 2" Length, .005" Stock Removal: 1 x 2 x .005 x 1725 = 18 seconds, assuming low-alloy steel, soft or hard, honed with Superabrasive roughing stone, such as K20-NM55 with MAN-863 Honing Oil.

Cycle times will be 2-5 times longer with 1800 series machines.

"Hand-Powered" Portable Hones

This method of estimating honing times is based on using G25, M27, N37, W47, or similar Sunnen stone with Sunnen Industrial Honing Oil.*

Honing Time Equation:

Millimeters:
Length x Diameter x Required Stock Removal
x 0.00076 = Honing Time in Minutes.

Example: 1220 mm x 101,6 mm x ,254 mm

x 0.00076 = 24 Minutes Honing Time.

Inches:
Length x Diameter x Required Stock Removal
x 12.5 = Honing Time in Minutes.

Example: 48" x 4" x .010" x 12.5 = 24 Minutes Honing Time.

**This equation should not be used to estimate "floor-to-floor" time if the operator manually strokes the hone as it does not include rest breaks or stops required to feed up stones. It is most accurate in estimating "floor-to-floor" times when using a remote feed honing unit and a power drive source.*

HTB Horizontal Tube Honing with H70 Stone Sets

This method of estimating cycle time is most accurate when considering soft low-alloy steel using a roughing aluminum oxide stone (H70-A45) with Sunnen Industrial Honing Oil.

Honing Time Equation:
Millimeters:
Length x Diameter x Required Stock Removal
x 0.0003 = Honing Time in Minutes.

Example: 1200 mm x 100 mm x 0,28 mm
x 0.0003 = 10 Minutes Honing Time.

Inches:
Length x Diameter x Required Stock Removal
x 5 = Honing Time in Minutes.

Example: 48" x 4" x .010" x 5 = 10 Minutes Honing Time.

H70 Stone Life

Another important factor essential for efficient honing is being able to estimate the number of workpieces that can be produced with a set of stones. This number is important when figuring the cost of honing a part and from the point of insuring that enough stones are available to complete the job. This formula is based on honing workpieces using H70 roughing Aluminum Oxide stone sets (H70-A45).

Millimeters:
(Final Diameter^2 - Starting Diameter^2) x Length x 0,0000018 = Sets of Stones

Example: (101,6 mm^2 - 101,3 mm^2) x 1220,0 mm x 0.0000018 = ,11 Sets of Stones
1,0 set of stone ÷,11 = 9 Parts Per Stone Set

Inch:
(Final Diameter^2 - Starting Diameter^2) x Length x .03 =
Sets of Stones

Example: (4.0"^{2} - 3.990"^{2}) x 48" x .03 = .11 Sets of Stones
1.0 set of stone ÷ .11 = 9 Parts Per Stone Set

Technical Data
Glossary of Terms

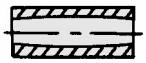
Adapter -A part used with certain mandrels to adapt them to fit the spindle chuck on the honing machine.

Alignment Bushing - A concentric bushing used to minimize conical and parallel runout on machines with fully adjustable spindle noses.

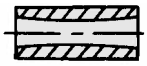
Altered Stone - A standard honing stone, which has been shortened or otherwise changed for a specific application.

Aluminum Oxide - A man-made abrasive most often used in honing soft and medium hard steel. Designated by the letter "A" in the Sunnen stone code. Example: K12-A57.

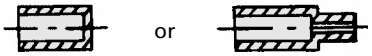
Barrel Shape - A condition where the extreme ends of a bore are smaller in diameter than the middle.



Bellmouth - A condition where the extreme end or ends of a bore are larger in diameter than the middle.



Blind Hole - A bore that is constricted or closed at one end.



Bond -The material that holds the abrasive grains together in a honing stone. Conventional Abrasives use fused clay or glass and are know as Vitrified bonded stones. Superabrasive stones use a metal bond, resinoid bond, or a vitrified bond.

CBN - A man-made abrasive (cubic boron nitride) especially useful for honing the tough alloy steels and other abrasive resistant materials. Designated by the letter "N" in the Sunnen stone code. Example: P28-NM55.

Cork Bond - A bonding material composed of powdered cork and phenolic resin. Cork bonded honing stones are used where extremely fine surface finished is required. (Best results are achieved when used with bronze guide shoes.)

Deburring - A honing process used to remove burrs, sharp edges or similar materials from rough bores.

Diamond - A very hard abrasive grain, which is essential to the honing of carbide, glass and ceramic materials. Designated by the letter "D" in the Sunnen stone code. Example: K8-DV57

Diamond Dresser - A diamond abrasive used to dress honing stones other than Borazon or diamond.

Fixturing - a method used to hold the workpiece while honing. Suggestions on different fixturing methods can be found in Data Files #107, 108, and 109.

Glazed Stone - A stone with cutting action impaired because the abrasive particles failed to break out of the bond when the cutting edges wore off. This condition shows up when the bond is too hard.

Guide Shoes - A part of the honing unit that stabilizes the bore being honed on the tool.

Hardness - As applied to a honing stone, describes the strength of the bond that holds the abrasive grains longer; a soft bond will permit the stone to "break down" faster, exposing new sharp abrasive grains. Hard-Tip Stone - A honing stone having a tip or end of harder abrasive than the body of the stone. Used for honing blind holes where relief cannot be provided.

Hard-Tip Stones - Used primarily for blind hole applications, the tip of the stone is engineered to be more wear-resistant than rest of the stone.

Honing - An abrasive machining process primarily used for stock removal, precision sizing, and surfaces. It is characterized by the use of a self-sharpening abrasive stone, a relatively large area of contact with the work, and relatively low cutting speeds.

Honing Length -The actual length of the surface being honed.

Honing Stone - An abrasive stick consisting of thousands of small abrasive grains bonded together.

Honing Unit - A complete honing tool consisting of an adapter (if required), a mandrel and wedge, stone(s), guide shoes, truing sleeve, and stone retainer or tension block.

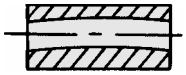
Loaded Stone - A honing stone with cutting action impaired due to the cutting surface being partially covered with a foreign material, usually the material being honed. This condition is sometimes encountered when honing soft materials.

Mandrel -That part of a honing unit which holds and positions the honing stone and guide shoes in their correct relative positions.

Metal Bond - A powdered metal bond often used with diamond or Borazon abrasives. Designated by the letter "M" in the Sunnen stone code. Example: P28-NM55.

Overstroke -The distance that the workpiece is stroked beyond the end of the stone. This distance is generally one-third the length of the stone (or of the part, whichever is the shortest).

Rainbow (or bow) - Sometimes called camber or banana shape. A condition where a bore's diameter may be the same over its full length but whose axis or center-line is curved. Correction of rainbow by honing requires a mandrel in which the stone and guide show length is at least 1-1/2 times the length of the bore.

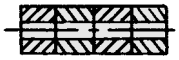


Relief - An enlargement of diameter at the bottom of a blind hole which makes it possible for the end of the honing stone to pass beyond the bottom end of the surface being hones.

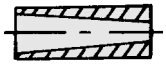
Runout - Off-center rotation of the honing unit which causes eccentric motion of the workpiece.

Silicon Carbide - A man-made abrasive most often used for stock removal in materials such as cast iron, brass, bronze or aluminum. Also used for fine finishes in all materials. Designated by the letter "J" in the Sunnen stone code. Example: K12-J47.

Stacking - A technique for honing short parts. Faces of the parts must be square with the bore prior to honing. A holding fixture is necessary for aligning and holding the parts on a common center.

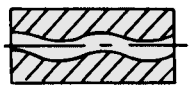


Taper - A bore condition where the diameter of a bore gradually increases from one end of the bore to the other.



Truing Sleeve - A cylinder or workpiece whose purpose is to make the guide shoes and stone straight and parallel to each other, and radiused to the approximate diameter to be honed.

Waviness - A longitudinal wave, series of waves or ripple in a bore surface.



Wedge -The part of the honing unit that expands the honing stone and applies cutting pressure.

Hardness Conversion Table

Brinell Hardness	Rockwell Hardness Number						Rockwell Superficial Hardness Number						Tensile Strength
	A Scale	B Scale	C Scale	D Scale	E Scale	F Scale	15-N Scale	30-N Scale	45-N Scale	15-T Scale	30-T Scale	45-T Scale	
10-mm Std. Ball 3000-kgf load	Diamond Penetrator 60-kgf load	1.588-mm 1/16" Ball 100-kgf load	Diamond Penetrator 150-kgf load	Diamond Penetrator 100-kgf load	3.175-mm 1/8" Ball 100-kgf load	1.588-mm 1/16" Ball 60-kgf load	Superficial Diamond Penetrator 30-kgf load	Superficial Diamond Penetrator 30-kgf load	Superficial Diamond Penetrator 45-kgf load	1.588-mm 1/16" Ball 15-kgf load	1.588-mm 1/16" Ball 30-kgf load	1.588-mm 1/16" Ball 45-kgf load	KSI
750	85.0	–	66.0	76.0	–	–	93.0	83.0	73.0	–	–	–	–
710	84.0	–	64.0	74.0	–	–	92.0	81.0	71.0	–	–	–	–
682	83.0	–	62.0	73.0	–	–	91.0	79.0	69.0	–	–	–	–
653	81.0	–	60.0	71.0	–	–	90.0	78.0	67.0	–	–	–	314
578	80.0	–	58.0	69.0	–	–	89.0	76.0	64.0	–	–	–	299
555	79.0	–	56.0	68.0	–	–	88.0	74.0	62.0	–	–	–	284
534	78.0	–	54.0	66.0	–	–	87.0	72.0	60.0	–	–	–	270
495	77.0	–	52.0	65.0	–	–	86.0	70.0	57.0	–	–	–	256
479	75.5	–	50.0	63.0	–	–	85.5	68.0	54.5	–	–	–	244
450	74.5	–	48.0	61.5	–	–	84.5	66.5	52.5	–	–	–	228
425	73.5	–	46.0	60.0	–	–	83.5	64.5	50.0	–	–	–	212
403	72.5	–	44.0	58.5	–	–	82.5	63.0	47.5	–	–	–	201
382	71.5	–	42.0	57.0	–	–	81.5	61.0	45.5	–	–	–	189
363	70.5	–	40.0	55.5	–	–	80.5	59.5	43.0	–	–	–	178
346	69.5	–	38.0	54.0	–	–	79.5	58.0	41.0	–	–	–	167
329	68.5	–	36.0	52.5	–	–	78.5	56.0	38.5	–	–	–	160
313	67.5	–	34.0	50.5	–	–	77.5	54.5	36.0	–	–	–	153
298	66.5	106	32.0	49.5	–	116.5	76.5	52.5	34.0	94.5	85.5	77.0	144
275	64.5	104	28.5	46.5	–	115.5	75.0	49.5	30.0	94.0	84.5	75.0	130
258	63.0	102	25.5	44.5	–	114.5	73.5	47.0	26.5	93.0	83.0	73.0	121
241	61.5	100	22.5	42.0	–	113.0	72.0	44.5	23.0	92.5	81.5	71.0	114
228	60.5	98	20.0	40.0	–	112.0	70.5	42.0	20.0	92.0	80.5	69.0	107
215	59.0	96	17.0	38.0	–	111.0	69.0	39.5	17.0	91.0	79.0	67.0	101
204	57.5	94	14.5	36.0	–	110.0	68.0	37.5	14.0	90.5	77.5	65.0	98
194	56.5	92	12.0	34.0	–	108.5	66.5	35.5	11.0	89.5	76.0	63.0	93
184	55.0	90	9.0	32.0	108.5	107.5	65.0	32.5	7.5	89.0	75.0	61.0	89
176	53.5	88	6.5	30.0	107.0	106.5	64.0	30.5	5.0	88.0	73.5	59.5	85
168	52.5	86	4.0	28.0	106.0	105.0	62.5	28.5	2.0	87.5	72.0	57.5	87
161	51.5	84	2.0	26.5	104.5	104.0	61.5	26.5	-.5	87.0	70.5	55.5	78
155	50.0	82	–	24.5	103.0	103.0	–	–	–	86.0	69.5	53.5	75
149	49.0	80	–	22.5	102.0	101.5	–	–	–	85.5	68.0	51.5	72
144	47.5	78	–	21.0	100.5	100.5	–	–	–	84.5	66.5	49.5	69
139	46.5	76	–	19.0	99.5	99.5	–	–	–	84.0	65.5	47.5	67
134	45.5	74	–	17.5	98.0	98.5	–	–	–	83.0	64.0	45.5	65
129	44.0	72	–	16.0	97.0	97.0	–	–	–	82.5	62.5	43.5	63
125	43.0	70	–	14.5	95.5	96.0	–	–	–	82.0	61.0	41.5	61
121	42.0	68	–	13.0	94.5	95.0	–	–	–	81.0	60.0	39.5	59
118	41.0	66	–	11.5	93.0	93.5	–	–	–	80.5	58.5	37.5	57
114	40.0	64	–	10.0	91.5	92.5	–	–	–	79.5	57.0	35.5	55
111	39.0	62	–	8.0	90.5	91.5	–	–	–	79.0	56.0	33.5	53
108	–	60	–	–	89.0	90.0	–	–	–	78.5	54.5	31.5	51
108	–	58	–	–	88.0	89.0	–	–	–	77.5	53.0	29.5	–
103	–	56	–	–	86.5	88.0	–	–	–	77.0	51.5	27.5	–
100	–	54	–	–	85.5	87.0	–	–	–	76.0	50.5	25.5	–
98	–	52	–	–	84.0	85.5	–	–	–	75.5	49.0	23.5	–
95	–	50	–	–	83.0	84.5	–	–	–	74.5	47.5	21.5	–
93	–	48	–	–	81.5	83.5	–	–	–	74.0	46.5	19.5	–
91	–	46	–	–	80.5	82.0	–	–	–	73.5	45.0	17.0	–

Notes