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50915

August, 1986

Tooling and Cutting Manual

for Magnetic Tracing Systems

ESAB CUTTING SYSTEMS

411 South Ebenezer Road
Florence, SC 29501-0545

TOOLING AND CUTTING MANUAL

CONTENTS

CUT QUALITY

Cuts of highest quality may be made with the ULTRA-GRAPH. With proper torch adjustment and smooth finished pattern edges, cut-surface finishes of 170 microinches have been measured on 3/8" material. The quality of such a cut compares to the surface smoothness obtained in the average drilled hole.

Commercial quality cuts may be made with relatively rough patterns. Such patterns may be cut quickly with the ULTRA-GRAPH, using 3/16" or 1/4" material and lightly smoothing down pattern edges with a file. (Commercial quality cuts are identified as cuts made at the maximum speed of machine travel that will allow the part to drop free of the scrap when the cut is completed.)

ACCURACY

Allowing for variations in the oxygen orifice size and for variations in the size of the oxygen jet itself, theoretical total tolerances of .007 to .010 are possible. With a specific tip, uniform oxygen pressure and cutting speed, the variation from part to part, cut with a given pattern, will not exceed the theoretical tolerance of .007 to .010 and generally will be closer. The alignment of the ULTRA-GRAPH is sufficiently precise to produce the best theoretical tolerances if other related factors permit the ideal to be reached.

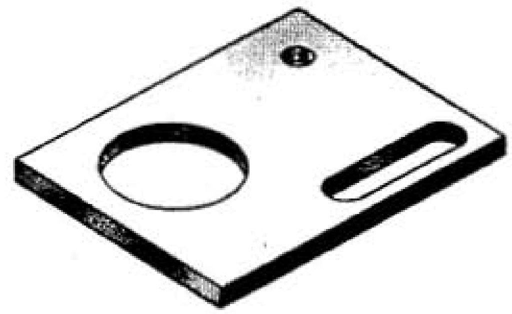
In general practice it is not uncommon to produce to ±1/64" of drawing dimensions. The total accuracy obtained depends upon the accuracy of the pattern, i.e. proper allowance for rotor size and width of kerf, and on the amount of distortion or creep of the material as the heat of cutting progresses around the part. Control of these factors is discussed in subsequent sections of these instructions.

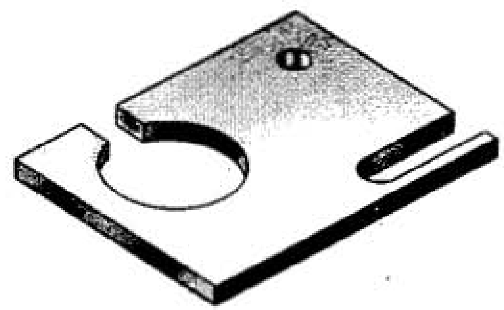
MATERIAL DISTORTION

Material distortion is not a serious limitation on cutting most parts with oxygen. However, it is a factor that must be anticipated and for which proper compensation must be made if the greatest possible precision is required.

While no set rules may be given for determining the amount of distortion that may be experienced in cutting a given part, consideration of certain factors may be found helpful in controlling possible distortion.

1. **Shape and size of the part:** Distortion in long narrow shapes will be greater than in symmetrical shapes.
2. **Type of cut:** A "Closed" cut will distort much less than an "open" cut. See following examples:

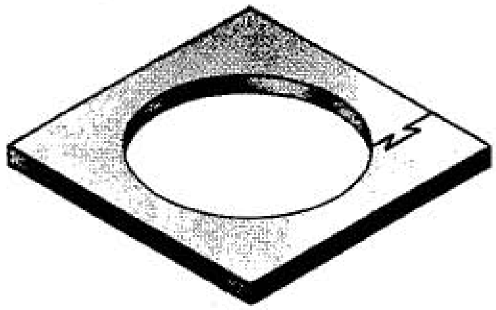




3. **Starting point of cut:** The total distortion in a given part shape may depend entirely on the direction of sequence in which the heat of cut progresses around the part outline.
4. **Material thickness:** Thin material tends to distort more than thick material.
5. **Relationship of length of cut to size of part:** Notching, slotting, cut-off, and short cuts have a minimum tendency to distort.
6. **Relationship of cut outline to edge of material blank:** The greatest distortion tends to occur in the smaller area.
7. **Method of supporting or holding the material blank:** Some shapes may require "floating" support to allow expansion in all directions, while other parts may require clamping of either the scrap or the part area.

Several techniques may be used to compensate for material distortion.

1. Selection, by trial, of starting point and/or direction of cut that produces the minimum of distortion.
2. Selection, by trial, of starting point and/or direction of cut to cause distortion to occur in direction of least critical accuracy.



3. Use of "locking lead-in" on open cuts as illustrated. The interlocking cut leading into the circle helps to control the tendency of the scrap area to spread as the cut progresses.
4. Conpensation in pattern shape. Through small changes in the pattern size and/or shape, allowance may be made for distortion at critical points.
5. Although rarely practiced, distortion can be largely eliminated by cutting material supported in a tank with approximately 1/8" of water covering the surface of the material. Larger than normal tip sizes, higher oxygen pressure, and other special techniques are required in this type of operation.
6. Uniform preheating of the entire material blank may be practical under certain conditions. Preheating to a temperature of approximately 250°F. greatly reduces the amount of distortion.
7. Cooling immediately following the cut with a hand controlled flow of water may be practiced as a means of reducing distortion under certain conditions.

Some of the procedures described heretofore may appear tedious. Therefore it must be pointed out that all of the practices ordinarily are not required. However, they do emphasize the importance of following the same sequence of operations in a given setup if better than average accuracy is required.

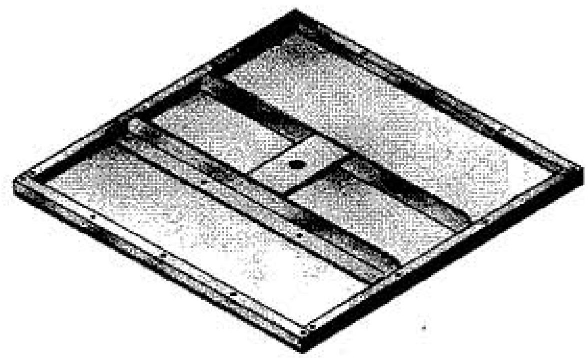
PATTERN MATERIAL

Patterns for the ULTRA-GRAPH are made of ordinary mild steel of various thicknesses. Masonite or plywood patterns may be used if hand pressure is applied to obtain traction for the rotor against the pattern. However when the ULTRA-GRAPH is properly set up, it is properly balanced to follow patterns made from steel as light as 18 ga. which is somewhat easier to make up to a smooth and accurate edge finish than is masonite or plywood.

PATTERN THICKNESS

Several factors may be considered in selecting the weight of material to use for patterns. No set rule is applicable in this respect, but the following general outline will be found helpful:

1. Pattern thickness is not directly related to the thickness of material to be cut.
2. Heavier gauge patterns have greater attraction for the magnetic rotor than lighter gauge patterns.
3. Thin patterns (10 ga. to 18 ga.) generally are useful under the following circumstances: A. For speed in pattern making. B. For small patterns of simple shape. C. For minimum weight in very large patterns. Stiffener strips frequently are required on such patterns, and edging strips may be added for additional magnetic attraction. See pattern cross section below for example.



SECTION OF LARGE PATTERN CONSTRUCTION
Using 3/4" by 3/4" stiffeners and 1/4" square edging strips on 18 ga. base. Heavy cross member in center provided for mounting. Assembly of pattern parts by bolting or light plug-welds avoids distortion.

4. Thick patterns (3/8" to 1/2") generally are useful under the following circumstances:
   A. For precision work, smoothest quality cuts and more positive magnetic control with standard knurled rotors.
   B. For wearing ability and durability on high quantity or long term production.
   C. For complex shapes . . . heavier material aids in controlling rotor movement in corners.
   D. For small diameter rotor, because of greater magnetic attraction.
   E. Heavier pattern material (1/4" minimum) usually is easier to handle in cutting patterns with the ULTRA-GRAPH as described in a later section.

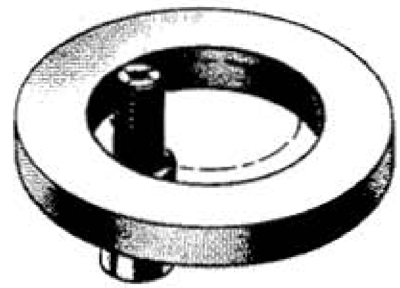
SELECTION OF ROTOR DIAMETER

The 1/4" rotor provides:
1. The greatest freedom in pattern layout for intricate shapes.
2. Sufficient magnetic attraction with an 18 ga. pattern to trace relatively simple shapes.

Because of the general convenience of the 1/4" rotor, ULTRA-GRAPH speed ratios are established to give the most used operating speeds with that size of rotor.

The 1/2" Rotor provides:
1. Greater magnetic attraction to large light guage patterns.
2. A higher range of speed.
3. A ready means of changing the size of a part, as in circle cutting, through substitution for the 1/4" rotor.

Relationship of size of rotor to cutting speed with various ULTRA-GRAPH models may be determined through reference to the specification chart or operating instructions applicable to the model.

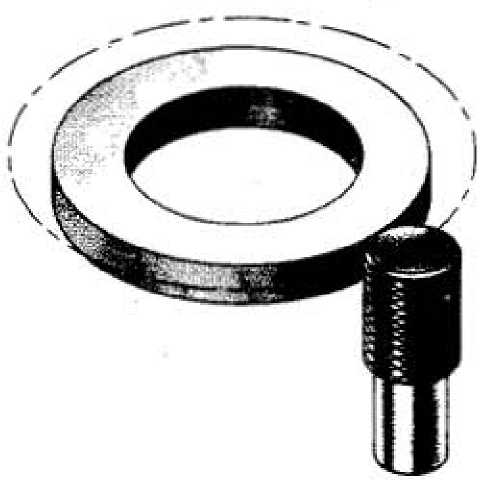


PATTERN SIZE

PATTERN DIMENSIONS WILL BE DIFFERENT FROM PART OR CUT DIMENSIONS BY:
1. ROTOR DIAMETER, OR RADIUS
2. KERF WIDTH, OR ONE-HALF WIDTH

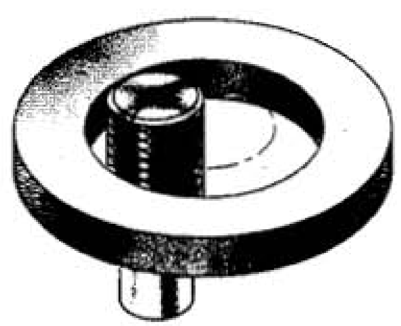
The cutting tip is on a center line with the rotor. Therefore in pattern making allowance must be made for the rotor diameter or radius. Kerf is the width of material removed by the oxygen jet in the cutting process. One-half of the kerf is removed from the part being cut and one-half from the scrap. Kerf width increases with increase in tip size.

Through application of the following basic rule, rotor and kerf allowance may be established: TO DETERMINE PATTERN DIMENSIONS MOVE THE PATTERN LINE BACK OR AWAY FROM THE DESIRED LINE OF CUT A DISTANCE EQUAL TO ROTOR RADIUS MINUS ONE-HALF OF KERF. IT SHOUD BE REMEMBERED THAT ONE-HALF OF THE KERF IS APPROXIMATELY EQUAL TO THE DIAMETER OF THE OXYGEN JET. APPLICATION OF THE RULE PERTAINING TO ROTOR AND KERF ALLOWANCES IS ILLUSTRATED IN THE FOLLOWING SECTIONS:

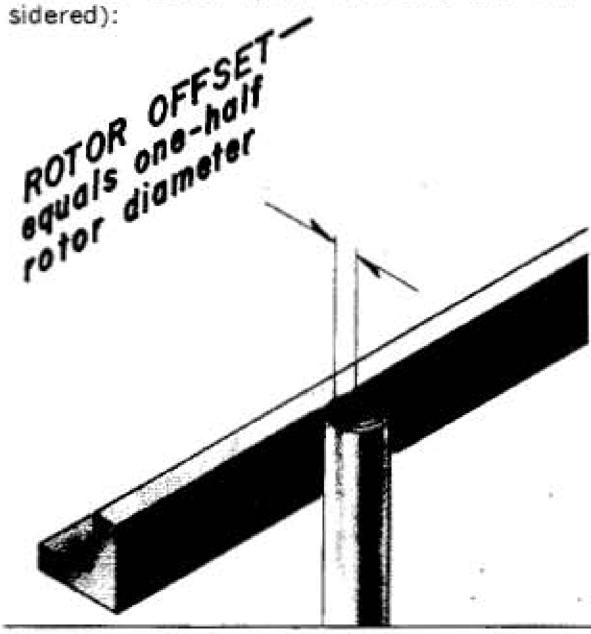


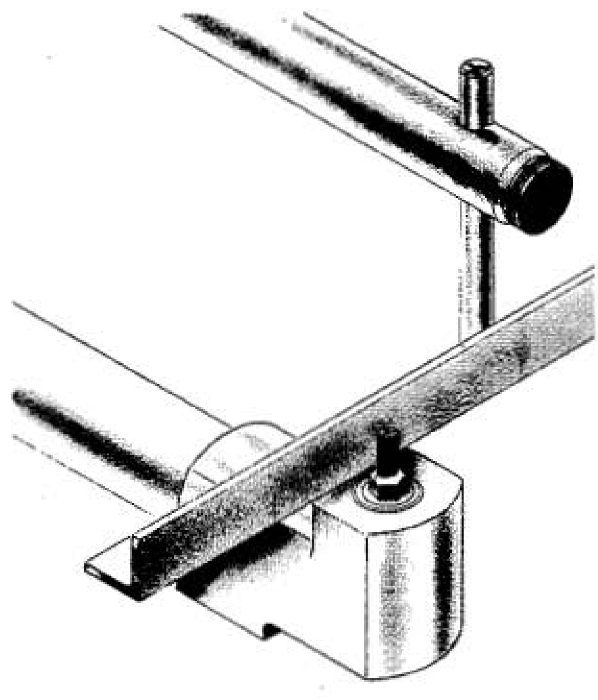
ROTOR ALLOWANCE

Example: If a short length of tubing is cut and mounted as a circular pattern the sizes of cuts which can be produced are illustrated below. The centerline represents centerline of cut without consideration of kerf which is covered next.



Example: If a select length of straight angle is set up as a straight-line pattern, the cut will be offset from the edge of the pattern as illustrated below (kerf allowance not considered):



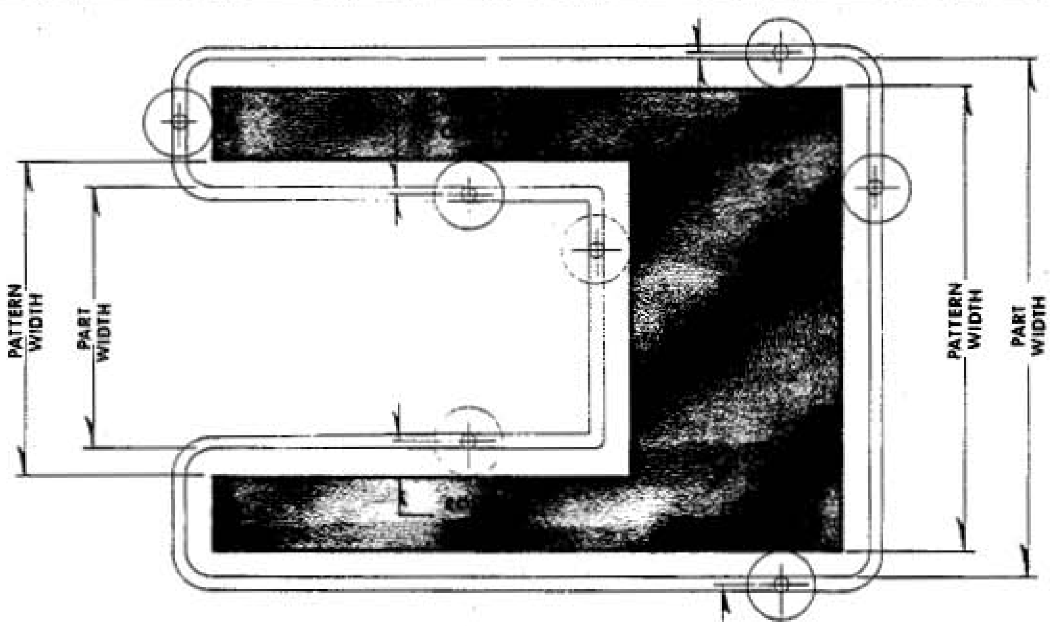


KERF ALLOWANCE

Allowance for the width of material removed by the oxygen jet must be made in pattern dimensions for precision work. The total width of material removed by the oxygen jet may be accurately estimated at twice the diameter of the cutting oxygen orifice. The effect of the width of kerf requires adjustment of rotor allowance in determining pattern dimensions as illustrated below.

Example: Width of cut part is to be 4". Assume material thickness is 1", and drill size of oxygen jet used is # 54 or .0550" x 2 equals .1100" (width of kerf) or 7/64". Assume rotor size is 1/4". PATTERN WIDTH IS 4" minus 1/4" plus 7/64" or 3-55/64".

Example: Width of part notch is to be 2". Assume material thickness is 1" and drill size of oxygen jet used is # 54 or .0550" x 2 equals .1100" (width of kerf) or 7/64". Assume rotor size is 1/4". WIDTH OF NOTCH IN PATTERN IS 2" plus 1/4" minus 7/64" or 2-9/64".



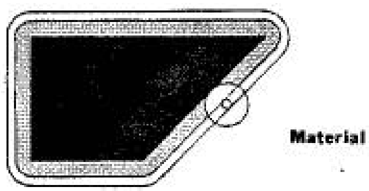
PATTERN CORNERS

OUTSIDE

If pattern has a square corner . . . torch will cut a radius equal to rotor radius minus 1/2 the kerf width.

If pattern has a narrow pointed corner magnetic attraction is greatly reduced at the very point of the pattern. A very small (1/64") radius added to such points will add sufficient attraction to allow the rotor to follow around.

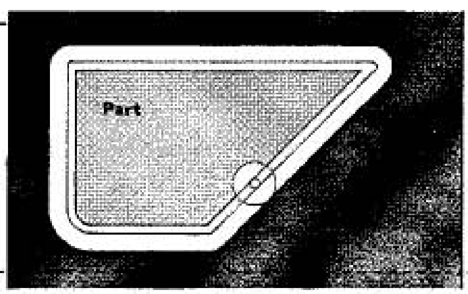
If pattern corner has a radius . . . torch will cut that radius plus rotor radius minus 1/2 the kerf width.



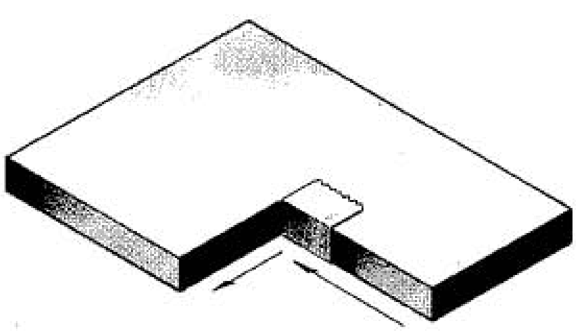
INSIDE

Equal magnetic attraction to each side of the corner tends to lock rotor in an inside square corner.

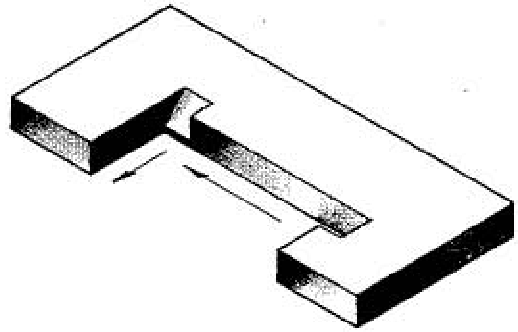
Inside corners of a pattern can have a radius equal to rotor radius and still cut a square corner. Pattern corner radius slightly larger than rotor radius gives smoothest rotor movement without seriously affecting dimensions.



On thin patterns, addition of several layers of masking tape to the side of the corner the rotor is attempting to pull away from will easily relieve the problem.



If inside corners are made square they may be relieved as shown to aid rotor movement. . . this can be done easily with a small round file.

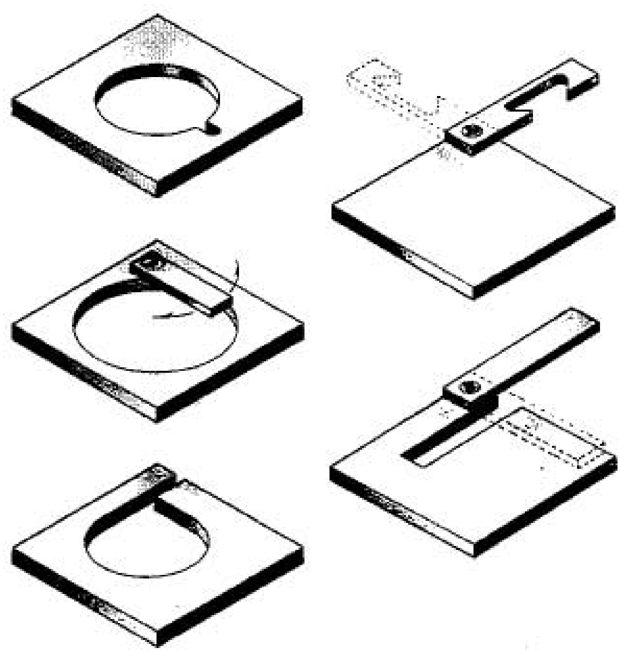


LEAD-IN LUGS . . . LEAD-IN SLOTS

Lead-in lugs for outside patterns and lead-in slots for inside patterns are a cost and time saving convenience for several reasons.

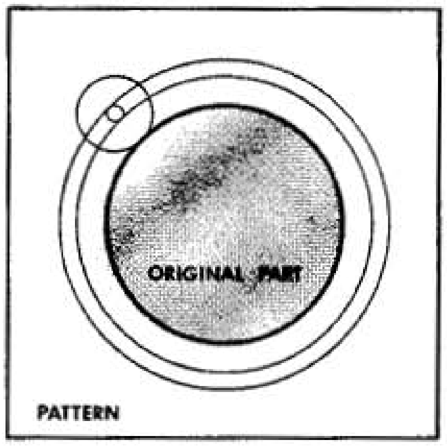
1. The starting point of cut is established for a given part.
2. Cut may be started in scrap area avoinding blow-through defect on line of cut.
3. Cut may be started at edge of material to reduce preheat time and eliminate the spatter of molten metal caused by piercing which is a nuisance to the operator and the greatest single cause of tip clogging.
4. Provides method of leading in and out to make the sharpest corners possible.
5. Eliminates excessive preheat required to pierce dirty or scaly material.
6. Reduces preheat accumulation in this material and helps avoid vertical warpage.

Different types of lead-in lugs and lead-in slots are illustrated as follows:

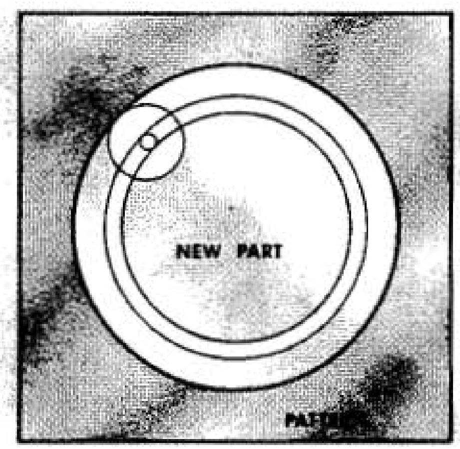


MAKING THE PATTERN

Several methods or combination of methods may be used in actually making the pattern. The most simple of all is the "original part method" illustrated below.



Tracing true size of circle to be reproduced and cutting from a blank of 1/4" pattern material produces a hole which is greater in diameter than the original part by the diameter of the rotor plus the width of the kerf.



Tracing the inside circle of the cut pattern subtracts the diameter of the rotor plus the width of the kerf from the oversize diameter of the pattern.

The original part method described above is very useful in duplicating complex shapes such as sprockets and gears. If an allowance for machining operations is required, the cut pattern may be made to reproduce oversize by building up the original part with masking tape before cutting the pattern.

If an inside pattern is convenient for a given part it may be desirable to make a temporary full size pattern of the pattern from 18 ga. material without allowance for rotor diameter or kerf width. The temporary full size pattern then may be used to cut a permanent pattern with the ULTRA-GRAPH, rotor and kerf allowances automatically being adjusted. This method is particularly accurate if the same tip size can be used to cut the pattern as will be used in the actual cutting of the part. Even if a larger tip must be used in the actual part cutting, allowance for the larger kerf is made by dressing out the inside of the pattern.

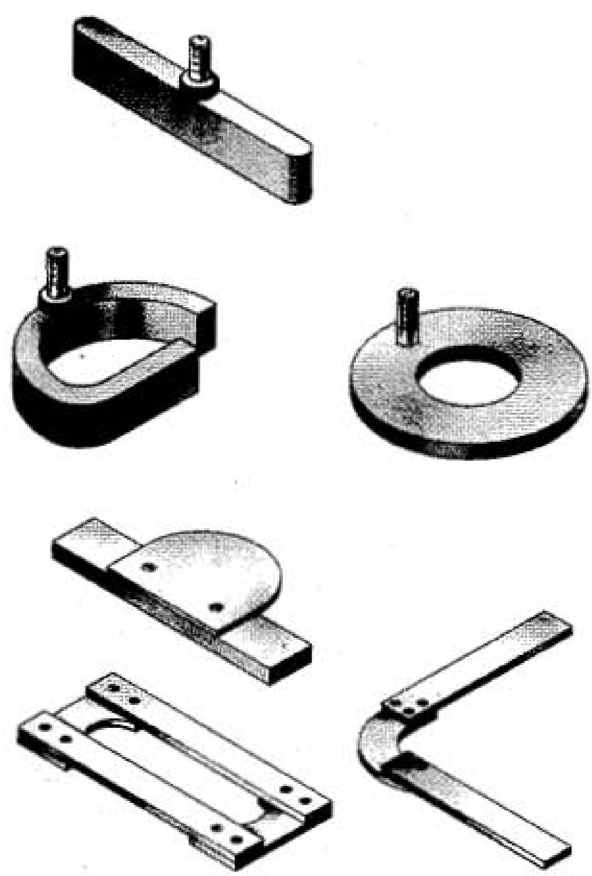
On some shapes of parts a pattern cut from a full size original will reproduce more accurately than any other, the distortion in cutting the pattern canceling the distortion in cutting the production part.

Thin patterns (18 ga.) easily are cut with hand shears.

Thicker patterns may be cut on a bandsaw or on the ULTRA-GRAPH by using a sequence of cuts with assorted circular and straight line patterns.

Cold rolled bar stock, 1/16" to 1/4" thick in assorted widths, makes excellent pattern material for slots and for combining with small plates to make up composite patterns.

Light bar stock also may be bent to shape for parts of simple outline.
Examples of various types of practical pattern construction are illustrated below.



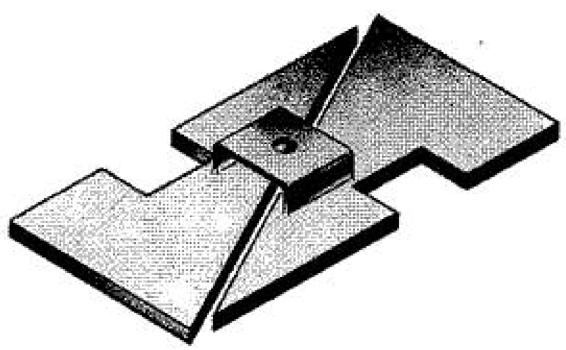
ADJUSTMENT OF PATTERN SIZE

If a pattern is made oversize, it can be filed or ground down to correct size.

If a pattern is made undersize, it can be built up by applying as many as four or five layers of adhesive or masking tape to the undersize portions. A length of light bar stock may be overlapped along an undersize straight portion of a pattern and brazed or bolted in place.

PATTERN MOUNTING

A 5/16" hole should be drilled in a central location to mount the pattern to the machine. One hole is required for small pattern (12" x 12"); two holes are required for larger patterns.



Often the shape of the pattern makes it possible to "nest" two patterns or mount two identical patterns into one assembly. The two patterns are attached to a common mounting bridge usually rotated 180° of each other with a common straight edge between them. This technique reduces set-up and cutting time in addition to reducing material waste. Likewise cut parts can be "nested" on the material by rotating the pattern 180° after each cut. This procedure can reduce material waste considerably.

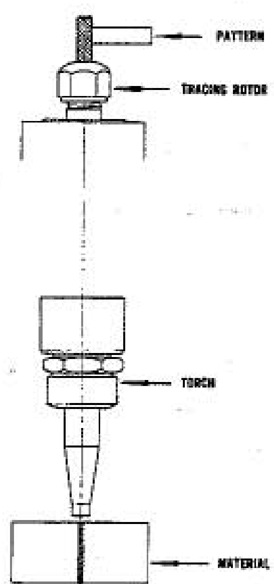
MATERIAL LOCATION

Material should be positioned directly in front of the ULTRA-GRAPH machine on a level work table approximately 28" high. A good work table can be made with flat steel bars, approximately 1/2" x 3" spaced 8" to 12" apart to support the material. The bars with the edge up can be welded in place or a small angle bracket can be attached to each bar to allow positioning for the support of various sizes of material. The width of the work table should equal the operating capacity of the machine to accommodate the widest material which can be cut. Movable supports should be provided to support the length of the material.

The edge of the material should be positioned no closer than 6" from the column of the machine. For best operation the material should be positioned so that the center line along the length of the material is one-half the distance from the column to the torch tip when the arms of the machine are fully extended. This allows the machine to cut the maximum width material without moving the work tabe. Before cutting begins the material should be clamped securely to the table.

ALIGNMENT OF PATTERN AND MATERIAL

The tracing rotor and the torch are on the same vertical center line as shown below. With a pattern adjusted for the diameter of the rotor and the width of the kerf the cutting oxygen jet will blow tangent to the edge of the material when the pattern and the material are in proper alignment. For most applications it is practical to align the material with the centerline of the torch. Since the allowance for one-half the diameter of the cutting jet is negligible it is often disregarded. Following this practice, a small pointer or guide can be inserted in the cutting orifice of the tip to align the torch with the edge of the material. This procedure is used when the edge of the material will be used for an edge of the part. When a part will be cut away from any edge, the tracing rotor should be moved manually around the pattern to determine the exact outline the machine will duplicate on the material. The torch should cut at least 1/4" from any edge.

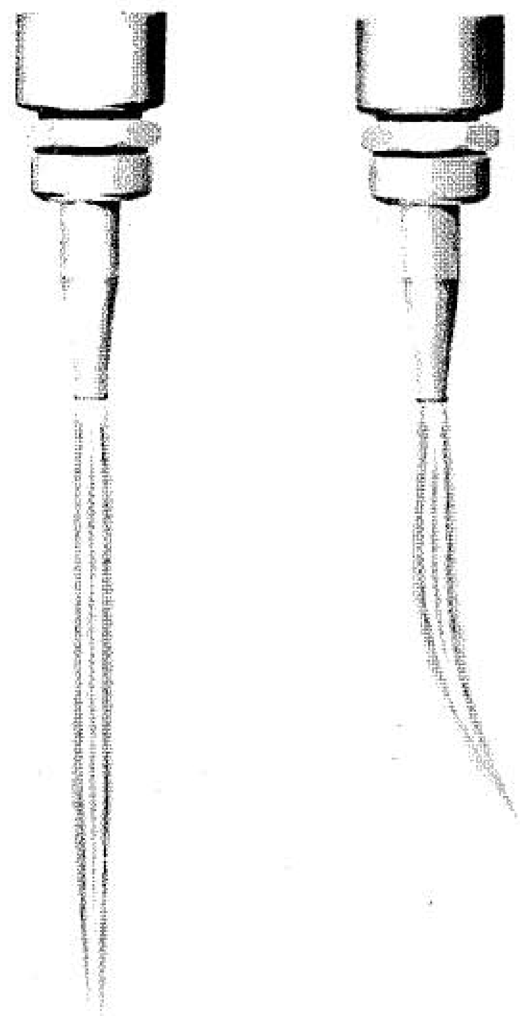


PROPER ADJUSTMENT OF THE TORCH

Two types of machine cutting torches, two-hose and three-hose may be used. The two-hose torch, with one common oxygen supply for both preheat and cutting and a fuel gas supply, is suitable for most general cutting operations. The three-hose torch is generally preferred when extreme accuracy and high quality cuts are required. The three-hose torch has independent preheat and cutting oxygen connections. This permits more accurate control and adjustment of the oxygen flow at the torch. The three-hose torch generally has better mixing characteristics to produce the best cutting flame.

The oxygen and fuel gas pressures should be regualted in accordance with pressures specified for the thickness of the material to be cut. Refer to the torch manufacturer's reference chart for this information. Often these pressures are high and may be lowered without affecting the cutting. Independent regulators placed near the machine are used to control the flow of gas from the main line to the torch.

The valves on the torch should be opened completely before the gases are released to the torch. Release and regulate the preheat oxygen and fuel gas to the recommended pressures and ignite the torch. Adjust the regulators until a clean burning neutral flame is produced. Release the cutting oxygen and regulate the pressure until a long and tapered flame is produced with the cutting oxygen stream visible as two narrow lines. Illustration A shows the proper adjustment of the cutting oxygen. A small white ball of gas should appear at the torch tip. Illustration B shows a flame with the cutting oxygen improperly adjusted. The flame is short and feathered at its tip and tends to turn out at the end. The cutting oxygen stream is short and thick and will blow erratically.



A B

Any final adjustments can be made with the valve controls on the torch. Some adjustment is often necessary after about ten minutes when the torch tip has become heated and the material has become preheated to a certain degree.

PROPER ADJUSTMENT OF THE MACHINE

Cutting speeds are an important factor in producing quality cuts. A constant speed is required to move the cutting flame along at a speed which will preheat the material sufficiently to allow the cutting oxygen jet to blow the kerf or cut material out cleanly. Good cutting will be accompanied by blowing the cut material in the form of sparks out ahead of the cutting on the underside of the material. When the cutting speed is adjusted properly with a good cutting flame the sparks will be blown ahead at an angle of 30° to 60° from vertical.

As travel speeds are increased the preheat time is decreased preceding the cutting action. The cut is lost when the cutting action of the oxygen jet encounters cold metal or metal which has not been preheated to the minimum temperature. As travel speeds decrease the cut become rougher and less accurate because excessive heat is built up and the cutting oxygen removes more material than is necessary. Gouging and undercutting occur. Excessive preheating burns off and rounds the top edges of the material along the cut. Mill scale on the material can affect the preheating action of the flame increasing the cutting time.

Illustration above shows a graphic example of the effects of improper and proper adjustment of the flame and cutting speed. Beginning with an improper cutting flame and slow travel speed at the left of the cut shows excessive slag formed on the underside of the material. A very irregular vertical surface with deep gouges is produced. As the cut progresses toward the right the cutting oxygen pressure is reduced slightly to blow cleaner and travel speed is increased. The result is the kerf is blown clear of the cut and no slag desposits are formed. As the speed increases the vertical surface becomes smoother and cleaner with sharp edges formed at the top and bottom. A good cut will show "drag lines" or cutting marks which are vertical and only slightly defined. A light paper-thin scale will be formed on the surface of a good cut. This scale brushes off easily.

Several factors influence the travel speeds of the machine. Fluctuations in line voltage cause variations in speed. Heavy current drainage by welders and similar equipment on the same line is a major source of trouble. In shop where this condition exists the ULTRAGRAPH machine should be connected to a line independent of the line which feeds the welding equipment.

A second factor which can cause speed variation is hose drag. If the hoses are not hung loosely from the arms they can restrict the movement of the tracing head. Hoses which are tied tightly to the arms without sufficient slack will push or hold the arms in certain positions. This will cause the machine to speed up, slow down, or stop completely although the speed output of the rotor remains constant.

FACTORS GOVERNING GOOD CUTTING

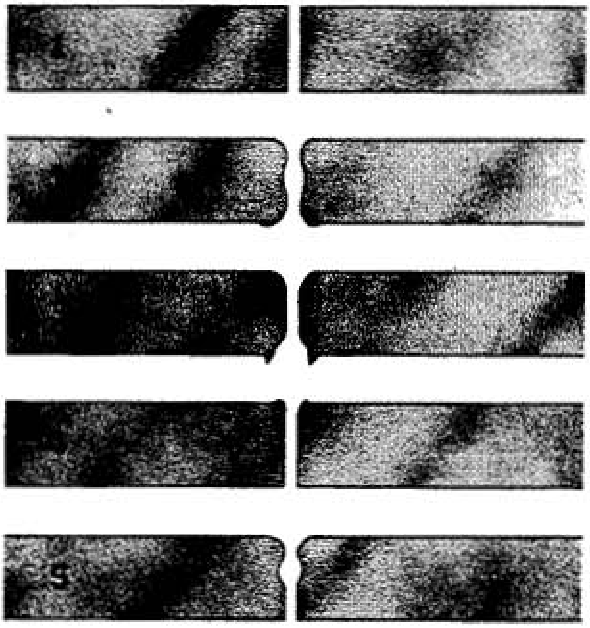
Proper adjustment of the cutting speed and the flame are important factors in producing good cuts.. . In addition to these factors it is important to use only clean torch tips in good condition.. . Torch tips become clogged when the torch blows out or when it is allowed to operate too close to the material. The torch tip should move approximately 1/8" to 3/16" above the surface of the material. Although this is an optimum distance, it should be noted that good cuts can be made with the torch tip up to 1" from the material. This is important when considerable warpage is evident in the material. It is unlikely that warpage will require the distance to vary more than 1/4". Extreme warpage is generally found only in large sheets of light gauge material. Often a certain amount of warpage can be overcome by clamping at several points close to the cutting area.

Good hose connections and properly operating regulators are important to maintain adequate pressures to the torch. New hoses should be used when initially setting up the machine. Old hoses become plugged and deteriorate, restricting the flow of gases, or develop leaks which cause erratic burning.

Accuracy will be affected by using an inaccurate pattern or by cutting on a work table which is not level in relation to the machine. The machine must be leveled with the column in a true vertical position. The surface of a level work table will be at a right angle to the column. This relationship allows the arms to move anywhere over the work with the torch perpendicular to the material. To achieve optimum accuracy the pattern should be level and parallel to the material. A pattern set at a slight angle will produce a part a few thousands of an inch undersize or oversize.

One condition which is hardest to control is material distortion. There is no effective way to eliminate distortion. It normally occurs in light gauge material where heat is not transferred from the cut evenly and quickly. Secure clamping of, the material and the part will overcome distortion to a certain extent. Often when distortion is severe the cutting is performed with the material submerged in a shallow tank so that a thin film of water covers the material.

Correct torch and machine operating speed adjustment will result in clean cuts and smooth edges, with a very slight near-vertical scored effect on the cut surface. The illustrated examples shown below indicate effect of improper adjustment as compared to a cut made with proper adjustment.



1. Clean cut, top and bottom edges sharp, and face smooth, with barely visible drag lines. Easily removed Oxide, if any. Adjustment correct.

2. Slight top edge beaded, under cut below edge and rounded under cut. Drag line rake back. Speed of cut too fast.

3. Surface of the top edge of cut is rounded and irregular shaped, adhering slag and bottom edge rough and irregular. Oxide tightly adhered. Cutting speed too slow.

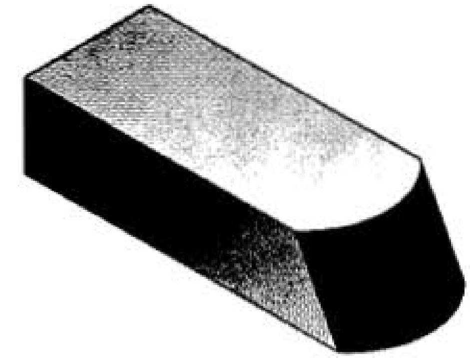
4. Heavy beads and rounded top edge. Face of cut square and bottom sharp. Fair cut. Flame of preheat too close.

5. If the flame is too far from the plate, the heat spreads and the kerf opens up. The top edge rounded and bottom edge slightly undercut. Preheat too high above the cut.

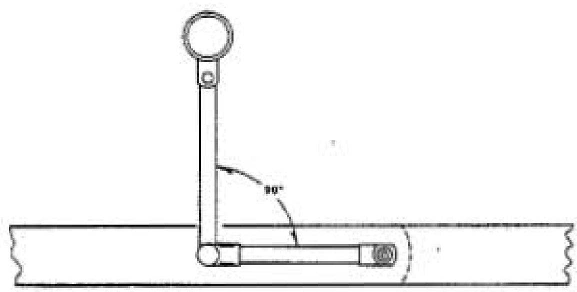
BEVEL CUTTING

Bevel shape cutting is limited in machines other than those that may be classed as special purpose machines. If an angle cutting tip is used on the ULTRA-GRAPH, the angle of bevel will vary between maximum and zero as the pattern is traced.

Straight line bevel cuts may be made by using a simple fixture to position the material at the desired angel to the vertical line of the torch.



A radius cutoff can be made with a fairly uniform bevel if the length of cut is not too great and the pattern is properly located in relation to the arm assembly hinge joints. The principle of this setup is illustrated below.

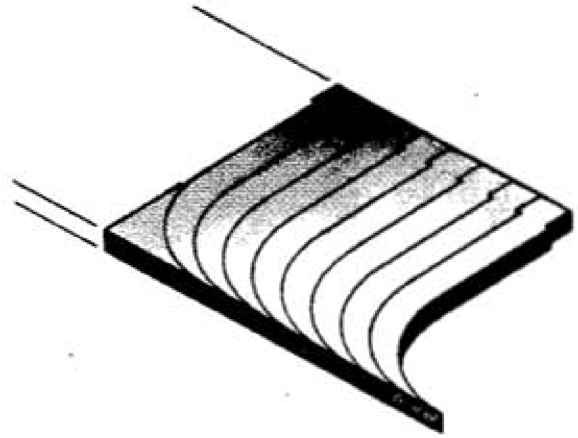


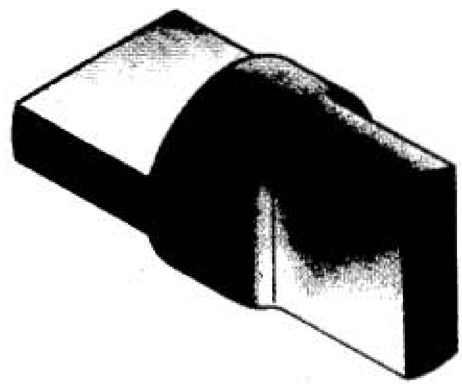
STACK CUTTING

Stack cutting requires special techniques and is not as widely practiced as it might be. Complete discussion of known techniques cannot be covered in these instructions. However, the following brief outline should prove helpful:

1. The principle advantage of stack cutting is illustrated by the fact that the cut surface of the 4" thick material is produced at a rate six times faster than on 1/4" material.
2. The principle disadvantage of stack cutting is the relatively complex setup required and the difficulty of providing adequate clamping in intricate shape cutting.
3. Stack cutting is practical on plates as thick as 1/2", but is best adapted to plates 1/4" thick or less.
4. Best results generally are obtained with stacks that do not exceed 3" or 4" in thickness.

5. Accuracy of parts decreases with increase in thickness of stack due to slight taper in kerf.
6. Material must be free of dirt, rust, paint and loose scale. Tight new mill scale appears to assist in preventing the edges of the layers from welding together, whereas bright cold rolled stock tends to weld easily along the edges.
7. Material must be tightly clamped together.
8. A smooth continuous edge must be provided as by running a heavy vertical weld bead for starting the cut.
9. Larger than normal tip size should be used with less than recommended cutting oxygen pressure for the total thickness of the stack. If the cut is forced with high oxygen pressure, the oxygen jet has a greater tendency to find separations between the plates. Care must be taken to provide cutting oxygen hoses to the torch with adequate capacity to avoid starving the oxygen flow at reduced pressures.





BAR STOCK

The general practice in production of parts by oxygen cutting has been to work from large plates. Handling and positioning of heavy plate material is a cumbersome, time-consuming operation. While the ULTRA-GRAPH conveniently may be used on large plates, it is particularly well adapted to cutting from bar stock and plate as wide as 24".

GENERAL

The following section is devoted to illustrations of typical parts. The examples shown are but a few of the hundreds of parts, of different dimension and shape, that users have found practicable and profitable to produce with the ULTRA-GRAPH. It is anticipated also that the illustrations will tend to expand the operator's scope of pattern making possibilities and application to more varied metal-working operations.

THE MANUFACTURER OF THE ULTRA-GRAPH EXTENDS THE SERVICES OF ITS STAFF TO ASSIST IN ANY PRODUCTION PROBLEM TO WHICH THE MACHINE MAY BE APPLIED.

Cutting-Tip Numbers Compared by Drill Size of Cutting-Oxygen Orifice

(When cleaning tips, it is recommended that one size smaller drill be used)

Tradename	Series	80 79 78	77 76 75	74 73 72	71 70 69	68 67 66	65 64 63	62 61 60	59 58 57	56 55 54	53 1/16" 52	51 50 49
Airco	124, 144, 164, 195, 198, 199					00		0		1 2	3	4
Craftsman	B							1		2	3	4
Dockson	All							1		2		3
Gasweld	HC-31, HC-32, HC-39, WC-20[1], WC-35[1]				00	0				1	2	
	WC-10[1], WC-55[1]					0		1	2			
Harris	2890-F				00			0		1	2	
	6290					00	0			1		2
	7490-A							00	0	1 2		3
K-G	M4, M5					68[2]		62		56	53	50
Marquette	E[1]						1B	2B				
	C, D[1], D1[1,3]							0A		1A		2A
	C, D[1], D1[1,4]							0A		1A	2A	
Meco	All					0[5]			1	2		
Milburn	X-100						00	0		1	2	
	X-2000						00	0	1	2		3
	X-2300								1	2		3
National	All							0	1	2		3
Oxweld	CW-29[1]		2					4				
	CW-23[1], C-31, C-32		2			3		4			6	
Prest-O-Weld	CW-109[1]						0	1				
	CW-110[1], C-111							1			2	
Purox	33[1]					0		1				
	34, 35							1		2		3
Rego	All					68		62		56	53	51
Smith	Lifetime, Longlife[1,3]							0		1 2	3	
	Lifetime, Longlife[1,4]						0			1	2	
	Airline[1], Midline[1]						1	2		3 5	4	
Torchweld	280, 250, 251					68[6]		62		56	53	51
Victor	All			000			00		0	1	2	3
Weldit	S-25, S-37, S-45									1	2	

Tradename	Series	48 47 46	45 44 43	42 41 40	39 38 37	36 35 34	33 32 31	1/8" 30 29	28 27 26	25 24 23	22 21 20	19 18 17
Airco	124, 144, 164, 195, 198, 199		5	6		7		8	9			10[7]
Craftsman	B		5	6		7						
Dockson	All		4			5	6		7 8			
Gasweld	HC-31, HC-32, HC-39, WC-20[1], WC-35[1]		3			4 5						
Harris	2890-F		3			4		5				
	6290		3			4	5	6				
	7490-A			4		5						
K-G	M4, M5		45									
	M6			40		35		30		25		
Marquette	C, D[1], D1[1,3]				3A			4A				
	C, D[1], D1[1,4]		3A		4A[8]			5A	6A			
Meco	All		3			4		5	6			
Milburn	X-100	3	4	5 6	7	8	9	10 11	12			
	X-2000	4	5	6	7	8						
	X-2300		4	5		6		7	8		9	10 11[9]
National	All	4		5	6		7	8				
Oxweld	CW-23[1], C-31, C-32	8			10		12					
Prest-O-Weld	CW-110[1], C-111	3				4 5						
Purox	35		4									
Rego	All	46		42		35		30		25		
Smith	Lifetime, Longlife[1,3]	4										
	Lifetime, Longlife[1,4]	3		4				5		6		
Torchweld	280, 250, 251	46		42		35		30		25		18[11]
Victor	All		4	5		6			7			
Weldit	S-25, S-37, S-45		3			4		5				

[1] Cutting Attachment. [2] Applies to M4 only. [3] Preheat: 4 flames. [4] Preheat: 6 flames. [5] Also 00 with 3 flame preheat. [6] Applies to 280 only. [7] Tip size 11 drill size 10; tip 12 drill 2; tip 13 drill 1/4" and tip 14 drill L. [8] Remaining tips for C only. [9] Tip 12 drill size 15. [10] Tip next size larger is drill size 12.

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Flame Cutting Data — Hand and Machine

Table No. 1—Hand Flame Cutting Table for ⅛-In. to 12-In. Thickness For Clean Mild Steel—Not Preheated—Type No. 1 Cutting Only

Thickness of Steel, in.	Diameter of cutting Orifice, in.	Oxygen Pressure, lb. per sq. in.	Cutting Speed, in. per min.**	GAS CONSUMPTIONS* Per Hour Oxygen, cu. ft.	Per Hour Acetylene, cu. ft.	Per Linear Foot** Oxygen, cu. ft.	Per Linear Foot** Acetylene, cu. ft.
⅛	0.0380-0.0400	15-23	20-30	45- 55	7- 9	0.37- 0.45	0.06-0.07
¼	0.0380-0.0595	11-20	16-26	50- 93	9-11	0.63- 0.72	0.08-0.11
⅜	0.0380-0.0595	17-25	15-24	60-115	10-12	0.80- 0.96	0.10-0.13
½	0.0465-0.0595	20-30	12-22	66-125	10-13	1.10- 1.14	0.12-0.17
¾	0.0465-0.0595	24-35	12-20	117-143	12-15	1.43- 1.95	0.15-0.20
1	0.0465-0.0595	28-40	9-18	130-160	13-16	1.78- 2.89	0.18-0.29
1½	0.0595-0.0810	-40	6-				
2	0.0670-0.0810	22-50	6-13	185-231	16-20	3.55- 6.16	0.31-0.53
3	0.0670-0.0810	33-55	4-10	240-290	19-23	5.80- 12.00	0.46-0.95
4	0.0810-0.0860	42-60	4- 8	293-388	21-26	9.70- 14.64	0.65-1.05
5	0.0810-0.0860	53-70	3.5- 6.4	347-437	24-29	13.66- 19.83	0.91-1.37
6	0.0980-0.0995	45-80	3.0- 5.4	400-567	27-32	21.00- 26.70	1.19-1.80
8	-0.0995	60-77	2.6- 4.2	505-615	31-5-38.5	29.30- 38.84	1.83-2.42
10	-0.0995	75-96	1.9- 3.2	610-750	36.9-45.1	46.90- 64.20	2.57-3.84
12***	.1200	69-86	1.4- 2.6	720-880	42.3-51.7	67.70-103.00	3.98-6.05

*As the pressure of acetylene for the preheating flames is more a function of blowpipe or torch design than of the thickness of the part being cut, the pressure data, therefore, have been omitted from this table. For acetylene pressure data, see cutting apparatus manufacturers' charts.

**Lowest speeds and highest gas consumptions per linear foot are for inexperienced operators, short cuts, dirty or poor material. Highest speeds and lowest gas consumptions per linear foot are for experienced operators long cuts, clean and good material.

***Beyond 12-in. thickness, the critical data of manual cutting practices are greatly affected by the condition of the metal and the skill of the operator, resulting in wide ranges of data. In view of this, the table has been terminated at the 12-in. thickness.

The reader is referred to Table No. 2, below, giving data on Machine Cutting wherein the thickness range has been extended to 20 in.

Table No. 2—Machine Flame Cutting Table for ⅛-In. to 20-In. Thickness For Mild Steel—Not Preheated—Type No. 1 Cutting Only***

Thickness of Steel, in.	Diameter of cutting Orifice, in.	Oxygen Pressure, lb. per sq. in.	Cutting Speed, in. per min.**	GAS CONSUMPTIONS* Per Hour Oxygen, cu. ft.	Per Hour Acetylene, cu. ft.	Per Linear Foot** Oxygen, cu. ft.	Per Linear Foot** Acetylene, cu. ft.
⅛	0.0250-0.0400	15- 23	22-32	40- 55	7- 9	0.34- 0.36	0.05- 0.06
¼	0.0310-0.0595	11- 35	20-28	45- 93	8-11	0.45- 0.66	0.07- 0.08
⅜	0.0310-0.0595	17- 40	19-26	82- 115	9-12	0.86- 0.89	0.09- 0.09
½	0.0310-0.0595	20- 55	17-24	105- 125	10-13	1.04- 1.24	0.11- 0.12
¾	0.0380-0.0595	24- 50	15-22	117- 159	12-15	1.45- 1.56	0.14- 0.16
1	0.0465-0.0595	28- 55	14-19	130- 174	13-16	1.83- 1.86	0.17- 0.19
1½	0.0670-0.0810	- 55	12-15	- 240	14-18	3.20-	0.23- 0.24
2	0.0670-0.0810	22- 60	10-14	185- 260	16-20	3.70- 3.72	0.29- 0.32
3	0.0810-0.0860	33- 50	8-11	240- 332	18-23	6.00- 6.04	0.42- 0.45
4	0.0810-0.0860	42- 60	6.5- 9	293- 384	21-26	8.53- 9.02	0.58- 0.65
5	0.0810-0.0860	53- 65	5.5- 7.5	347- 411	23-29	10.97- 12.62	0.77- 0.84
6	0.0980-0.0995	45- 65	4.5- 6.5	400- 490	26-32	15.10- 17.78	0.98- 1.16
8	0.0980-0.0995	60- 90	3.7- 4.9	505- 625	31-39	25.52- 27.30	1.59- 1.68
10	0.0995-0.1100	75- 90	2.9- 4.0	610- 750	37-45	37.50- 42.10	2.25- 2.55
12	0.0110-0.1200	69-105	2.4- 3.5	720- 880	42-52	49.70- 60.00	2.97- 3.50
14	0.0110-0.1200	-105	2.0- 3.2	830-1045	48-59	65.20- 83.00	3.69- 4.80
16	0.1285-0.1600	-110	1.8- 3.0	935-1360	57-70	90.60-104.00	4.67- 6.33
18	0.1495-0.1600	-120	1.7- 3.0	1045-1680	65-83	112.10-123.00	5.53- 7.65
20	0.1610-0.2000	-135	1.5- 3.0	1155-2050	75-99	136.70-154.00	6.60-10.00

*As the pressure of acetylene for the preheating flames is more a function of blowpipe or torch design than of the thickness of the part being cut, the pressure data, therefore, have been omitted from this table. For acetylene pressure data, see cutting apparatus manufacturers' charts.

**Lowest speeds and highest gas consumptions per linear foot are for inexperienced operators, short cuts, dirty or poor material. Highest speeds and lowest gas consumptions per linear foot are for experienced operators long cuts, clean and good material.

***The apparent inconsistencies which will be noted in some of the columns in the table are due to the fact that there does not exist a straight-line relationship between the elements of pressure, speed and orifice sizes for the range of apparatus data from which this table was devised.

(Courtesy International Acetylene Association)

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