3M

Surface Conditioning Products

Application Notes

3M™ Roto Peen Flap Assemblies TC330

Introduction

This bulletin provides the basic information necessary for using the 3M™ Roto Peen Flap Assemblies Type TC 330.

Peening time and RPM charts are simplified to cover the majority of conditions normally encountered. For further assistance, please contact a 3M surface conditioning products representative through your local 3M branch sales office.

Mil spec

All Type TC 330 assemblies are covered in MIL-R-81841 (AS) and MIL-W-81840 (AS). In-house specifications have also been established by Boeing Aircraft, McDonnell Douglas, Lockheed, and others.

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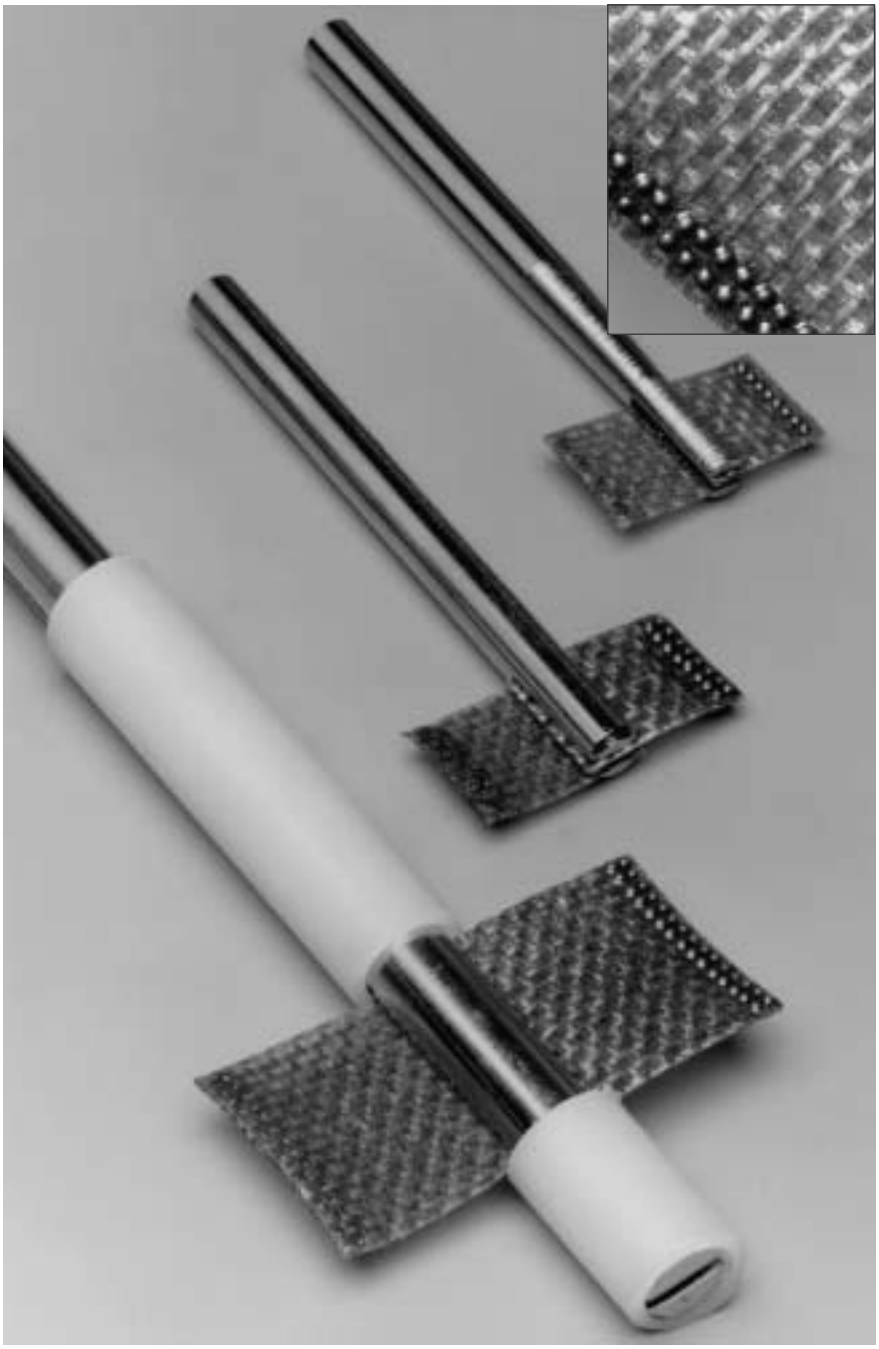
3M Roto Peen Flap Assemblies TC 330



(A) 9/16" x 1" flap for use with mandrel 7212. Single row of 330 shot. Suggested for 1/2" to 3/4" diameter hole peening.

(B) 9/16" x 1 1/4" flap for use with mandrel 7210. Double row of 330 shot. Suggested for 3/4" to 1 1/4" diameter holes and some smaller flat surfaces.

(C) 1" x 2" flap for use with mandrel 7211. Double row of 330 shot. Suggested for large, flat unobstructed surfaces. If increased coverage is needed, up to five 1" x 2" flaps can be loaded into the 7211.

The benefit of metal peening – improved material properties

Peening is an ancient cold working process for metal. When medieval blacksmiths hammered swords and shields they were peening the metal and imparting a residual compressive stress into the surface. This compressive surface stress strengthened the material, improving resistance to fatigue fracture and stress corrosion cracking.

Shot peening has generally replaced the blacksmith's hammer in modern industry. But benefits of the process are the same.

Most shot peening methods spray cast steel shot against the work surface. An air blast, similar to sand blasting, or a centrifugal wheel is used for moderately high speed propulsion.

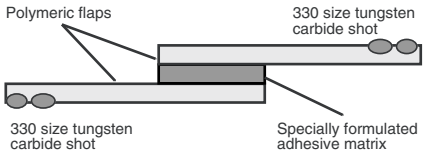
Captive shot

For small and/or hard-to-reach surfaces, the captive shot method is more convenient and effective. The shot is integrated into a rotating brush or flap. The spinning brush or flap is held near the surface so that the captive shot strikes the metal surface with each revolution.

3M Roto Peen Flap Assembly

The 3M™ Roto Peen Flap Assembly is a captive shot flap technology using high strength resin to bond tungsten carbide shot to a flexible polymeric flap. This provides a cleaner, more precise method than loose shot "blasting." Plus, the uniform 330 shot size contributes to consistent results.

Two polymeric flaps are bonded together with a specially formulated adhesive matrix for easy placement in a flap mandrel.



The flap/mandrel assemblies provide convenient portability and are especially effective for precision in-service rework, manufacturing, repair of small areas, and peening holes with diameters down to 1/2" (12.7mm).

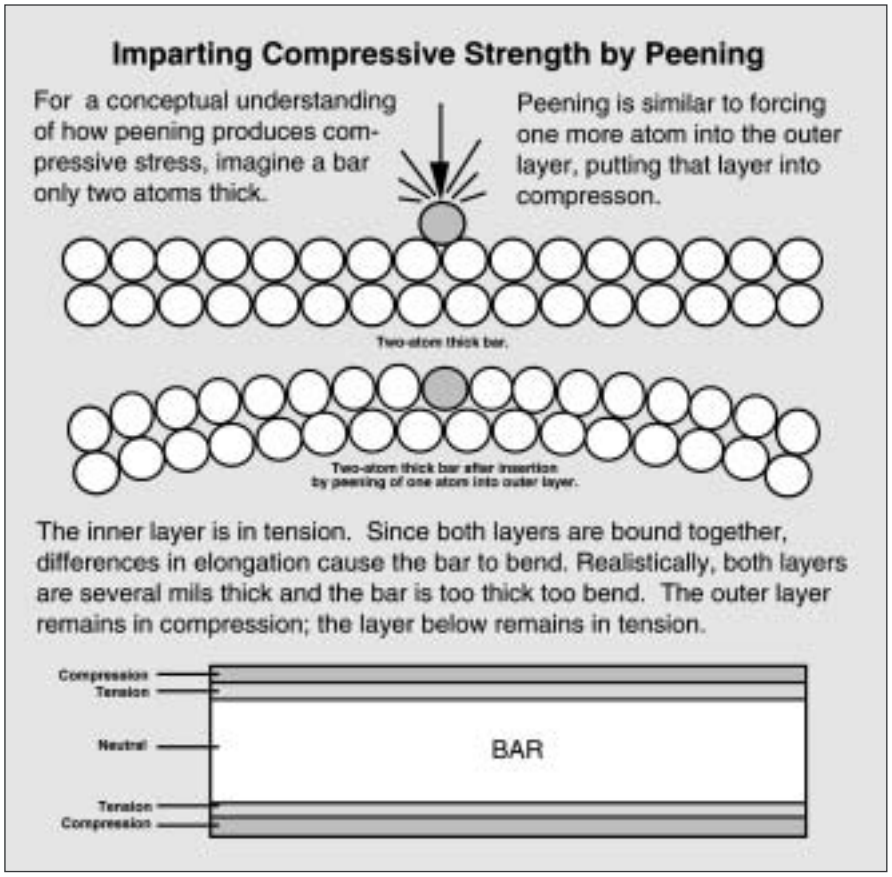
Flaps can also be cut with scissors to peen confined areas or peen into areas with a radius down to 1/16" (1.6mm).

If some shot is lost, the flap can still be used until peening time becomes unacceptable.

When shot is lost, re-check Almen intensity. (See pages 4 and 8 for making Almen readings).

Applications include –

- Landing gear assemblies
- Wing structures
- Helicopter rotor hubs
- Jet engine support members
- Peening after grinding
- Peening before plating
- Peening of surfaces subject to stress corrosion
- Peen straightening
- Peen forming
- Weld heat affect zone
- Bond testing



Determining the amount of necessary peening

In original design applications, the proper method to determine the amount of necessary peening is to peen the part and then subject it to fatigue testing. Once fatigue testing data is available, the problem is determining how much peening has been done so that subsequent parts can be manufactured to the same tolerances as the test samples.

J.O. Almen of the Research Laboratories Division of General Motors developed such a method.

Almen Scale of Peen Intensity

Adopted by the SAE (Society of Automotive Engineers), the Almen Scale of Peen Intensity measures the curvature of a standardized steel strip when peened on one side.

Three Almen strip thicknesses are available:

- Almen "A" generally used for most measurements
- Almen "C" for higher peening intensities
- Almen "N" for lighter peening intensities

The Almen strip is measured in an Almen gauge before and after peening. Curvature after peening is measured in thousandths of an inch over a specified span. This number is used to specify the Almen intensity.

To establish peening specifications, peen strips to various intensities by changing operating parameters. (See page 5). Take an Almen reading for each set of conditions. Once the desired properties are achieved in the fatigue studies, the Almen intensity for that sample is a reference number for the operating parameters that produced the desired results.

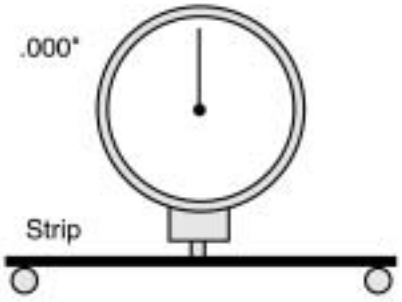
NOTE: Normally if a part needs peening, the desired intensity is specified by the manufacturer and is included in specifications or other manuals.

To make an Almen intensity reading, place an unpeened Almen strip on the Almen gauge. Adjust the gauge to read "0" as shown below.

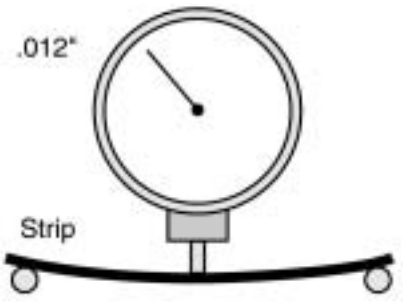
Remove the strip from the gauge and mount it on a 3M™ Magnetic Almen Strip Holder and peen (See page 8 for details). After peening, remeasure the strip. In the example shown below, the center was deflected .012". By convention this curvature indicates a peening intensity of Almen 12.

To achieve Almen 12 on larger areas in actual application, all conditions remain the same except peening time. Peening time increases in direct proportion to size. An area three times larger, for example, is peened three times longer.

Before peening



After peening



Factors affecting intensity (amount of peening)

When using 3M™ Roto Peen Flap Assemblies, three factors affect performance and dictate the amount of peening:

1. Flap rotation speed
2. Peening time or duration
3. Mandrel height

Flap rotation speed

Flap rotation speed is the most important factor affecting peening intensity. Increasing the speed of rotation increases the intensity. Decreasing the speed decreases the intensity.

Peening time

Peening time or duration controls surface coverage. Most peening specifications are stated to an Almen intensity at 98+% coverage or "saturation." This means the entire surface is covered with peening impressions.

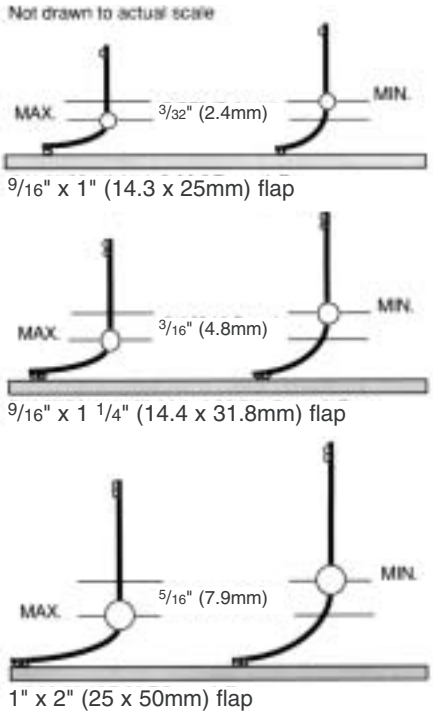
Saturation is also defined as the point at which doubling the peening time will produce less than a 15% increase in Almen intensity.

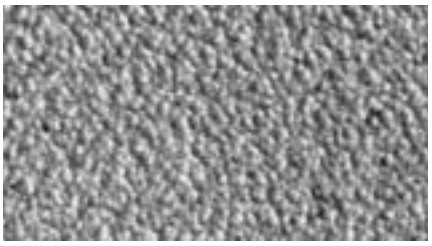
Mandrel height

Height of the mandrel above the surface controls flap deflection. And maximum deflection provides the best results. The point of maximum deflection is also the easiest to maintain. It is the point at which the mandrel, parallel to the work surface, does not quite touch the surface. If the mandrel is too high, there will be an uncomfortable vibration or bounce in the tool.

To insure uniform peening coverage, use a circular or oscillating motion over the entire area. Inspect the peened area with a 5-10X magnifier and repeen any area that does not show full coverage. All areas must be covered with peening impressions.

Flap Deflection Ranges

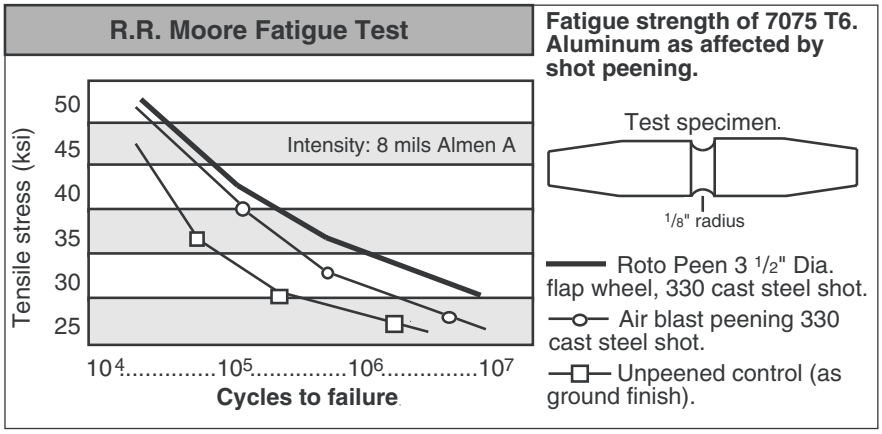




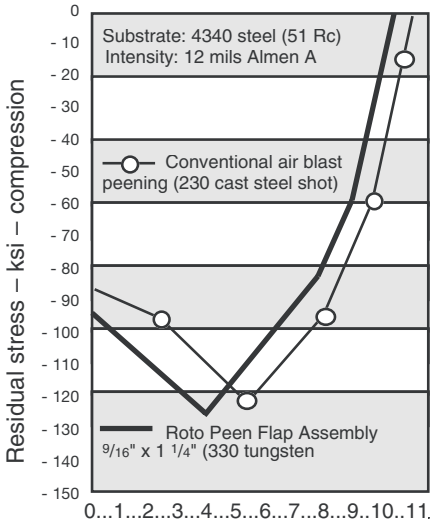
Magnification of peened surface.

The results of proper technique

With a peening technique based on the factors above, typical results are shown in these charts comparing 3M Roto Peen Flap Assemblies to conventional free shot peening.



Residual Stress vs. Depth



Peening a flat surface

Roto peening is a systematic process of essential steps. Each step is necessary for optimum results. To demonstrate the process, each step on this and the following pages is based on the example at right.

Flat surface 2" x 2 1/4" peened to 12 Almen "A" intensity with a 9/16" x 1 1/4" flap.

HINT: Spot of paint on the back side of the flap, opposite the shot, will help ensure that you are peening the surface with the shot and not the flap.

Step 1

Convert to 3M™ Almen Strip Holder intensity.

Conversion is necessary since the Almen strip bends more when using the 3M Almen Strip Holder than with the conventional screw-down holder.

In the chart at far right, Standard Almen "A" 12, for example, converts to 3M Almen A-17.

The magnetic grip of the 3M Almen Strip Holder eliminates hold-down screws for easier measurement. Plus, the same Almen strip can be used to measure intensity and then used to check for saturation.

3M™ Magnetic Almen Strip Holder

With the chart, you can readily make your own conversions.

Almen "A" intensity desired_____

3M Almen Strip Holder intensity desired_____

Almen "A" Intensity	3M Holder Intensity
3	3
4	4
5	5
6	6
7	7
8	10
9	12
10	14
11	15
12	17
13	18
14	20
15	22
16	23
17	25
18	26
19	28
20	30

Range generally used

Step 2

Determine area to be peened.

For a flat surface, area is length times the width. If the area to be peened is a hole, then the area is equal to 3.14 times the hole diameter times the hole depth.

Flat surface example:

L x W = A
2" x 2 1/4" = 4.5 $in.^2$

With the same formula, calculate your own flat surface sample.

L____ x W____= Area_____

Hole example:

3.14 x Dia. x Depth = A
3.14 x .75" x 1.25" = 2.94 $in.^2$

Calculate your own sample.

3.14 x Dia. _____
x Depth _____=
Area_____

Step 3

Determine appropriate flap size.

(A) If the area to be peened is flat with no obstructions or restrictions, use a 1" x 2" TC 330 flap.

(B) If peening a hole, use the 9/16" x 1" for a 1/2" to 3/4" diameter. Use the 9/16" x 1 1/4" for diameters over 3/4".

(C) In restricted areas use whatever size fits. For narrow slots or radius down to 1/16", cut the flaps narrower with scissors.

Go to Step 4A for 9/16" x 1" and 9/16" x 1 1/4" flaps.

Go to Step 4B for 1" x 2" flaps.

Step 4 A

Determining correct RPM for 9/16" x 1" and 9/16" x 1 1/4" flaps

4A is used only for establishing starting points. Tool and operator variability may require speed adjustments to obtain the desired 3M intensity.

Almen intensity	Desired 3M intensity	120 seconds peening	180 seconds peening	240 seconds peening
7.5	9	2900	2700	2600
8	10	3200	3000	2900
9	12	3800	3500	3400
10	14	4300	4100	3900
11	15	4600	4300	4200
12	17	5100	4980	4700
13	18	5400	5100	4900
14	20	6000	5700	5500
15	22	6500	6200	6000
16	23	6800	6500	6300
17	25	7300	7000	6800
18	26	7600	7300	7000
19	28	8100	7800	7600
20	30	8700	8400	8100

Verify that the time and RPM are correct by peening an Almen strip with the above conditions. See Step 6 for procedure. Slight RPM changes may be necessary.

Tool RPM_____

Example: 5100 RPM

Time_____

Example: 120 seconds

NOTE:

The maximum operating speed of the above flaps is 15,000 RPM.

Step 4 B

Determining correct RPM for 1" x 2" flap

4B is used only for establishing starting points. Tool and operator variability may require speed adjustments to obtain the desired 3M intensity.

Almen intensity	Desired 3M intensity	120 seconds peening	180 seconds peening	240 seconds peening
7.5	9	2000	1800	1800
8	10	2100	2000	1900
9	12	2400	2300	2200
10	14	2700	2500	2500
11	15	2800	2700	2600
12	17	3100	2900	2800
13	18	3200	3100	3000
14	20	3500	3300	3200
15	22	3800	3600	3500
16	23	3900	3700	3600
17	25	4200	4000	3900
18	26	4300	4200	4000
19	28	4600	4400	4300
20	30	4800	4700	4500

Verify that the time and RPM are correct by peening an Almen strip with the above conditions. See Step 6 for procedure. Slight RPM changes may be necessary.

Tool RPM_____
Write here

Time_____
Write here

NOTE:

The maximum operating speed of the above flap is 6000 RPM.

Step 5 Determining peening time

Area to be peened (from Step two)_____
Write here

Area of Almen strip is 2.25 in.^{2}

To calculate the time to peen the area –

$$\frac{\text{Area to be peened}}{2.25} \times \text{Time (from step 4A or 4B)} = \text{peening time}$$

$$\frac{4.5 \text{ in.}^2}{2.25} \times 120 \text{ seconds} = 240 \text{ seconds}$$

When an Almen strip is used to demonstrate roto peen capabilities, the peening time is taken directly from the charts.

Step 6 Making an Almen intensity reading

1. As noted on page 4, first place an unpeened Almen strip on the Almen gauge, and zero the dial.

Zero the dial.

The Almen strip must be clean, free of oil or grease to give consistent reproducible results.

2. Remove the strip from the gauge and place it on the 3M™ Almen Strip Holder. Be sure that the side that faces the gauge magnet, faces down on the holder magnet.

Place strip on 3M Almen Strip Holder.

As a rule of thumb when transferring the strip back and forth from the gauge to holder, always contact the magnet-facing side of the strip to the gauge or holder.

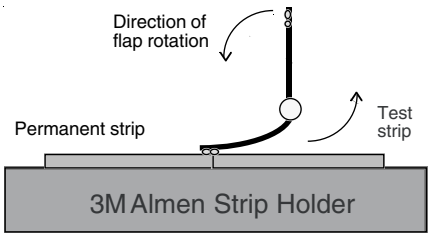
3. A constant flap rotation speed is necessary for consistent results.

Peen surface with a circular motion. Tool must be pre-set to a constant torque.

To minimize speed variability, set the tool speed using a non-contacting or strobe light tachometer while the flap is in contact with an Almen strip. To set the tool, use a different strip than the one to be measured.

When using a new flap, break it in first before conducting measurements. Simply run the new flap for a minute on a surface similar to the one to be peened.

4. Peen the strip with the time and speed determined from the charts.



NOTE: Generally you will peen the surface with the flap rotating away from the permanent strip (as shown below left).

If a gap appears between the permanent and test strip, reverse the direction of flap rotation. In this case, do not peen off the strip edge. Shot loss could occur.

5. Place the unpeened side of the strip against the Almen gauge.

6. Read the Almen intensity.

7. Compare reading in Step 6 to desired Almen intensity. If necessary, adjust speed to achieve desired result and repeat foregoing procedure to verify that the correct intensity is achieved.

Peening holes

.75" dia. x 1.25" deep hole peened to 10 Almen "A" intensity.

Since the Inner Diameter (ID) of a hole reduces flap swing, it is necessary to increase speed to achieve the same peening intensity. This increase is dependent on the hole diameter.

To use the charts, find the 3M Almen density desired, then read across to the diameter. To determine peening time, use the formula –

$$\frac{\text{Hole Dia. x 3.14 x Hole Depth}}{2.25} \times 120 = \text{Hole Peening Time (sec).}$$

Example: Hole with .75" diameter and 1.25" deep. Desired 3M peening intensity 14A (equal to Almen 10A).

$$\frac{.75" \times 3.14" \times 1.25"}{2.25} \times 120 = 157 \text{ seconds Hole Peening Time}$$

Correct tool RPM from Table B below is 7700 RPM. The proper operating conditions for this example are 7700 RPM, 157 seconds.

TABLE A: Conversion for .50" (12.7mm) to .75" (19.1mm) diameter peened with 9/16" x 1" TC 330 flap.

Almen intensity	3M Almen intensity	RPM for flat area (120 sec.)	RPM for 120 second peening of holes within diameter range specified .50-.53	.54-.57	.58-.61	.62-.65	.66-.69	.70-.73	.74-.77
6	7	2400	6000	5400	4900	4500	4200	3900	3700
7	9	2900	7300	6600	6000	5500	5100	4700	4400
8	10	3200	8000	7200	6600	6100	5600	5200	4900
9	12	3800	9500	8600	7800	7200	6700	6200	5800
10	14	4300	10800	9700	8900	8100	7500	7000	6600
11	15	4600	11500	10400	9500	8700	8100	7500	7000
12	17	5100	12800	11500	10500	9700	8900	8300	7800
13	18	5400	13500	12200	11100	10200	9500	8800	8200
14	20	6000	15000	13600	12400	11400	10500	9800	9100
15	22	6500	--	14700	13400	12300	11400	10600	9900
16	23	6800	--	--	14000	12900	11900	11100	10400
17	25	7300	--	--	15000	13800	12000	11900	11100
18	26	7600	--	--	--	14400	13300	12400	11600
19	28	8100	--	--	--	--	14200	13200	12300
20	30	8700	--	--	--	--	--	14200	13300

TABLE B: Conversion for .75" (19.1mm) to 1.25" (31.8mm) diameter peened with 9/16" x 1 1/4" TC 330 flap.

Almen intensity	3M Almen intensity	RPM for flat area (120 sec.)	RPM for 120 second peening of holes within diameter range specified .75-.81	.82-.88	.89-.94	.95-1.00	1.10-1.06	1.07-1.12	1.13-1.18	1.19-1.25
6	7	2400	4300	3900	3500	3300	3100	2900	2700	2500
7	9	2900	5200	4700	4300	4000	3700	3500	3200	3100
8	10	3200	5800	5200	4700	4400	4100	3800	3600	3400
9	12	3800	6800	6200	5600	5200	4800	4500	4300	4000
10	14	4300	7700	7000	6300	5900	5500	5100	4800	4500
11	15	4600	8300	7400	6800	6300	5800	5500	5100	4900
12	17	5100	9200	8300	7500	7000	6500	6100	5700	5400
13	18	5400	9700	8700	7900	7400	6900	6400	6000	5700
14	20	6000	10800	9700	8800	8200	7600	7100	6700	6300
15	22	6500	11700	10500	9600	8900	8300	7700	7300	6900
16	23	6800	12200	11000	10000	9300	8600	8100	7600	7200
17	25	7300	13100	11800	10700	10000	9300	8700	8200	7700
18	26	7600	13700	12300	11200	10400	9700	9000	8500	8000
19	28	8100	14600	13100	11900	11000	10300	9600	9100	8600
20	30	8700	--	14100	12800	11900	11100	10400	9700	9200

Do not exceed 15,000 RPM with 9/16" x 1" or 9/16" x 1 1/4" TC 330 flap assemblies.

Diameters over 1.25" treat as a flat surface.

Supporting data

Figure 1 **Correlation of peening intensity between 3M™ Almen Strip Holder and standard Almen Strip Holder**

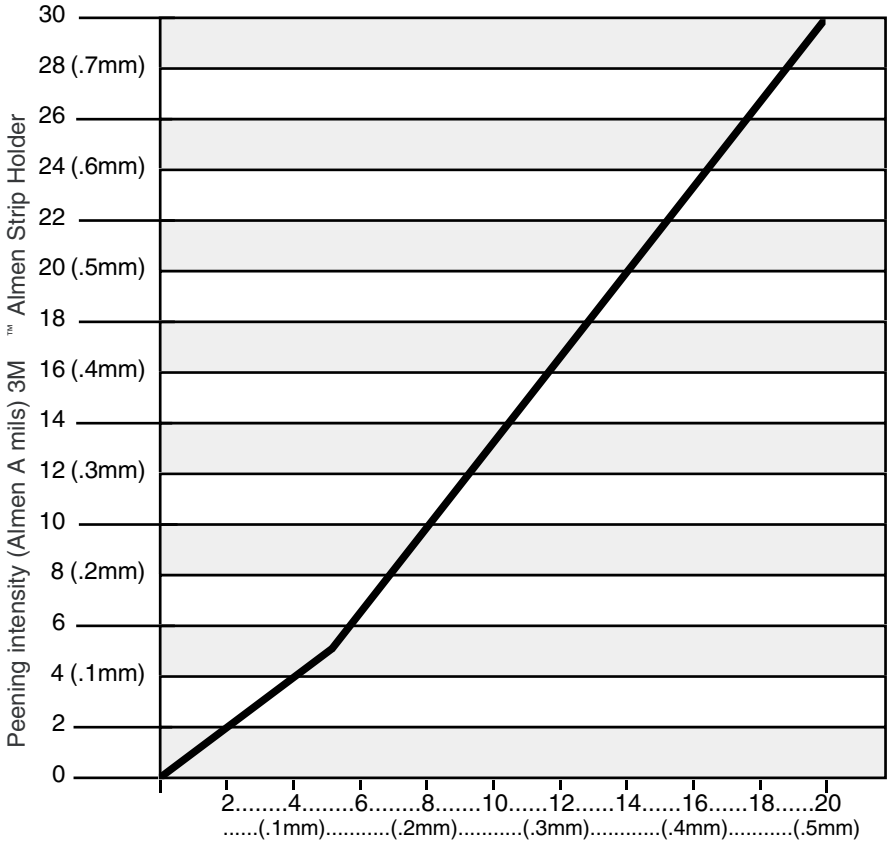
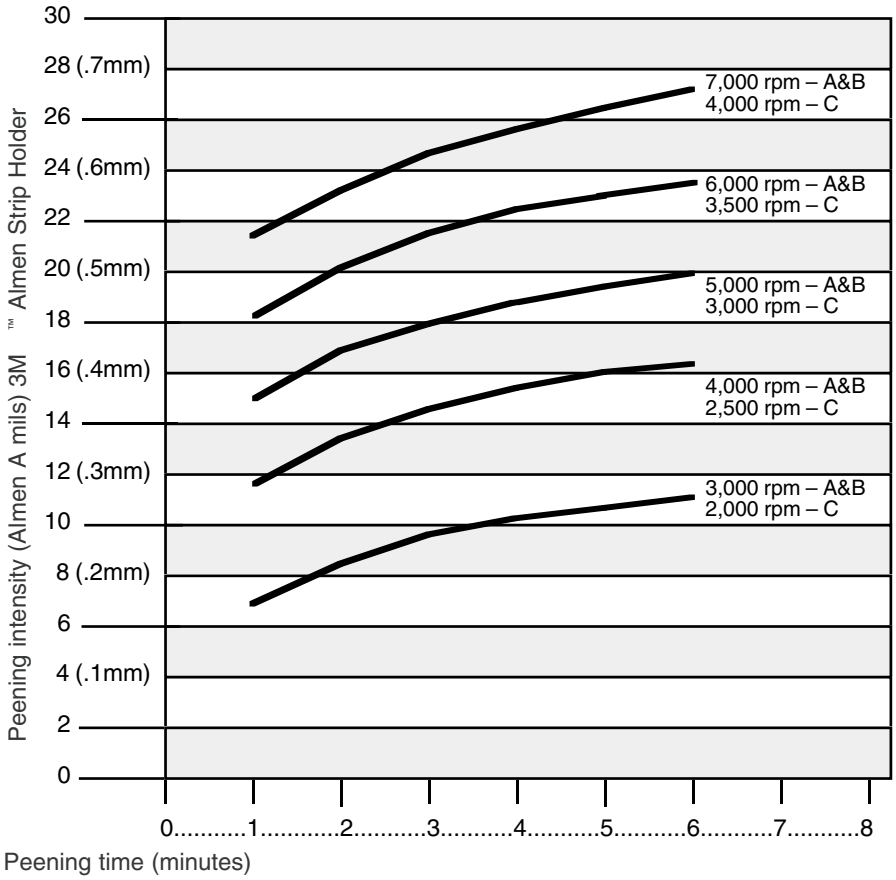


Figure 2 **Correlation of peening intensity and RPM**

A) 9/16" x 1" (14.3 x 25mm) flap assembly.

B) 9/16" x 1 1/4" (14.3 x 31.8 mm) flap assembly.

C) 1" x 2" (25 x 50mm) flap assembly.



3M Ordering Information

Description	UPC	Case Quantity
3M™ Roto Peen Assembly Kit Each kit contains: 1 – 3M™ Roto Peen Almen Strip Holder 1 – 3M™ Roto Peen Flap Assembly, TC 330, 9/16”x1-1/4” 1 – 3M™ Roto Peen Flap Assembly, TC 330, 1”x2” 1 – 3M™ Roto Peen Mandrel 7210 1 – 3M™ Roto Peen Mandrel 7211	048011-17157-9	1
3M Roto Peen Flap Assembly, TC 330, 9/16”x1-1/4”	048011-03766-0	10
3M™ Roto Peen Flap Assembly, TC 330, 9/16”x1”	048011-03760-8	10
3M Roto Peen Flap Assembly, TC 330, 1”x2”	048011-03765-3	5
3M Roto Peen Almen Strip Holder, 2”x7”x1”	048011-03764-6	1
3M Roto Peen Mandrel 7210 (Use with Roto Peen Flap Assemblies 9/16”x1-1/4”)	048011-03768-4	1
3 Roto Peen Mandrel 7211 (Use with Roto Peen Flap Assemblies 1”x2”)	048011-03767-7	1
3M™ Roto Peen Mandrel 7212 (Use with Roto Peen Flap Assemblies 9/16”x1”)	048011-05969-3	1

Distributor, Tool, and Accessory Information

Almen Gauge	Electronics Incorporated 1428 W. 6th Street Mishawaka, IN 46544 1-800-832-5653 www.shotpeener.com	
	Wheelabrator Corporation 1606 Executive Drive La Grange, GA 30240 1-800-544-4144 www.surfacepreparation.com	
Almen Strips	Foredom Electric Company 16 Stony Hill Road Bethel, CT 06801 1-800-441-0625 www.foredom.com	*Foredom Series H Power Tools used with hand piece 25H or 44HT and controller EMH-1*
	Dumore Corporation 1030 Veterans Street Mauston, WI 53948 1-888-467-8288 www.dumorecorp.com	*Dunmore Series 6-411 Flexible Shaft Grinder with 1-310 Speed Control*
Electric Power Tools	Ingersoll-Rand Fluid Products (IR ARO) PO Box 151 Bryan, OH 43506 (419) 636-4242 www.ingersoll-rand.com www.arozone.com	*Extension grinder 12L2693-01 with 3/8” collet*
	(Dotco Tools) Cooper Tools PO Box 1410 Lexington, SC 29071 1-800-845-5629 www.coopertools.com/brands/dotco	
Tachometers	www.instrumenation.com www.omnicontrols.com www.shimpoinstr.com www.kerncoinstr.com www.monachinstrument.com www.checkline.com/pioneer www.qualityinstrumentsinc.com www.geneq.com www.nemicmach.com	

3M Contact Information:

For more information and assistance contact your local 3M distributor or 3M directly at the numbers listed below.

For the contiguous 48 United States
Call **1-800-742-9546**
Fax **1-800-852-4668**

For Alaska **907-522-5200**
Canada **519-451-2500**
Hawaii **808-422-2721**
Northern Mexico . .**800-280-9528**
Puerto Rico **787-620-3000**

Visit our Website at: www.3M.com/abrasives

Suggested Readings:

Shot Peening Applications
7th Edition
Metal Improvement Company
10 Forest Avenue
Peramus, NJ 07652
(201) 843-7800

Shot Peening Theory and Application
IITT-International
40, Promenade Marx-Dormoy
F-93460 Gournay-Sur-Marne
France

Understanding How Components Fail
American Society for Metals
9639 Kinsman Road
Materials Park, OH 44073
1-800-336-5152

Safety Information: Always use appropriate protective glasses, face shields and body protection. Do not exceed maximum operating RPM's. Use guards provided with machine. Follow safety operation procedures posted in work areas.

3M Industrial Business
Customer Response Center

Building 21-1W-10
900 Bush Avenue
St. Paul, MN 55106
800-362-3550
651-733-9175 fax