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Instructions for using the

PRECISION DIGITAL PITCH GAUGE

Congratulations!

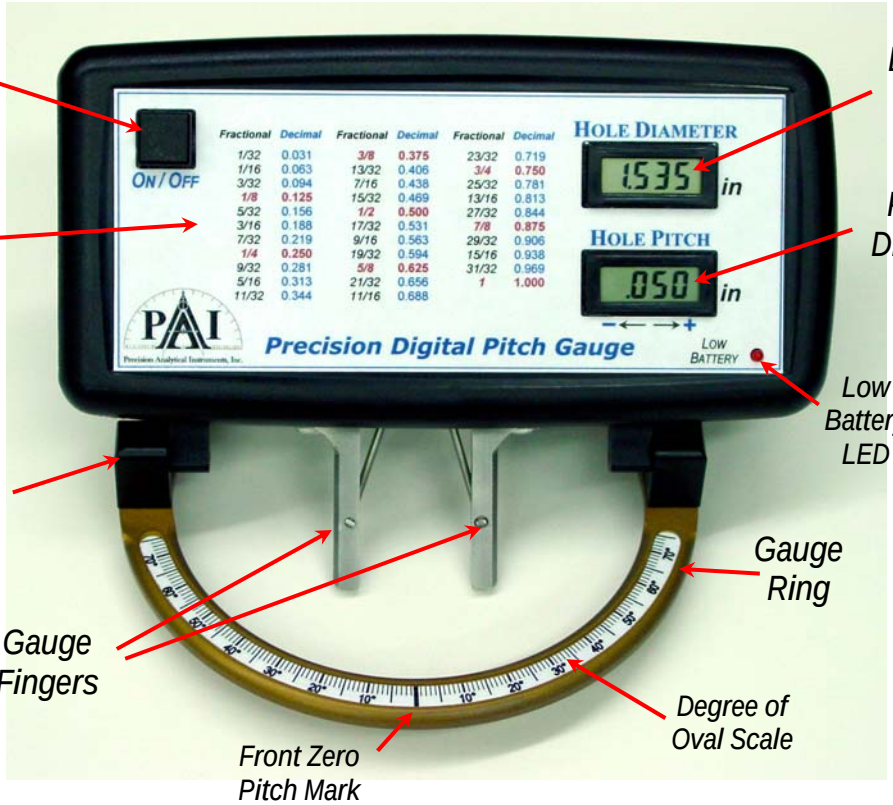
Congratulations on your purchase of the *Precision Digital Pitch Gauge*! We hope you will find the *Gauge* to be the most accurate and reliable device of its type on the market.

Please take a moment to review the following instructions. This device is very different than its predecessors, and we've found that it helps to review the following information. Armed with this advice and a few minutes of practice, you should be able to achieve excellent performance from your device.

First, we'll review the terminology, and then we'll show you how to use it.

LEGEND

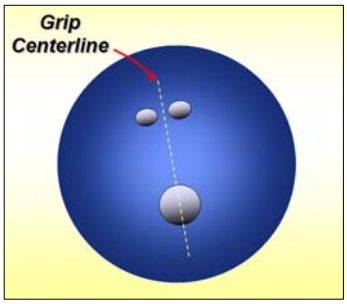
(Front View)



(Back View)

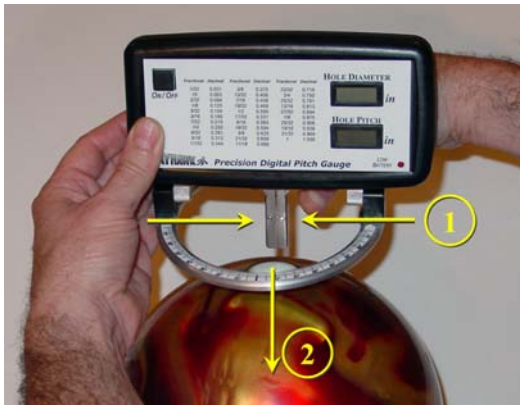
GAUGING A ROUND HOLE

1. Place the ball on a stable surface, with the hole to be measured pointing up.



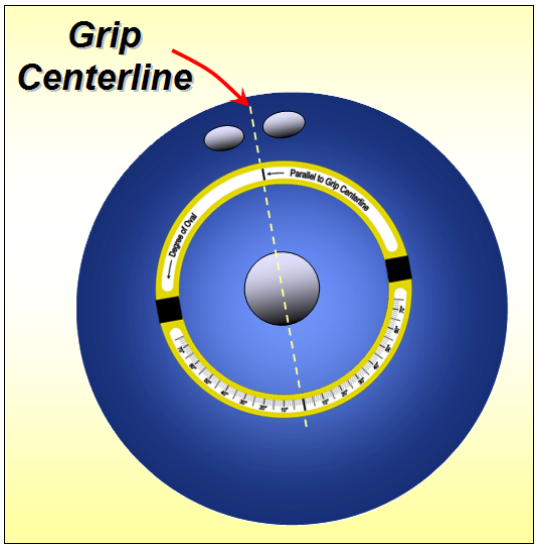
2. Using a compass or quarter scale, mark the grip centerline. (Not necessary if making approximate measurements.)

3. Hold the *Precision Digital Pitch Gauge* in the vicinity of the hole. Bring the *Gauge Fingers* together ((1)) by squeezing the *Finger Tabs* (located on the back of the gauge).

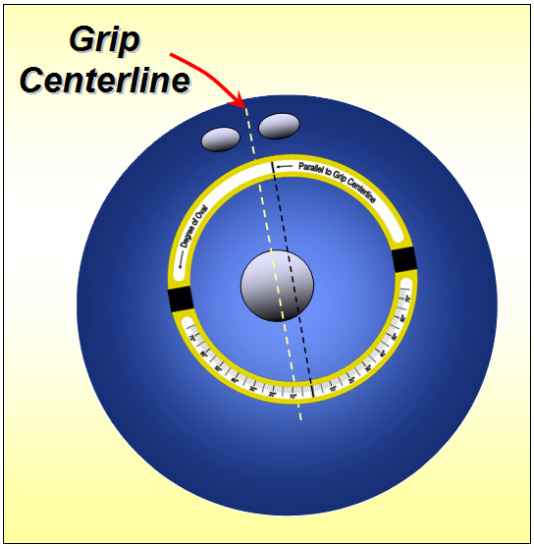


4. Insert the *Gauge Feelers* partially into the ball, and release the finger tabs. As you push the ring to the surface of the ball ((2)), you'll notice that the Gauge will seek a preferred location. Gently rock the Gauge back-and-forth to confirm that the Gauge is firmly seated and the fingers are aligned to the hole edges.

5. ***IMPORTANT!*** Rotate the *Gauge* so that the *Front* and *Back Zero Pitch Marks* on the *Gauge Ring* are ***aligned with or parallel to the grip centerline*** (see Figures).



*Zero pitch marks are **aligned with** the grip centerline*



*Zero pitch marks are aligned **parallel to** the grip centerline*

6. Keeping the *Gauge Ring* firmly against the ball, gently rock the *Gauge* back-and-forth and side-to-side to make sure that the fingers are fully inserted and aligned to the hole.

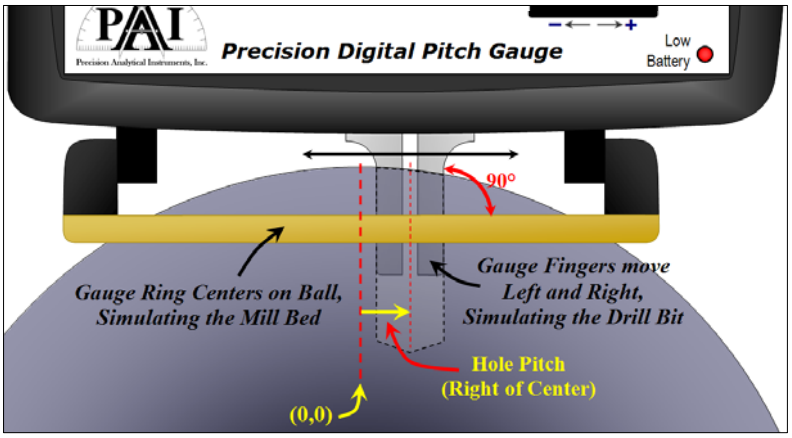
7. Turn the *Gauge* on, and gently rock it side-to-side to *find the hole's largest diameter*. Read the *Pitch Display* when the *Diameter Display* reading is largest. A positive pitch value signifies a pitch right of center, and a negative value signifies a pitch left of center.

8. Rotate the *Gauge* 90° (so the *Zero Pitch Marks* are perpendicular to the *Grip Centerline*), and repeat the alignment procedure described above to measure forward or reverse pitch.

9. To remove the *Gauge*, squeeze the *Finger Tabs* and lift the *Gauge* off of the ball.

NOTES AND OPERATING HINTS

- The *Gauge* works by a simple principle; it simulates the mill. The *Gauge Fingers* simulate the drill bit and the *Gauge Ring* simulates the plane of the mill. As is the case for a mill, the *Gauge Fingers* ('drill bit') are always perpendicular to the *Ball Ring* ('drill bed'), and the center of the *Gauge Ring* represents where a zero/zero pitch would occur.



- Keeping the *Front and Back Zero Pitch Marks* parallel to the grip centerline is important because the left-right axis of the *Gauge* needs to directly correspond to the left-right motions of a mill. An approximate visual alignment is usually sufficient if you only need to know the pitch to within 1/32 of an inch.

- When measuring holes that don't have parallel sides, you won't be able to 'feel' the *Gauge Fingers* align as firmly as with a cylindrical hole. So instead of feel, adjust the position of the *Gauge* to find the maximum *Hole Diameter* reading, and then read the pitch.

- Some pitch gauges make substantial errors when measuring holes that have pitch in more than one direction (e.g. right pitch and forward pitch), because they don't align properly to both pitches. By including the *Gauge Hinge*, the *Precision Digital Pitch Gauge* avoids this pitfall, allowing each pitch to be measured independent of the other. For best results, allow the *Gauge* to tilt forward and backward so that it aligns itself to the pitch *not* being measured.

- For best results with changeable grips, remove the grip and measure the pitch of the ***sleeve***.

GAUGING AN OVAL HOLE

Measuring ovals can be tricky regardless of which tools you use. But with common sense, a little detective work, and some simple math, you should be able to *precisely* determine the parameters of most ovals. The *Precision Digital Pitch Gauge* has features that make this detective work fast and accurate, and in addition to a description of the process, we've also provided a worksheet which you are free to photocopy to use with your *Gauge*.

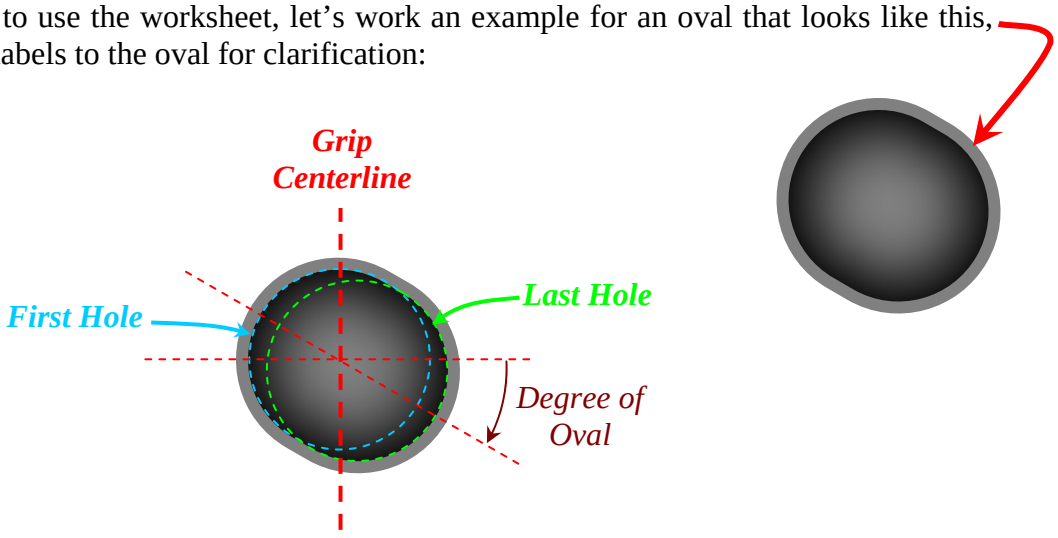
Why not just use the *Gauge* to measure the pitch of an oval hole and be done with it? This approach actually makes sense in some cases; it depends upon how accurate you want to be. Remember, when you cut an oval, you are also changing the pitch of the hole in at least one direction, often two. The amount the pitch changes depends upon the *Degree of Oval* and the *Oval Length*. The pitch can change up to ½ the *Oval Length*, so the pitch of a 0.090″ oval could measure up to 0.045″ different than the pitch that was originally used to drill the oval (the largest change is along the oval's long axis). Thus, for small *Oval Lengths*, or in cases where an approximate value may is close enough, you can just use the value displayed on the *Gauge*. However, if you want to be more precise, you need to do a bit of simple math.

There are five things you need to know to duplicate an oval:

i) What drill bit size to use;
ii) How far to move the drill bit (the distance between the first hole and the last hole drilled);
iii) Where and how to drill the first hole;
  a. The starting forward/reverse pitch;
  b. The starting left/right pitch;
iv) Along what angle to move the bit (the "Degree of Oval").

To begin, review the blank worksheet on the following page. Note that there are four measurements to be made (shown in blue boxes) and five results (shown in red boxes). There are a few simple calculations (subracting and dividing by two), which are shown in the gray boxes. The worksheet will help you to organize your work, and the math is simple enough that you will probably not need a calculator. If you don't want to use the worksheet, you can use the simple equation on page 8.

To illustrate how to use the worksheet, let's work an example for an oval that looks like this, and let's add some labels to the oval for clarification:



(discussion continues on page 7)

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PRECISION DIGITAL PITCH GAUGE

OVAL MEASUREMENT WORKSHEET

STEP 1 — *Measure Maximum and Minimum Diameters*

Maximum Diameter	D_{MAX}	
Minimum Diameter	D_{MIN}	-
Oval Length	$D_{MAX} - D_{MIN}$	

Calculate Oval Length
Subtract D_{MIN} from D_{MAX}

Find Drill Bit Size
Round Down from D_{MIN} to the nearest fractional bit size (use table to right)

Bit Size (decimal)		
Bit Size (fractional)	Bit	

STEP 2 — *Measure Left/Right Oval Diameter and Pitch*

Left/Right Oval Diameter	D_{LR}	
	D_{MIN}	-
	$D_{LR} - D_{MIN}$	
Left/Right Oval Pitch	P_{LR}	
	$(D_{LR} - D_{MIN}) \div 2$	-
Side Pitch	$P_{LR} - (D_{LR} - D_{MIN}) \div 2$	

Find Left/Right Pitch of Start Hole

STEP 3 — *Measure Forward-Reverse Oval Diameter and Pitch*

Forward/ Reverse Diameter	D_{FR}	
	D_{MIN}	-
	$D_{FR} - D_{MIN}$	
Forward/ Reverse Pitch	P_{FR}	
	$(D_{FR} - D_{MIN}) \div 2$	-
Forward Pitch	$P_{FR} - (D_{FR} - D_{MIN}) \div 2$	

Find Forward/Reverse Pitch of Start Hole

STEP 4 — *Measure Degree of Oval*

Degree of Oval

Fractional	Decimal
1/64	0.016
1/32	0.031
3/64	0.047
1/16	0.063
5/64	0.078
3/32	0.094
7/64	0.109
1/8	0.125
9/64	0.141
5/32	0.156
11/64	0.172
3/16	0.188
13/64	0.203
7/32	0.219
15/64	0.234
1/4	0.250
17/64	0.266
9/32	0.281
19/64	0.297
5/16	0.313
21/64	0.328
11/32	0.344
23/64	0.359
3/8	0.375
25/64	0.391
13/32	0.406
27/64	0.422
7/16	0.438
29/64	0.453
15/32	0.469
31/64	0.484
1/2	0.500
33/64	0.516
17/32	0.531
35/64	0.547
9/16	0.563
37/64	0.578
19/32	0.594
39/64	0.609
5/8	0.625
41/64	0.641
21/32	0.656
43/64	0.672
11/16	0.688
45/64	0.703
23/32	0.719
47/64	0.734
3/4	0.750
49/64	0.766
25/32	0.781
51/64	0.797
13/16	0.813
53/64	0.828
27/32	0.844
55/64	0.859
7/8	0.875
57/64	0.891
29/32	0.906
59/64	0.922
15/16	0.938
61/64	0.953
31/32	0.969
63/64	0.984
1	1.000

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PRECISION DIGITAL PITCH GAUGE

OVAL MEASUREMENT WORKSHEET

STEP 1 — *Measure Maximum and Minimum Diameters*

Maximum Diameter	D_{MAX}		1.065″
Minimum Diameter	D_{MIN}	-	0.945″

Calculate Oval Length
Subtract D_{MIN} from D_{MAX}

Oval Length	$D_{MAX} - D_{MIN}$	0.120″

Find Drill Bit Size
Round Down from D_{MIN} to the nearest fractional bit size (use table to right)

Bit Size (decimal)		0.938″
Bit Size (fractional)	Bit	15/16″

STEP 2 — *Measure Left/Right Oval Diameter and Pitch*

Left/Right Oval Diameter	D_{LR}		1.030″
	D_{MIN}	-	0.945″
	$D_{LR} - D_{MIN}$		0.085″
Left/Right Oval Pitch	P_{LR}		0.043″
	$(D_{LR} - D_{MIN}) \div 2$	-	0.042″

Find Left/Right Pitch of Start Hole

Side Pitch	$P_{LR} - (D_{LR} - D_{MIN}) \div 2$	0.001″

STEP 3 — *Measure Forward-Reverse Oval Diameter and Pitch*

Forward/ Reverse Diameter	D_{FR}		0.990″
	D_{MIN}	-	0.945″
	$D_{FR} - D_{MIN}$		0.045″
Forward/ Reverse Pitch	P_{FR}		0.273″
	$(D_{FR} - D_{MIN}) \div 2$	-	0.023″

Find Forward/Reverse Pitch of Start Hole

Forward Pitch	$P_{FR} - (D_{FR} - D_{MIN}) \div 2$	0.250″

STEP 4 — *Measure Degree of Oval*

Degree of Oval	30°

Fractional	Decimal
1/64	0.016
1/32	0.031
3/64	0.047
1/16	0.063
5/64	0.078
3/32	0.094
7/64	0.109
1/8	0.125
9/64	0.141
5/32	0.156
11/64	0.172
3/16	0.188
13/64	0.203
7/32	0.219
15/64	0.234
1/4	0.250
17/64	0.266
9/32	0.281
19/64	0.297
5/16	0.313
21/64	0.328
11/32	0.344
23/64	0.359
3/8	0.375
25/64	0.391
13/32	0.406
27/64	0.422
7/16	0.438
29/64	0.453
15/32	0.469
31/64	0.484
1/2	0.500
33/64	0.516
17/32	0.531
35/64	0.547
9/16	0.563
37/64	0.578
19/32	0.594
39/64	0.609
5/8	0.625
41/64	0.641
21/32	0.656
43/64	0.672
11/16	0.688
45/64	0.703
23/32	0.719
47/64	0.734
3/4	0.750
49/64	0.766
25/32	0.781
51/64	0.797
13/16	0.813
53/64	0.828
27/32	0.844
55/64	0.859
7/8	0.875
57/64	0.891
29/32	0.906
59/64	0.922
15/16	0.938
61/64	0.953
31/32	0.969
63/64	0.984
1	1.000

GAUGING AN OVAL HOLE

(continued from page 4)

Step 1. First, place the *Gauge* in the oval hole as described in the previous section. Then, rotate the *Gauge* to find the oval's minimum and maximum diameters. Record the measured values in the first two blue boxes of the worksheet (see Page 6), and copy the minimum diameter value to the two other boxes labeled D_{MIN} as shown (follow the arrow). Subtract the minimum diameter from the maximum diameter, and record the ***Oval Length*** in the first red box (***Oval Length*** = $D_{MAX} - D_{MIN}$ = **1.065" - 0.945" = 0.120"**).

Now find the drill bit size by ***rounding down*** the minimum diameter value to the nearest fractional size. A table is provided on the right side of the worksheet to help you with this step. In this case, the oval was probably cut with a 15/16" drill bit (**15/16″ = 0.938″**), and the distance between the first drilled hole and the last drilled hole was 0.120". Congratulations! We now we know two of the five oval parameters.

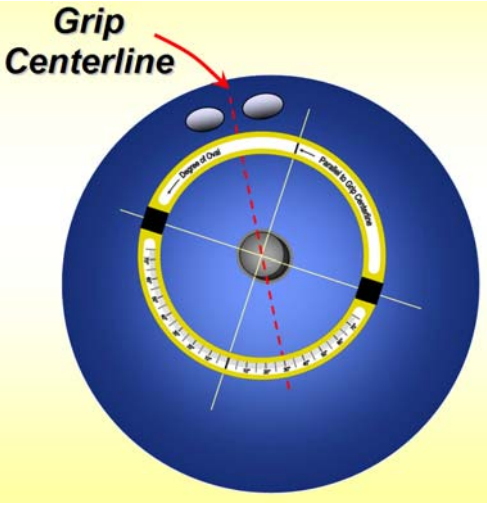
It is not uncommon to find drilled holes slightly larger than the drill bits, due to sanding, customer wear and adjustments (e.g. bevel knife), and unstable drilling conditions. In this example, the measured hole is only 0.007" oversize.

Step 2. To find the Left/Right pitch of the oval's first hole, measure the pitch of the oval hole just as if it were a round hole and record the values in the blue boxes as shown. Be careful to align the *Gauge* ***parallel*** to the Grip Centerline. *(With ovals it sometimes helps to squeeze the Finger Tabs, rotate/align the Gauge, and then gently re-release the Finger Tabs to re-seat the Fingers.).*

Now, subtract the minimum diameter from measured diameter ($D_{LR} - D_{MIN}$ **= 0.085″**) and record the difference. Divide the difference by two and record it in the box labled $(D_{LR} - D_{MIN}) \div 2$. Subtract this quotient from the measured Pitch to obtain the ***Side Pitch*** of the first hole. In this example the ***Side Pitch*** is essentially zero.

Step 3. Repeat the process in Step 2 to obtain the Forward/Reverse Pitch of the starting hole, but this time rotate the *Gauge* so that it is ***perpendicular*** to the Grip Centerline.

Step 4. Now all that remains is the *Degree of Oval*. We suggest you start by obtaining an ***approximate value*** as follows: Rotate the gauge so that it is displaying the longer diameter value (D_2), and then read along the drawn *Grip Centerline* to the *Degree of Oval Scale* on the *Gauge Ring*. In many situations, this will be close enough, as most pro-shops only drill ovals to the nearest 5 degrees.



Measuring the Degree of Oval

If you want to be more precise, however, you will need to adjust the *Gauge Ring* so that it is concentric with the first hole. (Think about it; protractors work from the center of a circle.)

To make this correction, slightly raise the *Gauge* off of the ball, so that the *Gauge Fingers* (still aligned in the hole) are supporting the *Gauge.* Then, carefully slide the ring left/right until the *Pitch Display* reads close to zero. Now re-check your more accurate *Degree of Oval* reading. Record your value on worksheet. Congratulations! You've precisely determined the parameters you need to reproduce the oval.

Here is the equation we used to adjust the measured pitch to find the drill pitch:

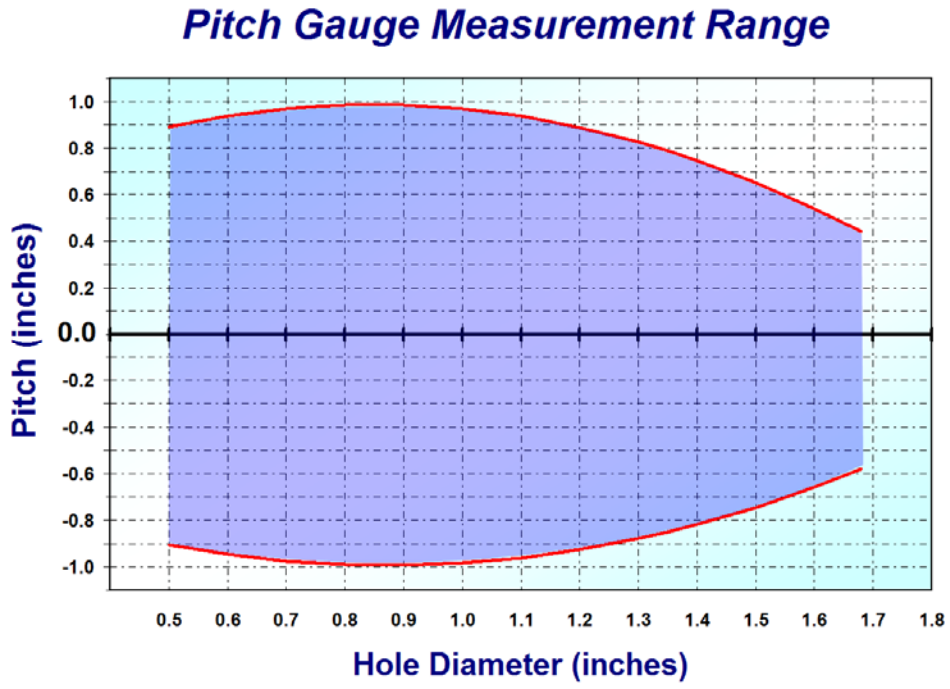
$$Drill\ Pitch = Measured\ Pitch - \frac{Measured\ Diameter - Minimum\ Diameter}{2}$$

GAUGE RANGE OF MEASUREMENT

The *Precision Digital Pitch Gauge* can measure a large range of hole diameters and pitches, and was designed to satisfy the needs of most pro-shops.

	Minimum	Maximum
Hole Diameter	0.50"	1.55"
Hole Pitch	-1.00"	1.00"

The measureable pitch range changes with hole diameter as shown in the following graph. In general, the larger the hole, the smaller the range of measureable pitches.



CHANGING THE BATTERY

Warning! Use only quality alkaline batteries in your device!

A good quality battery should last for about 20 hours of continuous use. To preserve battery life, the *Gauge* automatically turns itself off 90 seconds after pressing the on/off button. Thus, a good battery will last for about 800 uses. When the battery power gets too low for the device to function properly, the red LED located on the front panel will glow.

The device consumes very little power in the off state, so you don't need to remove the battery in routine use. However, if you use the gauge only infrequently, or are planning to store it for an extended time, we recommend that you remove the battery to prevent damage due to battery leakage.

To remove the battery, press down on the corrugated portion of the batter cover and slide the cover off in the direction shown. Once the cover is off, the battery is easily lifted out.

When inserting a new battery, make sure the polarity is correct, with the "+" side of the 9V battery toward the center of the device.