DESIGNING SPIRALS

Below is a diagram of a spiral staircase as viewed from above. 4 items of information are needed to construct a spiral staircase. In this case we will design the outer spiral.

1. The horizontal RADIUS or DIAMETER of the staircase at the railing.
2. The TOTAL HEIGHT of the staircase.
3. The TOTAL ANGLE OF ARC, in degrees, of the staircase.
4. The DIRECTION OF RISE of the staircase, indicates whether the direction of rise is clockwise or counterclockwise.

NOTE: The RISE and RUN of each step at the outside railing and the total number of steps in the staircase may replace items 2 & 3, but may not be as accurate.

The first step in determining a rolling radius is to find the horizontal circumference of the portion of a circle being used by the staircase, in this case 270°.

NOTE: A triangle (FIG. 2) best illustrates each of the following steps. The horizontal circumference is represented by the Base Line of the triangle.

Step #1 – Base Line of Triangle

48° x π = 150.8°
Now x 270°/Degrees of Arc = 40715
Then 40715 ÷ 180 = 226.2”.

This is the base of our triangle. With a total height of 120", we will now figure the length of the hypotenuse of our triangle, which will represent the Arc Length of your work-piece.

Step #2 – Figuring the Arc Length.

120 + 226.2 = 65566.44,
Now 1/2 of 65566.44 = 256.06”.
This number represents the amount of material (Arc Length) required to do the project.

Step #3 – Figuring the Rolling Radius.

256.06” ÷ 226.2 = 1.132.
Now 1.132^2 = 1.2814
Now 1.2814 x 48” = 61.59”
Your rolling radius is 61.5”.

In Short:

Step #1
Radius x π = ___ x Degrees of Arc = ___ ÷ 180 = Base Line

Step #2
Height^2 + Base Line^2 = _____ = Arc Length

Step #3
Arc Length ÷ Base Line = ____^2 x Radius = Rolling Radius.

NOTE: This method would work for any size spiral, including the INSIDE railing of a staircase.

WORKING WITH ARCS

To help you gain an understanding and a working knowledge of arcs, I have devised some sample problems you are likely to encounter in the shop or at the jobsite. These are solutions to problems anyone can work out. All you need is a Scientific Calculator e.g. Texas Instruments TI-30XA or something similar, with these functions SIN, COS, TAN, 1/X, X^2, (2nd or INV.), √ and π. Simply insert your numbers while following the instructions as they appear in the equation.

A)- In this first exercise we will determine the Arc Length of an arc, enough to make a 90° angle with a Radius of 36 inches.

On your calculator punch in 36 x π(3.14) = you get 113.1
Now 113.1 ÷ 180, you get .628. Now x 90 = you get 56.55°
The Arc LENGTH AT 90° with a 36” radius is 56.55”.

Step #1
Radius x π = ___ ÷ 180 = ____ x Angle of the Arc = ARC LENGTH.

B)- Here, we will determine the CHORD of an arc, if we know the RADIUS and the ARC LENGTH.

Our Radius will be 120” and the Arc Length will be 288”.
Punch in 120” x π = you get 376.99
Now 376.99 ÷ 288 = you get 1.309.
Now hit the 1/X key, you get .7639.
Now x 180 = you get 137.51 Now divide by 2 = 68.755
Punch SIN you get .932 now x 120” = 111.845
Now 111.845 x 2 = 223.69” Your CHORD is 223.69”.

Continued
**C)**- We will now determine the **RISE** of an arc.

If we know the **RADIUS** and the **ARC LENGTH**,

*Our Radius will be 300" and the Arc Length will be 240".*

\[
300 \pi \times 392.4778 = 452.9727 \quad \text{Now} \quad \frac{240}{2} = 3.927 \quad \text{Now} \quad \frac{1}{x} \quad \text{you get} \quad .2546 \quad \text{Now} x 180 = 45.8366 \quad \text{Now} \quad 2 = 22.9183 \quad \text{Now} \quad \cos \left( \frac{1}{x} \right) = .07894 \quad \text{Now} x 300 = 23.6817
\]

Your Rise is 23.6817".

In Short:

\[
\text{Radius} \times \pi = \frac{\text{Arc Length}}{x} \quad \text{Arc Length} = \frac{\text{Rise}}{x} \quad \text{Rise} = \frac{1}{x} \quad \cos \left( \frac{1}{x} \right) = \text{Rise}
\]

(Positive number here does not matter.)

This exercise is good for all **ANGLES** with less than 180 degrees of Arc.

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**Bump-Rolling Steel Plate**

Figuring, measuring and taking the guesswork out of adjusting the roll using the Arc Master Radius Gauge.

To bump roll steel plate on a brake, 3 variables must be known:

1. **The Radius of the arc.**
2. **The Arc-Length or the Total Angle of the roll in degrees.**
3. **The spacing between each hit or bump.**

For our Bump-Rolling example we will use the following:

- **Radius** is 36 inches
- **Arc-Length** is 60 inches
- The **Total Angle** is 95.49°

If you only know the **Radius** and the **Arc-Length**, the **Total Angle** must be determined. See exercise **B).**

\[
\begin{align*}
36'' \times \pi & = 113.1'' \div 60 = 1.885 \\
1/X & \quad \text{will give you} \quad .5305 \\
.5305 \times 180 & = 95.49° \text{(degrees of arc)}.
\end{align*}
\]

If you know the **Radius** and the **Total Angle**, the **Arc Length** must be determined. See exercise **A).**

\[
\begin{align*}
36'' \times \pi & = 113.1'' \div 180 = .628 \\
.628 \times 95.49° & = 60'' \text{(Arc Length)}
\end{align*}
\]

**Bump-Roll Spacing:**

The spacing of each hit depends on the required smoothness of the arc and the size of vee(bottom) die you will be using for the job. For a more uniform roll the previous hit should (where possible) reach and slightly pass the edge of the vee die opening. This will ensure that the bend angle will be the same for all other hits.

For a tighter spacing between bends while using the same vee die opening:

When making the second bend, the first bend will fall inside the vee opening causing the angle of the second bend to under-bend. The angle for the second bend must then be adjusted. All further bends will have this same adjustment.

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In our sample exercise the vee die opening will be 2.5" wide, the steel plate is ¾" thick and our bend spacing will be 1.5" apart. As mentioned before, the final **Radius** will be 36" with an **Arc Length** of 60".

**NOTE:**

(Bend angle is calculated by the number of spaces between bends, not the number of hits.)

With an **Arc Length** of 60" and bend spacing set at 1.5", there will be a total of 40 **spaces** whether there are 2 tangents, 1 or no tangents. (Tangents are unrolled sections at each end of the rolled section).

(The number of hits you will need with 2 tangents is 41, 40 hits with 1 tangent and 39 hits with 0 tangents.)

60" ÷ 1.5" = 40 spaces.

95.49° ÷ 40 = 2.39° per bend.

If there are 2 tangents, the first and last bend will be 1/2 the normal value or in this case 1.2°.

**NOTE:**

(Any bend that is next to a tangent is ½ normal bend value.)

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**Checking & Adjusting the Roll:**

Knowing the exact radius of a bump-rolled arc is essential to knowing how much you need to correct it.

Setting the brake to bend 2.39° can at best be set and measured to within ±1/4°. A sample roll will have to be made. You will need 12 inches of arc in order to take a radius measurement with the Arc Master 3600 radius gauge or 6 inches with the Arc Master 750 radius gauge. For this exercise, the measured radius is 40". You need 36". How much must you adjust the bend angle to get the required radius? Do the following exercise.

\[
\begin{align*}
36'' & \div 40'' = .9 \\
.9 \times 2.39° & = 2.151° \\
2.39° & \div 2.151° = .24°
\end{align*}
\]

Your bend angle must be increased by .24° in order to roll a radius of 36".

**In Short:**

- **Target Radius ÷ Formed Radius = ___ x Target Angle = Formed Angle.**
- **Target Angle ÷ Formed Angle = Adjustment Angle**

**Note:**

(Arc Master 750 measuring maximum is 30” radius.)

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For more useful formulas, go to **WWW.ARCMASTER.CA** and see Working With Arcs.