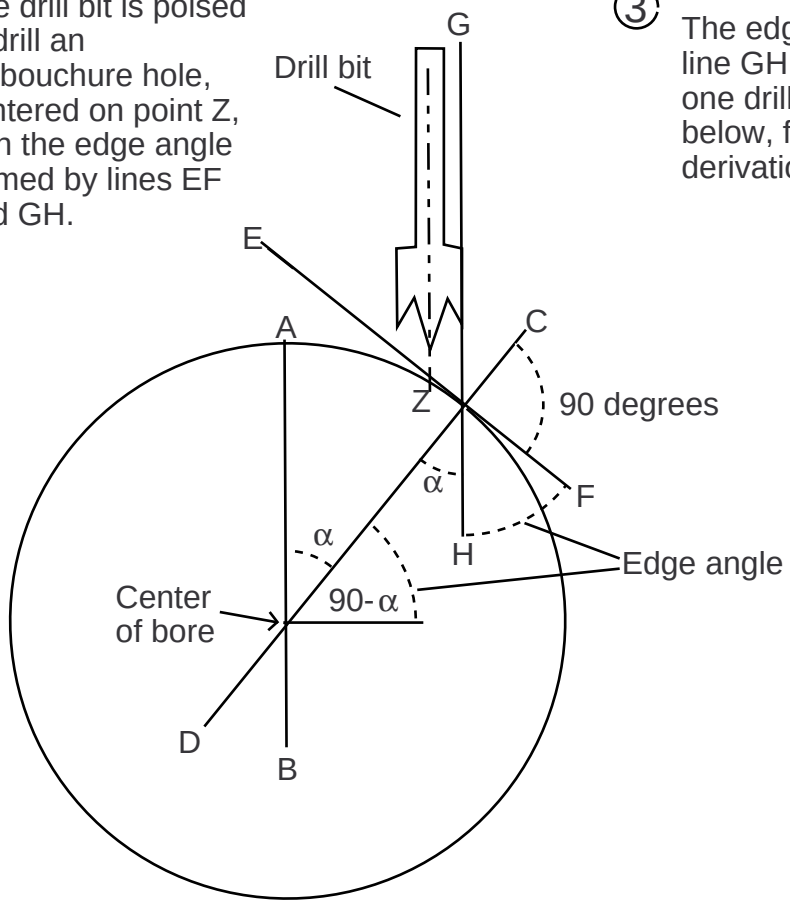
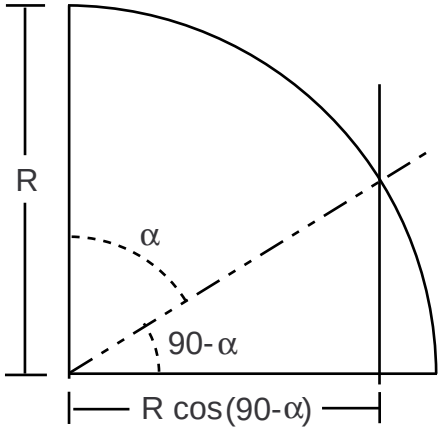
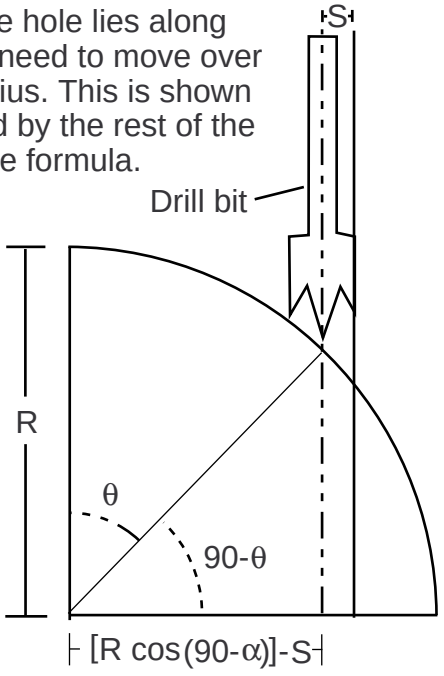
① The drill bit is poised to drill an embouchure hole, centered on point Z, with the edge angle formed by lines EF and GH.



② The distance between the parallel lines, AB and GH, is the radius times the cosine of the edge angle, as shown below.



③ The edge of the hole lies along line GH so we need to move over one drill bit radius. This is shown below, followed by the rest of the derivation of the formula.



$$\cos(90-\theta) = \frac{[R\cos(90-\alpha)]-S}{R}$$

$$\cos(90-\theta) = \sin(\theta)$$

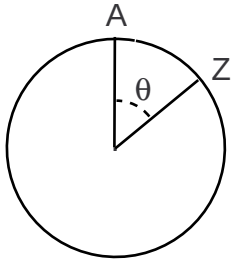
$$\text{Edge angle} = 90-\alpha$$

$$\sin(\theta) = \cos(\text{edge}) - S/R$$

$$S/R = \frac{.5\ \text{embouchure diam}}{.5\ \text{pipe diameter}} = \frac{\text{embouchure diam}}{\text{pipe diameter}}$$

$$\sin(\theta) = \cos(\text{edge}) - \frac{\text{embouchure diam}}{\text{pipe diameter}}$$

$$\theta = \sin^{-1}\left(\cos(\text{edge}) - \frac{\text{embouchure diam}}{\text{pipe diameter}}\right)$$



$$\frac{\theta}{360} = \frac{\overset{\frown}{AZ}}{\text{circumference}}$$

$$\text{circum} = 2\pi r$$

$$\overset{\frown}{AZ} = \theta/360 * \pi * \text{diameter}$$

$$\overset{\frown}{AZ} = \sin^{-1}\left(\cos(\text{edge}) - \frac{\text{embouchure diam}}{\text{pipe diameter}}\right) / 360 * \pi * \text{pipe diameter}$$