

# ULTRASONIC TESTING (UT) USEFUL FORMULAE

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1. **Velocity of Ultrasonic Waves in a medium (V) = f x λ**

OR

$$\lambda = \frac{V}{f}$$

Where

f = Number of cycles per second is called frequency. Measured in 'Hertz'. Abbreviated as 'Hz'. One Hertz is equivalent to One cycle per second

λ = Distance covered in one cycle is wavelength

V = Velocity of Ultrasonic wave inside the medium in 'mm/s'

2. **Acoustic Impedance (Z) = V x ρ**

Where:

Z = Acoustic Impedance

ρ = Density

V = Velocity

3. **Reflection Coefficient**

$$R = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$$

Where:

R = Reflection Coefficient

Z<sub>1</sub> = Acoustic Impedance of Medium 1

Z<sub>2</sub> = Acoustic Impedance of Medium 2



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#### 4. Transmission coefficient

$$T = \frac{4 Z_1 Z_2}{(Z_1 + Z_2)^2}$$

Where:

R = Reflection Coefficient

Z<sub>1</sub> = Acoustic Impedance of Medium 1

Z<sub>2</sub> = Acoustic Impedance of Medium 2

#### 5. Longitudinal Wave Velocity

$$V_L = \sqrt{\frac{E(1-\mu)}{\rho(1+\mu)(1-2\mu)}}$$

Where:

V<sub>L</sub> = Longitudinal Wave Velocity

E = Modulus of Elasticity

ρ = Density

μ = Poisson's Ratio

#### 6. Shear Wave Velocity

$$V_s = \sqrt{\frac{E}{2\rho(1+\mu)}} \text{ or } \sqrt{\frac{G}{\rho}}$$

Where:

V<sub>s</sub> = Shear Wave Velocity

E = Modulus of Elasticity

ρ = Density

μ = Poisson's Ratio

G = Shear Modulus

**7. Refraction - Snell's Law:** That is the ratio of sine of the angle to the respective wave velocities are proportional.

$$\frac{\sin \theta_I}{\sin \theta_R} = \frac{V_1}{V_2}$$

Where:

θ<sub>I</sub> = Angle of the Incident Wave

θ<sub>R</sub> = Angle of the Reflected Wave

V<sub>1</sub> = Velocity of Incident Wave

V<sub>2</sub> = Velocity of Reflected Wave

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## 8. Near Field

$$N = \frac{D^2}{4\lambda} \quad \text{or} \quad N = \frac{D^2 F}{4V}$$

Where:

N = Near Field

D = Transducer Diameter

$\lambda$  = Wavelength

V = Velocity

## 9. Beam Spread Half Angle

$$\sin\theta = 1.2 \frac{\lambda}{D} \quad \text{or} \quad \sin\theta = 1.2 \frac{V}{DF}$$

Where:

$\lambda$  = Wavelength

D = Transducer Diameter

V = Velocity

F = Frequency

## 10. Decibel (dB) Gain or Loss

$$\Delta I(\text{dB}) = 20 \log \frac{P_2}{P_1}$$

Where:

dB = Decibel

$P_1$  = Pressure Amplitude 1

$P_2$  = Pressure Amplitude 2

## 11. Angle Beam testing of Pipe

$$t = \frac{d(1 - \sin \theta)}{2}$$

$$\sin \theta = 1 - \left( \frac{2t}{d} \right)$$

d = O.D. of Pipe

t = Maximum wall thickness       $\theta$  = Probe angle

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## 12. Formulae for Angle Beam Calculations

$\beta$  = Sound beam refracted angle in the test material

T = Thickness of the test material

### Skip Distance

$$S = 2T \times \tan \beta$$

### V-Path Length

$$\text{V-Path} = \frac{2T}{\cos \beta}$$

### Leg Length

$$\text{Leg} = \frac{T}{\cos \beta}$$

### Surface Distnace

$$SD = \sin \beta \times \text{Soundpath Length}$$

### Depth in First Leg

$$\text{Depth (1<sup>st</sup> Leg)} = \cos \beta \times \text{Sound path Length}$$

### Depth in Second Leg

$$\text{Depth (2<sup>nd</sup> Leg)} = 2T - (\cos \beta \times \text{Sound path Length})$$



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Plot No. V-22(A), 2nd Stage, Peenya Industrial Estate, Bangalore - 560 058, INDIA.

Phone: +91 99009 29439, 98441 29439, Telefax: +91-80-28366466, e-mail: [training@trinityndt.com](mailto:training@trinityndt.com)

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