ULTRASONIC TESTING (UT) USEFUL FORMULAE

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_1 = Acoustic Impedance of Medium 1
Z_2 = Acoustic Impedance of Medium 2

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4. Transmission coefficient

$$T = 4 Z1Z2/ (Z1+Z2)^2$$

Where:

R = Reflection Coefficient

Z_1 = Acoustic Impedance of Medium 1

Z_2 = Acoustic Impedance of Medium 2

5. Longitudinal Wave Velocity

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

Where:

V_L = 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_s = 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_I = Angle of the Incident Wave

θ_R = Angle of the Reflected Wave

V_1 = Velocity of Incident Wave

V_2 = Velocity of Reflected Wa

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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
λ = 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: λ = Wavelength
D = Transducer Diameter
V = Velocity
F = Frequency

10. Decibel (dB) Gain or Loss

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

Where:

dB = Decibel
P_1 = Pressure Amplitude 1
P_2 = Pressure Amplitude 2

11. Angle Beam testing of Pipe

$$t = \frac{d(1 - \text{Sin } Ø)}{2}$$

$$\text{Sin } Ø = 1 - \left(\frac{2t}{d}\right)$$

d = O.D. of Pipe

t = Maximum wall thickness

Ø = Probe angle

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12. Formulae for Angle Beam Calculations

β = 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 = sinβ x Soundpath Length

Depth in First Leg

Depth (1^{st} Leg) = cosβ x Sound path Length

Depth in Second Leg

Depth (2^{nd} Leg) = 2T – (cosβ x Sound path Length)

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