UT Useful Formulas

Main ultrasonic parameters and their definition or relationship:

Feature	Formula	Remarks
Longitudinal (Compression) velocity	$V_L = \left[\frac{E(1-\nu)}{\rho(1+\nu)(1-2\nu)}\right]^{0.5}$; [m/s]	Where: E = Modulus of elasticity (Young's modulus) [N/m^2] ρ = Mass density [kg/m^3] ν = Poisson's ratio
Transverse (shear) velocity	$V_T = \left[\frac{E}{2\rho(1+\nu)}\right]^{0.5} = \sqrt{\frac{G}{\rho}}$; [m/s]	Where: G = Shear modulus [N/m^2]
Frequency	$f = \frac{V}{\lambda}$; [Hz]	Where: λ = Wave Length [m] V = Velocity [m/s]
Acoustic impedance	$Z = V\rho$; [kg/m^{2}s]	Where: V = Velocity [m/s] ρ = Density [kg/m^3]
Near-field (circular)	$N_o = \frac{D^2 f}{4\,V}$; [mm] $for\ \frac{D}{\lambda} > 10$	Where: D = Transduser diameter [mm] f = Transduser frequency [Hz] V = Sound velocity [mm/s]
Beam divergence-angle (circular)	$\sin\theta = \frac{1.2\,V}{D\,f}$	Where: θ = Beam divergence angle from centerline to point where signal is at half strength
Reflection coefficient	$R = \frac{(Z_2 - Z_1)^2}{(Z_1 + Z_2)^2}$	Where: Z_1 = Acoustic impedance of Medium 1 Z_2 = Acoustic impedance of Medium 2
Transmission coefficient	$T = (1 - R) = \frac{4\,Z_1 Z_2}{(Z_1 + Z_2)^2}$	Where: R = Reflection coefficient

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<td>Snell's law</td>
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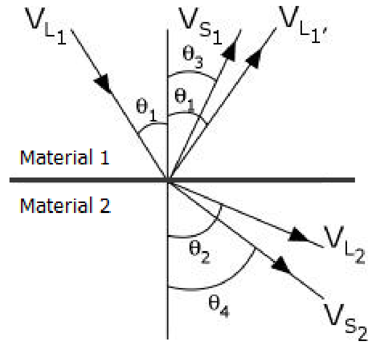
$$\frac{\sin\theta_1}{V_{L_1}} = \frac{\sin\theta_2}{V_{L_2}} = \frac{\sin\theta_3}{V_{S_1}} = \frac{\sin\theta_4}{V_{S_2}}$$



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Where:
V_{L_1} & V_{L_2} = the longitudinal wave velocities in the first and second materials, respectively
V_{S_1} & V_{S_2} = the shear wave velocities in the first and second materials, respectively
θ_1 & θ_2 = the angles of incident and refracted longitudinal waves, respectively
θ_3 & θ_4 = the angles of the converted reflected and refracted shear waves, respectively
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<td>Amplitude attenuation</td>
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$$A = A_o\, e^{-\alpha Z}$$

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Where:
A_o = Initial (unattenuated) amplitude
α = Attenuation coefficient [dB/m]
Z = Traveled distance [m]
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<td>Sound amplitude gain (or loss) in Decibel</td>
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$$\Delta A = 20\ \log\frac{A_2}{A_1} \qquad ; \text{[dB]}$$

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Where:
A_1 = Amblitude of the first pulse
A_2 = Amblitude of the second pulse
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<td>Distance to reflector or discontinuity (normal or angle beam)</td>
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$$d = \frac{V\,t}{2}$$

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Where:
V = Sound velocity (longitudinal or shear) [m/s]
t = Time difference [s]
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<td>Surface Distance & Depth (1st Leg)</td>
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$$\text{SD} = \text{Sound Path } \times \sin\theta_R$$

$$\text{Depth } (1^{st}\ leg) = \text{Sound Path } \times \cos\theta_R$$

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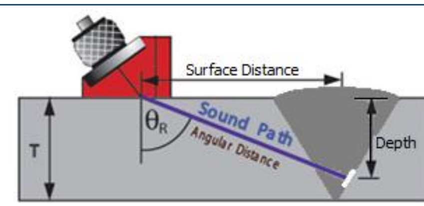

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<td>Surface Distance & Depth (2nd Leg)</td>
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$$\text{SD} = \text{Sound Path } \times \sin\theta_R$$

$$\text{Depth } \left(2^{nd}\ leg\right) = 2T - (\text{Total Sound Path } \times \cos\theta_R)$$

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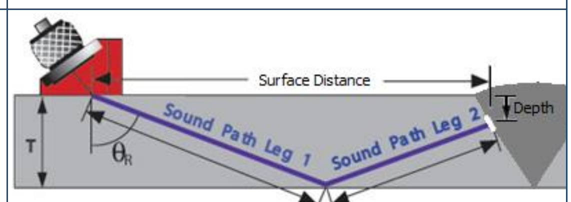

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<td>Skip Distance for weld inspection</td>
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$$\text{Skip Distance} = 2T\ \times \tan\theta_R$$

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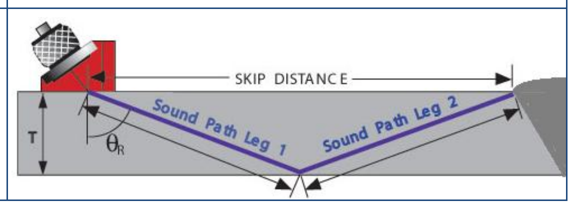

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