SOUND TRANSMISSION THROUGH PIPES AND DUCTS   Revision C

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Transmission Loss

The transmission loss TL in units of dB is

$$TL = 10 \log \left(\frac{1}{\tau} \right) \tag{1}$$

where τ is the transmission coefficient.

Pipe with Expanded Section

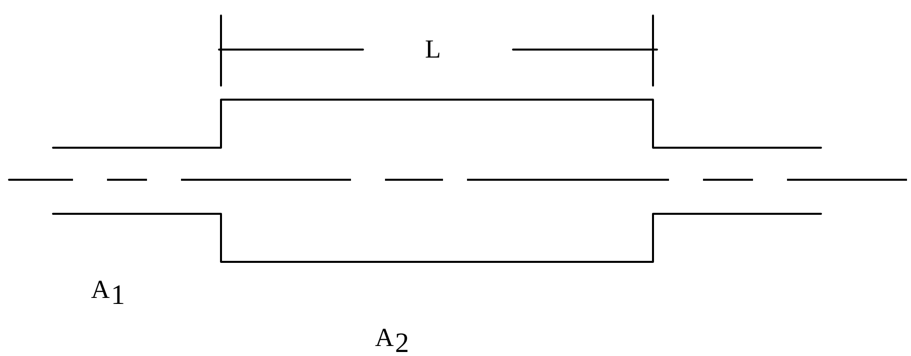

Figure A-1.

Assume

1. Plane acoustic waves propagating in the longitudinal direction
2. The pipe and expansion section are frictionless
3. The acoustic impedance is the same in each section

The sound power transmission coefficient τ for a pipe with an expansion section is

$$\tau = \frac{4}{4 + \left[\left(\frac{A_2}{A_1} \right)^2 - 2 \right] \sin^2 (kL)} \qquad \text{(A-1)}$$

where

$$k = \frac{\omega}{c} = \frac{2\pi f}{c}$$

c is the speed of sound

A_i is the cross section area of section i

Equation (1) is taken from Reference 1.

Example

An expanded pipe has the following properties. Calculate the transmission loss.

L = 1 m

c = 343 m/sec

A1 = 0.2 m^2

A2 = 0.8 m^2

The transmission loss spectrum is shown in Figure A-2.

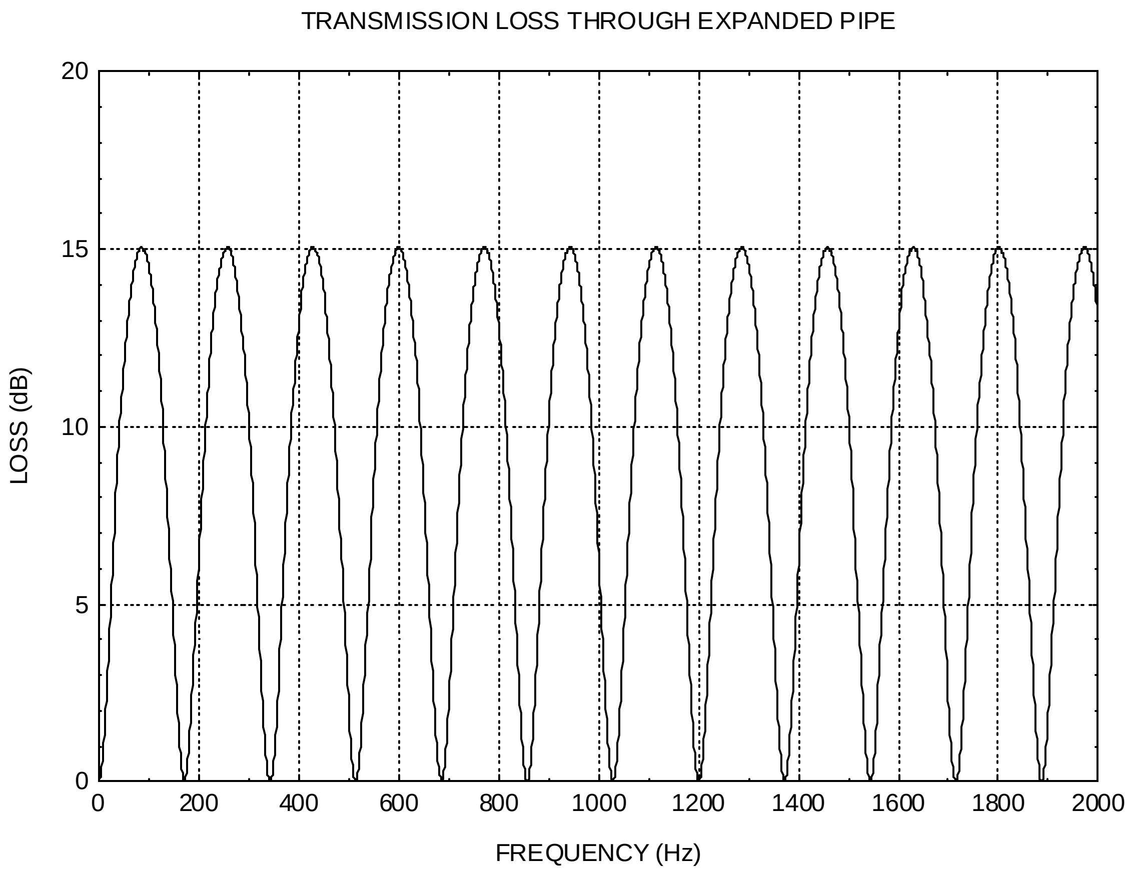

Figure A-2.

Note that equation (A-1) is also valid for a constriction section.

Reference 2, equation (10.48) gives an alternate formula

$$\tau = \frac{4}{4\cos^2(kL) + \left[\left(\frac{A_2}{A_1}\right) + \left(\frac{A_1}{A_2}\right)\right]^2 \sin^2(kL)} \qquad \text{(A-2)}$$

This equation can be expressed as

$$\tau = \frac{4}{4 + \left\{\left[\left(\frac{A_2}{A_1}\right) + \left(\frac{A_1}{A_2}\right)\right]^2 - 4\right\}\sin^2(kL)} \qquad \text{(A-3)}$$

$$\tau = \frac{4}{4 + \left\{\left[\left(\frac{A_2}{A_1}\right)^2 + 2 + \left(\frac{A_1}{A_2}\right)^2\right] - 4\right\}\sin^2(kL)} \qquad \text{(A-4)}$$

$$\tau = \frac{4}{4 + \left[\left(\frac{A_2}{A_1}\right)^2 - 2\right]\sin^2(kL)} \qquad \text{(A-5)}$$

Equations (A-1) and (A-5) are the same. Thus, References 1 and 2 agree.

Pipe with Abrupt Diameter Change

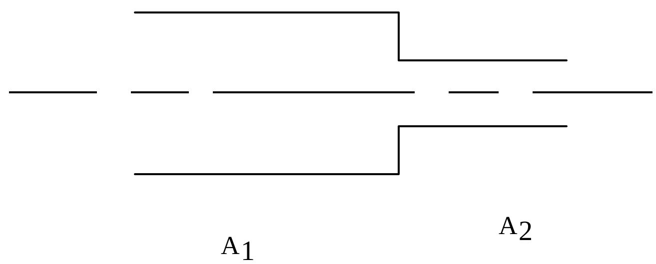

Figure B-1.

Assume

1. Plane acoustic waves propagating in the longitudinal direction
2. The pipe is frictionless
3. The acoustic impedance is the same in each section

The sound power transmission coefficient τ for a pipe with an abrupt diameter change is

$$\tau = 1 - \left[\frac{A_1 - A_2}{A_1 + A_2} \right]^2 \quad \text{(B-1)}$$

Equation (B-1) is taken from Reference 1.

Pipe with Abrupt Diameter Change and Impedance Change

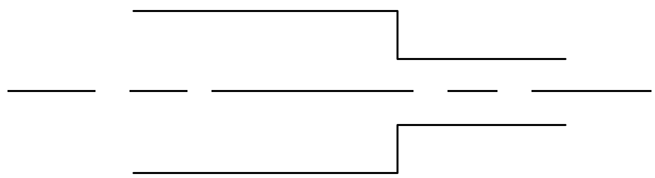

Figure C-1.

Assume

1. Plane acoustic waves propagating in the longitudinal direction
2. The pipe is frictionless

Let

$$R_1 = \rho_1 c_1 \qquad \text{(C-1)}$$

$$R_2 = \rho_2 c_2 \qquad \text{(C-2)}$$

The sound power transmission coefficient τ for a pipe with an abrupt diameter change and an impedance change is

$$\tau = \frac{4 A_1 A_2 R_1 R_2}{[A_1 R_2 + A_2 R_1]^2} \qquad \text{(C-3)}$$

Equation (C-3) is taken from Reference 1.

Main Pipe with Closed Pipe Branch

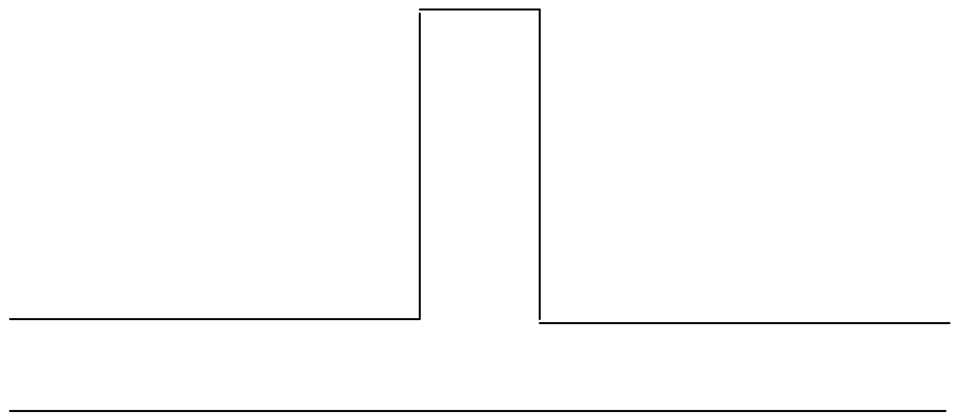

Figure D-1.

Assume that each pipe has the same cross-section.

The sound power transmission coefficient τ through the main pipe is

$$\tau = \frac{4}{\sec^2(kL) + 3} \qquad \text{(D-1)}$$

where

$$k = \frac{\omega}{c} = \frac{2\pi f}{c}$$

c is the speed of sound

L is the length of the main pipe

Equation (D-1) is taken from Reference 1.

Example

The pipe in Figure D-1 has the following properties. Calculate the transmission loss.

$L = 10$ m

$c = 343$ m/sec

The resulting transmission loss is shown in Figure D-2.

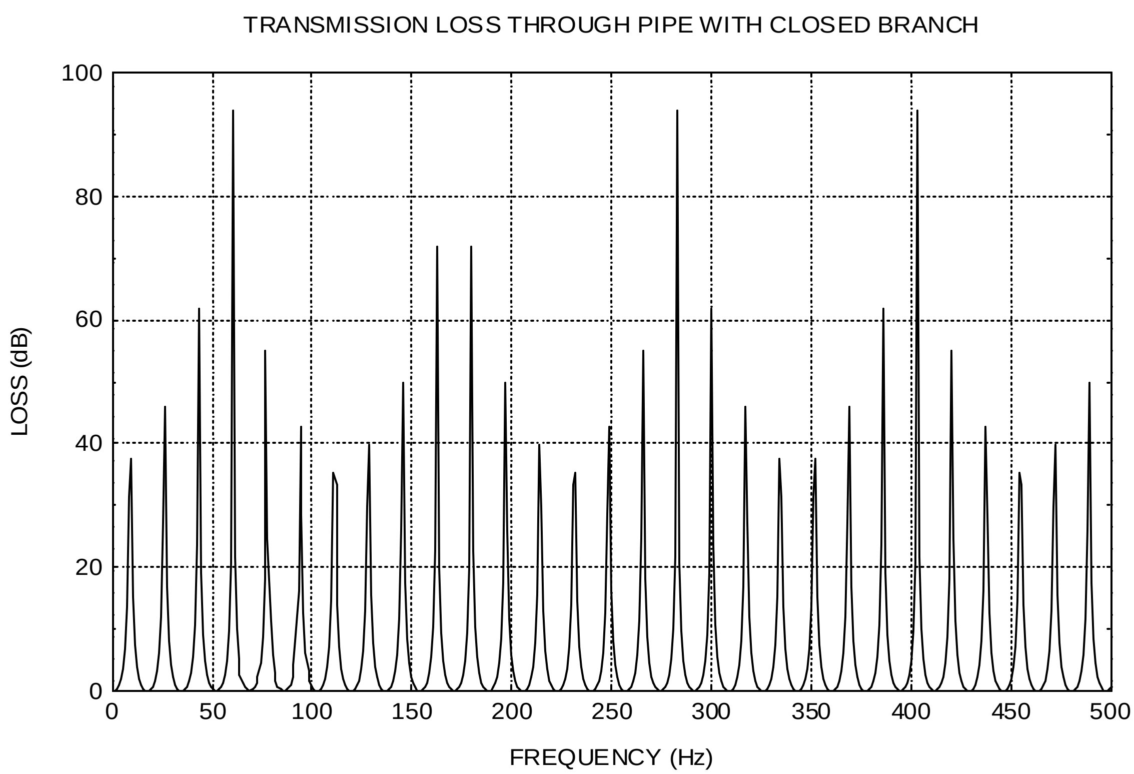

Figure D-2.

References

1. Seto, Acoustics, McGraw-Hill, New York 1971.
2. Lawrence Kinsler et al, Fundamentals of Acoustics, Third Edition, Wiley, New York, 1982.