WATER IMPACT SHOCK

By Tom Irvine
Email: tomirvine@aol.com

August 24, 2004

This tutorial gives a simplified approach for calculating the shock response of an object impacting water.

Assume

1. The object can be modeled as a single-degree-of-freedom system.
2. The object is dropped from rest.
3. There is no energy dissipation during the impact.
4. The specific gravity of the object is less than that of water.
5. The system has a linear response.
6. The object vibrates freely at its natural frequency in the water.

The natural frequency ω_n of the object in the water is

$$\omega_n = \sqrt{\frac{A \rho g}{m}} \tag{1}$$

where

A	is the cross sectional area of the object parallel to the water surface
m	is the mass of the object
ρ	is the mass density of water
g	is the acceleration of gravity

Equation (1) is derived in Reference 1.

The peak acceleration response $\ddot{x}$ of the object is

$$\ddot{x} = \omega_n \sqrt{2 g \Delta h} \tag{2}$$

where Δh is the drop height.

Equation (2) is derived in Reference 2.

Note that the drop height is related to the impact velocity $\dot{x}(0)$ by

$$\dot{x}(0) = \sqrt{2 g \Delta h} \tag{3}$$

Substitute equation (1) into (2).

$$\ddot{x} = \sqrt{\frac{A \rho g}{m}} \sqrt{2 g \Delta h} \tag{4}$$

$$\ddot{x} = \sqrt{\frac{2 \Delta h \; A \rho g^2}{m}} \tag{5}$$

The peak impact acceleration is thus

$$\ddot{x} = g \sqrt{\frac{2 \Delta h \; A \rho}{m}} \tag{6}$$

Table 1. Water

Liquid	Density (kg/m^3)	Density (lbm/ft^3)
Water (fresh) at 20 deg C	998	62.3
Water (sea) at 13 deg C	1026	64.1

References

1. T. Irvine, Natural Frequencies of Fluid Systems, Vibrationdata, 2001.
2. T. Irvine, Simple Drop Shock, Rev C, Vibrationdata, 2000.