

Z-factor (compressibility)

@wikipedia

Synonyms: [Compressibility factor](#) = Z-factor

Disclaimer: Not to be confused with [Compressibility](#) c .

Dimensionless multiplier describing the deviation of a [fluid density](#) from [ideal gas](#) estimate under the same [pressure](#) & [temperature](#) conditions:

(1)
$$Z = \frac{p V_m}{R T} = \frac{p}{\rho} \cdot \frac{M}{R T}$$

where

p	fluid pressure	$V_m = V/\nu$	fluid molar volume
T	fluid temperature	V	fluid volume
ρ	fluid density	ν	amount of substance
R	gas constant	M	molar mass of a fluid

Alternatively [Z-factor](#) can be expressed through the [dynamic fluid properties](#) at reference conditions as:

(2)
$$Z(T, p) = Z^\circ \cdot \frac{\rho^\circ T^\circ}{p^\circ} \cdot \frac{p}{\rho(T, p) T}$$

where $()^\circ$ means reference conditions, usually [Standard Conditions \(STP\)](#).

[Z-factor](#) can be used to calculate [fluid density](#) ρ and [Formation Volume Factor \(FVF\)](#) B as:

(3) $\rho(T, p) = \rho^\circ \cdot \frac{Z^\circ T^\circ}{p^\circ} \cdot \frac{p}{Z(T, p) T}$	(4) $B(T, p) = \frac{\rho^\circ}{\rho(T, p)} = \frac{p^\circ}{Z^\circ T^\circ} \cdot \frac{Z(T, p) T}{p}$
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[Z-factor](#) is related to [fluid compressibility](#) c as:

(5) $c(p) = \frac{1}{p} - \frac{1}{Z} \frac{dZ}{dp}$	(6) $Z(p) = Z_0 \cdot \frac{p}{p_0} \cdot \exp \left[- \int_{p_0}^p c(p) dp \right]$
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$$(7) \quad c = \frac{1}{\rho} \frac{d\rho}{dp} = \frac{d \ln \rho}{dp} = \frac{d}{dp} \left(\ln \left(\frac{p}{Z} \right) \right) = \frac{Z}{p} \cdot \frac{d}{dp} \left(\frac{p}{Z} \right) = \frac{Z}{p} \cdot \left(\frac{1}{Z} + p \cdot \frac{d}{dp} \left(\frac{1}{Z} \right) \right) = \frac{1}{p} - \frac{1}{Z} \frac{dZ}{dp}$$

Rewriting (5):

$$(8) \quad \frac{d \ln Z}{dp} = \frac{1}{p} - c(p) \rightarrow \ln \frac{Z}{Z_0} = \ln \frac{p}{p_0} - \int_{p_0}^p c(p) dp$$

which arrives to (6).

The **Z-factor** value for **Ideal Gas** is strictly unit: $Z(T, p) = 1$.

For many **real gases** (particularly for the most compositions of **natural gases**) the **Z-factor** is trending towards unit value ($Z \rightarrow 1$) while approaching the **STP**.

For **incompressible fluids** the **Z-factor** is trending to linear **pressure** dependence ($Z \rightarrow a \cdot p$) with pressure growth.

Modelling **Z-factor** $Z(T, p)$ as a function of **fluid pressure** p and **temperature** T is based on **Equation of State**.

There is also a good number of explicit **Z-factor Correlations @models**.

See also

[Natural Science](#) / [Physics](#) / [Thermodynamics](#) / [Equation of State](#)

[[Compressibility](#)] [[Fluid Compressibility](#)] [[Gas compressibility](#)]

References