# Mixture Quality

## Coefficient of Variation (CoV)

When two fluids are mixed in a pipe or channel, the quality of the radial mixing (across the pipe or channel) can be described statistically by the coefficient of variation, *CoV*, which is defined as:

$$CoV = \left[ \frac{\sum_{i=1}^{N} \left( \frac{c}{c_i} - 1 \right)^2}{N-1} \right]^{0.5} \frac{1}{c_{mean}}$$

Where:

- $c$ is the average measured concentration of the additive
- $c_{mean}$ is the theoretical mean concentration
- $c_i$ is the local concentration of the additive at the *i*th measurement position
- $N$ is the number of positions where concentration is measured
- Ó is the sum of all the terms in brackets i.e. $\left( \frac{c}{c_i} - 1 \right)^2$

In a radial mixing device such as an empty pipe or channel, the *CoV* describes the deviations of local concentrations from the mean within a cross section of the pipe or channel. Assuming a normal distribution, the following approximately applies:

- About 2/3 of the values will lie within $c(1 \pm CoV)$
- About 95% of the values will lie within $c(1 \pm 2CoV)$
- About 99.75% of the values will lie within $c(1 \pm 3CoV)$.

The lower the value of *CoV*, the better the mixture quality. The required level of mixture quality is usually process specific. However, a *CoV* of between 0.01 and 0.05 is a reasonable target for most applications. This means that 95% of all concentration measurements to be taken from the pipe or channel cross section will be within ±2% of the mean concentration for *CoV*=0.01 and ±10% for *CoV*=0.05.

## The Difference between Mixer Efficiency and Mixture Quality

Unfortunately, these terms are often used interchangeable, especially in process specifications for static mixers. It is important to understand the difference between mixer efficiency and mixture quality in order to correctly specify the performance requirements of a static mixer.

Mixture quality (Coefficient of Variation - CoV) defines the mixing objective and, for most applications, a CoV of 0.05 will ensure complete homogeneity. Mixer efficiency, on the other hand, indicates how the mixing objective is reached and not the objective itself. The same mixture quality can usually be achieved by both inefficient and efficient designs of static mixers:

- An inefficient mixer design will have a relatively high pressure drop and/or a long mixing length
- An efficient mixer design will have a relatively low pressure drop and/or a short mixing length

BHR Group Ltd has developed an interesting method of comparing the efficiencies of different designs of static mixers on the basis that a mixer with zero energy consumption (no pressure drop) and with zero length (instantaneous mixing) would have a theoretical 100% mixing efficiency. Detailed comparisons of mixer efficiencies for all the commonly available proprietary mixers, for both pipe and open channel designs, are available only to members of BHR's research consortiums (see research & development).

## G Factor (Velocity Gradient)

The G (or GT) factor, indicative of power per unit volume, was developed in the 1940s as a means of determining dynamic mixer performance in stirred tanks. More recently, attempts have been made to use G factor to describe static mixer performance, especially in water treatment dosing applications. However, G factor does not consider how effectively a particular mixer design converts power to mixture quality; neither does it consider how effective the injection method is. For these reasons Statiflo has not adopted G factor as a useful tool in static mixer design.