

# Technical Paper

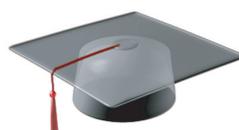
**kv: What, Why, How, Whence ?**

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$$k_v = \frac{Q}{\sqrt{\Delta p}} \text{ m}^3 / \text{h}$$

$$Q = k_v \sqrt{\Delta p} \text{ m}^3 / \text{h}$$

$$\Delta p = \left( \frac{Q}{k_v} \right)^2 \text{ Bar}$$



# k<sub>v</sub> What Why How Whence ?



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## What ?

The  $k_v$ -factor for a given valve is a constant which in a simple way states the valve capacity.

The  $k_v$ -factor is determined by the valve manufacturer by experiments. The  $k_v$ -factor specifies the water flow in  $m^3$  through the valve in one hour at a pressure drop across the valve of 1 Bar.

## Why ?

The  $k_v$ -factor is an exact and easily applicable value for use when calculating pressure drops, sizing, and ordering valves.

## How ?

Imagine that you are going to size a motorised valve for a room heating system in a District Heating Network (fig. 1).

The calculated flow rate  $Q$  is 1,8 l/sec. = 6,5  $m^3/h$ . And the pressure drop  $\Delta p$  available for the motorised valve is 50 kpa = 0,50 bar.

By using the formula

$$k_v = \frac{Q}{\sqrt{\Delta p}} \text{ m}^3 / \text{h}$$

the desired  $k_v$ -value can be calculated.

$$k_v = \frac{6,5}{\sqrt{0,50}} = 9,2 \text{ m}^3 / \text{h}$$

From the datasheets you will see that a VM2 or VB2 with the  $k_{vs} = 10 \text{ m}^3/h$  can be used.

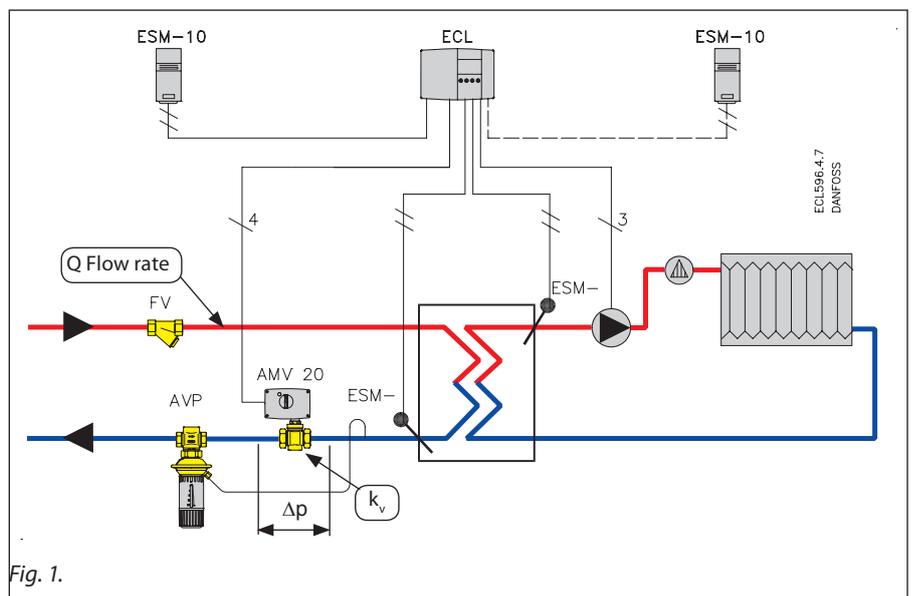


Fig. 1.

## Whence ?

The concept of  $k_v$  originates from U.S.A. and was published for the first time in November 1944. However,  $k_v$  is not used in U.S.A. but is replaced by  $C_v$ .  $C_v$  stands for Valve Flow Coefficient. In English  $C_v$  is today mostly described as  $C_v$ -factor or flow factor  $C_v$ .

To make the confusion complete, there is not one but two  $C_v$ -factors, because the American and the English measuring systems are not quite identical. If you wish to avoid any misunderstanding, and you should always try to do so today where even the smallest piece of information will find its way to the remotest places of the world, it is necessary to state the type of gallon used,

$C_{vUS}$  indicates the water flow in US gallons through the valve in one minute at a pressure drop across the valve of one pound per square inch.  $C_{vUK}$  indicates the water flow in UK gallons through the valve in one minute at a pressure drop across the valve of one pound per square inch.

One US gallon = 3.785 litres and one UK gallon = 4.546 litres. The other American and British units are identical. One pound per square inch is written 1 lb/in<sup>2</sup> = 1 psi.

The  $k_v$ -factor - or the  $k_v$ -value as it is also called - is defined in VDI/VDE-Richtlinien No. 2173.

A simplified version of the definition is: The  $k_v$ -factor of a valve indicates the water flow in  $\text{m}^3/\text{h}$  at a pressure drop across the valve of  $1 \text{ kg}/\text{cm}^2$  when the valve is completely open.

The complete definition also says that the flow medium must have a specific gravity of  $1000 \text{ kg}/\text{m}^3$  and a kinematic viscosity of  $10^{-6} \text{ m}^2/\text{s}$ .

Water for heating systems satisfies these conditions with sufficient accuracy. This is the reason that the subsequent summary of formulae can be made simple and clear.

### Some Theory

The concept of  $k_v$  is based on the hydrodynamic law saying that the pressure drop ( $\Delta p$ ) in a valve, is in any resistance to flow, is proportional to the square on the flow volume ( $Q$ ):  $\Delta p \sim$  proportional to  $Q^2$ .

If we take a few concrete examples, the ratio between these can be written:

$$\frac{\Delta p_1}{Q_1^2} = \frac{\Delta p_2}{Q_2^2}$$

or

$$\frac{\Delta p_1}{\Delta p_2} = \frac{Q_1^2}{Q_2^2}$$

or

$$Q_1 = Q_2 \sqrt{\frac{\Delta p_1}{\Delta p_2}}$$

Since the definition of  $k_v$  says that the  $k_v$ -factor indicates the capacity through the valve at a pressure drop of  $\Delta p = 1 \text{ Bar}$ , we can put  $Q_2 = k_v$  and  $p_2 = 1 \text{ Bar}$ .  $100 \text{ kpa} = \text{Bar}$ .

$$Q_1 \text{ then has the form } \sqrt{\frac{\Delta p_1}{\Delta p_2}}$$

$$Q_1 = k_v \sqrt{\frac{\Delta p_1}{1}} = k_v \sqrt{\Delta p_1}$$

The indices 1 can now be eliminated and are omitted.  $Q = k_v \sqrt{\Delta p}$  is transcribed once more, and the final formula for  $k_v$  emerges.

$$k_v = \frac{Q}{\sqrt{\Delta p}} \text{ m}^3/\text{h}$$

For practical reasons we are presenting the formula in three different versions

$$k_v = \frac{Q}{\sqrt{\Delta p}} \text{ m}^3/\text{h}$$

$$Q = k_v \sqrt{\Delta p} \text{ m}^3/\text{h}$$

$$\Delta p = \left( \frac{Q}{k_v} \right)^2 \text{ Bar}$$

By using one of these three formulae, we can always easily determine one value when we know the other two. It is often of importance to be able to convert from  $k_v$  into  $C_{vUS}$  or  $C_{vUK}$  or vice versa.

### Conversion Factors

$$1 k_v = 1 C_{vUS} \cdot 0.86 \text{ and } 1 C_{vUS} = 1 k_v \cdot 1.17$$

$$1 k_v = 1 C_{vUK} \cdot 1.03 \text{ and } 1 C_{vUK} = 1 k_v \cdot 0.97$$

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