5.4.5. Influence of viscosity

Flow conditions in pipes, fittings, control valves etc. are mainly turbulent. Unusual conditions are the laminar and transitional flow pattern characterized by their Reynolds numbers (transitional flow is a not fully developed laminar flow). Laminar flow is indicated by a well organized flow pattern, i.e. the stream lines follow exactly the direction of flow.

With turbulent flow conditions there are, besides the main direction of flow, push, roll, and transverse motions which yield a strong disorder of flow observed by the classic test of Reynolds. Transitional flow is a condition which lies between laminar and turbulent flow, for example, the flow is often at the wall area of the valve body still laminar while turbulence appears in the seat, which is the place of highest fluid velocity. Turbulence is more likely with higher velocities and with greater throttling areas (flow coefficients) and lower viscosity of the medium. This rule applies to fittings, pipes and other such resistances and control valves.

The Reynolds number factor F_R is required when non-turbulent flow conditions exist in a control valve because of a high viscosity of the fluid, a low differential pressure, a very small cross-sectional area, or very low flow coefficients, or a combination of all these. The F_R factor can be simply determined by dividing the flow rate when non-turbulent flow conditions exist by the flow rate measured in the same installation under standard conditions with turbulent flow. This means that F_R must always be smaller than 1.0.

The mathematical determination of the correction factor F_R assumes that the so-called **Valve-Reynolds-Number Re_v** is known. Otherwise Re_v can roughly be calculated according to equation (5-12):

$$Re_v = \frac{0.076 \cdot F_d \cdot Q}{\nu \cdot \sqrt{F_p \cdot F_L \cdot C_v}} \tag{5-12}$$

This calculation requires an iteration process, since neither Re_V nor the flow coefficient C_v are known. The valve Reynolds number Re_V provides information regarding the flow pattern expected:

Traditional Method for Standard valves.

Replaced with IEC 60534 2-1 Edition 98, Edition 2000, Edition 2008 (Draft) to increase accuracy:

- Valve Reynolds numbers $Re_v \leq 100$ mean laminar flow conditions Figure 5.4.5.-1 (Traditional method). The common valve sizing equations are, in such cases, no longer valid. The flow increases at laminar flow almost proportionally with the differential pressure. Disregarding the factor F_R results always in a too small flow coefficient and an undersized valve!
- Valve Reynolds numbers $Re_v \geq 33000$ Figure 5.4.5.-1 mean in all cases a fully

developed turbulent flow condition, usually found in standardized flow test stations. A correction becomes, in such a case, superfluous since F_R becomes 1.0.

- Valve Reynolds numbers Re_v between 100 and 33000 mean a transitional state which lies between laminar and turbulent flow. The use of the correction factor F_R in this range is mandatory.

A special problem which arises from using equation (5-12) is the fact that the required flow coefficient C_v for calculating the valve Reynolds number is not yet known. Therefore is a solution only possible by means of iteration.

At first the C_v-value is calculated in accordance with traditional methods and substituted in equation (5-12). This step gives preliminary results of Re_v and F_R from Figure 5.4.5.-1. Now the calculation procedure has to be repeated again until the valve Reynolds number ceases to change. This task is usually very laborious if the calculation is not carried out by using a computer and up-to-date tools like SAMSON SIZING and CONVAL, using the latest international standard IEC 60534 2-1 with higher accuracy. If this isn't possible the correction factor F_R can be determined from Figure 5.4.5.-1 following a calculation of the valve Reynolds number Re_v.

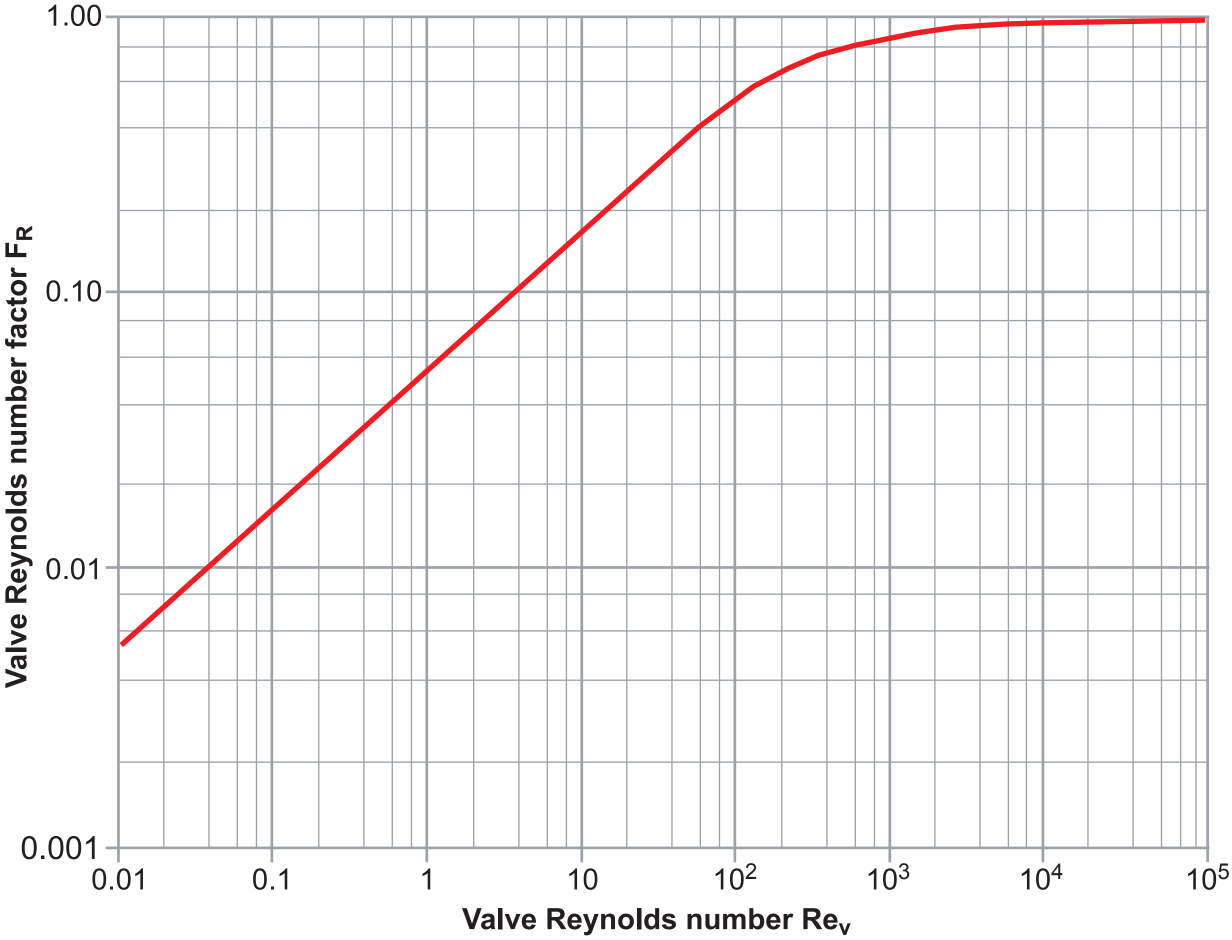

Figure 5.4.5.-1: Traditional Calculation: Graphical determination of F_R as a function of Re_v

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