Indian Standard

RECOMMENDATION FOR ESTIMATION OF FLOW OF LIQUIDS IN CLOSED CONDUITS

PART II HEAD LOSS IN VALVES AND FITTINGS

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INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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Indian Standard

RECOMMENDATION FOR ESTIMATION OF FLOW OF LIQUIDS IN CLOSED CONDUITS

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Indian Standard

RECOMMENDATION FOR ESTIMATION OF FLOW OF LIQUIDS IN CLOSED CONDUITS

PART II HEAD LOSS IN VALVES AND FITTINGS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 24 March 1965, after the draft finalized by the Fluid Flow Measurement Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Fittings in a pipe line like valves, bends, tees, reducers, couplings, branches offer considerable resistance to flow of liquids. The loss of head caused by a fitting is partly due to the sinuous motion set up by the expansion of the stream to fill the pipe after its contraction in passing the valve and partly to the irregularities in the shape of the water-way through the valve. The head loss due to valves and other fittings is relatively more important particularly in smooth and short pipe lines and a knowledge of these losses is essential for proper designing of pipe line systems.

0.3 Losses due to fittings are sometimes expressed in terms of the length of straight pipe of a given diameter which gives an equivalent loss of head. This method is very approximate as the equivalent length is dependent upon pipe friction law and to some extent on diameter. Experiments have been conducted on several occasions on various kinds and sizes of fittings. For example, systematic study for the revision of pipe friction data has been done by the Hydraulic Institution at New York and their publication entitled 'Pipe friction manual' gives the result of their investigation. In the light of such studies this standard recommends the values of resistance coefficients for different types of fittings.

0.4 The Sectional Committee responsible for the preparation of this standard has taken into consideration the views of users and technologists and has related the standard to the practices followed in the country in this field. Due weightage has also been given to the need for international co-ordination among standards prevailing in different countries of the world. These considerations led the Sectional Committee to derive assistance from the following publications:

ISO Draft Recommendation No. 532 Measurement of fluid flow by means of orifice plates and nozzles.

Pipe friction manual. 1954. Hydraulic Institute, New York.

0.5 This standard is one of a series of Indian Standards covering fluid flow measurement in closed conduits. Other standards in the series are:

IS : 2951 (Part I)-1965 Recommendation for estimation of flow of liquids in closed conduits : Part I Head loss in straight pipes due to frictional resistance.

IS : 2952 (Part I)-1964 Measurement of fluid flow by means of orifice plates and nozzles : Part I Incompressible fluids.

0.6 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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1. SCOPE

1.1 This standard recommends a method for estimating the loss of head during the flow of liquids through fully open, manually operated valves and fittings.

2. CALCULATION OF THE HEAD LOSS

2.1 Valves and Fittings — The head loss h_f caused by a fully open valve or fitting during the flow of a liquid may be computed from the formula:

$$h_f = K\frac{\bar{v}^2}{2g} \quad \ldots(1)$$

where

K = resistance coefficient for valve or fitting,

$\bar{v}$ = average velocity in a pipe of corresponding diameter in m/s, and

g = acceleration due to gravity in m/s^2.

2.1.1 Values of resistance coefficient K for valves and fittings carrying turbulent flow are given in Table 1 and Fig. 1 to 4. In valves carrying laminar flow, the head loss may be assumed to be negligibly small. Flanged valves and fittings should have lower resistance coefficients than screwed valves and fittings. The lower limits in Table 1 should be used with flanged valves and fittings, particularly with sizes above 10 cm nominal diameter.

*Rules for rounding off numerical values (*revised*).

TABLE 1 RESISTANCE COEFFICIENTS FOR VALVES AND FITTINGS

(*Clauses* 2.1.1 *and* 2.2)

Sl No.	Description of Valves and Fittings	Resistance Coefficient (K*)
(1)	(2)	(3)
i)	Inlets or Reducers	
	1) Bell mouth	0·04 to 0·05
	2) Square edged	0·47 ,, 0·56
ii)	Elbows	
	1) Regular screwed 45° elbow	0·30 to 0·42
	2) Regular screwed 90° elbow	0·55 ,, 0·90
	3) Regular flanged 90° elbow	0·21 ,, 0·30
	4) Long radius flanged 45° elbow	0·18 ,, 0·20
	5) Long radius flanged 90° elbow	0·14 ,, 0·23
	6) Long radius screwed 90° elbow	0·22 ,, 0·60
iii)	Bends	
	1) Screwed return bend, close-pattern	0·75 to 2·2
	2) Flanged return bend composed of two 90° flanged elbows	
	a) Regular	0·38
	b) Long radius	0·25
iv)	Inward Projecting Pipe	0·62 to 1·0
v)	Valves	
	1) Globe valves	
	a) Composition disc globe valve	0·23 to 5·2
	b) Bevel seat globe valve	6·2 ,, 7·2
	c) Plug disc globe valve	7·2 ,, 10·3
	2) Gate valves	
	a) Wedge disc gate valve	0·05 to 0·19
	b) Double disc gate valve	0·08 ,, 0·13
	3) Check valves	
	a) Swing check valve	0·6 to 2·3
	b) Horizontal (left) check valve	8 ,, 12
	c) Ball check valve	65 ,, 70
	4) Angle valve	2·1 to 3·1
	5) Y or blow off valve	2·9
	6) Foot valve	15
vi)	Standard Screwed Tee	
	1) Branch blanked off	0·4
	2) Line blanked off	
	a) Flow from line to branch	0·85 to 1·3
	b) Flow from branch to line	0·92 ,, 2·15
vii)	Long Radius Screwed Tee	
	1) Line blanked off	
	a) Flow from line to branch	0·37 to 0·80
	b) Flow from branch to line	0·50 ,, 0·52
viii)	Couplings and Unions	0·02 ,, 0·07
ix)	Reducing Bushing and Coupling Used as Reducer	0·05 to 2·0

NOTE — Used as increaser loss is up to 40 percent more than that caused by a sudden enlargement (*see* equation 3).

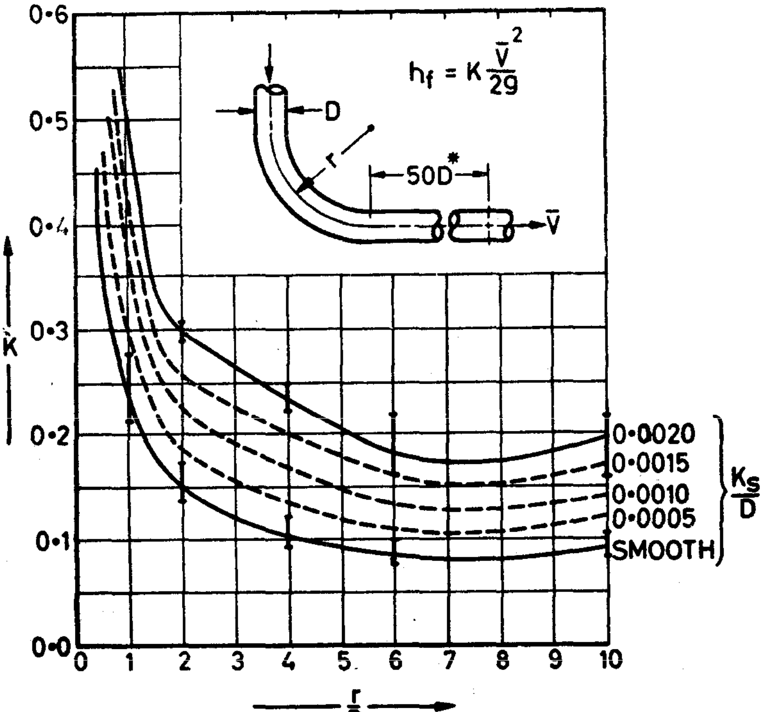
*K decreases with increasing wall thickness of pipe and rounding of edges.

2.2 Pipe-Bends and Elbows — Values of the absolute roughness K_s shall be obtained from Fig. 1 or Table 1 of IS : 2951 (Part I) - 1965†, and knowing the relative roughness K_s/D, the values of K for 90° bends may be taken from Fig. 1 for the given ratio of r/D, where r is radius of the bend and D the diameter of the pipe.

2.2.1 The resistance coefficient K for smooth bends with deflection angles less than 90° shall be obtained from Fig. 2

2.2.2 Where the pipes are not smooth, these coefficients may have to be increased from 30 to 50 percent or depending upon their roughness. The value of K given in Table 1 and in Fig. 1 and 2 applies only if the pipe has linear lengths upstream and downstream not less than those shown in the respective figures.

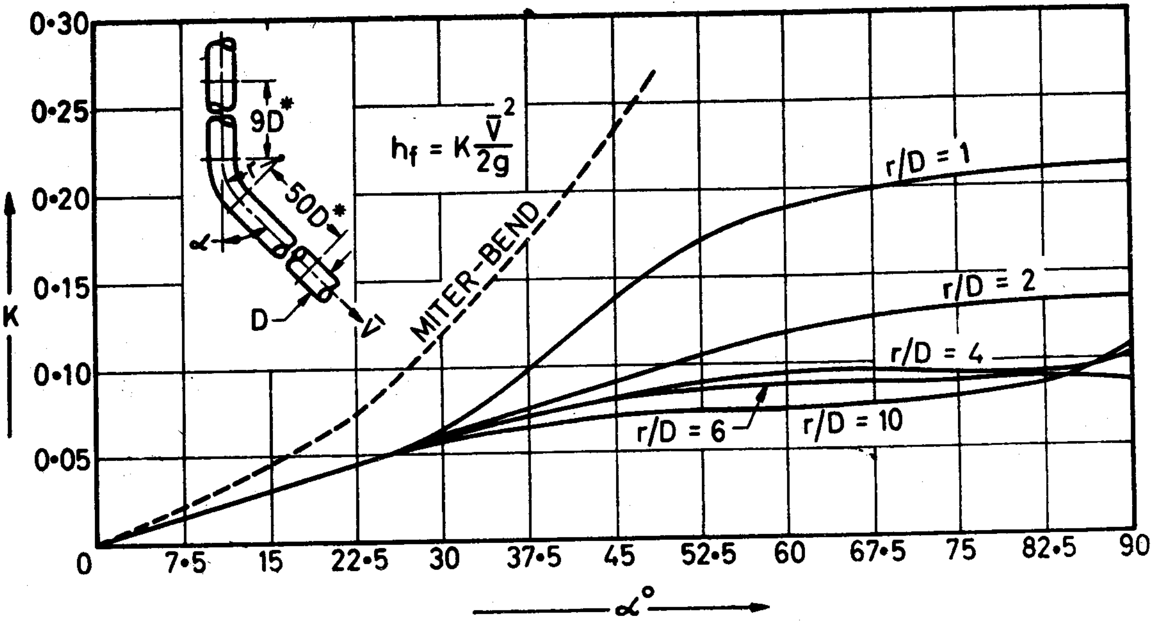
2.2.3 For r/D values less than unity, use of Fig. 1 and 2 is not recommended.



*Minimum straight length.

Fig. 1 Resistance Coefficients for 90° Bends of Uniform Diameter

†Recommendation for estimation of flow of liquids in closed conduits: Part I Head loss in straight pipes due to frictional resistance.



*Minimum straight lengths.

FIG. 2 RESISTANCE COEFFICIENTS FOR BENDS OF UNIFORM DIAMETER AND SMOOTH SURFACE FOR TURBULENT FLOW

2.2.4 For a circular arc smooth 90° bend for which the ratio of the radius of curvature of the bend to the diameter of the pipe exceeds a value of 6, resistance coefficient K, shall be determined by using the formula:

$$K = \frac{0{\cdot}187}{\left(\frac{\bar{v}D}{\nu}\right)^{0{\cdot}176}} \left(\frac{2r}{D}\right)^{0{\cdot}192} \qquad \ldots(2)$$

where

K = resistance coefficient for valve or fitting,
r = radius of curvature,
$\bar{v}$ = average velocity in m/s,
D = diameter of the pipe in m, and
ν = kinematic viscosity in m^2/s.

This equation is valid for long radius bends.

2.3 Mitre Bends — The resistance coefficients for mitre bends are shown in Fig. 3 for both smooth and rough pipes assuming the relative roughness to be 0·002 2. For mitre bends of any other intermediate relative roughness, the values may be suitably chosen between these values.

2.4 Sudden Enlargement — The loss of head h_f caused by a sudden enlargement shall be computed from the following equation:

$$h_f = K\frac{(\bar{v}_1 - \bar{v}_2)^2}{2g} = K\left[\left(\frac{D_2}{D_1}\right)^2 - 1\right]\frac{\bar{v}_2^2}{2g} \qquad \ldots(3)$$

where

K = resistance coefficient (usually taken as unity since the variation from unity is ±3 percent only),
$\bar{v}_1$ = average velocity in m/s in the smaller pipe,
$\bar{v}_2$ = average velocity in m/s in the larger pipe,
g = acceleration due to gravity in m/s^2,
D_2 = diameter of larger pipe in m, and
D_1 = diameter of smaller pipe in m.

Equation (3) shall be used for computing the loss of head due to flow in conical diffusers with suitable modification of K value depending upon the total conical angle (α) of the diffusers in degrees.

α being in the range of 40° to 60°, the value of K is unity as in the case of sudden enlargement.

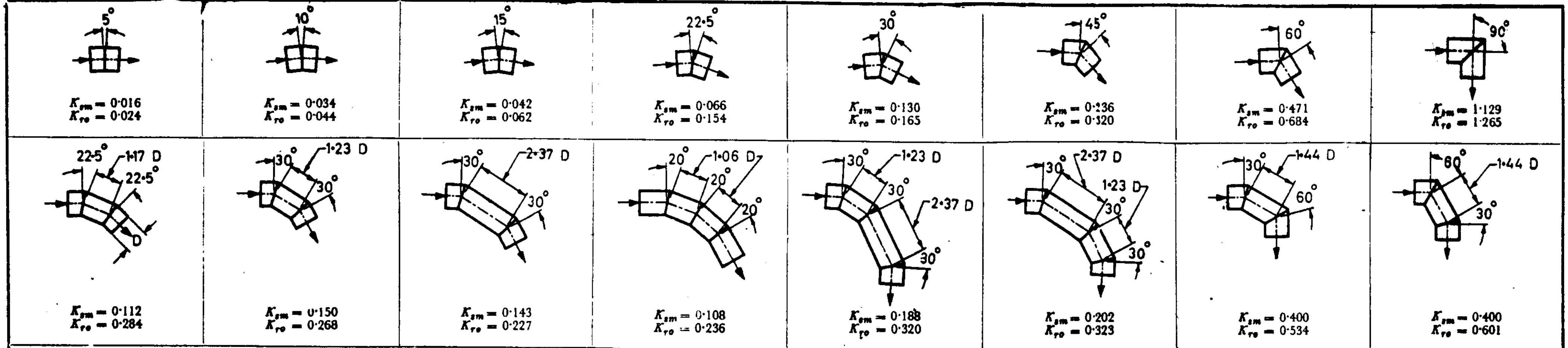
α being in the range of 7·5° to 35°, the accurate formula for K value is given by:

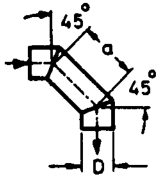
$$K = 3{\cdot}50\left(\tan\frac{\alpha}{2}\right)^{1{\cdot}22}$$

These values are shown in Fig. 4.

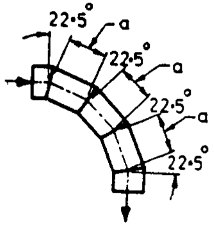
2.5 Reducers — Resistance coefficients for reducers are given in Fig. 5.

2.6 Branched Connections — Details of head loss in branched connections are given in Tables 2 and 3.

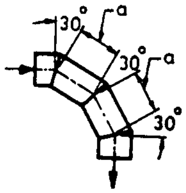




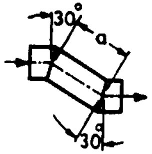
a/D	K_{sm}	K_{ro}
0·71	0·507	0·510
0·943	0·350	0·415
1·174	0·333	0·384
1·42	0·261	0·377
1·50*	0·280	0·376
1·86	0·289	0·390
2·56	0·356	0·429
3·14	0·346	0·426
3·72	0·356	0·460
4·89	0·389	0·455
5·59	0·392	0·444
6·28	0·399	0·444



a/D	K_{sm}	K_{ro}
1·186	0·120	0·294
1·40	0·125	0·252
1·50*	—	0·250
1·63	0·124	0·266
1·86	0·117	0·272
2·325	0·096	0·317
2·40	0·095	—
2·91	0·108	0·317
3·49	0·130	0·318
4·65	0·148	0·310
6·05	0·142	0·313



a/D	K_{sm}	K_{ro}
1·23	0·195	0·347
1·44	0·196	0·320
1·67	0·150	0·300
1·70*	0·149	0·299
1·91	0·154	0·312
2·37	0·167	0·337
2·96	0·172	0·342
4·11	0·190	0·354
4·70	0·192	0·360
6·10	0·201	0·360



a/D	K_{sm}	K_{ro}
1·23	0·157	0·300
1·67	0·156	0·378
2·37	0·143	0·264
3·77	0·160	0·242

K_{sm} = Resistance coefficient for smooth surface.

K_{ro} = Resistance coefficient for rough surface, $\frac{K_s}{D} \simeq 0{\cdot}002\,2$.

*Optimum value of *a* interpolated.

FIG. 3 RESISTANCE COEFFICIENTS FOR MITRE BENDS AT REYNOLDS NUMBER $\sim 2{\cdot}25 \times 10^5$

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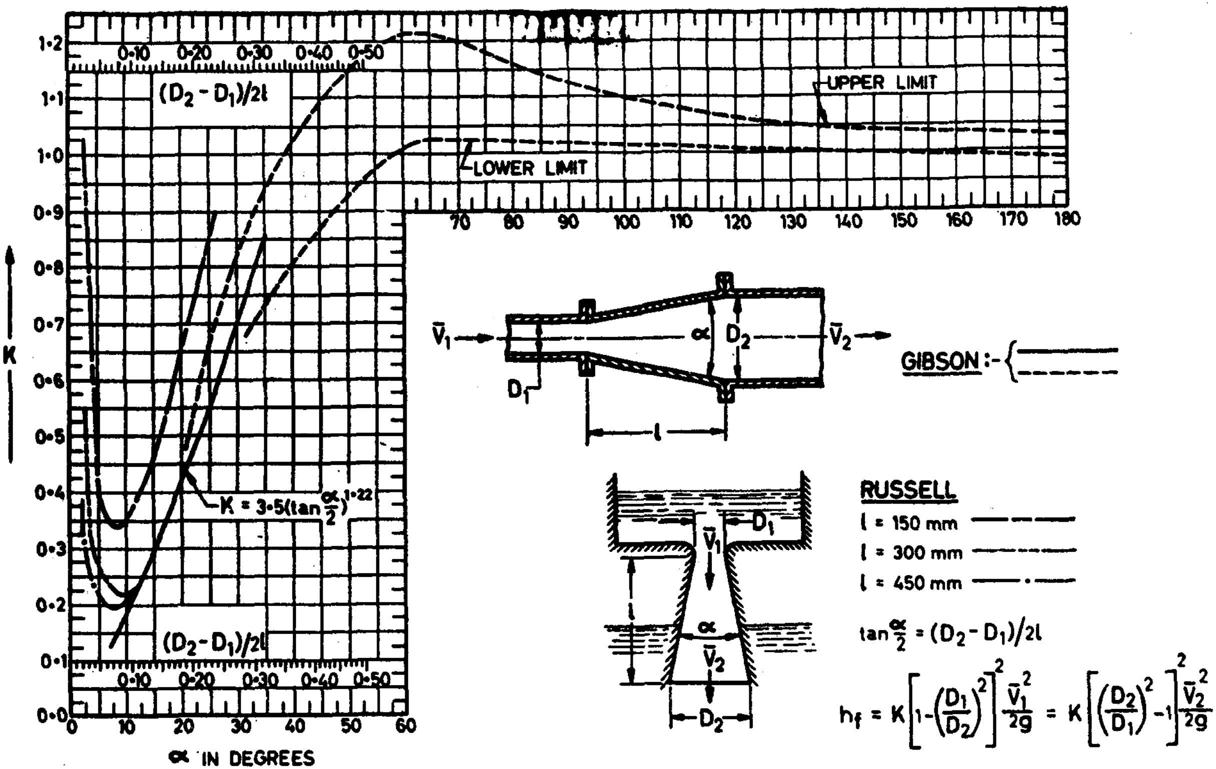


FIG. 4 RESISTANCE COEFFICIENTS FOR INCREASERS AND DIFFUSERS

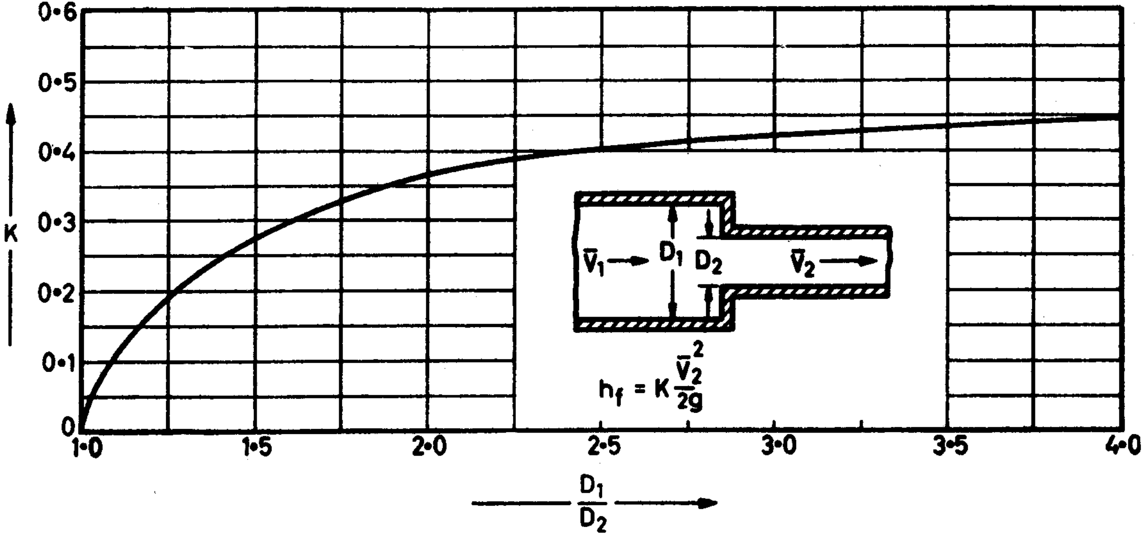
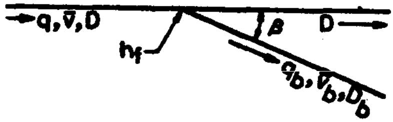


FIG. 5 RESISTANCE COEFFICIENTS FOR REDUCERS

TABLE 2 HEAD LOSS IN BRANCHED CONNECTIONS (DIVIDED FLOW)

(*Clause* 2.6)



Head loss at branching $(h_f) = K \frac{\bar{v}^2}{2g}$

where

K is resistance coefficient, and

q, $\bar{v}$, D and q_b, $\bar{v}_b$, D_b are discharge, average velocity and diameter of original and branch pipes respectively.

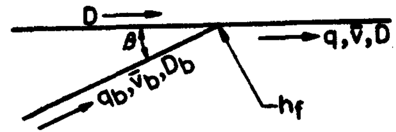
Angle of Divergence β in Degrees	$q_b/q = 0·3$		$q_b/q = 0·5$		$q_b/q = 0·7$	
	Sharp Edged	Rounded $r = 0·1\ D_b$	Sharp Edged	Rounded $r = 0·1\ D_b$	Sharp Edged	Rounded $r = 0·1\ D_b$
(1)	(2)	(3)	(4)	(5)	(6)	(7)
90	$D_b = D$	$D_b = D$	$D_b = D$	$D_b = D$	$D_b = D$	$D_b = D$
	$\bar{v}_b = 0·3\bar{v}$	$\bar{v}_b = 0·3\bar{v}$	$\bar{v}_b = 0·5\bar{v}$	$\bar{v}_b = 0·5\bar{v}$	$\bar{v}_b = 0·7\bar{v}$	$\bar{v}_b = 0·7\bar{v}$
	$K = 0·85$	$K = 0·76$	$K = 0·87$	$K = 0·74$	$K = 1·00$	$K = 0·80$
60	$D_b = D$	$D_b = 0·61D$	$D_b = D$	$D_b = 0·79D$	$D_b = D$	$D_b = D$
	$\bar{v}_b = 0·3\bar{v}$	$\bar{v}_b = 0·8\bar{v}$	$\bar{v}_b = 0·5\bar{v}$	$\bar{v}_b = 0·8\bar{v}$	$\bar{v}_b = 0·7\bar{v}$	$\bar{v}_b = 0·7\bar{v}$
	$K = 0·7$	$K = 0·59$	$K = 0·59$	$K = 0·54$	$K = 0·57$	$K = 0·52$
45	$D_b = 0·58D$	$D_b = 0·58D$	$D_b = D$	$D_b = 0·75D$	$D_b = D$	$D_b = D$
	$\bar{v}_b = 0·9\bar{v}$	$\bar{v}_b = 0·9\bar{v}$	$\bar{v}_b = 0·5\bar{v}$	$\bar{v}_b = 0·9\bar{v}$	$\bar{v}_b = 0·7\bar{v}$	$\bar{v}_b = 0·7$
	$K = 0·43$	$K = 0·35$	$K = 0·42$	$K = 0·32$	$K = 0·34$	$K = 0·3$

Note — These values are based on the experiments conducted at the Hydraulic Laboratory of the Technical University of Munich, Germany, for most efficient case.

TABLE 3 HEAD LOSS IN BRANCHED CONNECTIONS (COMBINED FLOW)

(*Clause* 2.6)

Head loss at junction $(h_f) = K \frac{\bar{v}^2}{2g}$



where

K is resistance coefficient, and

q_b, $\bar{v}_b$, D_b and q, $\bar{v}$, D are discharge, average velocity and diameter of auxiliary and combined pipes respectively.

Angle of Convergence β in Degrees	$q_b/q = 0.3$		$q_b/q = 0.5$		$q_b/q = 0.7$		$q_b/q = 1.0$	
	Sharp Edged	Rounded	Sharp Edged	Rounded	Sharp Edged	Rounded	Sharp Edged	Rounded
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
60	$D_b = 0.58D$	$D_b = D$	$D_b = 0.58D$	$D_b = 0.58D$	$D_b = 0.58D$	$D_b = 0.58D$	$D_b = D$	$D_b = D$
	$\bar{v}_b = 0.9\bar{v}$	$\bar{v}_b = 0.3\bar{v}$	$\bar{v}_b = 1.5\bar{v}$	$\bar{v}_b = 1.5\bar{v}$	$\bar{v}_b = 2.0\bar{v}$	$\bar{v}_b = 2.0\bar{v}$	$\bar{v}_b = \bar{v}$	$\bar{v}_b = \bar{v}$
	$K = 0.475$	$K = 0.33$	$K = 0.637$	$K = 0.563$	$K = 0.715$	$K = 0.655$	$K = 0.645$	$K = 0.53$
45	$D_b = 0.58D$	$D_b = 0.58D$	$D_b = 0.58D$	$D_b = 0.58D$	$D_b = D$	$D_b = D$	$D_b = D$	$D_b = D$
	$\bar{v}_b = 0.9\bar{v}$	$\bar{v}_b = 0.9\bar{v}$	$\bar{v}_b = 1.5\bar{v}$	$\bar{v}_b = 1.5\bar{v}$	$\bar{v}_b = 0.7\bar{v}$	$\bar{v}_b = 0.7\bar{v}$	$\bar{v}_b = \bar{v}$	$\bar{v}_b = \bar{v}$
	$K = 0.2$	$K = 0.2$	$K = 0.425$	$K = 0.425$	$K = 0.540$	$K = 0.525$	$K = 0.38$	$K = 0.38$

NOTE — These values are based on the experiments conducted at the Hydraulic Laboratory of the Technical University of Munich, Germany, for most efficient case.

AMENDMENT NO. 1 MARCH 1993
TO
IS 2951 (Part 2) : 1965 RECOMMENDATION FOR ESTIMATION OF FLOW OF LIQUIDS IN CLOSED CONDUITS

PART 2 HEAD LOSS IN VALVES AND FITTINGS

[*Page* 5, *Table* 1, *Sl No.* (v) (6), *col* 3] — Substitute '0.8' *for* '15'.

(RVD 1)

Reprography Unit, BIS, New Delhi, India