6. Standard manholes

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6. Standard manholes

Goals of this chapter
Standard manhole = control or inspection manhole

- What are the purposes of a standard manhole?
- How do they look like?
- What about local energy losses in manhole?

6. Standard manholes

Content:

6.1 Types
6.2 Standard manholes
6.3 Bench height
6.4 Hydraulic phenomena
6.5 Energy losses
6.6 Special manholes (overview)
6.7 Pro memoria

Literature:

W.H. Hager (1999). *Wastewater Hydraulics*, Springer, Berlin
DWA (1995). *Bau und Betrieb der Kanalisation*. Ernst & Sohn, Berlin
SIA 190, SIA Documentation 40, ATV 110

6.1 Types

6.1 Types

Manhole = connecting element between conduits

All changes in (standard/special) manhole
(i.e. of bottom slope, diameter, profile shape, direction of sewer, discharge, junction, bottom drop, and wall roughness)

At least every 120 m a manhole

6.1 Types

Purposes of manholes:

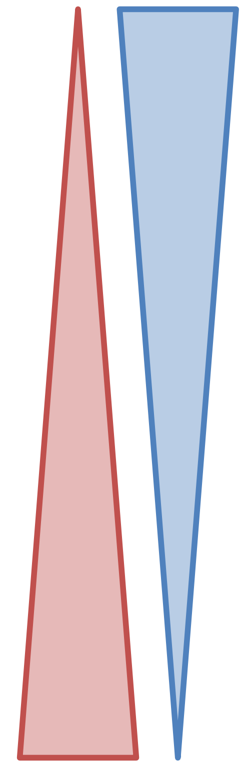
6.1 Types

Two basic manhole types exist:

Standard manholes

- inspection manhole (no changes)
- change in bottom slope (and/or diameter)
- change in wall roughness (combination of new and old sewer branch)
- change of direction
- change of sewer geometry (diameter or shape)
- change in discharge (surface run-off collector)
- drop manholes (drop shaft, vortex drop shaft)
- junction manhole
- distribution channel (side-weir or bottom opening)
- retention
- pumping station

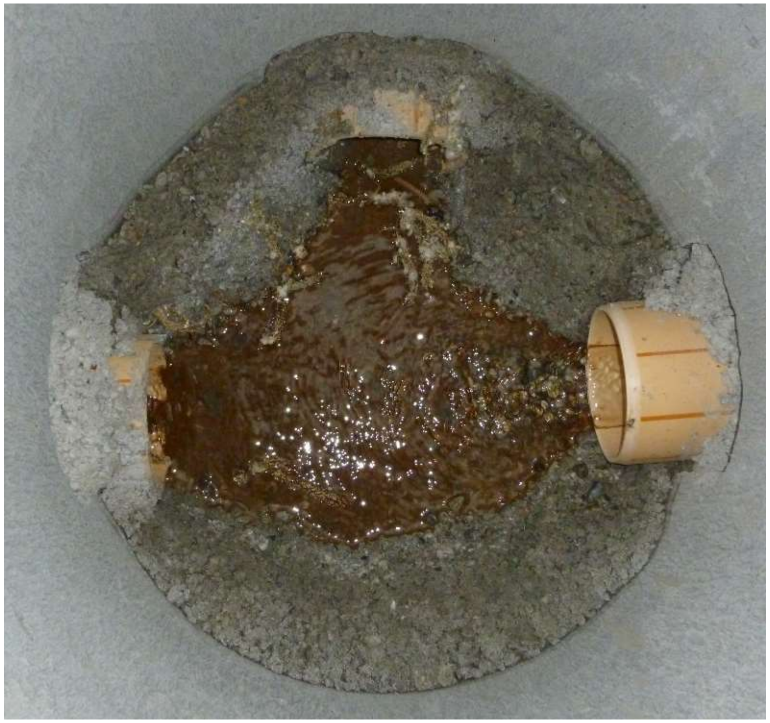
Special manholes



6.1 Types

Standard manholes (>90% of applications)

Fabricated in-situ, no (sophisticated) hydraulic design

The chapter 7 to 9 treat special manholes (<10% of applications)

6.1 Types

Standard manholes (>90% of applications)

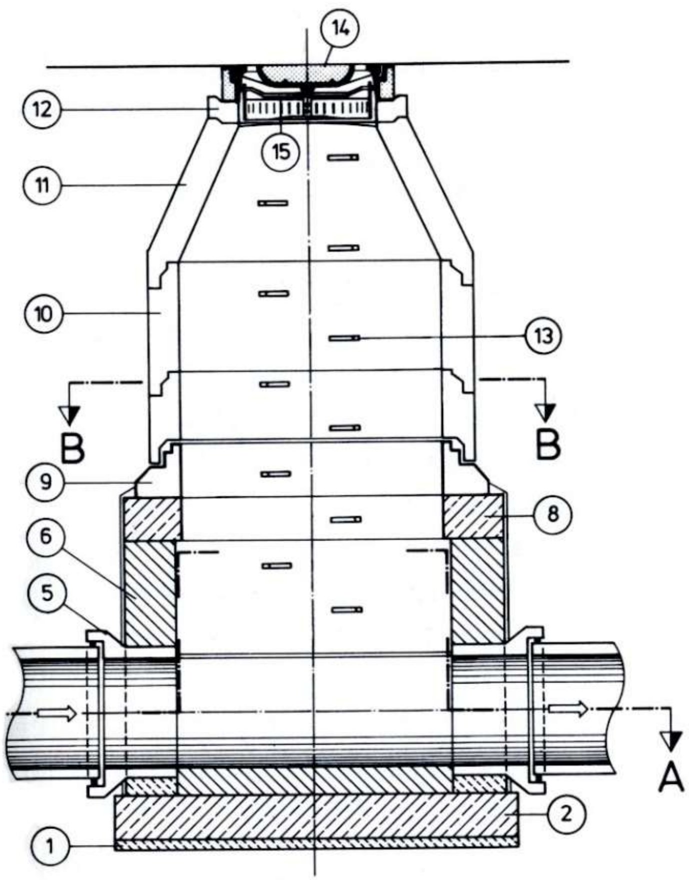
Prefabricated, no (sophisticated) hydraulic design

The chapter 7 to 9 treat special manholes (<10% of applications)

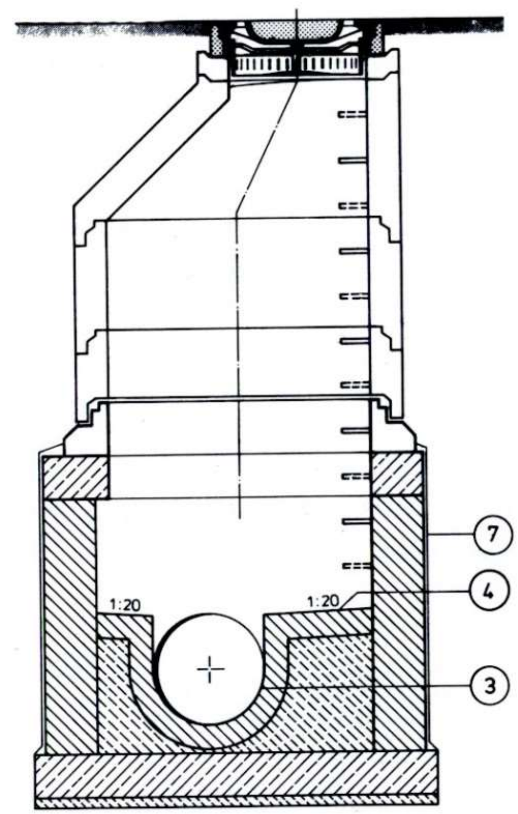
6.2 Standard manholes

6.2 Standard manholes

Standard inspection manhole (ATV 110)



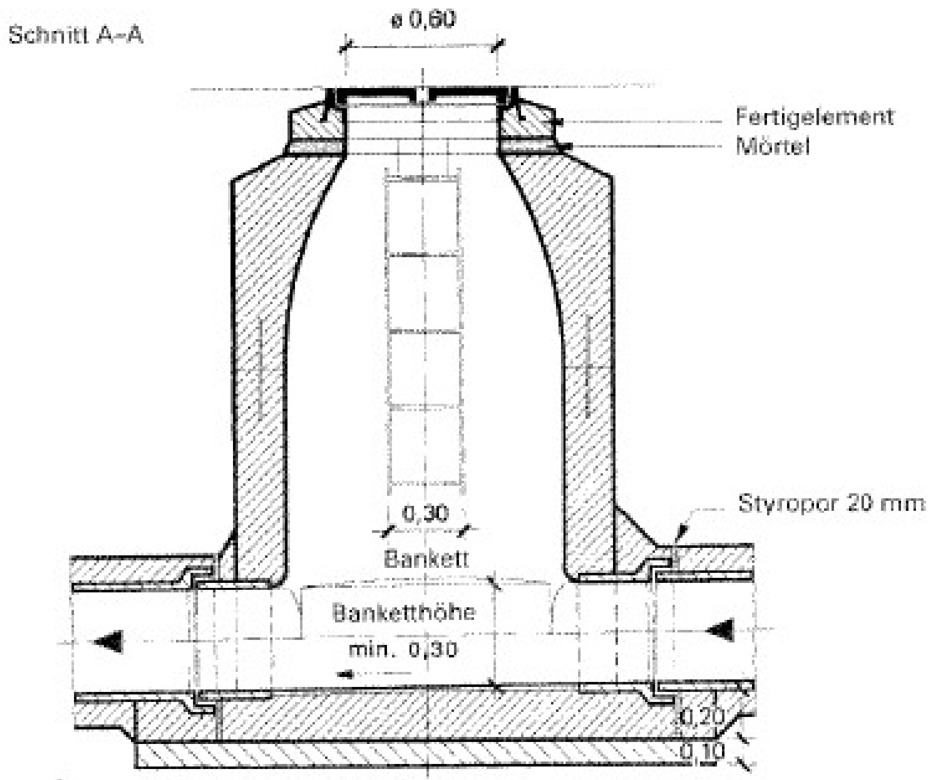
Schnitt C-C

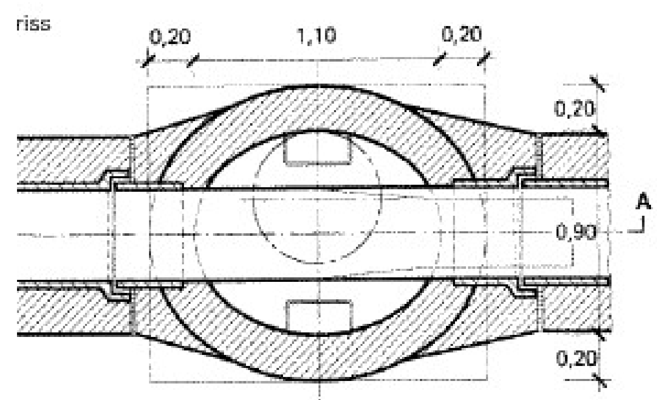


Schnitt D-D

6.2 Standard manholes

Standard inspection manhole (SIA 190)





6.3 Bench height

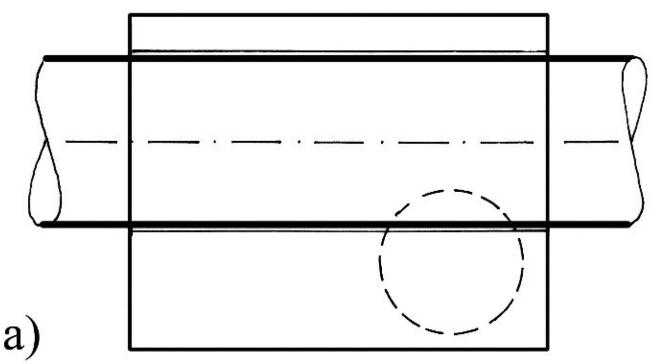
6.3 Bench height

Manhole geometry

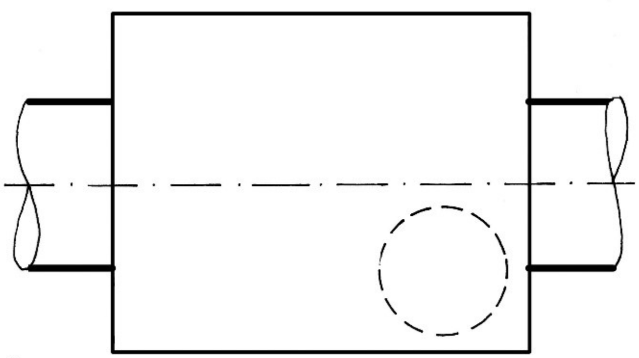
Many parameters may vary:

- Ground plan rectangular or circular-shaped
- Guided (through channel) or un-guided wastewater flow in the manhole
- Bench height normally equal to (or slightly larger than) *D*

Hygienic, operational and hydraulic reasons prohibit the application of manholes with un-guided wastewater flow!!!



a)



b)

Reasons: rotting despots, maintenance, hydraulic losses

6.3 Bench height

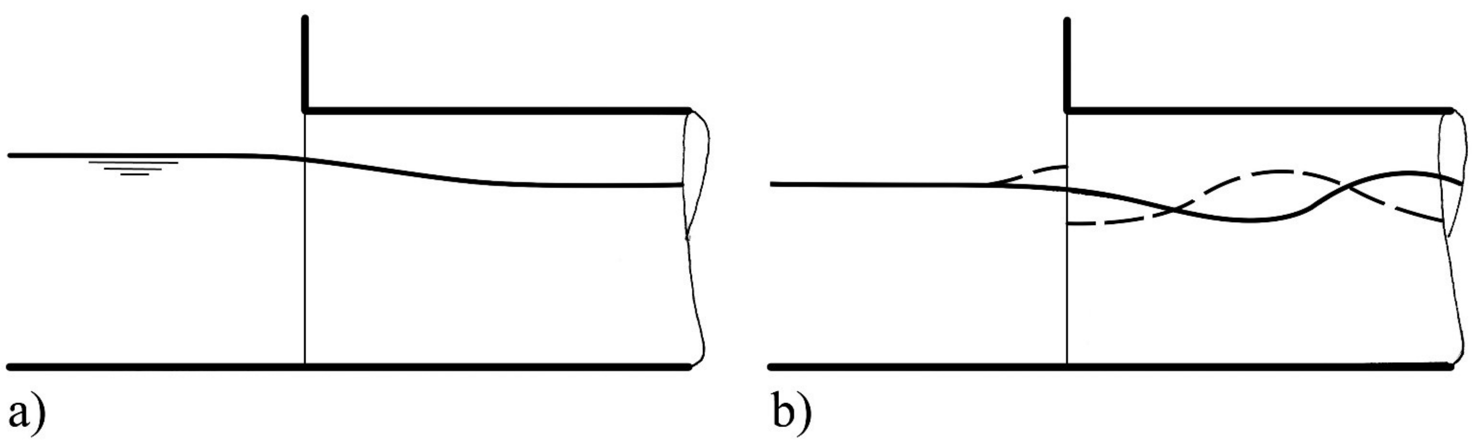
In manhole transition from O ⇨ U ⇨ O profile

Sub-critical flow (a)

- Constriction (U ⇨ O profile)
- Backwater effect
- Vortex generation if submerged
- Air entrainment into sewer

Super-critical flow (b)

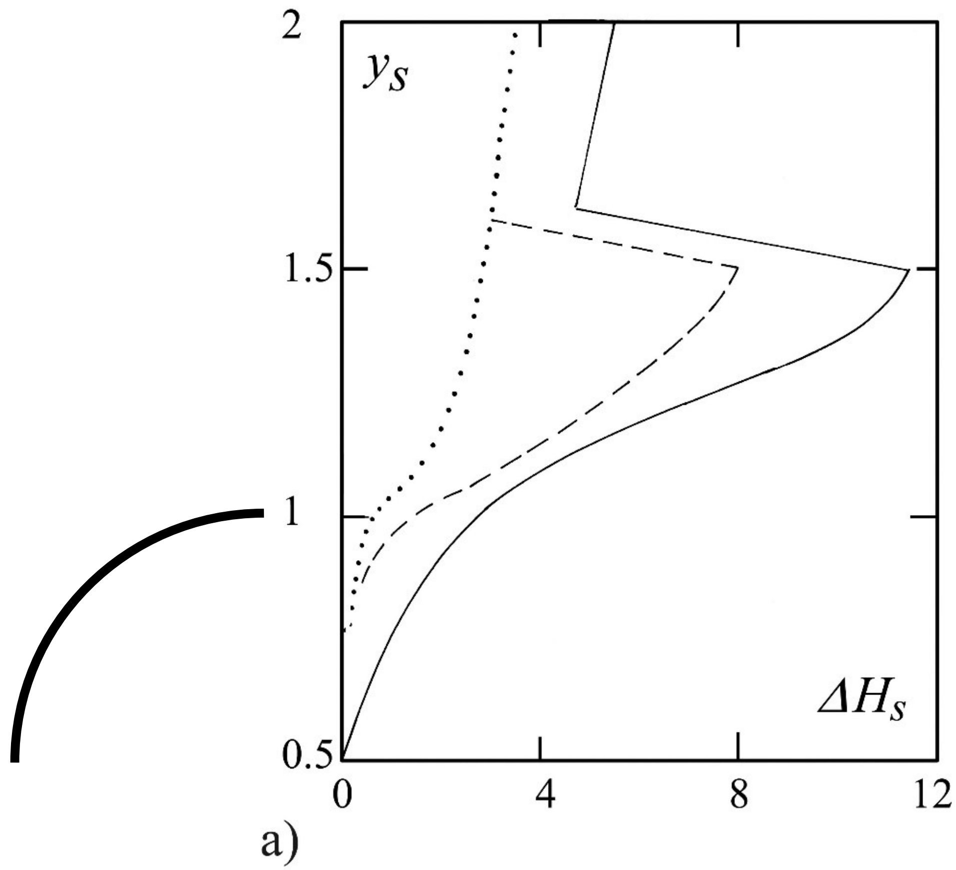
- Spatial flow pattern
- Shockwaves, reflections
- Hydraulic jump, swell



6.3 Bench height

Bench height

Local losses at standard manhole in [cm] for different y_s for variable submergence with bench height of h_b/D= (—) 50%, (- -) 75%, (•••) 100%



6.3 Bench height

Bench height
For standard manhole, a bench height of D provides good hydraulic, operational and hygienic conditions.

SIA 190 request bench heights >0.3 m, and no submergence for $2Q_m$
Transversal slope is 5 to 10% (SIA) or 20% (DWA)

The average local energy loss is

$$\xi_s = \frac{\Delta H_s}{V^2/2g} = \frac{1}{6}$$

or (with D_s for manhole diameter)

$$\xi_s = \frac{1}{12}\left(\frac{D_s}{D} - 1\right)$$

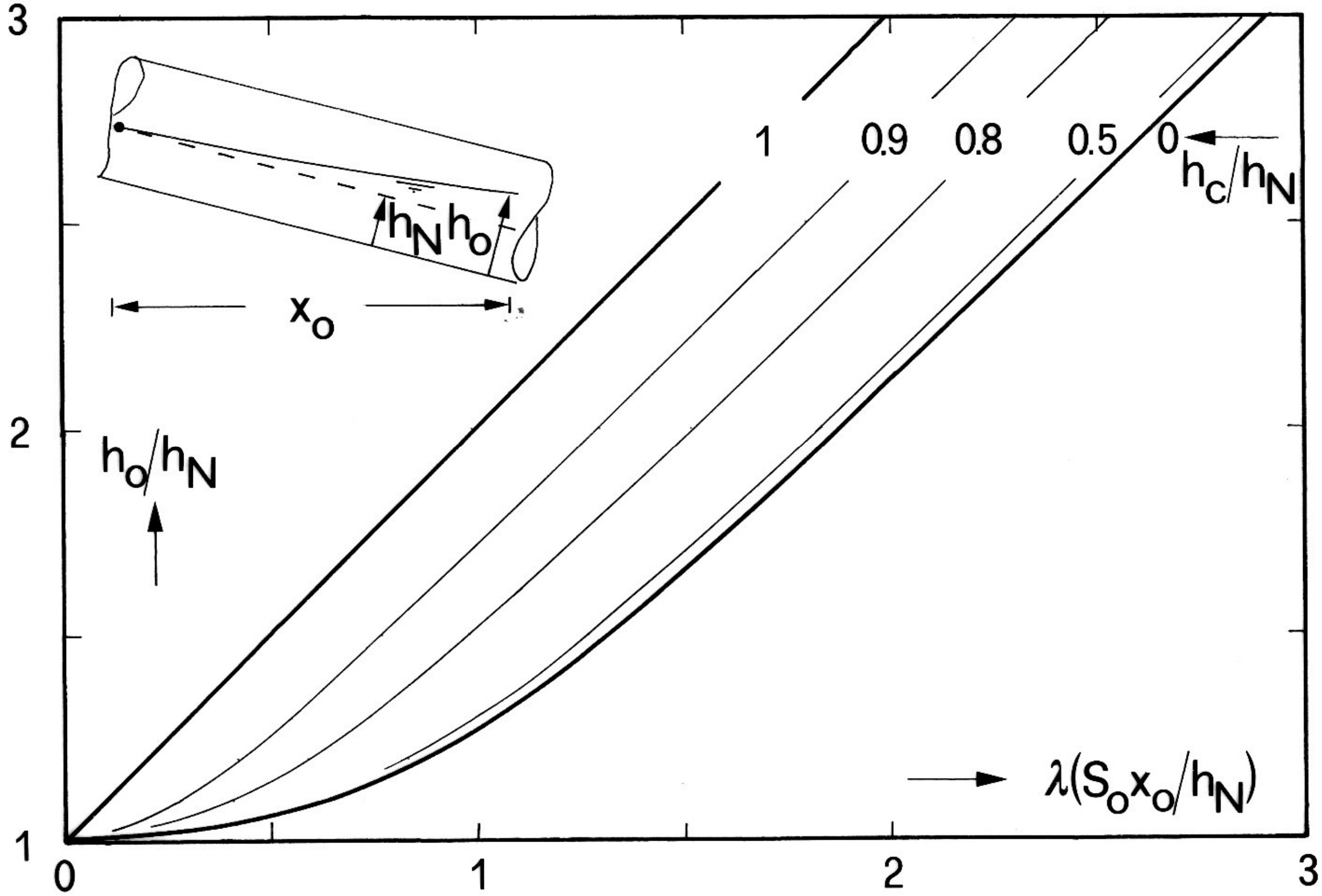
6.4 Hydraulic phenomena

6.4 Hydraulic phenomena

Backwater length in manhole?

- If in manhole: no adaption of conduit necessary
- If in conduit: increase D

with $\lambda=(1-1.1y_N^2)^{1/2}$ and $y_N=h_N/D$

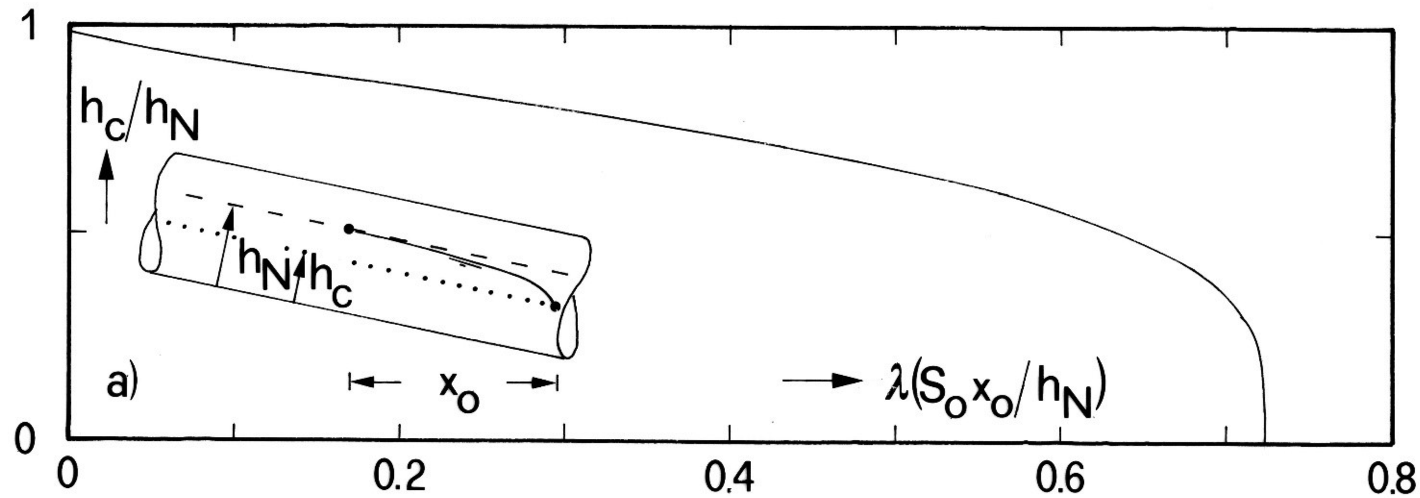


6.4 Hydraulic phenomena

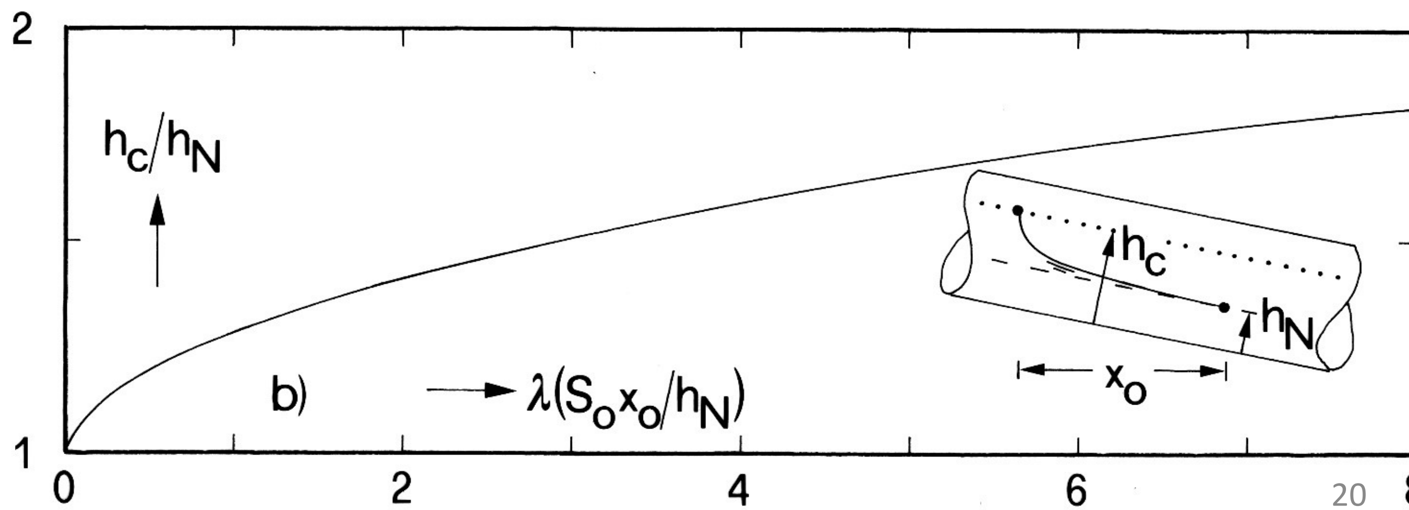
Drawdown length in manhole?

with λ=$(1–1.1y_N^{\,2})^{1/2}$ and y_N=h_N/D

Sub-critical flow



Super-critical flow

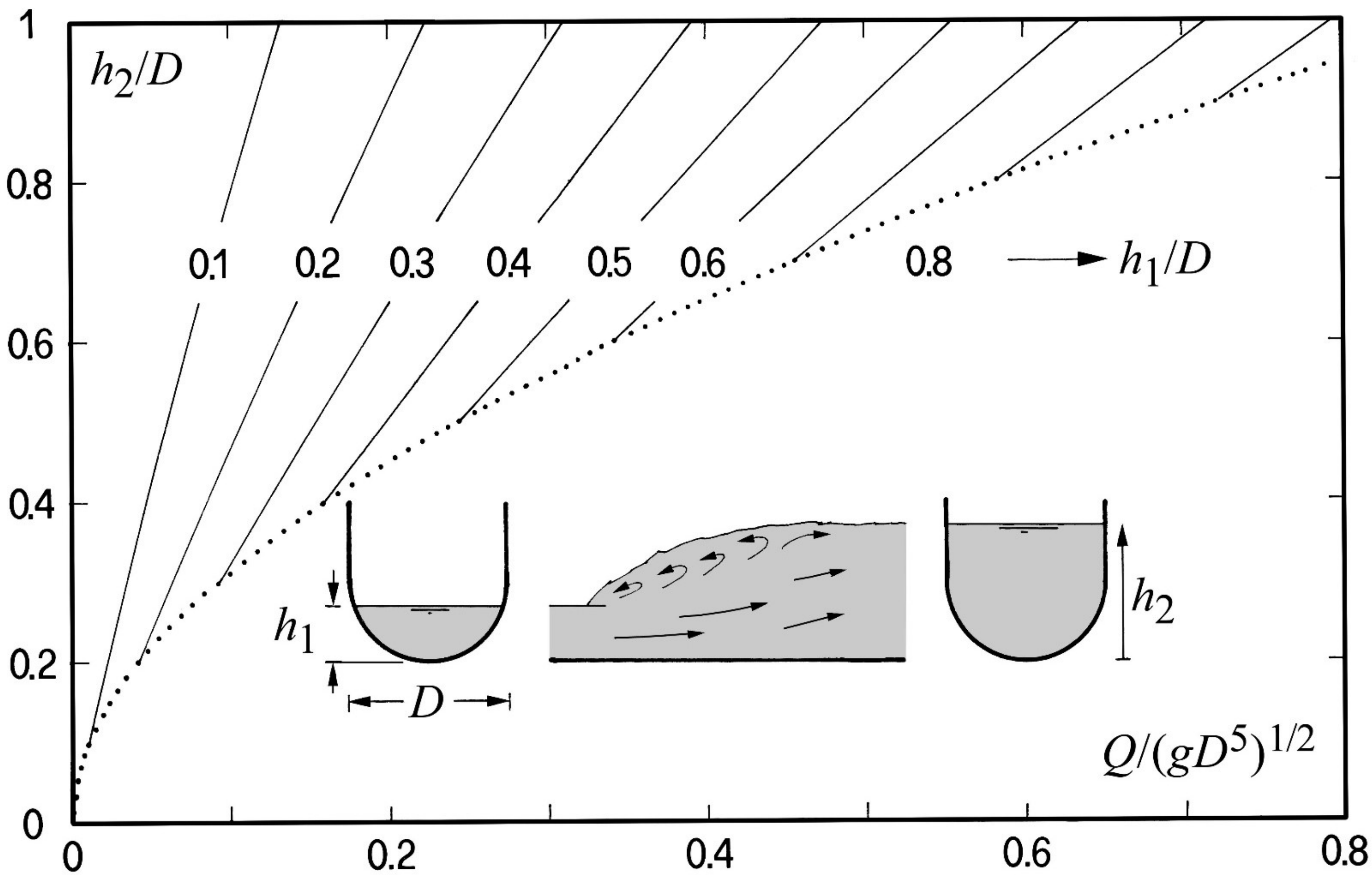


6.4 Hydraulic phenomena

Hydraulic jump (Hager 1999)

Approximation for U-profile

Jump length L=6h_2

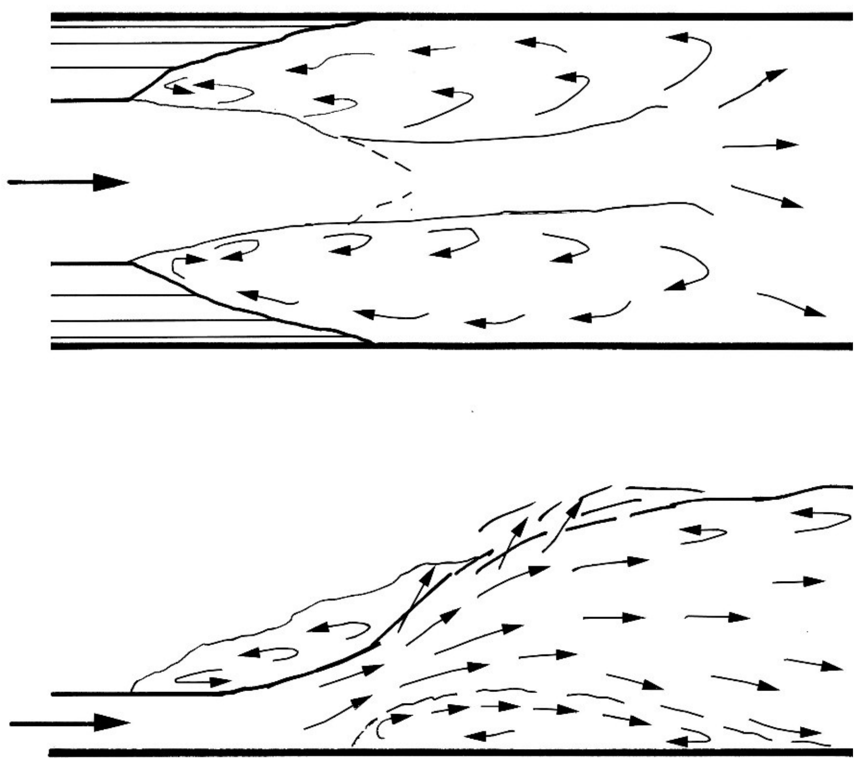


6.4 Hydraulic phenomena

Hydraulic jump (Hager 1999)

- for small y_1<0.3 to 0.4 spatial jump
- for large y_1>0.4 to 0.5 plain jump

with $y_1=h_1/D$



a)

b)

a)

b)

6.4 Hydraulic phenomena

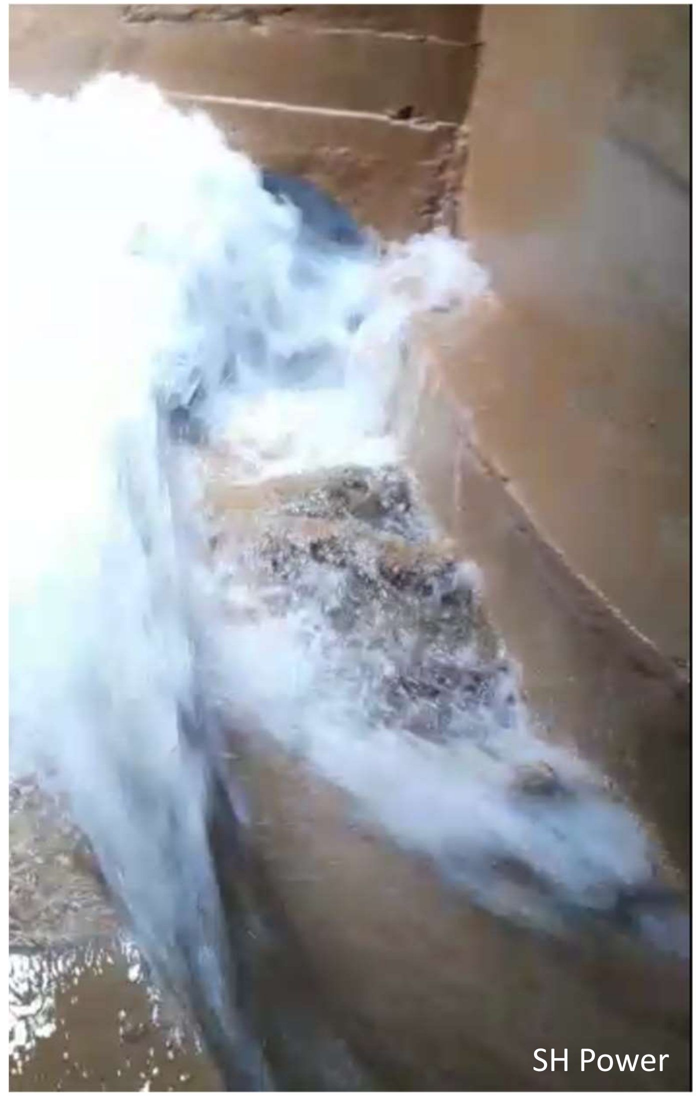
Inspection manhole
(Regard de contrôle, aucun changement de géométrie)
Changement section O ⇨ U ⇨ O (Gisonni & Hager)

- avec un écoulement fluvial: sans effet sur la capacité

- réduction de la capacité de débit pour un écoulement torrentiel
  (le regard fixe normalement le diamètre de la conduite et non l'hydraulique de la conduite).
  Condition admissible dans le regard sans effet sur la capacité
  $$Y_a \leq 0.70 = \frac{h}{D}$$
  Capacité réduite du regard pour 0.70<Y≤0.75, étant
  $$\mathrm{F}_c = \frac{Q}{\sqrt{gD^5}} = 14.6 - 17.3Y$$
  Étouffement pour Y>0.75

6.4 Hydraulic phenomena

Bend manhole: sub-critical versus super-critical inflow



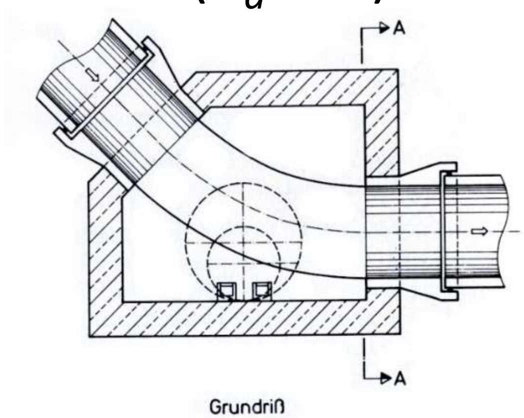
6.4 Hydraulic phenomena

Bend manhole
(exclusivement un changement de direction)

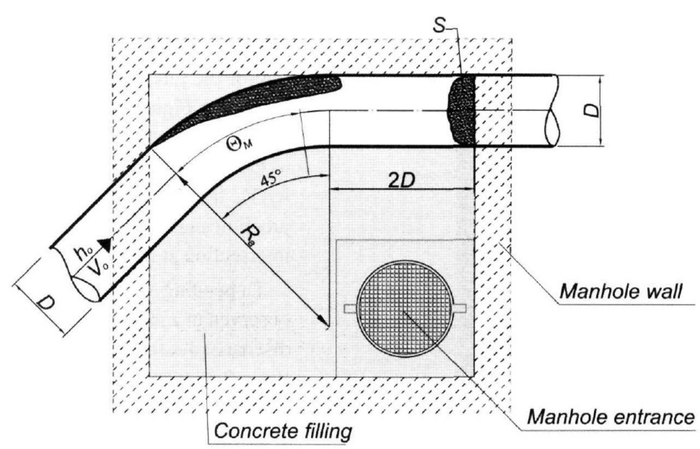
- avec un écoulement fluvial: sans effet sur la capacité

- réduction de la capacité de débit pour un écoulement torrentiel (onde de choc génère un étouffement). Deux approches:

1. Coude sans pièce de transition rectiligne (R_a=3D)



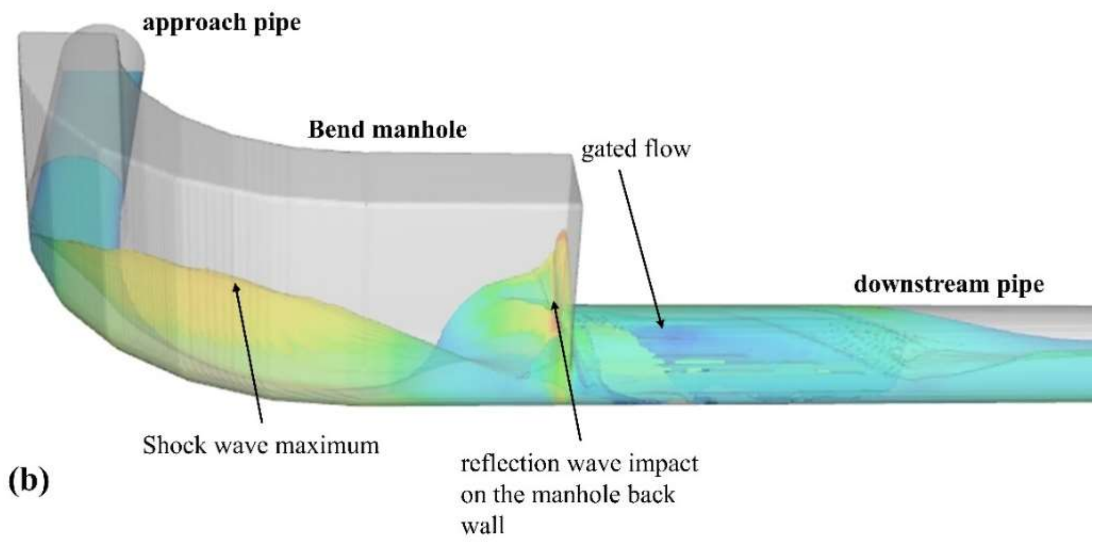
2. Coude avec pièce de transition rectiligne (après la courbe R_a=3D, longueur 2D)

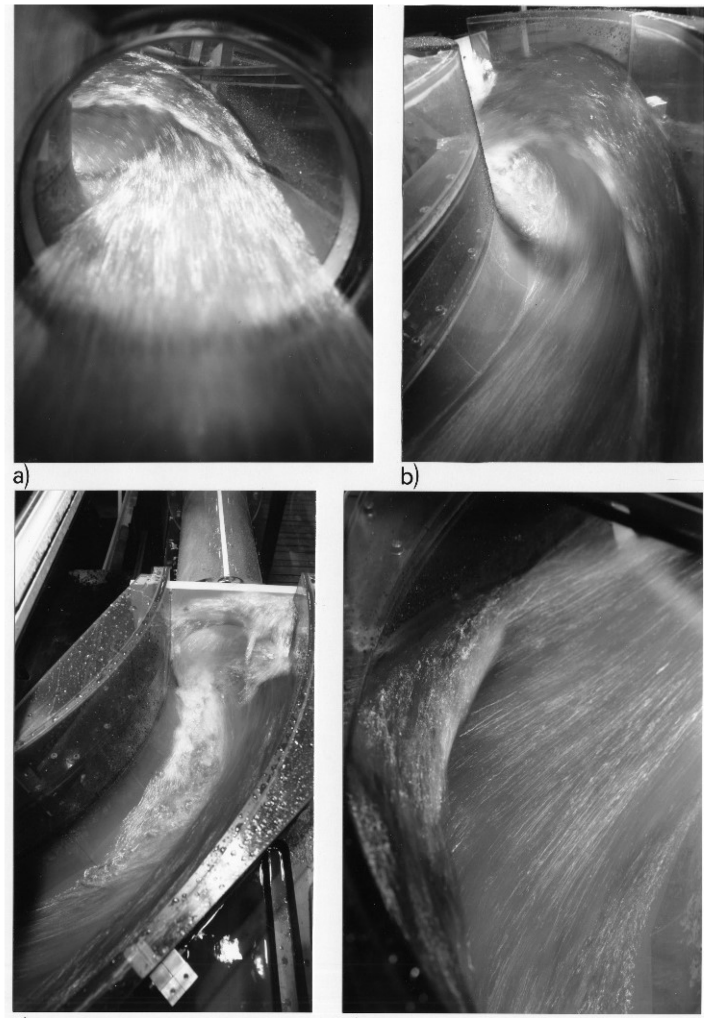


6.4 Hydraulic phenomena

Bend manhole for supercritical flow

Onde de choc et étouffement à la sortie du regard (Hager 2010, Crispino et al. 2022)

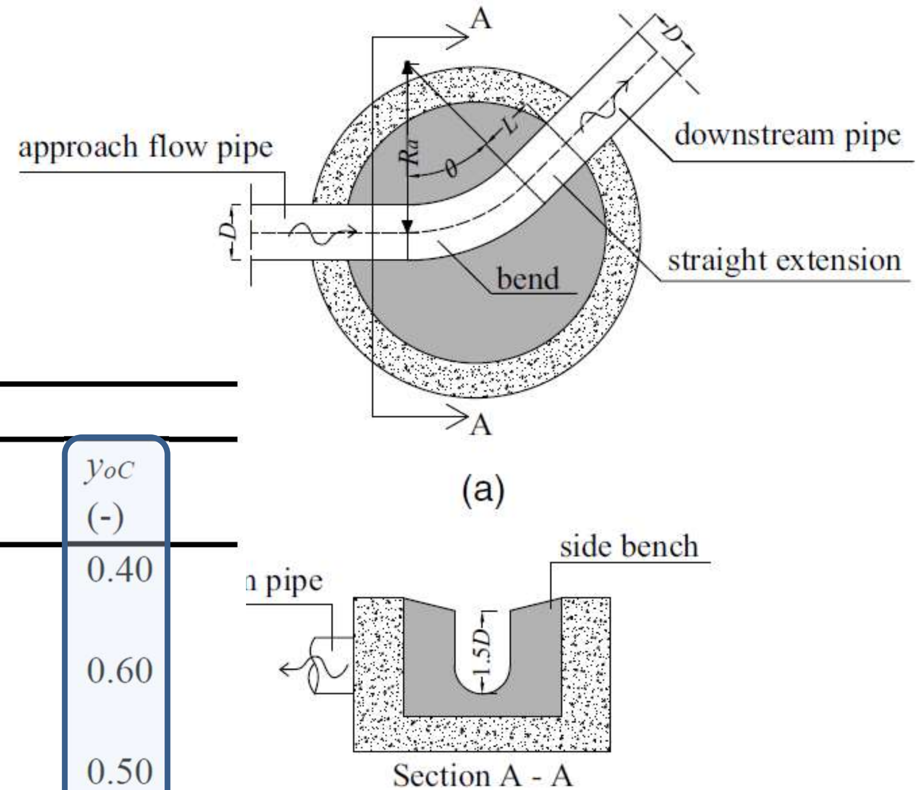




6.4 Hydraulic phenomena

Bend manhole for supercritical flow (R_a=1..3D et L=0..2D)
Exclusively change of direction (Hager 2010, Crispino et al. 2022)

1. Limitation of the partial filling ratio y_M in the upstream conduit (uniform flow) to y_{oC} according to the table below



		$\theta = 45°$			$\theta = 90°$		
L/D (-)	R_a/D (-)	k (-)	α (-)	y_{oC} (-)	k (-)	α (-)	y_{oC} (-)
0	1	0.60	0.6	0.40	0.75	0.8	0.40
0	2	0.70	0.6	0.50			
0	3	0.80	0.6	0.60	1.25	0.8	0.60
1	2	0.80	0.6	0.50			
2	1	0.80	0.6	0.50	1.00	0.8	0.50
2	2	0.85	0.6	0.50			
2	3	0.90	0.6	0.60	1.40	0.8	0.60

6.4 Hydraulic phenomena

Bend manhole for supercritical flow (R_a=1..3D et L=0..2D)
Exclusively change of direction (Hager 2010, Crispino et al. 2022)

1. Determination of the discharge capacity

Normalized discharge
$$Q^* = \frac{Q}{\sqrt{gY^3D^5}}$$

Normalized capacity
$$Q_C^* = kY^{(\alpha-1.5)}$$

$$k = 0.1\left(\frac{R_a}{D} + \frac{L}{D} + 5\right)$$

$$\alpha = 0.7 - sin\left(\frac{\delta}{8}\right)$$

Bend operational if $Q^*_C > Q^*$
Bench height of 1.5D

6.4 Hydraulic phenomena

Bend manhole for supercritical flow

Does the following bend manhole operate hydraulically correctly?

θ=45°, d_i=0.8 m, Q_M=0.9 m^3/s,
J_S=0.02, R_a=2.4 m, L=0 m

6.4 Hydraulic phenomena

Regards de chute à faible dénivelé (*Δh=D,* longueur de 2*D*)
(exclusivement un changement de direction) (Gisonni & Hager)

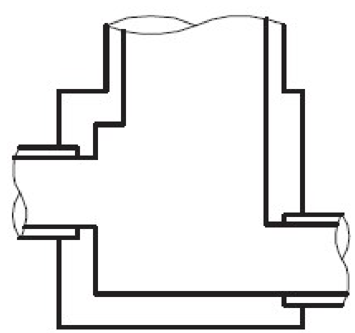
- réduction de la capacité de débit pour un écoulement torrentiel (étouffement). Limite de capacité

  Condition admissible dans le regard sans effet sur la capacité

  $Y_a \leq 0.75$

  Capacité réduite du regard pour 0.70<*Y*≤0.75, étant

  $$\mathrm{F}_c = \frac{Q}{\sqrt{gD^5}} = 1$$



6.5 Energy losses

6.5 Energy losses

Local losses

- Occur typically in manholes
- Change of wall geometry
- Change of discharge
- Change of roughness

Local losses [m] increase with the flow velocity. The local energy loss head ΔH is thus defined in function of the loss coefficient ξ as

$$\Delta H = \xi \frac{V^2}{2g}$$

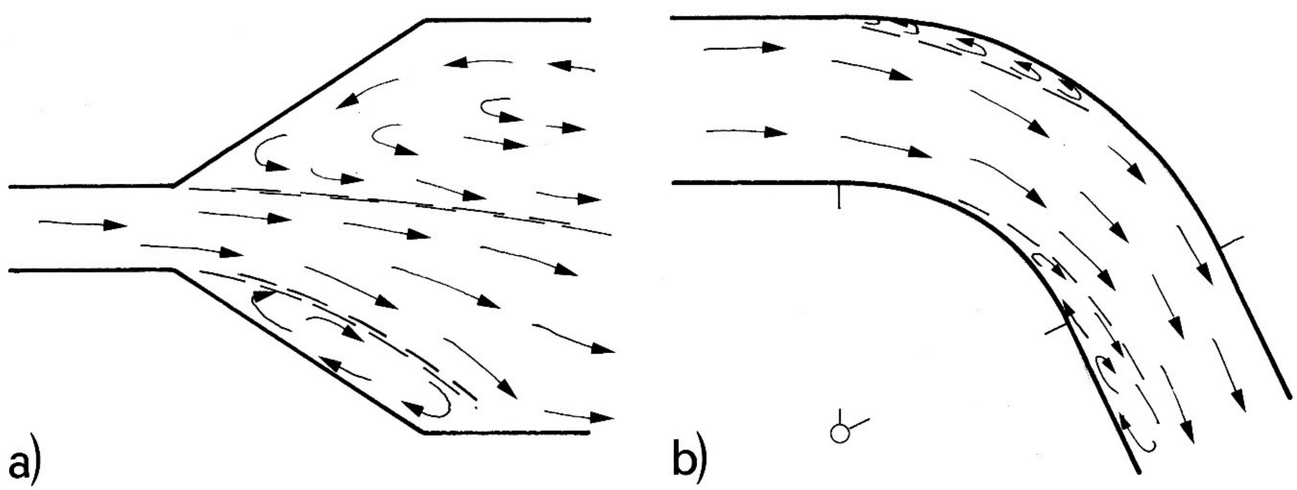
To derive the local losses, the values V and ξ are requested.

- V is typically the *larger* value of the two cross sections considered
- The ξ-values refer to pressurized flow, similar if F<0.7 (Idel'cik 1979 and Blevins 1984)
- Superstition: the frictional losses are assumed to be zero!
- Wastewater: V=1…2 m/s ⇨ $V^2/2g$=0.05…0.10 m

6.5 Energy losses

Local losses
Occur whenever streamlines are directed away from the axial direction

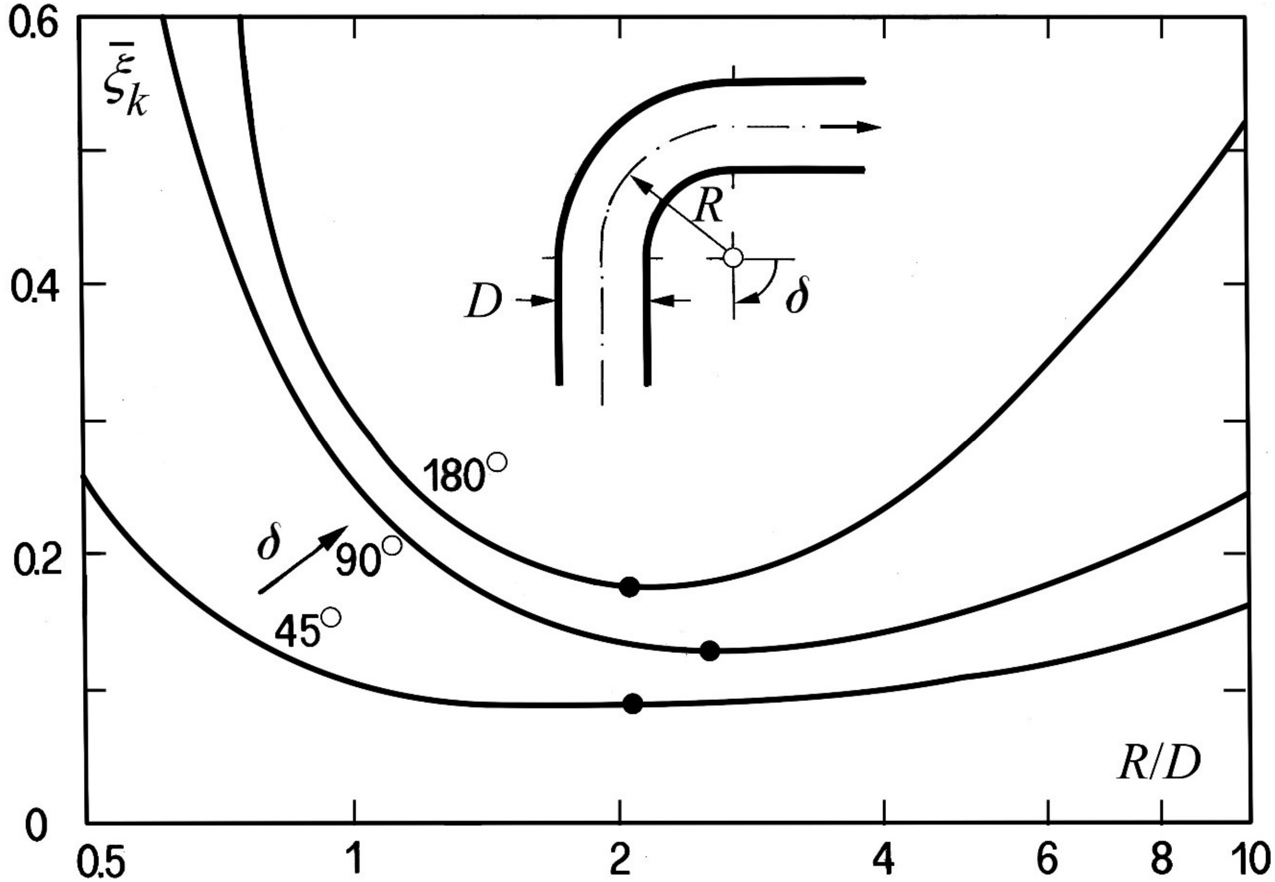
Then,
- the flow accelerates or retards
- separation zones establish



Diverging streamlines: “large” losses (momentum “force” principle)
Converging streamlines: “small” losses (energy principle)

6.5 Energy losses

Bend manhole (circular conduit bend)
(Ito 1960)



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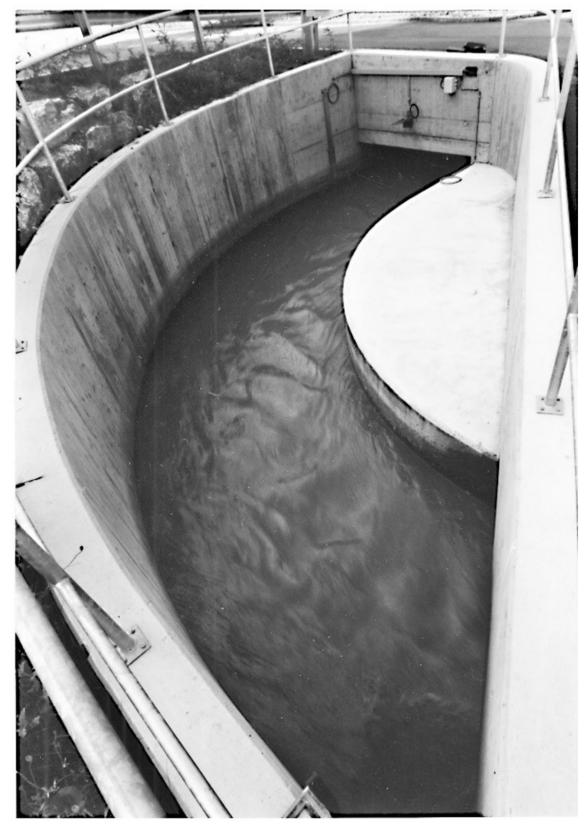


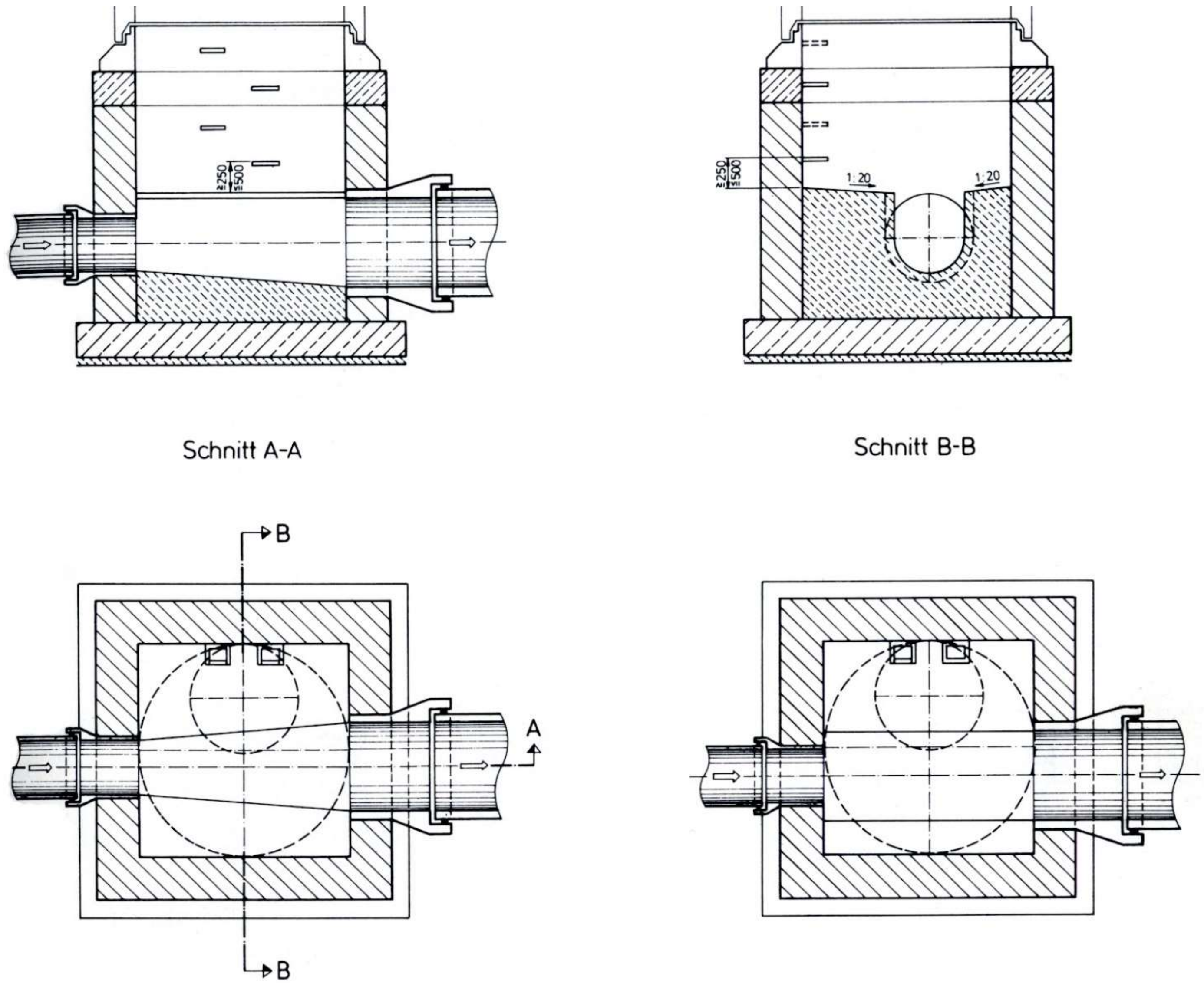
b)

6.5 Energy losses

Expansion manhole
ATV proposes smooth
or abrupt transition

Optimum related to
energy losses: abrupt

Borda-Carnot



6.5 Energy losses

Expansion manhole

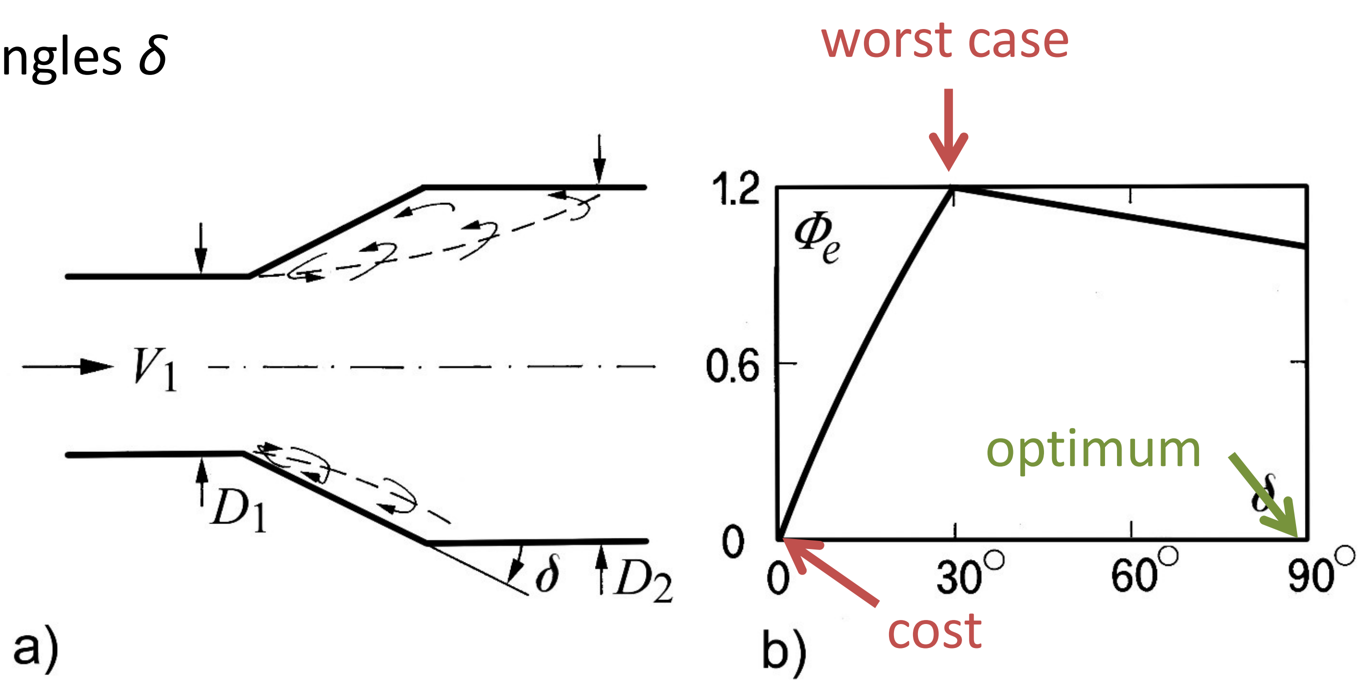
Borda-Carnot for abrupt expansion (δ=90°)

$$\xi_{e90^\circ} = \Delta H_{12} / \left(\frac{V_1^2}{2g} \right) = \left(1 - \frac{A_1}{A_2} \right)^2$$

With A_1=A_2 ⇨ ξ=0 ⇨ no loss and A_1<<A_2 ⇨ ξ=1 ⇨ entire velocity head lost

For variable expansion angles δ

$$\xi_e = \Phi_e(\delta) \cdot \xi_{e90^\circ}$$

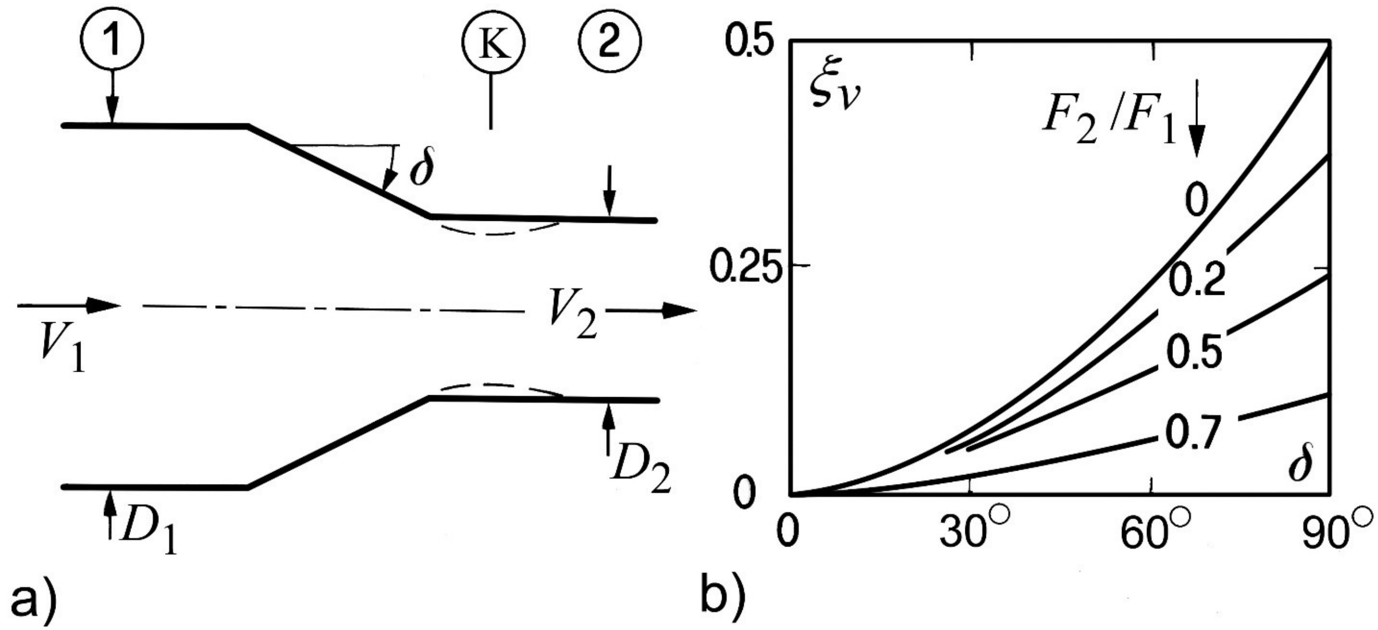


6.5 Energy losses

Contraction manhole

No analogy to expansion!

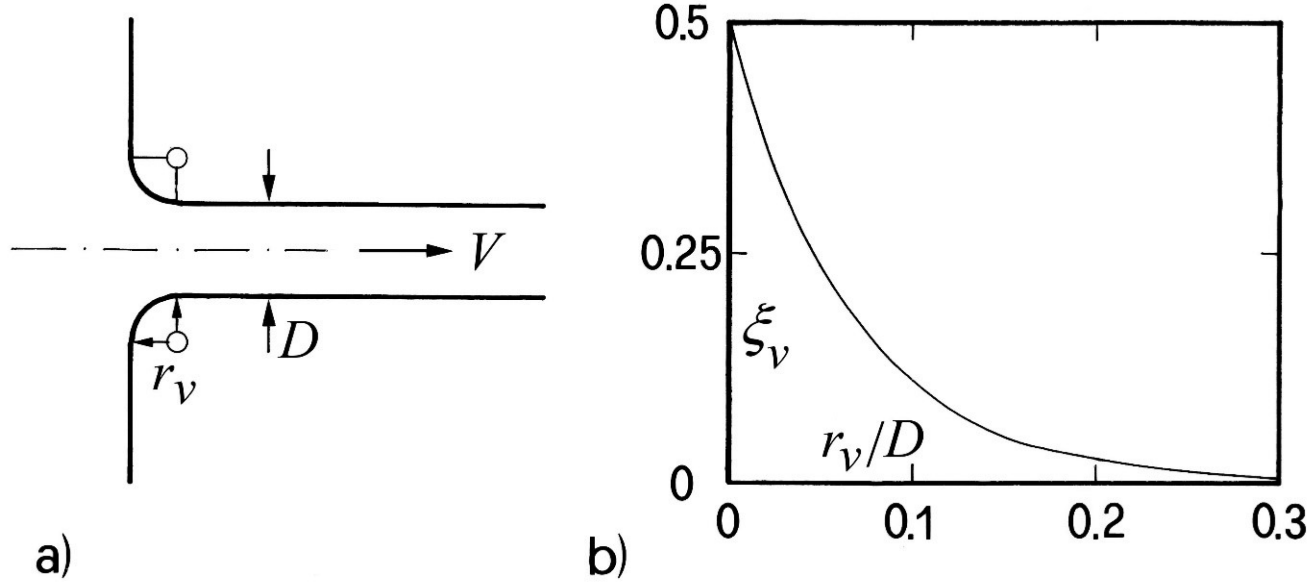
Reference velocity is V_2, as V_1 could be zero



Maximum for δ=90° and $A_2/A_1 \to 0$: $\xi \to 0.5$ (small)

6.5 Energy losses

Contraction manhole
Inlet geometry

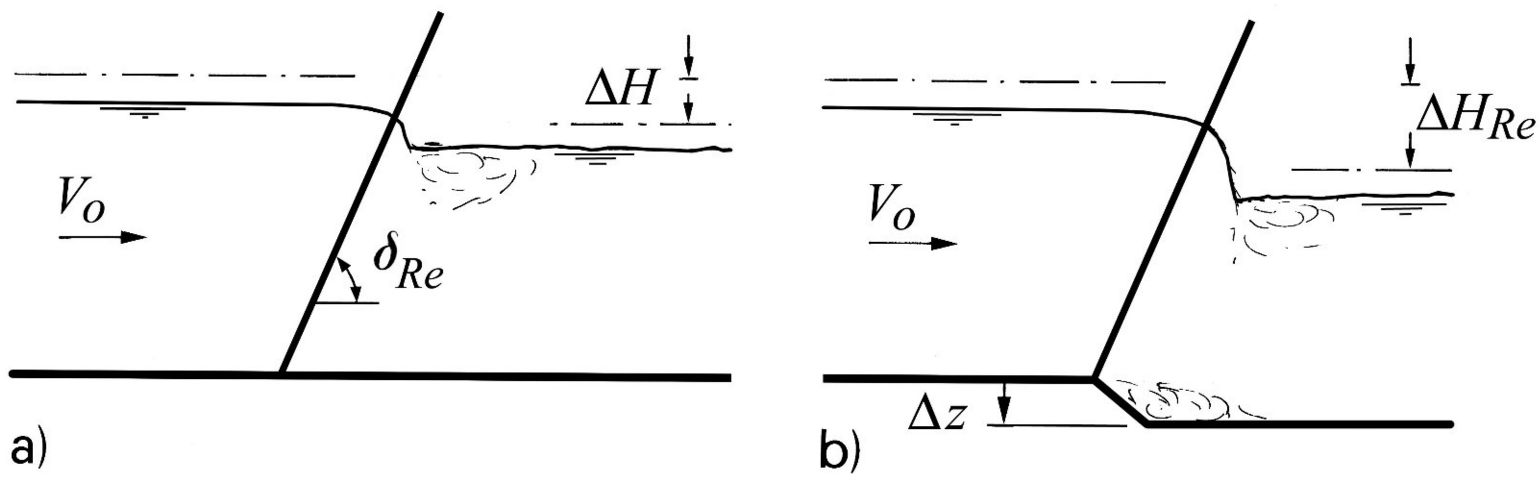


With rounded edges at intake: for $r_v/D > 1/6$ is $\xi \rightarrow 0$

6.5 Energy losses

Trash racks

At intakes and water treatment plants, to retain thrash and drift wood



Many parameters affect ξ, as vertical angle, rack bar coefficient, cleaning procedure, rack density

In general: Use for V_o=1 m/s approximately H_L=0.05 to 0.10 m

6.6 Special manholes

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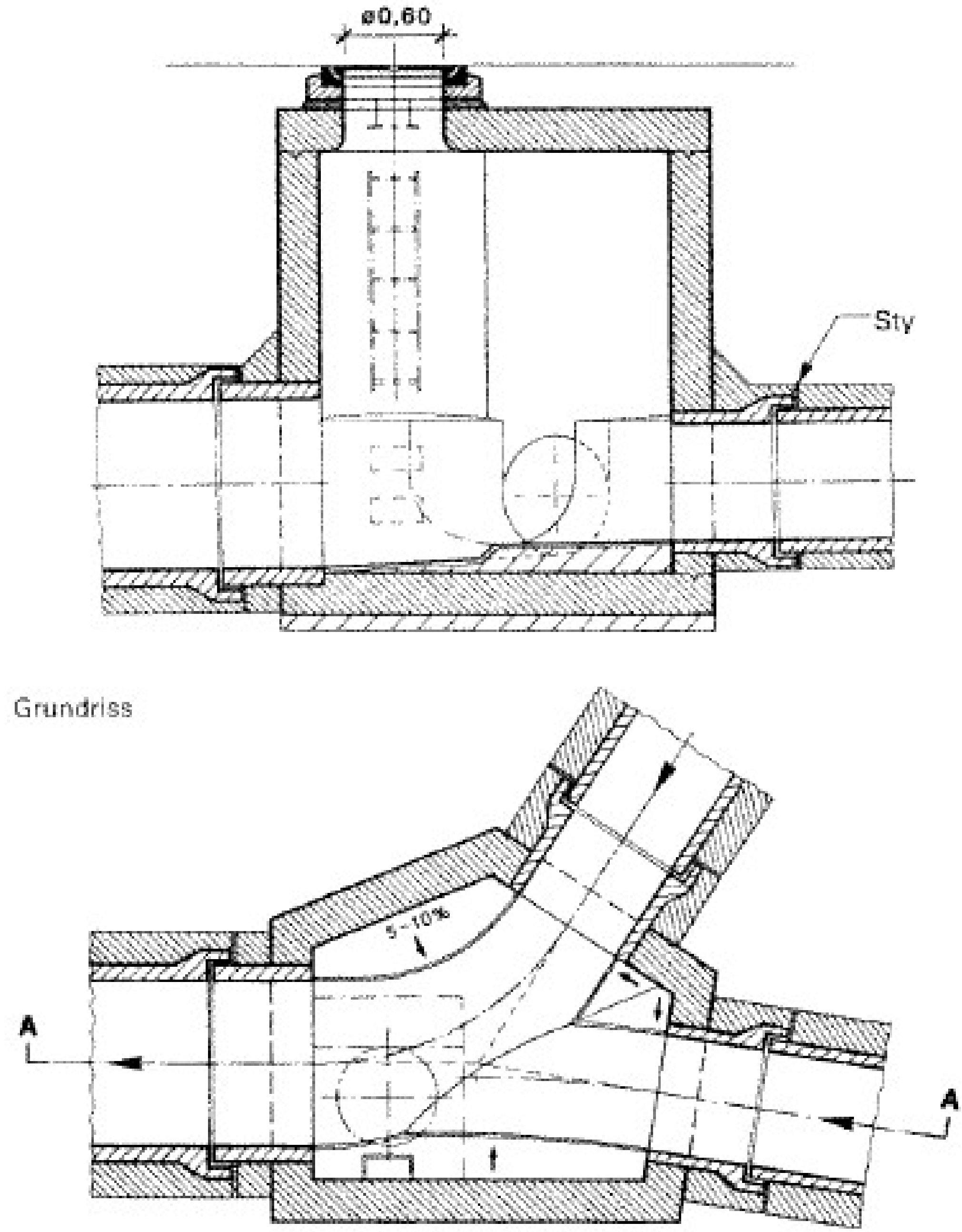
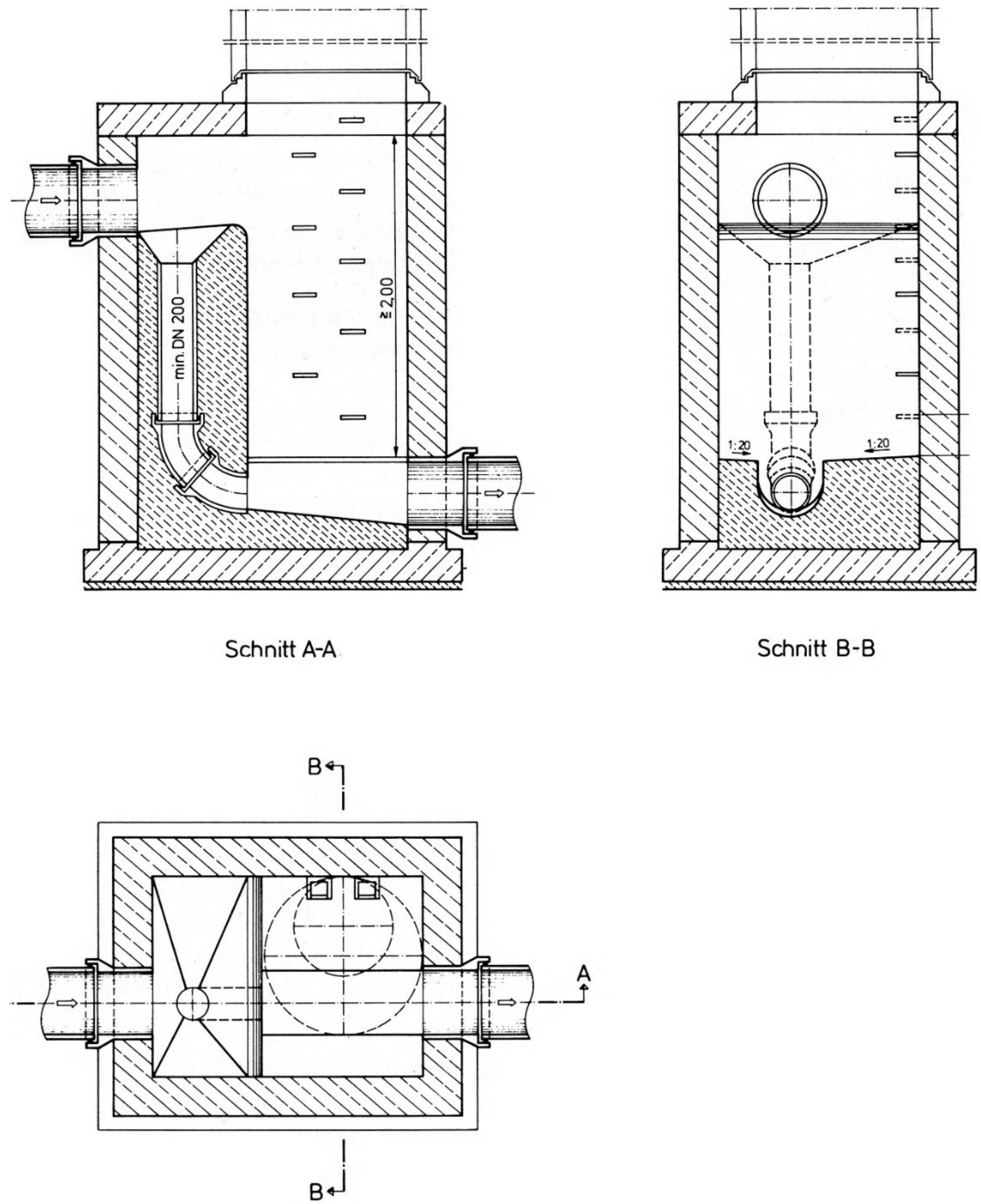
Junction manhole

(SIA 190)



6.6 Special manholes

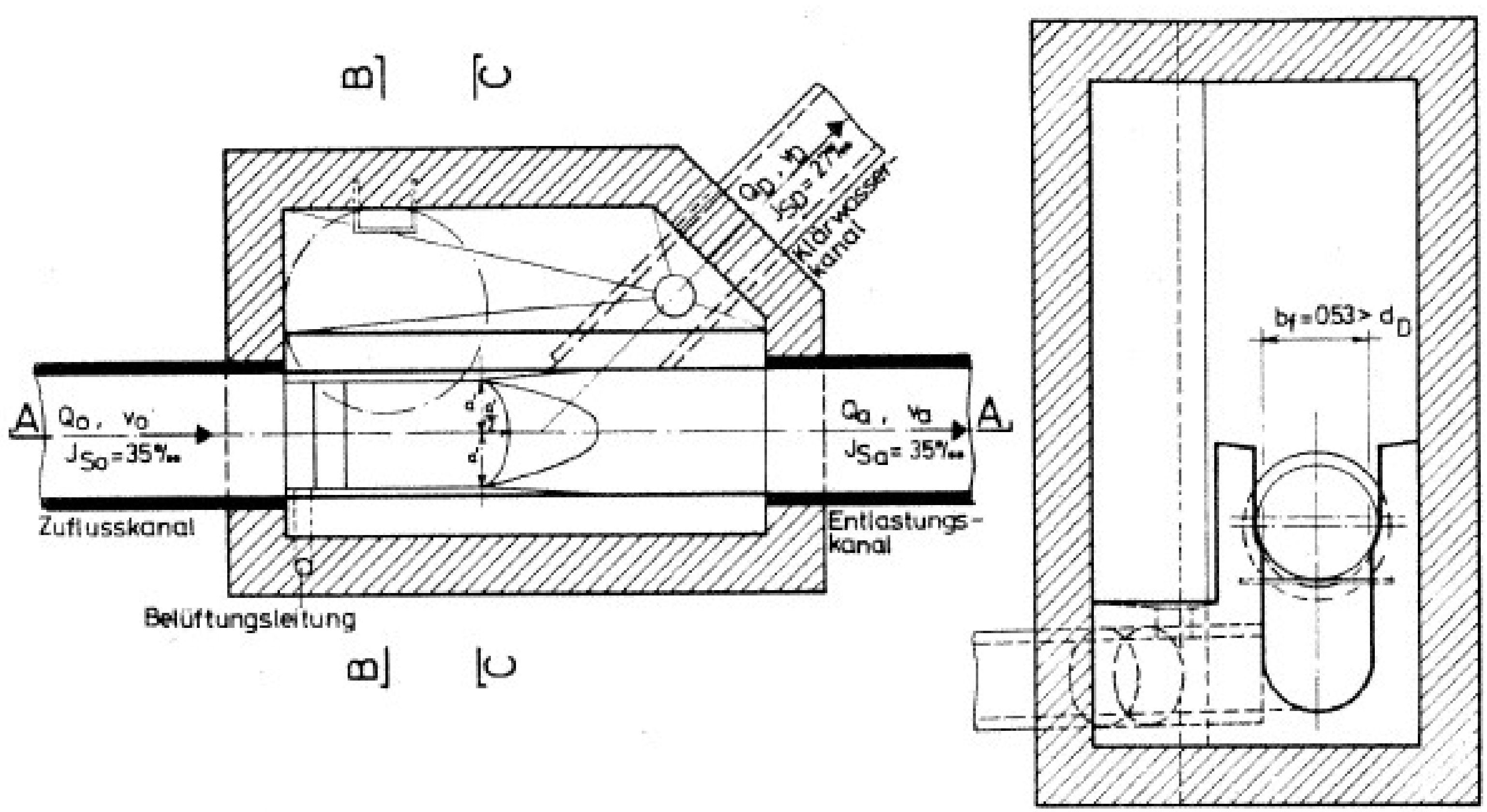
Drop manhole
(ATV)



6.6 Special manholes

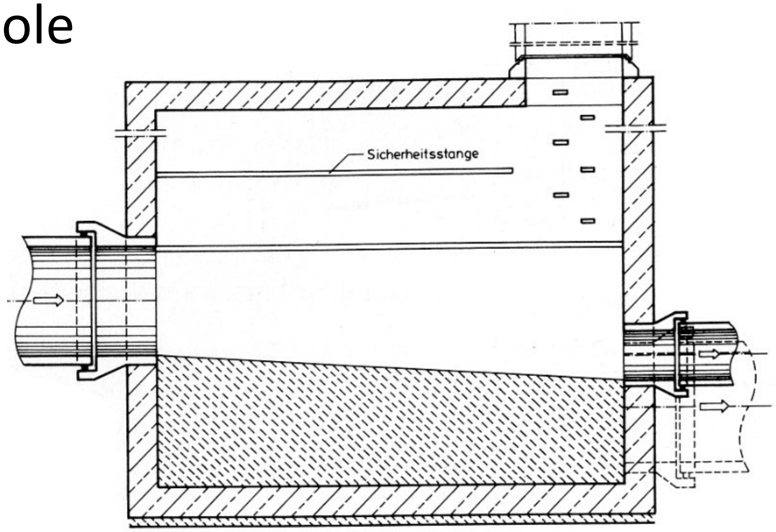
Bottom opening manhole

(SIA Documentation 40)

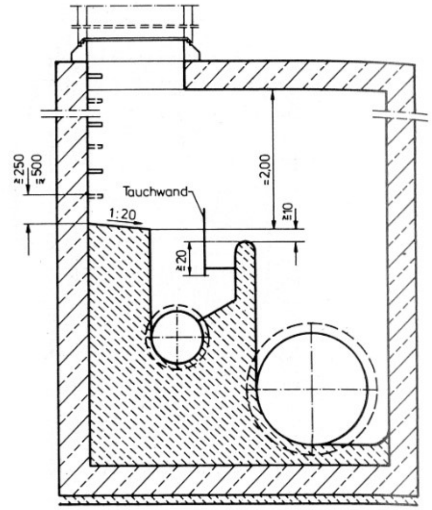


6.6 Special manholes

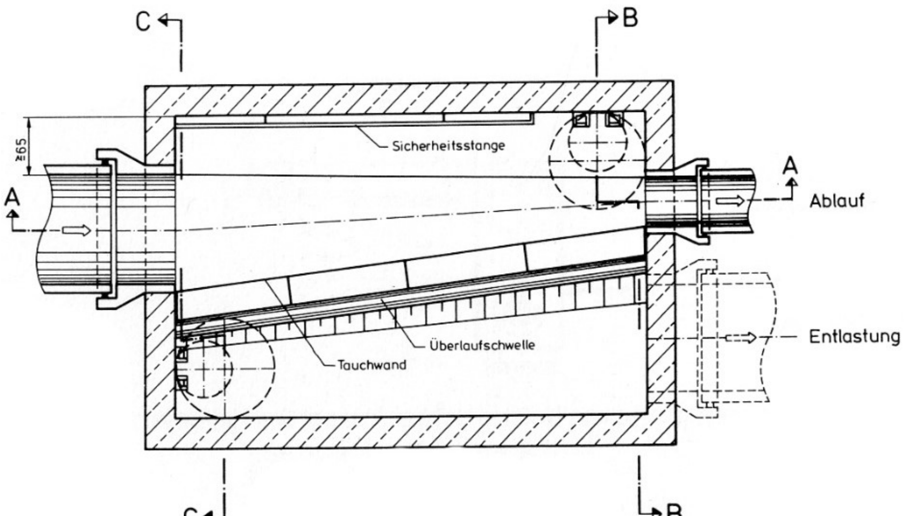
Side weir manhole
(ATV)



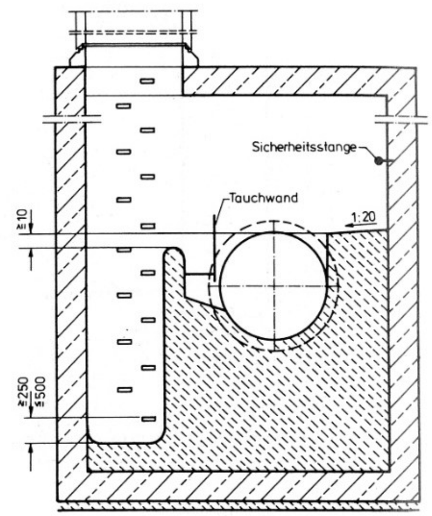
Schnitt A-A



Schnitt B-B



Grundriß



Schnitt C-C

6.7 Pro memoria

6.7 Pro memoria

- Two types of manholes: standard and special manholes
- Standard manholes: inspection, bottom slope, wall roughness, direction, geometry, and discharge
- Special manholes: drop, junction and distribution
- All changes in manhole
- Only guided flow, i.e. through channels
- Bench height 100% equivalent to D
- Manhole = local energy loss
- Superposition of local and fictional losses
- Loss coefficient ξ is related to reference velocity head (for pressurized flow, or free surface flow with $F<0.7$)
- Bend manhole: $R/D=2 \ldots 3$
- Intakes: $r_V/D>1/6$

Questions?