MANHOLE SIZING RECOMMENDATIONS

Introduction

Round manholes are the most widely used maintenance utility structures that provide access to pipelines for inspection and cleanout. Manholes are used for connecting two or more converging storm or sanitary sewers, permitting pipe size changes, accommodating abrupt changes in alignment or grade and allowing for direct surface flow interception. The largest impact on the size of these structures is the diameter and angle of entrance of the intersecting pipe.

This document provides a guideline for sizing round manhole structures for various sizes and angles of incoming pipe.

Sizing Considerations

Two main criteria in designing manholes are that they must be large enough to accept the maximum pipe size, and the minimum structural leg width between pipe holes must be maintained.

The minimum pipe opening is assumed to be the pipe's inside diameter plus the wall thickness. The minimum structural leg is, as a practical minimum, 6 inches. Anything less than this width may allow cracking, which can lead to leakage, structural distress or durability concerns. This minimum value may need to be increased based on specific experience or anticipated handling conditions. In those cases a general guide has been to designate the interior structural dimension to be equal to the manhole wall thickness.

A typical additional over-sizing of no more than 6 inches larger than the outside diameter of the pipe is used for the cutout. The final cutout or opening, therefore, includes all of these design provisions with respect to all other pipe openings, relative pipe elevations and vertical clearances.

The type of pipe entering the structure, and the connection method (boot, compression or mortar) must be known to accurately determine the required holes size and consequently, the manhole size.

When possible, avoid pipes entering into structure joints and corners, as this may compromise the structural integrity and watertightness of the structure. However, this practice may be necessary for certain installations and should be left to the discretion of an experienced precast concrete manufacturer.

Always consult your local precast concrete manufacturer and connector supplier for exact design requirements and product specifications.

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Design Method

The following method can be used to determine minimum manhole size for as many as three incoming pipes. The analysis assumes a conservative assumption of all the openings to be at the same springline elevation. (For installations where more than three pipes enter a manhole, the design equations in the Appendix must be used.)

Note: *Always consult your local precast concrete manufacturer for exact design requirements and manhole size availability. Additionally, when pipe-to-manhole connections use resilient rubber connectors, additional manhole sizing considerations may be required to meet structural and sealing performance expectations.*

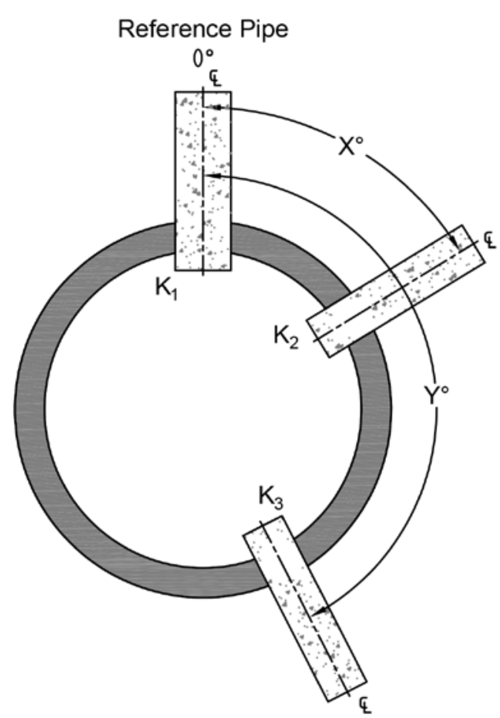
The formulas are:

- **One Pipe:** $180° > K$
- **Two Pipes:** $180° > X° > (K_1+K_2)/ 2$
- **Three Pipes:** $180° > X° > (K_1+K_2)/ 2$ *and*
  $X° + (K_2+K_3)/ 2 < Y° < 360° - (K_1+K_3)/ 2$

Where **K** represents the **K Factor** that can be found in the tables that follow for different types of pipe.

X° and Y° are the angles between the pipes with respect to the reference pipe, measured at the pipe centerlines.

Opening in manhole = Pipe O.D. + 6"



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REINFORCED CONCRETE PIPE AND HDPE PIPE K FACTORS

Pipe Diameter (in)	Pipe Wall Thickness (in)	Manhole Diameter (inches)						
		48	60	72	84	96	108	120
72	7.75					161	126	108
66	7.25					136	113	98
60	6.75				151	119	101	89
54	6.25				128	105	91	80
48	5.75			140	111	93	81	72
42	5.25		166	118	96	82	72	64
36	4.75		130	101	84	72	63	57
33	4.50		118	93	78	67	59	53
30	4.25	150	107	86	72	62	55	49
27	4.00	132	98	79	67	58	51	46
24	3.75	117	89	72	61	53	47	42
21	3.50	105	80	66	56	49	43	39
18	3.25	93	73	60	51	44	39	35
15	3.00	83	65	54	46	40	35	32
12	2.75	73	58	48	41	36	32	28

PVC PIPE AND DUCTILE IRON PIPE K FACTOR

Pipe Diameter (in)	Pipe Outside Diameter (in)	Manhole Diameter (inches)						
		48	60	72	84	96	108	120
64	65.67			179	125	104	90	79
60	61.61			149	115	97	84	74
54	57.56			134	107	90	78	70
48	50.80		154	114	93	80	70	62
42	44.50		126	99	82	71	62	56
36	38.30	149	107	85	72	62	55	49
30	32.00	119	90	73	62	54	48	43
24	25.80	97	75	62	53	46	41	36
20	21.60	85	66	55	47	41	36	32
18	19.50	79	62	51	44	38	34	30
16	17.40	73	57	47	41	35	31	28
14	15.30	67	53	44	38	33	29	26
12	13.20	61	49	40	35	30	27	24
10	11.10	56	45	37	32	28	25	22
8	9.05	51	41	34	29	25	22	20
6	6.90	46	36	30	26	23	20	18
4	4.80	40	32	27	23	20	18	16

CORRUGATED METAL PIPE K FACTORS

Pipe Diameter (in)	Corrugation Depth Plus Pipe Metal Thickness (in)	Manhole Diameter (inches)						
		48	60	72	84	96	108	120
72	0.609				149	118	101	88
66	0.609				129	107	92	81
60	0.609			148	114	96	83	74
54	0.609			126	102	86	75	67
48	0.579		145	110	90	77	68	60
42	0.579		121	96	80	69	61	54
36	0.579	142	103	83	70	61	53	48
30	0.564	116	88	72	61	53	47	42
24	0.564	95	74	61	52	45	40	36
21	0.564	86	67	56	47	41	37	33
18	0.564	77	61	50	43	38	33	30
15	0.564	69	55	45	39	34	30	27
12	0.564	61	49	40	35	30	27	24
10	0.310	55	44	36	31	27	24	22
8	0.310	50	40	33	28	25	22	20
6	0.310	45	36	30	25	22	20	18

Design Tables

Since the wall thickness for the design of reinforced concrete pipe and high-density polyethylene pipe are similar, a standard precast concrete C-wall pipe thickness was used for the development of the tables for these products. For inlet pipes, which have greater total outside diameters than standard ASTM C76 C-wall pipes, you must use the design equations in the Appendix to determine the acceptable manhole diameter.

Similarly, if an internal distance between openings is required to be greater than 6" use the design equations to calculate "K."

The design tables for PVC and ductile iron pipe were based on the outside pipe diameters specified in the AWWA C150 standards for ductile iron pipe. Profile wall PVC pipe that does not conform to the maximum ductile iron outside diameters may need to use either the RCP/HDPE or corrugated metal tables depending on which is closer to its cross-sectional thickness.

The corrugated metal pipe tables were developed using a 0.064 wall thickness and a 0.5-inch corrugation pattern for all sizes. Since there are a great number of corrugation depths available for this product, the designer should adjust the design values in the table accordingly.

The equations presented in the Appendix of this document are simplified in the tables as previously noted for each pipe type. These tables are used to determine the minimum size manhole required for one, two and three pipes entering a single manhole structure at various angles. The "K" factors are based on the pipe diameter including its wall thickness and an appropriate supporting wall between the entering pipe for each manhole diameter. Maximum vertical cutoffs are limited to an 8-foot high riser.

Example

Given: *Two pipes entering a manhole: 42-inch RCP and 36-inch PVC at 115°*

Find: *Smallest size manhole*

Solution: *For two pipes* $180° > 115° > (K_1 + K_2)/2$

Trial 1 (60-inch manhole)
K_1 (42-inch RCP)=166 (from RCP Table)
K_2 (36-inch PVC)=107 (from PVC Table)
(166 + 107)/2 = 137 >115
Result: Not Acceptable

Trial 2 (72-inch manhole)
K_1 (42-inch RCP)=118 (from RCP Table)
K_2 (36-inch PVC)=85 (from PVC Table)
(118 + 85)/2 = 102<115
Result: Acceptable

Summary

The procedures presented in this document provide a quick and easy solution for estimating the optimal size for manholes depending on the incoming pipe and type of connections being used. The ultimate design is the responsibility of the engineer, who must ensure the angles are correct. The contractor must also confirm these angles in the field.

APPENDIX

The determination of acceptability of each entering pipe relative to all the other incoming pipe is based on the reference pipe, which is arbitrarily selected by the designer. For ease of design, it is best to use the largest pipe diameter as the reference pipe. The other incoming pipe are determined by their angle, X and Y, to this reference pipe. The illustration below and corresponding equations are used for making these calculations:

Variables:

r: manhole internal radius (inches)

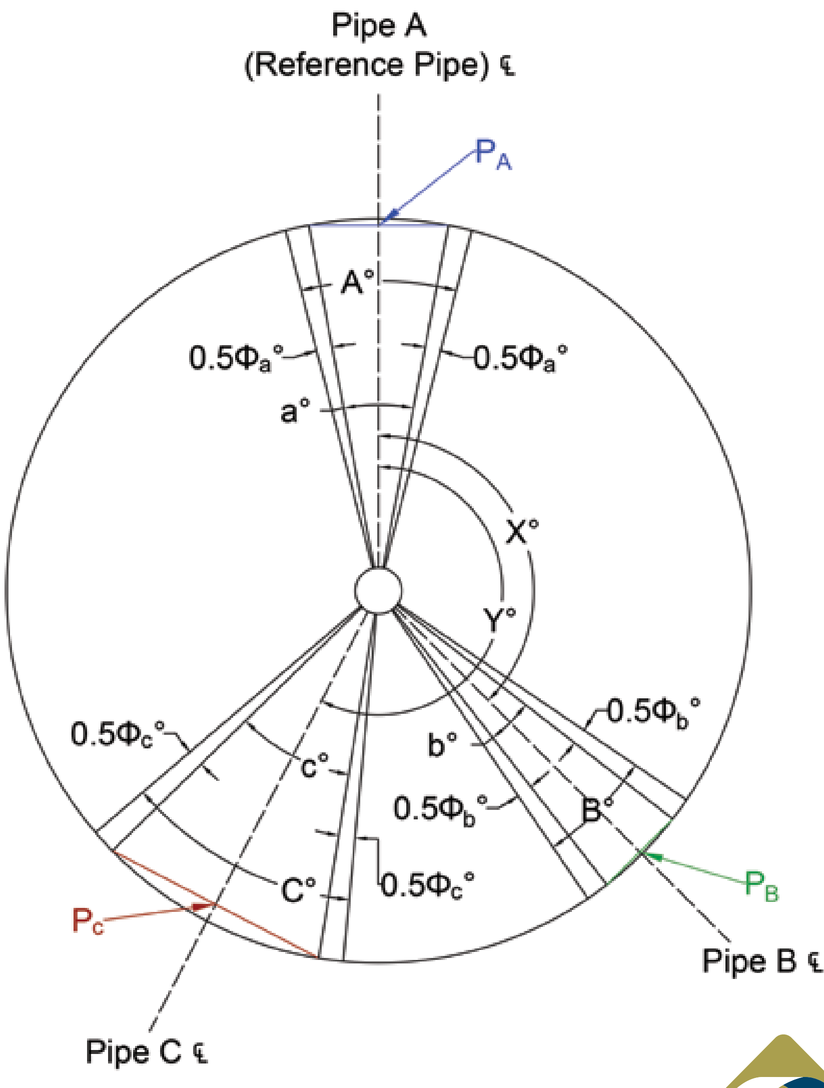
S: minimum structural leg, which must be 6 in. or greater (inches)

P_A, P_B, P_C: penetration in manhole to accommodate specified pipe (inches)

Pipe Penetration Equation:

P_A, P_B, P_C = pipe O.D. + 6 inches

Note: Pipe outside diameter must also be given in inches.



DESIGN PARAMETERS FOR THREE PIPES

Pipe Penetration in Manhole	Pipe Angle with Respect to Reference Point	Pipe Angle Equations		Final Angle	Allowable Angle Range
		Initial Angle	Additional Angle to Account for Structural Leg		
Pipe A (Reference Pipe)	0°	$a° = 2\,x\,\sin^{-1}(\frac{0.5\,x\,P_A}{r})$	$\Phi_a° = \frac{S\,x\,180°}{\pi\,x\,r}$	$A° = a° + \Phi_a°$	$A° < 180°$
Pipe B	X°	$b° = 2\,x\,\sin^{-1}(\frac{0.5\,x\,P_B}{r})$	$\Phi_b° = \frac{S\,x\,180°}{\pi\,x\,r}$	$B° = b° + \Phi_b°$	$X° - \frac{B°}{2} > \frac{A°}{2}$
Pipe C	Y°	$c° = 2\,x\,\sin^{-1}(\frac{0.5\,x\,P_C}{r})$	$\Phi_c° = \frac{S\,x\,180°}{\pi\,x\,r}$	$C° = c° + \Phi_c°$	$Y° - \frac{C°}{2} > X° + \frac{B°}{2}$ and $Y° + \frac{C°}{2} < 360° - \frac{A°}{2}$

DESIGN PARAMETERS FOR FOUR PIPES

Pipe Penetration in Manhole	Pipe Angle with Respect to Reference Point	Pipe Angle Equations		Final Angle	Allowable Angle Range
		Initial Angle	Additional Angle to Account for Structural Leg		
Pipe A (Reference Pipe)	0°	$a° = 2\,x\,\sin^{-1}(\frac{0.5\,x\,P_A}{r})$	$\Phi_a° = \frac{S\,x\,180°}{\pi\,x\,r}$	$A° = a° + \Phi_a°$	$A° < 180°$
Pipe B	X°	$b° = 2\,x\,\sin^{-1}(\frac{0.5\,x\,P_B}{r})$	$\Phi_b° = \frac{S\,x\,180°}{\pi\,x\,r}$	$B° = b° + \Phi_b°$	$X° - \frac{B°}{2} > \frac{A°}{2}$
Pipe C	Y°	$c° = 2\,x\,\sin^{-1}(\frac{0.5\,x\,P_C}{r})$	$\Phi_c° = \frac{S\,x\,180°}{\pi\,x\,r}$	$C° = c° + \Phi_c°$	$Y° - \frac{C°}{2} > X° + \frac{B°}{2}$
Pipe D	Z°	$d° = 2\,x\,\sin^{-1}(\frac{0.5\,x\,P_D}{r})$	$\Phi_d° = \frac{S\,x\,180°}{\pi\,x\,r}$	$D° = d° + \Phi_d°$	$Z° - \frac{D°}{2} > Y° + \frac{C°}{2}$ and $Z° + \frac{D°}{2} < 360° - \frac{A°}{2}$

NOTE: Pipe D is not displayed on the diagram on page 4, but it would follow the same convention as Pipe A, Pipe B and Pipe C that are displayed on the diagram.

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