

## SUDAS Revision Submittal Form

**Status Date:** As of 11/14/2025      **Topic:** Determining structure diameter (round 2)  
**Manual:** Design      **Manual Location:** Section 2C-3, F and G

**Requested Revision:**

From Section 2C-3 (Intake Design and Spacing)

**F. Design of Intakes in Sag Locations**

**Table 2C-3.03: Factors for Weir and Orifice Calculations**

Figure No. <sup>1</sup>	Grate Type	Description	Perimeter <sup>2,4</sup> P (ft)	Open Area <sup>4</sup> A <sub>g</sub> , (sq-ft)	Weir to Orifice <sup>3</sup> Transition (ft)
<a href="#">6010.603</a>	Type Q	Driveway	9.91	2.62	0.4
<a href="#">6010.603</a>	Type R	Curb Inlet with Vane	5.86	1.95	0.5
<a href="#">6010.603</a>	Type S	Median Barrier	7.52	2.3	0.4
<a href="#">6010.604</a>	Type 3A	Beehive for 18" RCP	5.2	1.2	0.4
<a href="#">6010.604</a>	Type 3B	Beehive for 24" RCP	6.77	1.64	0.5
<a href="#">6010.604</a>	Type 4A	Flat Round for 18" RCP	5.2	0.8	0.3
<a href="#">6010.604</a>	Type 4B	Flat Round for 24" RCP	6.82	1.29	0.3
<a href="#">6010.604</a>	Type 4C	Flat Round for 30" RCP	8.41	2.2	0.5
<a href="#">6010.604</a>	Type 4D	Flat Round for 36" RCP	9.99	2.93	0.5
<a href="#">6010.604</a>	Type 5	Stool Type for 24" to 30" RCP	6	3.06	0.9
<a href="#">6010.604</a>	Type 6	30" x 42" Rectangular	10.54	2.91	0.5

<sup>1</sup> The figure numbers listed in this table refer to figures from the SUDAS Specifications.

<sup>2</sup> Perimeter length disregards side against curb for curb inlets.

<sup>3</sup> This is the approximate depth at which the intake transitions from weir flow to orifice flow and should be verified by the designer.

<sup>4</sup> Average of Neenah Foundry and East Jordan Iron Works values.

$$Q_i = 0.67hL(2gd_0)^{0.5} \qquad \text{Equation 2C-3.16}$$

or

$$Q_i = 0.67A_g \left[ 2g \left( d_i - \left( \frac{h}{2} \right) \sin\theta \right) \right]^{0.5} \qquad \text{Equation 2C-3.17}$$

where:

$d_0$  = Effective head on the center of the orifice throat, ft - (see note below)

$d_i$  = Depth at the lip of the curb opening, ft (see Figure 2C-3.04)

L = Length of the open-throat section, ft

$A_g$  = Clear area of opening, ft<sup>2</sup>

h = Height of open-throat orifice, ft

Note: the configuration of the SUDAS/Iowa DOT style intakes is an "inclined throat" according to HEC-22. Based upon this configuration HEC-22 provides the following definition:  $d_0 = d_i - (h/2) \sin\theta$

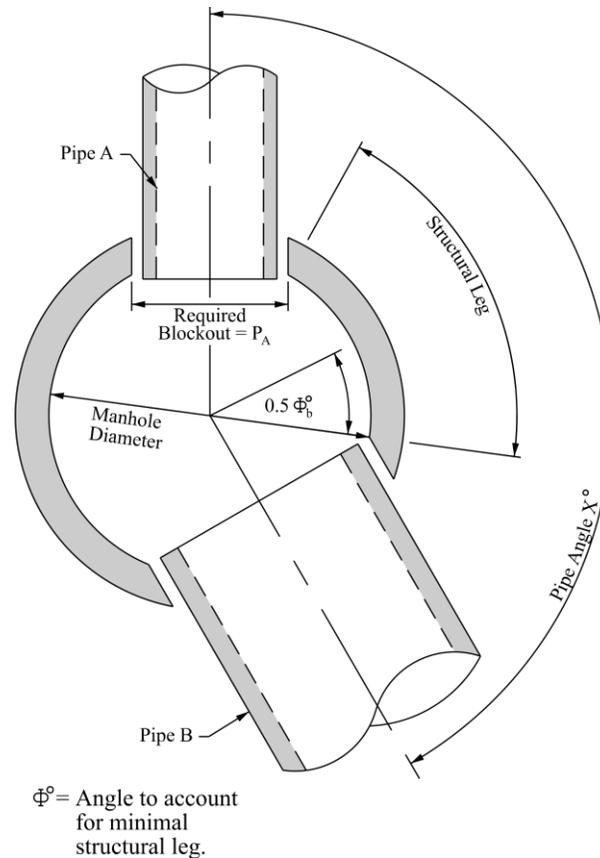
**G. Storm Sewer Structure Requirements**

**2. Openings:**

- c. Determining Diameters:** When utilizing circular precast manholes, it is necessary to determine the diameter required to maintain the structural integrity of the manhole. As a general rule, a minimum structural leg of 12 inches should remain between the manhole blockouts for adjacent pipes.

There are two methods to determining the minimum manhole diameter. The first method utilizes corresponding equations and making the calculations. The second and quicker method uses the tables provided with the associated assumptions of outside pipe diameter, opening clearance, breakout sizing, manhole size, and a 12 inch minimum structural leg.

**Figure 2C-3.05: Manhole Sizing Requirements**

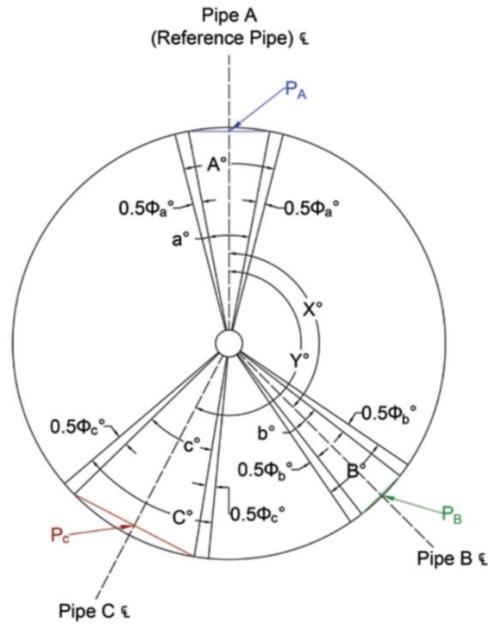


**1) Option 1 - Sizing Method based on Calculations:**

- a) Determine the breakout diameters for each opening. The breakout is the opening provided in the manhole for the pipe. Breakout dimensions are based on the outside diameter of the pipe. For storm sewer, a circular or doghouse type opening is provided with additional clearance to allow for the insertion of the pipe and sufficient space to accommodate placement of concrete grout in the opening. Typical breakout dimensions for various pipe sizes and materials are given in Table 2C-3.04.
- b) Select a manhole size. If unsure start with the diameter for the largest penetration from Table 2C-3.04.

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, Y, and Z (not shown in the figure below), to this reference pipe. The figure below and corresponding equations are used for making these verifiable calculations:

**Figure 2C-3.06: Three Pipe Configuration**



Variables:

- r = manhole internal radius (in inches)
- S = minimum structural leg (in inches) (recommended 12 inches)
- P<sub>A</sub>, P<sub>B</sub>, P<sub>C</sub>, P<sub>D</sub> = penetration in manhole to accommodate specified pipe (inches)

Pipe Penetration Equation:

P<sub>A</sub>, P<sub>B</sub>, P<sub>C</sub>, P<sub>D</sub> = pipe OD (in inches) + additional allowance for insertion (if unsure use 6 inches)

**Table 2C-3.04: Minimum Manhole Diameter Required for Pipe Size**

Pipe Diameter (inches)	Minimum Manhole Diameter (inches)					
	RCP	PVC	DIP	VCP	Polypropylene	HDPE
8	N/A	48	48	48	N/A	N/A
10	N/A	48	48	N/A	N/A	N/A
12	48	48	48	48	48	48
14	N/A	N/A	48	N/A	N/A	N/A
15	48	48	N/A	48	48	48
16	N/A	N/A	48	N/A	N/A	N/A
18	48	48	48	N/A	48	48
20	N/A	N/A	48	N/A	N/A	N/A
21	48	48	N/A	48	N/A	N/A
24	48	48	48	N/A	48	48
27	*60	48	N/A	48	N/A	N/A
30	*60	*60	*60	60	60	60
33	*60	N/A	N/A	N/A	N/A	N/A
36	*60	*60	*60	60	60	60
42	*72			72	N/A	N/A
48	*84				72	72
54	96				N/A	N/A
60	96				96	96

\*48 inch diameter tee-section manhole may be used for storm sewer pipes 27 inches and greater, up to 48 inches.

**Table 2C-3.05:** Design Parameters for Two Pipes

Pipe Penetrations 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°	$a^\circ = 2x \sin^{-1}\left(\frac{0.5x P_A}{r}\right)$	$\Phi_a^\circ = \frac{Sx 180^\circ}{\pi x r}$	$A^\circ = a^\circ + \Phi_a^\circ$	$A^\circ < 180^\circ$
Pipe B	X°	$b^\circ = 2x \sin^{-1}\left(\frac{0.5x P_B}{r}\right)$	$\Phi_b^\circ = \frac{Sx 180^\circ}{\pi x r}$	$B^\circ = b^\circ + \Phi_b^\circ$	$X^\circ - \frac{B^\circ}{2} > \frac{A^\circ}{2}$

**Table 2C-3.06:** Design Parameters for Three Pipes

Pipe Penetrations 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°	$a^\circ = 2x \sin^{-1}\left(\frac{0.5x P_A}{r}\right)$	$\Phi_a^\circ = \frac{Sx 180^\circ}{\pi x r}$	$A^\circ = a^\circ + \Phi_a^\circ$	$A^\circ < 180^\circ$
Pipe B	X°	$b^\circ = 2x \sin^{-1}\left(\frac{0.5x P_B}{r}\right)$	$\Phi_b^\circ = \frac{Sx 180^\circ}{\pi x r}$	$B^\circ = b^\circ + \Phi_b^\circ$	$X^\circ - \frac{B^\circ}{2} > \frac{A^\circ}{2}$
Pipe C	Y°	$c^\circ = 2x \sin^{-1}\left(\frac{0.5x P_C}{r}\right)$	$\Phi_c^\circ = \frac{Sx 180^\circ}{\pi x r}$	$C^\circ = c^\circ + \Phi_c^\circ$	$Y^\circ - \frac{C^\circ}{2} > X^\circ + \frac{B^\circ}{2}$ and $Y^\circ + \frac{C^\circ}{2} < 360^\circ - \frac{A^\circ}{2}$

**Table 2C-3.07:** Design Parameters for Four Pipes

Pipe Penetrations 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°	$a^\circ = 2x \sin^{-1}\left(\frac{0.5x P_A}{r}\right)$	$\Phi_a^\circ = \frac{Sx 180^\circ}{\pi x r}$	$A^\circ = a^\circ + \Phi_a^\circ$	$A^\circ < 180^\circ$
Pipe B	X°	$b^\circ = 2x \sin^{-1}\left(\frac{0.5x P_B}{r}\right)$	$\Phi_b^\circ = \frac{Sx 180^\circ}{\pi x r}$	$B^\circ = b^\circ + \Phi_b^\circ$	$X^\circ - \frac{B^\circ}{2} > \frac{A^\circ}{2}$
Pipe C	Y°	$c^\circ = 2x \sin^{-1}\left(\frac{0.5x P_C}{r}\right)$	$\Phi_c^\circ = \frac{Sx 180^\circ}{\pi x r}$	$C^\circ = c^\circ + \Phi_c^\circ$	$Y^\circ - \frac{C^\circ}{2} > X^\circ + \frac{B^\circ}{2}$
Pipe D	Z°	$d^\circ = 2x \sin^{-1}\left(\frac{0.5x P_D}{r}\right)$	$\Phi_d^\circ = \frac{Sx 180^\circ}{\pi x r}$	$D^\circ = d^\circ + \Phi_d^\circ$	$Z^\circ - \frac{D^\circ}{2} > Y^\circ + \frac{C^\circ}{2}$ and $Z^\circ + \frac{D^\circ}{2} < 360^\circ - \frac{A^\circ}{2}$

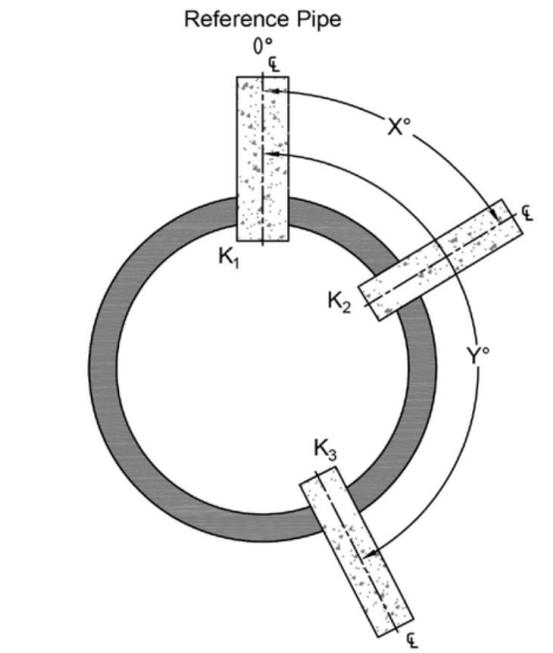
NOTE: Pipe D is not displayed on Figure 2C-3.05, but it would follow the same convention as Pipe A, Pipe B, and Pipe C as displayed on the diagram.

Both methods are from the National Precast Concrete Association's Manhole Sizing Recommendations

**2) Option 2 - Sizing Method Based on Assumptions and K Values in Tables 2C-3.03:** This method can be used to determine minimum manhole size for as many as three incoming pipes. The analysis utilizes conservative assumptions of all the openings to be at the same springline elevation. The “K” Factor tables detail the assumptions regarding pipe wall thickness and clearances to determine the blockout size for the specified pipe materials. For installations with more than 3 pipes, reduced or increased structural leg requirements, or for materials with differing blockouts, use the equations in Tables 2C-3.05, 2C-3.06, and 2C-3.07.

a) Based on the material and diameters of the pipes in question, select a manhole based on Table 2C-3.04.

**Figure 2C-3.07: Typical Manhole Layout**



b) Select the formula applicable to the structure based on the number of pipes and configuration:

One Pipe:  $180^\circ > K$

Two Pipes:  $180^\circ \geq X^\circ > (K_1 + K_2) / 2$

Three Pipes:  $180^\circ \geq X^\circ > (K_1 + K_2) / 2$  and

$$X^\circ + (K_2 + K_3) / 2 < Y^\circ < 360^\circ - (K_1 + K_3) / 2$$

Where K represents the K Factor found in the tables below 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.

**Table 2C-3.08: Manhole Blockout Sizes and K Factor Tables****Table 2C-3.08A: RCP - Class III or Class IV Wall Type B**

Pipe Diameter (inches)	Pipe Wall Thickness (inches)	Opening Clearance (inches)	Manhole Blockout (inches)	Manhole Diameter (inches)						
				48	60	72	84	96	108	120
72	7	6	92						130	112
66	6.5	6	85						117	102
60	6	6	78					123	105	93
54	5.5	6	71					110	95	84
48	5	6	64				116	98	85	76
42	4.5	6	57			124	102	87	76	68
36	4	6	50		136	107	89	77	68	61
33	3.75	6	47		125	100	84	72	64	57
30	3.5	6	43		114	92	78	68	60	53
27	3.25	5	39		103	84	71	62	55	49
24	3	5	35	122	94	77	66	57	51	45
21	2.75	5	32	111	86	71	60	53	47	42
18	2.5	5	28	100	79	65	55	48	43	38
15	2.25	5	25	90	71	59	50	44	39	35
12	2	5	21	81	64	53	45	40	35	32

**Table 2C-3.08B: PVC- Solid Wall**

Pipe Diameter (inches)	Pipe Wall Thickness (inches)	Opening Clearance (inches)	Manhole Blockout (inches)	Manhole Diameter (inches)						
				48	60	72	84	96	108	120
48	1.4	6	57			123	101	87	76	68
42	1.25	6	51			108	90	78	68	61
36	1.15	4	42		113	91	77	67	59	53
30	1	3	35		94	77	66	57	51	45
27	0.4765	3	31	109	85	70	60	52	46	41
24	0.4	3	28	99	78	65	55	48	43	38
21	0.375	3	25	91	72	59	51	44	39	35
18	0.35	3	22	82	65	54	46	40	36	32
15	0.15	3	18	73	58	49	42	36	32	29
12	0.25	3	16	66	53	44	38	33	29	26
8	0.2	3	11	56	45	37	32	28	25	22

**Table 2C-3.08: Manhole Blockout Sizes and K Factor Tables (continued)****Table 2C-3.08C: DIP - Class 52**

Pipe Diameter (inches)	Pipe Wall Thickness (inches)	Opening Clearance (inches)	Manhole Blockout (inches)	Manhole Diameter (inches)						
				48	60	72	84	96	108	120
54	0.73	6	61				110	94	82	73
48	0.65	6	55			119	99	85	74	66
42	0.59	6	49			105	88	76	67	60
36	0.53	4	41		109	89	75	65	57	51
30	0.47	4	35		94	77	66	57	50	45
24	0.44	3	28	100	78	65	55	48	43	38
20	0.42	3	24	88	70	58	49	43	38	34
18	0.41	3	22	83	66	54	46	41	36	32
16	0.4	3	20	77	61	51	44	38	34	30
12	0.37	3	16	67	53	44	38	33	29	27
8	0.33	3	12	57	45	38	32	28	25	23

**Table 2C-3.08D: VCP - ASTM C 700**

Pipe Diameter (inches)	Pipe Wall Thickness (inches)	Opening Clearance (inches)	Manhole Blockout (inches)	Manhole Diameter (inches)						
				48	60	72	84	96	108	120
42	4.085	6	56			122	100	86	75	67
36	3.505	4	47		126	101	84	73	64	58
30	3.03	4	40		107	87	73	64	56	50
27	2.885	4	37	129	99	81	68	59	53	47
24	2.425	3	32	112	87	72	61	53	47	42
21	2.39	3	29	102	80	66	56	49	44	39
18	1.935	3	25	91	72	60	51	44	39	35
15	1.65	3	21	81	65	54	46	40	35	32
12	1.26	3	18	71	57	47	40	35	31	28
8	1.01	3	13	60	48	40	34	30	27	24

**Table 2C-3.08E: Polypropylene - ASTM F 2764**

Pipe Diameter (inches)	Pipe Wall Thickness (inches)	Opening Clearance (inches)	Manhole Blockout (inches)	Manhole Diameter (inches)						
				48	60	72	84	96	108	120
60	3.5	5	72					112	96	85
48	3	5	59			129	106	90	79	70
36	2.5	5	46		123	99	83	72	63	57
30	3	5	41		109	89	75	65	57	51
24	2	5	33	116	90	74	63	55	48	43
18	2	5	27	97	76	63	54	47	42	37
15	1.5	5	23	86	68	56	48	42	37	34
12	1.25	5	20	78	62	51	44	38	34	31

**Table 2C-3.08: Manhole Blockout Sizes and K Factor Tables (continued)**

**Table 2C-3.08F: HDPE - AASHTO M 294**

Pipe Diameter (inches)	Pipe Wall Thickness (inches)	Opening Clearance (inches)	Manhole Blockout (inches)	Manhole Diameter (inches)						
				48	60	72	84	96	108	120
60	3.5	5	72					112	96	85
48	3	5	59			129	106	90	79	70
36	2.5	5	46		123	99	83	72	63	57
30	3	5	41		109	89	75	65	57	51
24	2	5	33	116	90	74	63	55	48	43
18	2	5	27	97	76	63	54	47	42	37
15	1.5	5	23	86	68	56	48	42	37	34
12	1.25	5	20	78	62	51	44	38	34	31

**Table 2C-3.03: Manhole Blockout Sizes**

Pipe Diameter (inches)	Manhole Blockout (inches)		
	RCP	PVC	DIP
12	21	16	16
14	N/A	16	18
15	24	19	N/A
16	N/A	N/A	20
18	28	22	23
20	N/A	N/A	24
21	31	25	N/A
24	35	28	29
27	38	31	N/A
30	42	35	36
33	47	N/A	N/A
36	48	42	41
42	57	N/A	N/A
48	64	N/A	N/A
54	71	N/A	N/A
60	78	N/A	N/A

Example #1: Two pipes - one 24 inch RCP pipe and one 27 inch PVC pipe at 115°

Trial #1 - 48 inch diameter manhole

$180^\circ \geq X^\circ > (K_1 + K_2) / 2$   
 $180^\circ \geq 115^\circ > (122 + 109) / 2$   
 $180^\circ \geq 115^\circ > 115.5$   
 Result: Not Acceptable

Trial #2 - 60 inch diameter manhole

$180^\circ \geq X^\circ > (K_1 + K_2) / 2$   
 $180^\circ \geq 115^\circ > (94 + 85) / 2$   
 $180^\circ \geq 115^\circ > 89.5$   
 Result: Acceptable

Example #2: Three pipes - one 18 inch PVC pipe, one 12 inch PVC at 90°, and one 27 inch VCP pipe at 180°

Trial #1 - 48 inch diameter manhole

$$\begin{aligned} 180^\circ &\geq X^\circ > (K_1 + K_2) / 2 & X^\circ + (K_2 + K_3) / 2 < Y^\circ < 360^\circ - (K_1 + K_3) / 2 \\ 180^\circ &\geq 90^\circ > (82 + 66) / 2 & 90^\circ + (66 + 129) / 2 < 180^\circ < 360^\circ - (82 + 129) / 2 \\ 180^\circ &\geq 90^\circ > 74 & 90^\circ + 97.5 < 180^\circ < 360^\circ - 105.5 \\ & & 187.5 < 180^\circ < 254.5 \end{aligned}$$

Result: Not Acceptable

Trial #2 - 60 inch diameter manhole

$$\begin{aligned} 180^\circ &\geq X^\circ > (K_1 + K_2) / 2 & X^\circ + (K_2 + K_3) / 2 < Y^\circ < 360^\circ - (K_1 + K_3) / 2 \\ 180^\circ &\geq 90^\circ > (65 + 53) / 2 & 90^\circ + (53 + 99) / 2 < 180^\circ < 360^\circ - (65 + 99) / 2 \\ 180^\circ &\geq 90^\circ > 59 & 90^\circ + 76 < 180^\circ < 360^\circ - 82 \\ & & 166 < 180^\circ < 278 \end{aligned}$$

Result: Acceptable

**Reason for Revision:** Additional revisions came up after the May Board meeting.

**Comments:** None.

<b>Region:</b>	<input checked="" type="checkbox"/> Central	<input type="checkbox"/> East	<input type="checkbox"/> West
<b>Comments:</b>	None.		
<b>Action:</b>	<input type="checkbox"/> Deferred	<input type="checkbox"/> Not Approved	<input checked="" type="checkbox"/> Approved
<b>Region:</b>	<input type="checkbox"/> Central	<input checked="" type="checkbox"/> East	<input type="checkbox"/> West
<b>Comments:</b>	None.		
<b>Action:</b>	<input type="checkbox"/> Deferred	<input type="checkbox"/> Not Approved	<input checked="" type="checkbox"/> Approved
<b>Region:</b>	<input type="checkbox"/> Central	<input type="checkbox"/> East	<input checked="" type="checkbox"/> West
<b>Comments:</b>	None.		
<b>Action:</b>	<input type="checkbox"/> Deferred	<input type="checkbox"/> Not Approved	<input checked="" type="checkbox"/> Approved

**Final Regional Action Summary:** All 3 regions approved.

**Board of Directors Action:** Approved.