



**PIMA COUNTY  
REGIONAL WASTEWATER RECLAMATION DEPARTMENT  
DIRECTIVE**

Directive: ENG2009-18

Effective Date: May 1, 2009

**SUBJECT: Sewer Pipe Slope and Manhole Invert Construction Tolerances**

**STATEMENT OF PURPOSE**

This Directive shall define post-construction sewer elevation and slope tolerances to be used when evaluating the impact of construction variability, as documented by as-built survey information, with respect to the intended operation of a sanitary sewer system as designed and sealed by a registered professional engineer. Construction tolerances are defined as a range of values (within and including the stated limits) that are acceptable variations from the design slope and manhole elevation. As-built sewer slopes and manhole invert elevations within the established tolerances are considered to be inconsequential to the design intent of the sewer system, except where more stringent requirements are noted on the Sewer Improvement Plans. The professional engineer signing the Arizona Department of Environmental Quality (ADEQ) Engineer's Certificate of Completion (ECC) retains the authority to deny variations within the stated tolerances, based on their professional judgment and experience.

**GENERAL PROVISIONS**

**Construction Tolerances for 8-inch Diameter Sewer Pipe**

1. For sewer design slopes from 0.33% up to 0.44%, the minimum allowable slope is 0.33%, as established by ADEQ. The slope tolerance from the design slope is +/- 0.06% (as added to or subtracted from the design slope), but is constrained by the ADEQ minimum slope (see Table 1). Note that Pima County Regional Wastewater Reclamation Department's (PCRWRD) design standard sets the minimum slope of an 8" sewer at 0.44% and use of flatter slopes during design requires written approval by the Chief Engineer and utilization of more precise and redundant construction surveying quality control methods.
2. For sewer design slopes from 0.44% up to, and including, 0.71%, the maximum sewer pipe slope tolerance from the design slope is +/- 0.06% (see Table 1).
3. For sewer design slopes greater than 0.71%, the maximum sewer pipe slope tolerance from the design slope is plus or minus 10% of the design slope (as multiplied by the design slope), but not to fall below the minimum slope of 0.65% as constrained by the smaller design slope tolerance (-0.06%) noted above (see Table 1).

**Construction Tolerances for 10-inch to 15-inch Diameter Sewer Pipe**

The minimum allowable slope, to generate a 2 feet/second velocity when flowing full, is defined by ADEQ as shown in Table 2. For design slopes less than 0.60%, the maximum sewer pipe slope tolerance from the design slope is 0.06%, as added to or subtracted from the design slope, and which is also not below the ADEQ minimum slope for that pipe diameter. For design slopes 0.60% and greater, the tolerance is plus or minus 10%, as multiplied by the design slope. Where the tolerances overlap, the lower tolerance will be used (see Table 3). Tolerances for larger diameter sewer pipe will use this tolerance method unless otherwise noted on the plans or specifications by RWRD.

**TABLE 1**

Slope Tolerances for 8" pipe as % (ft/100ft)

Lower Range	Design Slope	Upper Range
0.33	0.33*	0.39
0.33	0.34	0.40
0.33	0.35	0.41
0.33	0.36	0.42
0.33	0.37	0.43
0.33	0.38	0.44
0.33	0.39	0.45
0.34	0.40	0.46
0.35	0.41	0.47
0.36	0.42	0.48
0.37	0.43	0.49
0.38	0.44	0.50
0.39	0.45	0.51
0.40	0.46	0.52
0.41	0.47	0.53
0.42	0.48	0.54
0.43	0.49	0.55
0.44	0.50	0.56
0.45	0.51	0.57
0.46	0.52	0.58
0.47	0.53	0.59
0.48	0.54	0.60
0.49	0.55	0.61
0.50	0.56	0.62
0.51	0.57	0.63
0.52	0.58	0.64
0.53	0.59	0.65
0.54	0.60	0.66
0.55	0.61	0.67
0.56	0.62	0.68
0.57	0.63	0.69
0.58	0.64	0.70
0.59	0.65	0.71
0.60	0.66	0.72
0.61	0.67	0.73
0.62	0.68	0.74
0.63	0.69	0.75
0.64	0.70	0.76
0.65	0.71	0.77
0.65	0.72	0.79
0.66	0.73	0.80
0.67	0.74	0.81
0.68	0.75	0.83
0.68	0.76	0.84
0.69	0.77	0.85

Design slope requires prior approval

**TABLE 2**

ADEQ Minimum Slope Requirements

Diameter	Slope
10"	0.25%
12"	0.19%
15"	0.14%
18"	0.11%
21"	0.09%
24"	0.08%

**TABLE 3**

Slope Tolerances for 15" pipe as % (ft/100ft)

-10% (multiplied)	-0.06% (subtract)	Design Slope	+0.06% (add)	+10% (multiplied)
	<b>0.14</b>	<b>0.14</b>	0.20	
	<b>0.14</b>	0.15	0.21	
	<b>0.14</b>	0.16	0.22	
	<b>0.14</b>	0.17	0.23	
	<b>0.14</b>	0.18	0.24	
	<b>0.14</b>	0.19	0.25	
	<b>0.14</b>	0.20	0.26	
	0.15	0.21	0.27	
	0.16	0.22	0.28	
	0.17	0.23	0.29	
	0.18	0.24	0.30	
	0.19	0.25	0.31	
	0.20	0.26	0.32	
	0.21	0.27	0.33	
	0.22	0.28	0.34	
	0.23	0.29	0.35	
	0.24	0.30	0.36	
	0.25	0.31	0.37	
	0.26	0.32	0.38	
	~	~	~	
	0.51	0.57	0.63	
	0.52	0.58	0.64	
	0.53	0.59	0.65	
	0.54	<b>0.60</b>		0.66
	0.55	0.61		0.67
	0.56	0.62		0.68
	0.57	0.63		0.69
	0.58	0.64		0.70
	0.59	0.65		0.72
	0.60	0.66		0.73
0.60		0.67		0.74
0.61		0.68		0.75
0.62		0.69		0.76
0.63		0.70		0.77

\*ADEQ design slope minimum for 8" sewer

**Construction Tolerances – Manholes**

1. Manhole invert elevations shall not exceed 0.25 feet higher or lower than the design elevation for terminal manholes or manholes with connecting inverts. Construction tolerances for in-line manholes are, by default, constrained by the pipe slope tolerances.
2. From 0 to 9 degrees invert turns, the slope tolerance across a manhole is the same as the average pipe slope tolerance entering or exiting the manhole if the slope follows the pipe slope (see Table 4).
3. From 10 to 45 degrees invert turns, the slope tolerance across a manhole can be plus or minus 50% of the RWRD required 0.10 feet standard drop across the manhole (see Table 4).
4. From 46 to 90 degrees, the slope tolerance across a manhole can be plus or minus 50% of the RWRD required 0.20 feet standard drop across the manhole (see Table 4).
5. All invert slopes shall always be positively sloping downstream. Absolutely no standing water caused by reverse slope is permitted in a constructed manhole invert. (Note: a 0.33% pipe slope converts to only a 0.013 ft. invert elevation difference in a 4 foot diameter manhole).

Table 4 Manhole Invert Tolerances (from directive ENG2006-13)

Horizontal Sewer Deflection Angle	Required Invert Drop within Manhole	Invert Tolerance
0 to 9 degrees	Drop shall be the average slope between inlet and outlet pipe slopes	average slope
10 to 45 degrees	Drop shall be 0.10 feet between inlet and outlet pipes	0.05
46 to 90 degrees	Drop shall be 0.20 feet between inlet and outlet pipes	0.10

**AUTHORITY**

Federal Regulations, Arizona State Regulations, Pima County Ordinances and other enabling legislation which affect the collection, conveyance, treatment, and control of sanitary sewage.

**PROCEDURE**

If a sewer is constructed within the established slope and manhole elevation tolerances, those slopes and elevations will be accepted on the as-builts.


If a sewer is constructed with a slope or elevation outside the established tolerance, a post-construction variance request from the contractor shall be submitted to the Field Engineering Inspector. PCRWRD will evaluate the variance request and may elect to require the sewer to be removed and re-constructed, approve the variance based on PCRWRD’s engineering review, or require the engineer-of-record to certify that the as-built system “meets the design intent and system operability requirements of PCRWRD and ADEQ” with his/her seal and statement affixed to the as-built drawing.

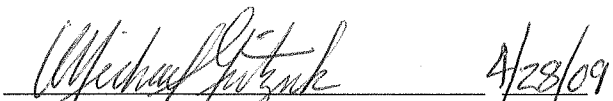
**PROCEDURAL RESPONSIBILITY**

The Chief Engineer of Pima County Regional Wastewater Reclamation Department, and designated representatives, are responsible for the enforcement of this Directive and the associated Standards.

**RECOMMEND**

**APPROVED**

  
 Eric Wieduwilt, P.E. Date  
 Deputy Director- Planning & Engineering

  
 Michael Gritzuk, P.E. Date  
 Director