15.   Pipe Slope and Manhole Distance.

a. Design.

1) Indicate the invert elevation on profile for each pipe entering and leaving the manhole at the inside manhole wall.

2) Pipe slope and distance for sewers smaller than 48-inch diameter.

   a) To determine the pipe distance for sewers smaller than 48-inch, subtract one-half (1/2) the inside manhole dimension for both manholes from the total distance between the centerline of both manholes. The distance between the manholes that is shown on the profile is the total distance between the centerlines of the manholes.

      <u>Example:</u>
      If both manholes are 48-inch diameter, the total distance between both manholes (centerline to centerline) is 304 feet, and the distance between the centerline of the manhole to the inside wall of the manhole is two (2) feet.

      Since both manholes are the same diameter, subtract four (4) feet from the total distance.
        $304 - 4 = 300$,   the pipe distance between manholes will be 300 feet but a distance of 304 feet should be shown on the profile.

   b) To determine the pipe slope, subtract the two manhole inverts and divide the difference by the pipe distance and multiply by one hundred (100) to obtain the percent grade of the pipe.

      Example:
      If the manhole invert elevations are 101.00 for one manhole and 99.00 for the other, then the difference between the two manhole inverts will be 2.0 feet.

      Take the invert difference (2.0 feet) and divide it by the pipe distance (300 feet). The pipe slope will be 0.0067 feet per hundred feet or 0.67%. Show the pipe slope on the profile.

3) <u>Pipe slope and distance for sewer pipelines 48-inch and larger diameter</u>.

   a) To determine the pipe distance for 48-inch and larger sewers in circular manholes, determine the amount of pipe that is extended into the inside diameter of the manhole (d), See Sketch "S".

      First determine (a), which is one half (1/2) the pipe OD and (c), which is one half (1/2) the manhole inside diameter. Solve for (b), using this formula. $b = (c^2 - a^2)^{1/2}$

      Then, determine the amount of pipe that is extended into the inside of the manhole.
      Solve for (d), using this formula $d = c - b$

      After determining (b) for each manhole (each end of the sewer run), then determine the pipe distance between the two (2) manholes. To determine the pipe distance, add the two (b) dimensions and subtract it from the total distance between the centerline of the two (2) manholes.

Example:

If both manholes are seven (7) foot diameter, the pipe is 48-inch RCP, wall C and the total distance between both centerline of manholes is 600 feet.

   c = 3.5 feet (1/2 of 84-inch diameter manhole)

   a = 2.48 feet (1/2 of OD of 48-inch RCP, wall C pipe, which has an OD of 59.5")

Solve for b.

$$
\begin{aligned}
b &= (c^2 - a^2)^{1/2} \\
  &= (3.5^2 - 2.48^2)^{1/2} \\
  &= (12.25 - 6.15)^{1/2} \\
  &= (6.10)^{1/2} \\
b &= 2.47 \text{ feet}
\end{aligned}
$$

Then, determine the pipe distance, since both manholes are 84-inch diameter, multiply 2.47 (b) by 2 and subtract it from the total distance between the two manholes.

   $2.47 \times 2 = 4.94$ $600 - 4.94 = 595.06$ The pipe distance will be 595.06 feet.

b) To determine the pipe slope, subtract the two manhole inverts and divide the difference by the pipe distance and multiply by one hundred (100) to obtain the percent grade of the pipe.

Example:

If the manhole invert elevations are 200.00 for one manhole and 199.00 for the other, than the difference between the two manhole inverts will be 1.0 foot.

Take the invert difference (1.0 foot) and divide it by the pipe distance (595.06 feet). The pipe slope will be 0.0017 feet per hundred feet or 0.17%. Show this pipe slope on the profile.

c) For non-circular manholes, determine the pipe distance from the special details for the manhole, see Part Two, Section 14 (Pipe to Manhole Geometry), non-circular manholes.
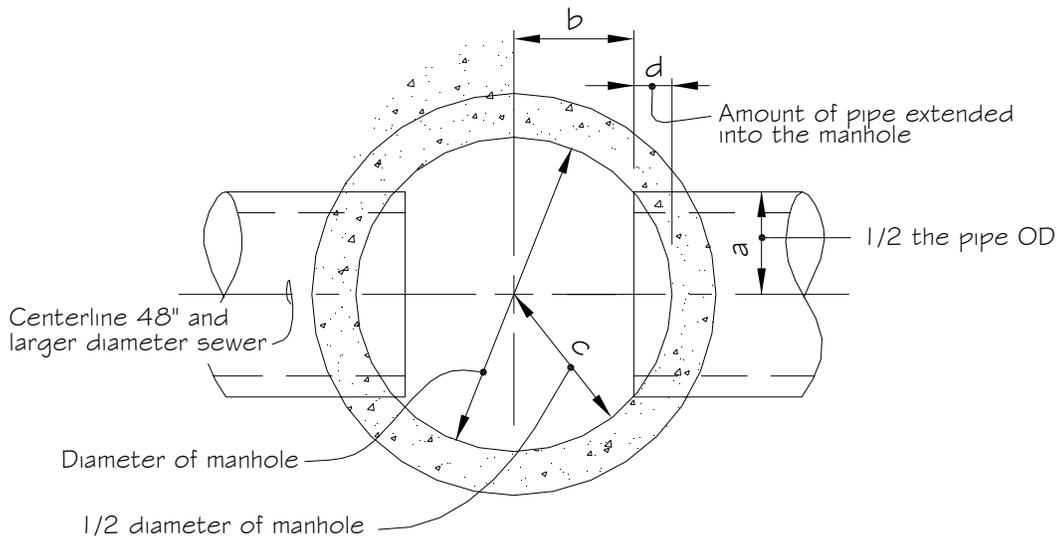
SKETCH "S"

Determining Pipe Length Between Manholes
For Sewer Pipelines 48" and Larger

4) Verify that the pipe distances and pipe size shown on the plan drawings are the same as the profile drawings.

b. High Velocities in Pipelines.

1) When pipe grades produce velocities approaching fifteen (15) fps (feet per second) or greater at full capacity flow, provide a design according to one of the following and all flows, designs and details to account for high sewer velocities.

   a) Review the pipe slope and determine if the velocity can be reduced by changing the vertical alignment slope by adjusting manhole distances, invert elevations, etc., or design the vertical alignment with a drop manhole connection, see requirements in Part Two, Section 17 (Manhole Drop Connections).

   b) If the vertical alignment cannot be reduced, provide DIP or AWWA C900 PVC pipe for 12-inch and smaller sewer pipelines and DIP or PVC AWWA C905 for sewers larger than 12-inch, within the limits of high velocities, see design requirements in Part Two, Section 3 (Selection of Pipe Material).

2) In any case, orient manhole channel and other influent sewers/sewer house connections such that incoming flow from steep sewer pipelines is not directed into other incoming sewer/sewer house connections.

c. Pipe Slope 10% to 35%.

1) Review the pipe slope and determine if the slope can be reduced to under ten (10%) percent. This can be done by providing more distance between the manholes, providing more of a channel drop across the inside of the manhole so that the pipe slope can be reduced to under ten (10%) percent, see Sketch "T" and Part Two, Section 16 (Manhole Channel Design) or design a manhole drop connection at the manhole, see Part Two, Section 16 (Manhole Drop Connections).

2) If the slope cannot be reduced, specify AWWA C900 PVC pipe, see the Specifications for 12-inch and smaller sewer pipelines. Indicate the limits in the General Notes and on the profile drawing, to use only AWWA C900 PVC. For sewers larger than 12-inch, specify DIP or PVC AWWA C905. See design requirements in Part Two, Section 3 (Selection of Pipe Material). See Special Pipe Openings in Manholes under Part Two, Section 14 (Pipe to Manhole Geometry) for additional information. Also, see design requirements under Part Three, Section 14 (Anchoring Pipes on Steep Slopes).

3) In any case, orient manhole channel and other influent sewers/sewer house connections such that incoming flow from steep sewer pipelines is not directed into other incoming sewer/sewer house connections.

d. Pipe Slope Greater Than 35%.

1) When the pipe slope is greater than thirty-five (35%) percent, AWWA C900 PVC pipe for 12-inch and smaller sewer pipelines, can be used if Standard Detail S/3.03 is specified and a note is added indicating to see Specifications for exterior pipe wall at manhole wall. Specify and indicate the limits in the General Notes and on the profile drawing to use only AWWA C900 PVC.

2) See Special Pipe Openings in Manholes under Part Two, Section 14 (Pipe to Manhole Geometry) for additional information. Also, see design requirements under Part Three, Section 14 (Anchoring Pipes on Steep Slopes).

3) In any case, orient manhole channel and other influent sewers/sewer house connections such that incoming flow from steep sewer pipelines is not directed into other incoming sewer/sewer house connections.

SKETCH "T"

Pipe Slope 10.00% or Greater