LAYING OUT CIRCULAR CURVES

The following steps are usually followed in laying out a circular curve in the field:

1. Starting from a known control point for alinement as established by the Locator, run in and physically position each intersection of tangents (P.I.).

2. Measure the tangent distance (T) from each point of intersection (P.I.) along each tangent and set points P.C. and P.T. using a transit and steel measuring tape.

3. Set all intermediate points required on the curve by the method shown below.

EXAMPLE PROBLEM—SIMPLE CIRCULAR CURVES

Computing Deflections:

Data for this example problem is as follows:

P.I. Sta. = 100+00
$\Delta = 26°29'$ Rt.
$R = 2000'$

Compute values for L and T (see page 6) as follows:
$L = (0.2)\ 4622.214 = 924.44'$
$T = (0.2)\ 2353.152 = 470.63'$

The stationing of the P.C. and P.T. of the curve should now be determined as follows:

P.C. Station = P.I. Station — T = 100+00.00 — 4+70.63 = 95+29.37

P.T. Station = P.C. Station + L = 95+29.37 + 9+24.44 = 104+53.81

Deflections (dc) will be required to the intermediate points to be set on the curve, and in all cases the deflections should be computed and recorded for at least each fifty feet of stationing. Special conditions may require 25 or 10 ft. increments. Deflections for a circular curve are recorded from the P.C. towards the P. T., beginning at the bottom of the sheet. One set of deflections for a circular curve is adaptable to all points on the circular curve, and can be used either back or ahead of intermediate instrument setup points on the curve. The unit deflection per foot of arc, as shown on pages 9 to 12 multiplied by the various lengths on the curve in feet will yield the deflections to those points in minutes, which are then converted to degrees and minutes for recording in the field notes. See the example of field transit notes on page 242 to record deflections.

Deflection Field Note Example

Station	Point	Deflection	Curve Data	Calc. Crse.	Mag. Crse.
110+00	P.O.T.			N38°41′W	N38½°W
104+53.81	P.T.	13°14.5′			
+50		13°11.2′			
104		12°28.2′			
+50		11°45.3′			
103		11°02.3′			
+50		10°19.3′			
102		9°36.3′	P.I. Ahd. 119+25		
+50		8°53.4′	P.I. 100+00.0		
101		8°10.4′	△ 26°29′ Rt.		
+50		7°27.4′	R 2000.0′		
100		6°44.5′	T 470.63′		
+50		6°01.5′	L 924.44′		
99		5°18.5′	P.I. Bk. 80+00		
+75	P.O.C.	4°57.0′			
+50		4°35.6′			
98		3°52.6′			
+50		3°09.6′			
97		2°26.6′			
+50		1°43.7′			
96		1°00.7′			
+50		0°17.7′			
95+29.37	P.C.	0°00.0′			
90+00	P.O.T.			N65°10′W	N65°W

After setting the points for the P.C. and P.T., the usual practice is to begin the curve at the P.C., carrying stationing ahead. With the transit occupying the point P.C., leveled and with the horizontal circle set at 0°, sight on the P.I. The deflection angle (dc) for the first point ahead of the transit (0°17.7′) is set off on the circle, and the distance to that point (20.63′) is chained from the P.C. The deflection angle for the second point (1°00.7′) is then turned, and chainage made from the first point to the second point using chord values as shown on pages 9 to 12 (Sta. 95+50.0 to Sta. 96+00.0). This procedure is followed until the full deflection (DC) has been reached, or until local conditions require an intermediate setup on the curve.

For this illustrative problem, as shown in the Deflection Field Note Example, a setup on the curve is required at station 98+75.0. A point is carefully set at this station with the transit. If the circle is clamped at the deflection for the new setup, the direction in which to set the horizontal circle at the new setup is more easily identified. The instrument is then moved ahead to point 98+75.0, make setup, and level transit, facing ahead on line. From any intermediate setup on a circular curve, the deflection for the point backsighted upon shall be first set on the transit circle. In this case, the P.C. will be used as a back sight; hence, the deflection recorded for the P.C. is 0°.00.0′ which will be set on the circle. To eliminate repeated trips around the instrument, the back sight on the P.C. is taken with the instrument plunged. When the telescope is reversed back to normal, and the deflection for the point occupied is set off the circle, the line of sight is tangent to the curve at that point, and the instrument is ready to set off the deflections to the remaining points on the curve. Chainage is made between the intermediate points as previously described. Deflections can also be backed-in from the P.T.

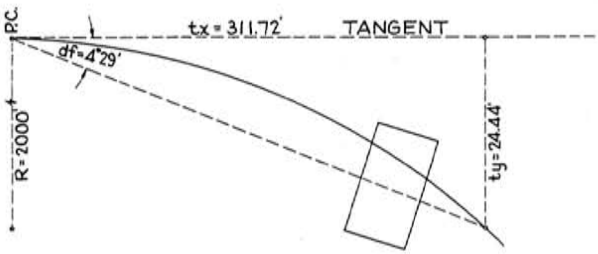
TANGENT OFFSET:

Occasions arise on location where the use of offsets from the semi-tangents to intermediate points on a circular curve are mandatory. The accuracy of points set by offsets is dependent upon the method used in setting them, and the practice of placing curve points by lining in stakes by eye and turning of right-angles by hand methods is unsatisfactory. Even though tangent offsets are used, the field notes for the curve should be completed showing the deflections in the normal manner shown on page 248.

The method of tangent offsets requires that distances (tx) be established along the semi-tangent, measured from the P.C. (or P.T.) and offsets (ty) perpendicular to that tangent be measured out to the points required on the curve.

The tangent offset values of "tx" and "ty" for a 2000 ft. radius curve to a point with a deflection angle of 4°29′ as shown in the illustration below can be computed using values shown on page 149 as follows:

$$tx = (0.2)\ 1558.60 = 311.72'$$
$$ty = (0.2)\ 122.21 = 24.44'$$



The tangent offset method can be used advantageously many times when an obstruction prevents placement of a point on a circular curve by the deflection method.

TRANSIT

In order that the effect of one adjustment may not be reflected in the others, adjustments must be made in the following order. 1. Plate bubbles. 2. Vertical Cross-hair. 3. Line of sight. 4. Standards. 5. Telescope bubble.

No. 1. Adjustment of Plate Bubbles.

Problem:. To have the axis of each plate bubble perpendicular to the verical axis of the transit.

Test: Set up the transit and center both plate bubbles. Next turn the instrument 180° about its vertical axis, observing each bubble separately and determine whether the bubble remains in the center.

Correction: Turn the capstan-headed screws on the bubble-tube casing by means of an adjusting pin, thus raising or lowering one end until the bubble moves half-way back to its center. After these steps are completed for both plate bubbles re-center using the leveling screws and repeat the test. If this correction has been carefully made the bubbles will remain centered.

No. 2. Adjustment for Vertical Cross-Hair.

Problem: To make the vertical cross-hair truly vertical.

Test: Bisect a well defined point near the upper end of the vertical cross-hair as viewed in the telescope. Slowly rotate the telescope about its horizontal axis until the point appears near the lower end of the hair. If the point appears to remain on the vertical hair during this maneuver, the hair is in adjustment.

Correction: Rotate the cross-hair diaphragm in its plane by loosening slightly the four capstan-headed screws holding it in place, tap one of the screws with a pencil, and repeat the operation until the point remains on the hair line, then tighten the screws.

No. 3. Adjustment for Line of Sight.

Problem: Line of sight should be perpendicular to the horizontal axis.

Test: Set up transit, level it, clamp both plates, and sight on some point. Plunge the telescope and set another point at about the same level as the first point. This should result in a straight line between the two points and the transit.
Turn the instrument 180° about the vertical axis until the 1st point is again sighted. Clamp the plate, reverse the telescope and observe if the 2nd point is in line. If not set this third point.

Correction: Move the cross-hair ring laterally until the vertical hair appears to have moved ¼ the distance from the 3rd point to the 2nd. The cross-hair ring is moved by loosening the screw on one side of the telescope tube and tightening the opposite screw. Repeat this process until no further adjustment is required. When finished the screws should be holding the ring firmly without straining it.

No. 4. Adjustment of Standards.

Problem: When the instrument is set up and leveled, the horizontal axis should be truly horizontal, and perpendicular to the vertical axis.

Test: Set the transit up near a building and sight some definite point on the building as high up as possible to observe with the telescope. Lower the telescope to a horizontal position and mark a second point on the building in the line of sight. Plunge the telescope and turn the transit about its vertical axis 180°. Sight on the first or upper point again then lower the telescope and set a third point on the building at the same level as the second point. Check whether the third point falls on the second point. If these two points coincide then the standards are in adjustment.

Correction: Set a 4th point on the building half-way between the 2nd and 3rd points then raise or lower the adjustable end of the horizontal axis by means of the capstan-headed screw until the 4th point coincides on the vertical cross-hair with the upper 1st point.

No. 5. Adjustment of the Telescope Bubble.

Problem: The line of sight and the axis of the telescope bubble must be parallel.

Test: Drive two stakes equidistant from the instrument in exactly opposite directions, level the plate carefully, clamp the telescope in a horizontal position and observe a rod placed on each stake. Center the telescope bubble before each observation. Have the two stakes driven by trial until the rod reads alike on both. Remove the instrument beyond one of the stakes and set it up in line with the two stakes. Level the plate and elevate or depress the telescope to a position which will again give equal readings on the stakes. When equal readings are obtained, the line of collimation is level. The telescope bubble should now be in the center of the tube.

Correction: If the readings were not equal then Adjustment No. 1 was not properly made and should be repeated. If the readings are equal and the telescope bubble is not centered then the bubble should be brought to its center by turning the nuts at the adjustable end of the bubble tube.

LEVEL

1. Adjustment of Plate Bubbles.

Problem: The bubble should center when the axis of the spindle is vertical.

Test: Same as Transit Adjustment No. 1.

Correction: Same as Transit Adjustment No. 1.

2. Adjustment of the Telescope Bubble.

Problem: The bubble of the attached telescope level should center when the axis of the telescope is horizontal.

Test: Same as Transit Adjustment No. 5.

Correction: Change the position of the reticule which carries the cross-hairs while the telescope bubble remains centered for sightings on both stakes.

SELF COMPENSATING LEVEL

Problem: The line of collimation should be truly horizontal.

Test: Set instrument up between 2 stakes 200 ft. apart. Center box level and take a reading on the lower stake and record, then take a reading on the upper stake and subtract this reading from the lower reading and record as the pegged difference. Set up the instrument about 11½ feet from the upper stake and take a reading on the upper stake. Add this reading to the pegged difference and record. This recorded value should equal the reading of the lower stake within 0.01 ft.

Correction: Follow the instructions to adjust, as given for each type of instrument by the manufacturer.

SPECIFICATIONS FOR TRAVERSE, TRIANGULATION AND LEVELING

TRAVERSE			
ITEM	FIRST ORDER	SECOND ORDER	THIRD ORDER
Number of azimuth courses between azimuth checks not to exceed	15	25	50
Astronomical azimuths, probable error of results	0.5"	2"	5"
Azimuth closure at azimuth check points not to exceed	2" $\sqrt{N}$ or 1" per station	10" $\sqrt{N}$ or 3" per station	30" $\sqrt{N}$ or 8" per station
Distance measurements, accurate within	1 in 35,000	1 in 15,000	1 in 7,500
After azimuth adjustment, closing error in position not to exceed	0.66 Ft. $\sqrt{M}$ or 1:25,000	1.67 Ft. $\sqrt{M}$ or 1:10,000	3.34 Ft. $\sqrt{M}$ or 1:5,000
Type of instrument and method	First-order theodolite	First-order theodolite or theodolite such as Kern DKM-2 or Wild T-2 1", EDM or precise taping procedures	Theodolite or transit and standard procedures. EDM or tape or combination, or subtense bar

TRIANGULATION						
	FIRST ORDER			SECOND ORDER		THIRD ORDER
	Class I	Class II	Class III	Class I	Class II	
ITEM / Principal Use	Urban surveys, scientific studies	Basic network of United States	State, County, private	Area networks and supplemental cross arcs in national net	Coastal areas and inland waterways. Supplemental and cadastral	Topographic
Base measurement, probable error not to exceed	1 in 10^6	1 in 10^6	1 in 10^6	1 in 10^6	1 in 0.5×10^6	1 in 0.25×10^6
Triangle closure, average not to exceed	1"	1"	1"	1.5"	3"	5"
Closure in length, discrepancy between computed length and measured length of base, or adjusted, length of check line not to exceed	1 in 100,000	1 in 50,000	1 in 25,000	1 in 20,000	1 in 10,000	1 in 5,000
Type of instrument and method	First-order theodolite			First-order theodolite or theodolite such as Kern DKM-2 or Wild T-2 1" and precise base measurement		Theodolite or transit and standard procedures

LEVELING			
ITEM	FIRST ORDER	SECOND ORDER	THIRD ORDER
Check between forward and backward running between fixed elevations or loop closures, not to exceed	4 mm $\sqrt{K}$ or 0.017 Ft. $\sqrt{M}$	8.4 mm $\sqrt{K}$ or 0.035 Ft. $\sqrt{M}$	12 mm $\sqrt{K}$ or 0.05 Ft. $\sqrt{M}$
Type of instrument and method	First-order level	First-order or level such as Wild or Kern	Self-leveling or Dumpy level with standard procedures

NOTES: N is the number of stations for carrying azimuth.
M is the distance in miles.
K is the distance in kilometers.
The expression containing the square root is designed for longer lines where higher proportional accuracy is required. The formula which gives the smaller permissible closure will be used.

SURVEY ORDERS OF ACCURACY

TYPE OF WORK	ORDER OF SURVEY			
	FIRST	SECOND	THIRD	LOWER
MAPPING (LARGE AND HIGH-DENSITY AREAS)	▨			
PRIMARY CONTROL	▨	▨		
MAJOR STRUCTURES	▨			
MINOR STRUCTURES		▨		
CENTERLINE SURVEY (HIGH-DENSITY URBAN AREA)		▨		
FINAL LOCATION SURVEY			▨	
PRELIMINARY LOCATION SURVEY			▨	▨
ADVANCE PLANNING SURVEY				▨