STATE OF ARIZONA
STATE HIGHWAY DEPARTMENT
PLANS DIVISION
1955
"D" STD'S.

ROADWAY STANDARDS
FOR USE IN
FIELD AND OFFICE

ISSUED TO
### Sight Distance

<table>
<thead>
<tr>
<th>DRWG NO.</th>
<th>SUBJECT</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1-1</td>
<td>STOPPING DISTANCES &amp; PASSING DISTANCES AS RELATED TO SPEEDS</td>
<td>MAR. 1941</td>
</tr>
<tr>
<td>D1-2</td>
<td>ACCELERATION &amp; DECELERATION DISTANCES AND VISIBILITY AT NIGHT</td>
<td>JUNE 1941</td>
</tr>
<tr>
<td>D1-3</td>
<td>SIGHT RESTRICTIONS &amp; APPROACH SPEEDS AT NON-STOP INTERSECTIONS</td>
<td>APR. 1941</td>
</tr>
<tr>
<td>D1-4</td>
<td>SIGHT RESTRICTIONS &amp; APPROACH SPEEDS AT &quot;STOP&quot; INTERSECTIONS</td>
<td>APR. 1941</td>
</tr>
<tr>
<td>D1-5</td>
<td>NON-PASSING SIGHT DISTANCE ON VERTICAL &amp; HORIZONTAL CURVES</td>
<td>JUNE 1945</td>
</tr>
<tr>
<td>D1-6</td>
<td>PASSING SIGHT DISTANCE ON VERTICAL CURVES</td>
<td>JUNE 1945</td>
</tr>
</tbody>
</table>

### Curvature

<table>
<thead>
<tr>
<th>DRWG NO.</th>
<th>SUBJECT</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>D2-1</td>
<td>SUPERELEVATION FOR CURVES AS RELATED TO DESIGN SPEEDS (CHART)</td>
<td>APR. 1941</td>
</tr>
<tr>
<td>D2-2</td>
<td>MINIMUM TURNING SPACE, CURVE WIDENING, AND CROWN TO SUPERELEVATION RUN-OFF</td>
<td>APR. 1941</td>
</tr>
<tr>
<td>D2-3</td>
<td>SUPERELEVATION TABLES (SUPPLEMENT TO DRWG NO D2-1)</td>
<td>JUNE 1947</td>
</tr>
</tbody>
</table>

### Transition Spirals

<table>
<thead>
<tr>
<th>DRWG NO.</th>
<th>SUBJECT</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>D3-1</td>
<td>CORRELATION OF TRANSITION SPIRALS TO CIRCULAR CURVE - FORMULAE</td>
<td>JUNE 1941</td>
</tr>
<tr>
<td>D3-2</td>
<td>TRANSITION SPIRAL FORMULAE, CONTINUED</td>
<td>JUNE 1941</td>
</tr>
<tr>
<td>D3-3</td>
<td>TABLE $a = \frac{1}{2}$</td>
<td>APR. 1941</td>
</tr>
<tr>
<td>D3-4</td>
<td>TABLE $a = \frac{1}{3}$</td>
<td>APR. 1941</td>
</tr>
<tr>
<td>D3-5</td>
<td>TABLE $a = \frac{1}{3}$</td>
<td>APR. 1941</td>
</tr>
<tr>
<td>D3-6</td>
<td>TABLE $a = 1$</td>
<td>APR. 1941</td>
</tr>
<tr>
<td>D3-7</td>
<td>TABLE $a = \frac{1}{2}$</td>
<td>APR. 1941</td>
</tr>
<tr>
<td>D3-8</td>
<td>TABLE $a = \frac{1}{3}$</td>
<td>APR. 1941</td>
</tr>
<tr>
<td>D3-9</td>
<td>TABLE $a = 2$</td>
<td>APR. 1941</td>
</tr>
<tr>
<td>D3-10</td>
<td>TABLE $a = \frac{2}{3}$</td>
<td>APR. 1941</td>
</tr>
<tr>
<td>D3-11</td>
<td>TABLE $a = \frac{3}{3}$</td>
<td>APR. 1941</td>
</tr>
<tr>
<td>D3-12</td>
<td>TABLE $a = 3$</td>
<td>APR. 1941</td>
</tr>
<tr>
<td>D3-13</td>
<td>TABLE $a = 5$</td>
<td>APR. 1941</td>
</tr>
</tbody>
</table>

### Regulation of Roadside Developments

<table>
<thead>
<tr>
<th>DRWG NO.</th>
<th>SUBJECT</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>D4-1</td>
<td>CLEARANCE OF UTILITY POLE LINES AS RELATED TO HIGHWAYS</td>
<td>MAY 1941</td>
</tr>
<tr>
<td>D5-1</td>
<td>PRIVATE DRIVEWAY ENTRANCE RESTRICTIONS - URBAN TYPE</td>
<td>MAY 1941</td>
</tr>
<tr>
<td>D5-2</td>
<td>PRIVATE DRIVEWAY ENTRANCE RESTRICTIONS - RURAL TYPE</td>
<td>MAY 1941</td>
</tr>
<tr>
<td>D5-3</td>
<td>PICTORIAL LAYOUT OF DRIVEWAY ENTRANCES - RIGHT ANGLE</td>
<td>MAY 1941</td>
</tr>
<tr>
<td>D5-4</td>
<td>PICTORIAL LAYOUT OF DRIVEWAY ENTRANCES - SKEW</td>
<td>MAY 1941</td>
</tr>
<tr>
<td>D5-5</td>
<td>MULTIPLE DRIVEWAY ARRANGEMENTS</td>
<td>APR. 1941</td>
</tr>
</tbody>
</table>

### Public and Traffic

<table>
<thead>
<tr>
<th>DRWG NO.</th>
<th>SUBJECT</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>D6-1</td>
<td>PARKING ON STATE HIGHWAYS</td>
<td>MAY 1941</td>
</tr>
</tbody>
</table>

### Drafting of Plans & Profile, Office Procedure, etc.

<table>
<thead>
<tr>
<th>DRWG NO.</th>
<th>SUBJECT</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>D7-1</td>
<td>ROADWAY PLANS STANDARD</td>
<td>FEB. 1946</td>
</tr>
<tr>
<td>D7-2</td>
<td>STRUCTURE NOTATIONS</td>
<td>FEB. 1946</td>
</tr>
<tr>
<td>D7-3</td>
<td>PLANS SYMBOLS</td>
<td>FEB. 1946</td>
</tr>
</tbody>
</table>

### Miscellaneous Criteria Affecting Design Requirements

<table>
<thead>
<tr>
<th>DRWG NO.</th>
<th>SUBJECT</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>D8-1</td>
<td>DRAINAGE TABLE CHART</td>
<td></td>
</tr>
</tbody>
</table>
PLAN DIAGRAM - HEADLIGHT REALM OF VISIBILITY - NIGHT DRIVING

BEAM DISTANCE AHEAD OF VEHICLE - FEET

0 50 100 150 200 250 300 350 400 450 500 550

SPREAD OF BEAM FROM CENTER OF VEHICLE IN FEET

75 50 25 0

0 25 50 75

-0.1 FOOT-CANDELA LIGHT CONTOURS
-1.0 FOOT-CANDELA LIGHT CONTOUR
-1938 DUAL-BEAM
-1940 SEALED BEAM
-STRAIGHT AHEAD
-CURVES

SPEED STOPPING DISTANCE
M.P.H. FEET
70 ~ 481
50 ~ 368
40 ~ 274
30 ~ 192
20 ~ 120
10 ~ 57

INCLUDES PERCEPTION, REACTION, AND BRAKING DISTANCES

OBJECTS OUTSIDE OF THE 0.1 FOOT-CANDELA LIGHT CONTOUR ARE OBLSCURE.

HEADLIGHT CONTOURS ARE BASED ON DATA CONTAINED IN A REPORT OF A COOPERATIVE INVESTIGATION BY COMMITTEE ON CURVATURE AND SPEED, HIGHWAY RESEARCH BOARD; COMMITTEE ON SPEED REGULATION, NATIONAL SAFETY COUNCIL; AND THE HIGHWAY RESEARCH STAFF, IOWA ENGINEERING EXPERIMENT STATION. PRESENTED AT HIGHWAY RESEARCH BOARD MEETING 1940.

GENERAL NOTE:
AVAILABLE RESEARCH DATA UPON WHICH THIS DRAWING IS BASED ARE MEAGRE. A MORE ABUNDANT AND EXACTING RESEARCH ON THESE SUBJECTS IS INDISPENSABLE TO GREATER ACCURACY IN CALCULATIONS.

ARIZONA STATE HIGHWAY DEPARTMENT PLANS DIVISION

ACCELERATION & DECELERATION CHART, AND DIAGRAM SHOWING VISIBILITY WITH HEADLIGHTS AT NIGHT
CALCULATED AND DRAWN JUNE 1951
BY LESLIE MCGUIGALL, HIGHWAY DESIGNER
CHECKED BY
APPROVED BY ENGINEER OF PLANS

REV.
D 1-2
ASSUMPTIONS

\[ V_a \text{ and } V_b = \text{approach speeds in m.p.h. of vehicles at 'A' and 'B' respectively.} \]

\[ d_a \text{ and } d_b = \text{safe stopping distances corresponding to } V_a \text{ and } V_b. \]

\[ a = \text{distance from path of 'A' to obstruction, measured parallel to path of 'B'.} \]

\[ b = \text{distance from path of 'B' to obstruction, parallel to path of 'A'.} \]

ALL DISTANCES EXPRESSED IN FEET.

NOTE: TO CONVERT \( a \) AND \( b \) INTO PERPENDICULAR DISTANCES MULTIPLY EACH BY THE SINE OF ANGLE \( \Delta \).

FORMULA

SINCE THE TRIANGLE FORMED BY SIDES \( d_a, d_b, \) AND SIGHT LINE IS SIMILAR TO THAT OF THE TRIANGLE \( d_a-b, a, \) AND PART OF SIGHT LINE, THEN

\[ \frac{d_a}{d_a-b} = \frac{a}{b} \text{ or } d_a = \frac{a}{d_a-b} \]

INTER-RELATION OF \( V_a, V_b, a, \) AND \( b \)

WHEN RELATION OF \( V \) TO \( d \) =

ARIZONA STATE HIGHWAY DEPARTMENT PLANS DIVISION

MINIMUM SAFE SIGHT RESTRICTIONS AT INTERSECTIONS AS RELATED TO INTERSECTION APPROACH SPEEDS ON PREFERENCE ROAD AND ON NON-PREFERENCE ROAD, BASED ON AVAILABLE SAFE STOPPING DISTANCES.}

CALCULATED AND DRAWN APRIL 1940 BY LESLIE M. MOWRRELL, HIGHWAY ENGINEER TRACED BY L. L. M. DATING.

CHECKED BY APPROVED BY ENGINEER OF PLANS

REV. STANDARD DNG. NO.

NON-STOP INTERSECTION

NOTE:

THE DIAGRAMS, CHARTS, AND FORMULAS SHOWN ON THIS DRAWING CONFORM TO 1940 AASHTO POLICY ON INTERSECTIONS AT GRADE.

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

\( V_b = \text{approach speed on non-preference road - miles per hour} \)

EXAMPLE: WHEN \( V_a = 60, \) \( b = 200, \) AND \( a = 100, \) THEN \( V_b = 33 \)}
FORMULA

Vehicle at "A" travels non-stop at design speed of preference road.
Vehicle at "B" starts from stopped position on non-preference road and
travels distance "S" in the time "t". It takes vehicle "A" to travel distance "d".

\[ D = \text{Distance from near edge of pavement to front of vehicle "B" when stopped, in feet} \]
\[ W = \text{Width of pavement along path of crossing vehicle "B", in feet} \]
\[ L = \text{Over-all length of vehicle "B", in feet} \] (See tabulation listing various design lengths)
\[ S = \text{The distance vehicle "B" must travel to be clear of traffic on preference road} \]
\[ t = \text{The required time to accomplish "S", in seconds} \]
\[ \alpha = \text{The average overall rate of acceleration from a stopped position - miles per hour per second} \]
\[ K = \text{The sum of perception time and time required to shift to first gear. Assumed at 2 seconds} \]
\[ V = \text{The design speed on the preference road, in miles per hour.} \]
\[ V = \frac{d + 1.47t}{\alpha} \]
\[ \text{Then:} \]
\[ t = \frac{K + \frac{2.5}{1.47t}}{1.47t}, \text{or } K + \frac{1.365}{\alpha}, \text{or } 2 + \frac{1.365}{\alpha} \]
\[ d = 1.47t \left(2 + \frac{1.365}{\alpha}\right), \text{or } V = \frac{1.47}{\alpha} \]

\[ S = \text{Distance traveled from stopped position = feet} \]

OVERALL LENGTHS FOR VARIOUS VEHICLES

<table>
<thead>
<tr>
<th>TYPE OF VEHICLE</th>
<th>SIGNIFICANT LENGTHS</th>
<th>OCCASIONAL LENGTHS</th>
<th>DESIGN LENGTHS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PASSENGER VEHICLE</td>
<td>X 8.85</td>
<td>X 9.95</td>
<td>X 115</td>
</tr>
<tr>
<td>SINGLE-UNIT TRUCK OR BUS</td>
<td>UNDER 30</td>
<td>OVER 30</td>
<td>0</td>
</tr>
<tr>
<td>TRACTOR TRUCK - SEMITRAILER</td>
<td>60</td>
<td>60</td>
<td>0.45</td>
</tr>
<tr>
<td>TRUCK &amp; TRAILER COMBINATION</td>
<td>UNDER 60</td>
<td>OVER 60</td>
<td>0.70</td>
</tr>
</tbody>
</table>

NOTE: Over-all lengths are limited by law in Arizona as follows:
Single unit vehicles - 33 feet
Combination vehicles - 85 feet

NOTES:
The values shown for "a" & "k" are assumed values used by A.A.S.H.O. and based on research.
Values for "t" are based on analysis of highway planning survey data for trucks & busses, and on
A.A.S.H.O. data for passenger vehicles.
In the calculations presented here it is assumed that "V" the speed of vehicle on the
preference road is constant. Should vehicle "A" reduce speed below design speed of preference road
upon sighting vehicle "B", additional safety is introduced. (Compare values for "a" with safe stopping distance for "V".)

ARIZONA STATE HIGHWAY DEPARTMENT PLANS DIVISION

MINIMUM SAFE SIGHT RESTRICTIONS AT INTERSECTIONS WHERE TRAFFIC ON PRE朕ERENCE ROAD PROCEEDS AT
DESIGN SPEED, AND TRAFFIC ON NON-PREFERENCE ROAD CEASES BEFORE CROSSING PREERENCE ROAD

DRAWN APRIL 1961

TRACED BY L. PEDRO

CHECKED BY

APPROVED BY

ENGINEER OF PLANS

D 1-4

STOP

INTERSECTION
**FORMULA**

(A.A.S.H.O. Policy 1940)

For Vertical Non-Passing Sight Distance:

When $S_{np} > L$, $S_{np} = \frac{720}{A + \frac{L}{2}}.$

When $S_{np} < L$, $S_{np} = 38.2 \sqrt{\frac{L}{A}}.$

Where, $S_{np} =$ Non-Passing Sight Distance in feet.

$L =$ Length of Vertical Curve in feet.

$A =$ Algebraic difference in grades expressed in percent.

Height of eye = 4.5 feet.

Height of object = 4 inches.

Note: The term "Non-Passing Sight Distance" applies to two-lane and three-lane highways where opposing traffic may be encountered.

In the case of four-lane or divided highways, the figures shown here for Non-Passing become Minimum Passing Sight Distance.

- **Purpose of Chart:** To determine minimum length of V.C. for various Algebraic differences in grade, to attain Min. N.P. Sight Dist.

Vehicle assumed to be traveling at Design Speed MPH.

- **Basis of Computations for Minimum Non-Passing Sight Dist.**

---

**FORMULA**

(Horizontal Sight Distance)

$$S_{m} = 2\sqrt{(R-5)^2 - (R-m)^2}$$

**ARIZONA STATE HIGHWAY DEPARTMENT PLANS DIVISION**

**NON-PASSING SIGHT DISTANCE VERTICAL & HORIZONTAL**

**REV.**

DRAWN: GH & IDY, JUNE 45

TRADED: GH, JUNE 45

CHECKED: APY, MAY 15, 1945

D1-5
FORMULA (A.A.S.H.O. Policy 1940)
For Vertical Passing Sight Distance

When \( S_p > L \), \( S_p = \frac{1800}{A} + \frac{L}{2} \)

When \( S_p < L \), \( S_p = 60 \sqrt{\frac{L}{A}} \)

Where, \( S_p \) = Passing Sight Distance in feet
\( L \) = Length of Vertical Curve in feet
\( A \) = Algebraic difference in grades in percent

Height of eye = 4.5 Feet
Height of Object = 4.5 Feet.

Purpose of Chart: To determine minimum length of Vert. Curve for various Alg. diff. in Grades to attain minimum Passing Sight Distance.

ARIZONA STATE HIGHWAY DEPARTMENT
PLANS DIVISION

PASSING SIGHT DISTANCE
ON VERTICAL CURVES

D1-6
**DESIGN POLICY** It is recommended that minimum superhelevation used for any curve not be less than 0.015" per foot.

In the case of simple curves, transition between normal and minimum superhelevation sections should be accomplished in a minimum of 200' of tangent distance. Superhelevation slopes less than 0.015" to be used only in the case of reverse curves with spirals.

In the case of spirals with tangents, refer to Standard D2-1 for method of transition.

**FORMULA**

Centrifugal ratio, or the slope at which centrifugal force is fully compensated is 

\[ \frac{V^2}{R} \]

Hence, the basic formula for superhelevation is:

\[ S = 0.0001164 V^2 D - F \]

in which: 
- \( V \) = Velocity in miles per hour
- \( D \) = Degree of curvature
- \( F \) = Friction factor (smooth road surface)

Then to compute the adjusted values of \( S \) for curvature of lesser degree than that which is indicated when \( S = 0.080 \), the following formula is applied:

\[ S_a = 0.080 - \frac{D}{3} \]

in which:
- \( S_a \) = Adjusted value of \( S \) at \( D \)
- \( D \) = Degree of lesser curvature than \( D \)

**NOTES:** The figures for "non-compensated centrifugal force tolerance" as shown on Table (lower left), are products of analysis and extension of Highway research data endorsed by A.A.S.H.O. and National Safety Council. These figures are based on normal road surface conditions, free of mud, snow or ice.

**ARIZONA STATE HIGHWAY DEPARTMENT PLANS DIVISION**

CALCULATED AND DRAWN APRIL 1941

BY LESLIE D. HUDSON - HIGHWAY DESIGNER

APPROVED BY

ENGINEER OF PLANS

D2-1
MINIMUM TURNING SPACE FOR VARIOUS DESIGN VEHICLE TYPES

NOTE: DIMENSIONS OF DESIGN VEHICLES SHOWN HERE CONFORM TO AASHTO DESIGN STANDARDS AS OF 1960

DESIGN POLICY FOR MINIMUM TURNING SPACE

<table>
<thead>
<tr>
<th>CURB RADIUS</th>
<th>TURNING LANE WIDTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 Feet</td>
<td>26 Feet</td>
</tr>
<tr>
<td>30 Feet</td>
<td>20 Feet</td>
</tr>
<tr>
<td>20 Feet</td>
<td>16 Feet</td>
</tr>
</tbody>
</table>

FOR HEAVY TRUCK COMBINATIONS
FOR MEDIUM TRUCKS & BUSES
FOR PASSENGER VEHICLES

SCALE 1" = 20'

DESIGN TRACTOR TRUCK - SEMI TRAILER COMBINATION

TRUCK OR BUS

MINIMUM TURNING SPACE

NOTE: THE ABOVE INSTRUCTIONS WITH REFERENCE TO TAPERING SLOPES FROM CROWN TO SUPERELEVATED CURVE, APPLY ONLY TO CURVES FOLLOWING A TANGENT. IN THE CASE OF REVERSE CURVES, SUPERELEVATION STARTS AT BEGINNING OF SPIRAL.

DESIGN POLICY FOR HIGHWAY CURVE WIDENING

TO NORMAL TRAFFIC LANE WIDTHS ADD 0.1 FOOT PER LANE PER DEGREE OF CURVATURE.

(NO PAVEMENT WIDENING REQUIRED FOR CURVES OF 5 DEGREES OR LESS.)

SPIRAL TRANSITION OF SUPERELEVATION AND WIDENING FROM TANGENT SECTION TO CURVE SECTION

SECTION C-C

NOTE: SUPERELEVATION SLOPE AT ANY GIVEN POINT ON SPIRAL OR CURVE IS COMPUTED ACCORDING TO DEGREE OF CURVATURE AND DESIGN SPEED. SEE CHART AND FORMULAS FOR CURVE STD DRAWING NO. D 2-1.

(REFERENCE TO ADJUSTED VALUES OF "F")

TO COMPUTE: DEGREE OF CURVATURE AT ANY POINT ON SPIRAL:

\[
\frac{d}{t} = \frac{d}{t_s} \text{ in which}
\]

\[
\frac{d}{t} = \text{Degree of Curvature on Spiral}
\]

\[
\frac{d}{t_s} = \text{Degree of Circular Arc Curve}
\]

\[
L_s = \text{Length of Spiral from T.S. To C.C.}
\]

\[
L_t = \text{Length on Spiral from T.S. To Point}
\]

WIDENING IS ALSO DETERMINED BY DEGREE OF CURVATURE AS STATED AT THE TOP OF THIS SHEET.

ARIZONA STATE HIGHWAY DEPARTMENT PLANS DIVISION

NOTE: THE ABOVE INSTRUCTIONS WITH REFERENCE TO TAPERING SLOPES FROM CROWN TO SUPERELEVATED CURVE, APPLY ONLY TO CURVES FOLLOWING A TANGENT. IN THE CASE OF REVERSE CURVES, SUPERELEVATION STARTS AT BEGINNING OF SPIRAL.

CALCULATED AND DRAWN: APRIL 1941

LESLIE MOODALL - HIGHWAY DESIGNER

CHECKED BY:

APPROVED BY:

ENGINEER OF PLANS

REVISION

D 2-2
<table>
<thead>
<tr>
<th>DEGREE OF CURVE</th>
<th>DESIGN SPEED IN MILES PER HOUR</th>
<th>DEGREE OF CURVE</th>
<th>DESIGN SPEED IN MILES PER HOUR</th>
<th>DEGREE OF CURVE</th>
<th>DESIGN SPEED MPH</th>
</tr>
</thead>
<tbody>
<tr>
<td>20°</td>
<td>100  95  90  85  80  75  70</td>
<td>150°</td>
<td>65   60   55   50   45   40</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>20°</td>
<td>1270</td>
<td>150°</td>
<td>1274</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>4° 15'</td>
<td>1224</td>
<td>150°</td>
<td>1200</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>10°</td>
<td>1176</td>
<td>150°</td>
<td>1176</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>15°</td>
<td>1126</td>
<td>150°</td>
<td>1126</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>20°</td>
<td>1081</td>
<td>150°</td>
<td>1081</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>30°</td>
<td>1034</td>
<td>150°</td>
<td>1034</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>40°</td>
<td>0984</td>
<td>150°</td>
<td>0984</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>50°</td>
<td>0936</td>
<td>150°</td>
<td>0936</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>60°</td>
<td>0886</td>
<td>150°</td>
<td>0886</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>70°</td>
<td>0836</td>
<td>150°</td>
<td>0836</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>3° 15'</td>
<td>1.056</td>
<td>150°</td>
<td>1.056</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>5°</td>
<td>1.013</td>
<td>150°</td>
<td>1.013</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>7°</td>
<td>0969</td>
<td>150°</td>
<td>0969</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>9°</td>
<td>0923</td>
<td>150°</td>
<td>0923</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>11°</td>
<td>0878</td>
<td>150°</td>
<td>0878</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>13°</td>
<td>0834</td>
<td>150°</td>
<td>0834</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>15°</td>
<td>0792</td>
<td>150°</td>
<td>0792</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>17°</td>
<td>0752</td>
<td>150°</td>
<td>0752</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>19°</td>
<td>0713</td>
<td>150°</td>
<td>0713</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>21°</td>
<td>0675</td>
<td>150°</td>
<td>0675</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>23°</td>
<td>0639</td>
<td>150°</td>
<td>0639</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>25°</td>
<td>0602</td>
<td>150°</td>
<td>0602</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>27°</td>
<td>0567</td>
<td>150°</td>
<td>0567</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>29°</td>
<td>0533</td>
<td>150°</td>
<td>0533</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>31°</td>
<td>0500</td>
<td>150°</td>
<td>0500</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>33°</td>
<td>0469</td>
<td>150°</td>
<td>0469</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>35°</td>
<td>0439</td>
<td>150°</td>
<td>0439</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>37°</td>
<td>0409</td>
<td>150°</td>
<td>0409</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>39°</td>
<td>0381</td>
<td>150°</td>
<td>0381</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>41°</td>
<td>0354</td>
<td>150°</td>
<td>0354</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>43°</td>
<td>0328</td>
<td>150°</td>
<td>0328</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>45°</td>
<td>0304</td>
<td>150°</td>
<td>0304</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>47°</td>
<td>0281</td>
<td>150°</td>
<td>0281</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>49°</td>
<td>0259</td>
<td>150°</td>
<td>0259</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>51°</td>
<td>0239</td>
<td>150°</td>
<td>0239</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>53°</td>
<td>0219</td>
<td>150°</td>
<td>0219</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>55°</td>
<td>0199</td>
<td>150°</td>
<td>0199</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>57°</td>
<td>0179</td>
<td>150°</td>
<td>0179</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>59°</td>
<td>0159</td>
<td>150°</td>
<td>0159</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>61°</td>
<td>0138</td>
<td>150°</td>
<td>0138</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>63°</td>
<td>0117</td>
<td>150°</td>
<td>0117</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>65°</td>
<td>0094</td>
<td>150°</td>
<td>0094</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>67°</td>
<td>0071</td>
<td>150°</td>
<td>0071</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>69°</td>
<td>0047</td>
<td>150°</td>
<td>0047</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>71°</td>
<td>0022</td>
<td>150°</td>
<td>0022</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
<tr>
<td>73°</td>
<td>0000</td>
<td>150°</td>
<td>0000</td>
<td>20°</td>
<td>35   30   25</td>
</tr>
</tbody>
</table>

For superposition of Tables, use Design Speed, 35, 30, 25 MPH, and Formula 5.5, 20°, 17°, 14°, 11°, 8°, 5°, 2°, 1°, 0°, 0°.
CIRCULAR CURVE WITH TRANSITION SPIRALS

\[ \Delta = \text{Degree of curvature for final circular arc} \]
\[ L_x = \text{Length in 100 stations of final circular arc} \]
\[ L_v = \text{Length in 100 stations of full spiral arc} \]
\[ I = \text{Deviation angle at intersection of main tangents expressed in degrees} \]
\[ T = \text{Offset of final circular arc from original circular arc expressed in feet} \]

\[ \Delta_0 = \text{Rate of change in degree of curvature per 100' along spiral} \]
\[ L_1 = \text{Length of full spiral expressed in 100's stations from D_0} \]
\[ L_2 = \text{Length of partial spiral expressed in 100's stations from D_0} \]
\[ D_0 = \text{Culminating degree of curvature at point D_0} \]
\[ D_1 = \text{Degree of spiral at point D_1} \]
\[ D_2 = \text{Degree of spiral at point D_2} \]
\[ a = \text{Rate of change in degree of curvature along spiral per 100'} \]

**Partial Transition Spiral**

\[ a = \text{Rate of change in degree of curvature along spiral per 100' of spiral} \]
\[ L_1 = \text{Length of full spiral expressed in 100's stations from D_0 to D_1} \]
\[ L_2 = \text{Length of partial spiral expressed in 100's stations from D_0 to D_1} \]
\[ D_0 = \text{Culminating degree of curvature at point D_0} \]
\[ D_1 = \text{Degree of spiral at point D_1} \]
\[ D_2 = \text{Degree of spiral at point D_2} \]
\[ a = \text{Rate of change in degree of curvature per 100' along spiral} \]

Note: For all functions regarding spiral itself, see full transition spirals.

Example: If \( a = 1/2 \) and \( D_0 = 200' \), then \( D_1 = 300' \), length between is 300'.

Instruction to transitman to turn partial spiral deflections \( a_1 \) and \( a_2 \).

CIRCULAR CURVE WITH TRANSITION SPIRAL AND PARTIAL TRANS. SPIRAL

ARIZONA HIGHWAY DEPARTMENT
PLANS DIVISION

CIRCULAR CURVE WITH TRANSITION SPIRAL AND PARTIAL TRANS. SPIRAL

DRAWING NO. D 3-1

REV. JUL 31

CHECKED: S.P.
DRAFTED: E.T.
APPROVED: JUL 31

2000 + 0'30" = 2'30", Answer.
INTERMEDIATE SPIRAL TRANSITION FOR COMPOUND CURVES.

Note: This line is not a radius of Dp, but an offset of Dp mid-point on spiral.

Radial of Dp at mid-point on spiral (shown for illustration)

Degree of curvature at any point on spiral shown above: \( Dp \)

Degree of curvature for circular arc adjacent to

Degree of curvature of circular arc projected to common radial line

Offset of circular arc projected to common radial line

Note: Above spiral transition is basically the same as "Partial Transition Spiral" Dra. D 3-1

INSTRUCTIONS FOR DETERMINING BASIC DATA.

First determine value of \( a \) with \( V \), the design speed in MPH.

\[ a = \frac{100}{V^2} \]

Max. rate of change in degree of curvature per 100' along spiral

Note: Above value for \( a \) may be decreased slightly for convenience of computations, this corrected value to be used in equations below and accepted as the value of \( a \) as a constant.

Then "D" = \( \frac{C \times D}{D_0 - D_1} \) \( (D_0 - D_1)^2 \), where "D" = Distance between D0 and D1

Note: If figure deflection angles, or length, for any point on above spiral, simply substitute the value of \( Dp \) in place of \( D_0 \) or \( D_1 \).

FULL TRANSITION SPIRAL.

\( D = \) Cumingating Degree of curvature = al

\( L_s = \) Length of full spiral measured along spiral curve, expressed in 100' stations from \( D_0 \) to point 28 maximum chord lengths are recommended.

\( a = \) Rate change in degree of curvature along spiral per 100', \( \frac{D}{100} \)

\( \Delta_s = \) Control or deflection angle of full spiral, expressed in degrees, \( \frac{D}{L_s} \times \frac{D_0}{D_1} \)

\( \theta = \) Deflection angle of full spiral at any point on spiral, \( \frac{D}{L_s} + \frac{D_1}{D_0} = \frac{D}{L_s} + \frac{D_0}{D_1} \times \frac{D}{L_s} \)

\( \Delta = \) Deflection angle of full spiral at culmination and \( \frac{D_0}{D_1} \times \frac{D}{L_s} \)

\[ C = 100 \times 0.00034 \times a^2 \times L_s^3 \]

\[ U = \frac{C \times \sin \theta}{\sin \theta} \]

\[ Y = \frac{C \times \sin \theta}{\sin \theta} \]

Note: See "Partial Transition Spiral for Compound Curves and Full Transition Spiral" for determining proper \( al \) or \( a \), if necessary is given.

ARIZONA HIGHWAY DEPARTMENT
PLANS DIVISION

Spiral Transition for Compound Curves and Full Transition Spiral

Drawn by:...

REV.
JUNE 1965
ARCHIV ED:...
IN 3-1233
APPROVED:...
JUNE 1965
### Tabulation of Spiral Functions as Related to \( \alpha \) Set Up at T.S. When \( \alpha = \frac{1}{3} \)

<table>
<thead>
<tr>
<th>Length From T.S.</th>
<th>&quot;O&quot;</th>
<th>&quot;R&quot;</th>
<th>&quot;S&quot;</th>
<th>&quot;T&quot;</th>
<th>&quot;U&quot;</th>
<th>&quot;V&quot;</th>
<th>&quot;Y&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0°</td>
<td>0°</td>
<td>0°</td>
<td>0°</td>
<td>0°</td>
<td>0°</td>
<td>0°</td>
<td>0°</td>
</tr>
<tr>
<td>0°10'</td>
<td>0°10'</td>
<td>0°10'</td>
<td>0°10'</td>
<td>0°10'</td>
<td>0°10'</td>
<td>0°10'</td>
<td>0°10'</td>
</tr>
<tr>
<td>0°20'</td>
<td>0°20'</td>
<td>0°20'</td>
<td>0°20'</td>
<td>0°20'</td>
<td>0°20'</td>
<td>0°20'</td>
<td>0°20'</td>
</tr>
<tr>
<td>0°30'</td>
<td>0°30'</td>
<td>0°30'</td>
<td>0°30'</td>
<td>0°30'</td>
<td>0°30'</td>
<td>0°30'</td>
<td>0°30'</td>
</tr>
<tr>
<td>0°40'</td>
<td>0°40'</td>
<td>0°40'</td>
<td>0°40'</td>
<td>0°40'</td>
<td>0°40'</td>
<td>0°40'</td>
<td>0°40'</td>
</tr>
<tr>
<td>0°50'</td>
<td>0°50'</td>
<td>0°50'</td>
<td>0°50'</td>
<td>0°50'</td>
<td>0°50'</td>
<td>0°50'</td>
<td>0°50'</td>
</tr>
<tr>
<td>0°60'</td>
<td>0°60'</td>
<td>0°60'</td>
<td>0°60'</td>
<td>0°60'</td>
<td>0°60'</td>
<td>0°60'</td>
<td>0°60'</td>
</tr>
</tbody>
</table>

**Formulas for Computing Deflection Angles \( \alpha \) and \( \lambda \)**

\[
\alpha = \frac{1}{3} \alpha_1 \left( \frac{l_1 - l_2}{3} \right) + \frac{1}{3} \alpha_1 \left( \frac{l_2 - l_3}{3} \right)
\]

\[
\lambda = \frac{1}{3} \alpha_1 \left( \frac{l_1 - l_2}{3} \right) - \frac{1}{3} \alpha_1 \left( \frac{l_2 - l_3}{3} \right)
\]

**Notes:**
- For additional data and formula related to the use of transition spiral, refer to Standard Drawings No. D-3-1 & D-3-2.
- For super-elevation refer to D-21 & D-22.
TABULATION OF SPIRAL FUNCTIONS AS RELATED TO X SET UP AT TS. WHEN $\alpha = \frac{1}{2}$

<table>
<thead>
<tr>
<th>Length From TS</th>
<th>Cumulative Degree of Curvature</th>
<th>Circular Radius of Curvature in Feet</th>
<th>Radial Offset of Set in Feet ($\frac{1}{2}$a)</th>
<th>Deviation Angle $\theta$</th>
<th>Deviation from TS Only to Point on Spiral = $\frac{1}{2}$a</th>
<th>Deviation from Point on Spiral to End of Spiral = $\frac{1}{2}$a</th>
<th>Deflection in Feet</th>
<th>U in Feet</th>
<th>C in Feet</th>
<th>Y in Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>0'00.00</td>
<td>0'00.00</td>
<td>0'00.00</td>
<td>0'00.00</td>
<td>0'00.00</td>
<td>0'00.00</td>
<td>0'00.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>0'01.00</td>
<td>0'01.00</td>
<td>0'01.00</td>
<td>0'01.00</td>
<td>0'01.00</td>
<td>0'01.00</td>
<td>0'01.00</td>
<td>0.00</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>0'02.00</td>
<td>0'02.00</td>
<td>0'02.00</td>
<td>0'02.00</td>
<td>0'02.00</td>
<td>0'02.00</td>
<td>0'02.00</td>
<td>0.00</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

FORMULA FOR COMPUTING DEFLECTION ANGLES $\alpha$ and $\lambda$ AHEAD AND BACK TO OTHER POINTS ON SPIRAL WHEN $\alpha$ SET UP IS AT A POINT ON SPIRAL

$\alpha = \frac{1}{2}a \left( L_1 - L_2 \right) + \frac{5}{8}a \left( L_3 - L_1 \right)^2$

$\lambda = \frac{1}{2}a \left( L_1 - L_2 \right) - \frac{5}{8}a \left( L_3 - L_1 \right)^2$

NOTE: FOR ADDITIONAL DATA AND FORMULAE RELATED TO THE USE OF TRANSITION SPIRALES REFER TO STANDARD DRAWINGS NO. D 3-1 & D 3-2 FOR SURREELEVATION REFER TO D 2-1 & D 2-2

ARIZONA STATE HIGHWAY DEPARTMENT PLANS DIVISION

TRANSITION SPIRAL TABLE FOR $\alpha = \frac{1}{2}$

RECOMMENDED FOR 30 M.P.H. DESIGN SPEED

CALCULATED AND DRAWN APRIL '76 BY LESLIE MONROE - HIGHWAY ENGINEER"
**TABULATION OF SPIRAL FUNCTIONS AS RELATED TO TS WHEN \( \alpha = \frac{2}{3} \)**

<table>
<thead>
<tr>
<th>Length From TS Along Spiral in Feet</th>
<th>( R )</th>
<th>Corresponding Circular Arc Radius in Feet</th>
<th>( t ) In Feet</th>
<th>( \Delta \alpha )</th>
<th>( \Delta )</th>
<th>( \Delta )</th>
<th>( \delta )</th>
<th>( U ) In Feet</th>
<th>( V ) In Feet</th>
<th>( X ) Long Chord IN Feet</th>
<th>( Y ) In Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0°00'</td>
<td>INFINITY</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>25</td>
<td>0°20'</td>
<td>34,977.46</td>
<td>0.00</td>
<td>10.25</td>
<td>0.00</td>
<td>0.04</td>
<td>0.96</td>
<td>0.00</td>
<td>15.17</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>50</td>
<td>0°20'</td>
<td>17,168.74</td>
<td>0.00</td>
<td>25.00</td>
<td>0.00</td>
<td>0.10</td>
<td>1.06</td>
<td>0.00</td>
<td>26.99</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>75</td>
<td>0°20'</td>
<td>11,459.16</td>
<td>0.00</td>
<td>37.50</td>
<td>0.00</td>
<td>0.15</td>
<td>1.35</td>
<td>0.00</td>
<td>29.88</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>100</td>
<td>0°20'</td>
<td>6,594.37</td>
<td>0.00</td>
<td>50.00</td>
<td>0.00</td>
<td>0.20</td>
<td>2.04</td>
<td>0.00</td>
<td>32.77</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>125</td>
<td>0°20'</td>
<td>5,875.70</td>
<td>0.00</td>
<td>62.50</td>
<td>0.00</td>
<td>0.25</td>
<td>2.64</td>
<td>0.00</td>
<td>35.66</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>150</td>
<td>0°20'</td>
<td>5,729.58</td>
<td>0.00</td>
<td>75.00</td>
<td>0.00</td>
<td>0.30</td>
<td>3.23</td>
<td>0.00</td>
<td>38.55</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>175</td>
<td>0°20'</td>
<td>5,501.76</td>
<td>0.00</td>
<td>87.50</td>
<td>0.00</td>
<td>0.35</td>
<td>3.82</td>
<td>0.00</td>
<td>41.44</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>200</td>
<td>0°20'</td>
<td>5,246.32</td>
<td>0.00</td>
<td>100.00</td>
<td>0.00</td>
<td>0.40</td>
<td>4.40</td>
<td>0.00</td>
<td>44.33</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>225</td>
<td>0°20'</td>
<td>5,000.00</td>
<td>0.00</td>
<td>112.50</td>
<td>0.00</td>
<td>0.45</td>
<td>4.97</td>
<td>0.00</td>
<td>47.22</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>250</td>
<td>0°20'</td>
<td>4,719.17</td>
<td>0.00</td>
<td>125.00</td>
<td>0.00</td>
<td>0.50</td>
<td>5.54</td>
<td>0.00</td>
<td>50.11</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>275</td>
<td>0°20'</td>
<td>4,381.77</td>
<td>0.00</td>
<td>137.50</td>
<td>0.00</td>
<td>0.55</td>
<td>6.11</td>
<td>0.00</td>
<td>53.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>300</td>
<td>0°20'</td>
<td>4,000.00</td>
<td>0.00</td>
<td>150.00</td>
<td>0.00</td>
<td>0.60</td>
<td>6.66</td>
<td>0.00</td>
<td>55.99</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>325</td>
<td>0°20'</td>
<td>3,644.42</td>
<td>0.00</td>
<td>162.50</td>
<td>0.00</td>
<td>0.65</td>
<td>7.22</td>
<td>0.00</td>
<td>58.88</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>350</td>
<td>0°20'</td>
<td>3,245.53</td>
<td>0.00</td>
<td>175.00</td>
<td>0.00</td>
<td>0.70</td>
<td>7.78</td>
<td>0.00</td>
<td>61.77</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>375</td>
<td>0°20'</td>
<td>2,891.83</td>
<td>0.00</td>
<td>187.50</td>
<td>0.00</td>
<td>0.75</td>
<td>8.34</td>
<td>0.00</td>
<td>64.66</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>400</td>
<td>0°20'</td>
<td>2,465.59</td>
<td>3.10</td>
<td>200.00</td>
<td>0.00</td>
<td>0.80</td>
<td>8.90</td>
<td>0.00</td>
<td>67.55</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>425</td>
<td>0°20'</td>
<td>2,022.20</td>
<td>3.72</td>
<td>212.50</td>
<td>0.00</td>
<td>0.85</td>
<td>9.46</td>
<td>0.00</td>
<td>70.44</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>450</td>
<td>0°20'</td>
<td>1,559.86</td>
<td>4.34</td>
<td>225.00</td>
<td>0.00</td>
<td>0.90</td>
<td>10.01</td>
<td>0.00</td>
<td>73.33</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>475</td>
<td>0°20'</td>
<td>1,003.34</td>
<td>5.19</td>
<td>237.50</td>
<td>0.00</td>
<td>0.95</td>
<td>10.57</td>
<td>0.00</td>
<td>76.22</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**FORMULA FOR COMPUTING DEFLECTION ANGLES \( \alpha \) AND \( \beta \) AHEAD AND BEHIND TO OTHER POINTS ON SPIRAL.**

\[ \alpha = \frac{2}{3} \left( \left( L_1 - L_2 \right)^2 + \frac{1}{6} \left( L_3 - L_4 \right)^2 \right) \]

\[ \beta = \frac{1}{3} \left( \left( L_1 - L_2 \right)^2 - \frac{1}{6} \left( L_3 - L_4 \right)^2 \right) \]

**NOTE:**

For additional data and formulae related to the use of transition spirals refer to standard drawings No. D 3-1 and D 3-2. For super-elevation, refer to D 2-1 and D 2-2.

---

**TRANSITION SPIRAL TABLE FOR \( \alpha = \frac{2}{3} \)**

Recommended for 80 MPH Design Speed

Calculated and Drawn April 1961

By Leslie McDougall - Highway Designer

Standard Size No. D 3-5

INITIAL TANGENT

\( T_5 = \left[ \tan \left( \frac{1}{2} I \right) (R + \delta) \right] + t \)

\( I = \) Deviation Angle at Point of Intersection of Initial Tangents

\( T_5 = \) Varies According to Angle \( I \)

\( I \) = Initial Tangent Angle

\( R \) = Initial Tangent Back

\( T_5 \) = Initial Tangent Point

\( \delta \) = Long Chord

\( t \) = Initial Tangent Back

\( \alpha \) = Rate of Increase in Degrees of Curvature per 100 Feet on Spiral

\( \beta \) = Cumulative Length in Feet on Spiral Beginning at Point 'S.'

\( L_1 \) = First Tangent

\( L_2 \) = Spiral

\( L_3 \) = Second Tangent

\( L_4 \) = Third Tangent

\( \alpha \) = Cumulating Degree of Curvature on Spiral (computed in degrees and decimal parts)

\( \beta \) = Circular Arc at Point 'S.'

\( \delta \) = deviation of circular arc from tangent line at 'S.'

\( t \) = length of tangent section

\( \delta \) = deviation angle at point of intersection of initial tangents

\( \delta \) = deviation angle along spiral

\( \delta \) = deviation angle from tangent

\( \delta \) = deviation angle at point of intersection of spiral and tangent

\( \delta \) = deviation angle from point of spiral to point of tangent

---

**ARIZONA STATE HIGHWAY DEPARTMENT PLANS DIVISION**

**RECOMMENDED FOR 80 MPH DESIGN SPEED**

**CALCULATED AND DRAWN APRIL 1961**

**CHECKED BY L. M. D.**

**APPROVED BY ENGR. OF P. N.**

D 3-5
### Tabulation of Spiral Functions as Related to R Set Up at TS, When \( \alpha = 1 \)

<table>
<thead>
<tr>
<th>Length from TS along Spiral in Feet</th>
<th>Degree of Curve</th>
<th>Radian Corresponding to Degree of Curve</th>
<th>Radial Offset in Feet</th>
<th>( t ) in Feet</th>
<th>Deviation Angle</th>
<th>Deflection from Point of Tangent to Point on Spiral</th>
<th>Deflection in Feet</th>
<th>Deviation in Feet</th>
<th>Long Chord in Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0°0'0&quot;</td>
<td>INFINITY</td>
<td>0.00</td>
<td>0.00</td>
<td>0°0'0&quot;</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>25</td>
<td>0°0'15&quot;</td>
<td>22,718.32</td>
<td>-0.01</td>
<td>0.00</td>
<td>0°0'15&quot;</td>
<td>0°0'15&quot;</td>
<td>8.33</td>
<td>16.67</td>
<td>25.00</td>
</tr>
<tr>
<td>50</td>
<td>0°0'30&quot;</td>
<td>11,659.16</td>
<td>-0.71</td>
<td>0.00</td>
<td>0°0'30&quot;</td>
<td>0°0'30&quot;</td>
<td>16.67</td>
<td>33.33</td>
<td>50.00</td>
</tr>
<tr>
<td>75</td>
<td>0°0'45&quot;</td>
<td>7,639.44</td>
<td>-2.13</td>
<td>0.00</td>
<td>0°0'45&quot;</td>
<td>0°0'45&quot;</td>
<td>11.15</td>
<td>22.30</td>
<td>44.50</td>
</tr>
<tr>
<td>100</td>
<td>0°1'00&quot;</td>
<td>5,729.58</td>
<td>-7.00</td>
<td>0.00</td>
<td>0°1'00&quot;</td>
<td>0°1'00&quot;</td>
<td>12.50</td>
<td>25.00</td>
<td>50.00</td>
</tr>
<tr>
<td>125</td>
<td>0°1'15&quot;</td>
<td>4,985.16</td>
<td>-11.98</td>
<td>0.00</td>
<td>0°1'15&quot;</td>
<td>0°1'15&quot;</td>
<td>18.75</td>
<td>37.50</td>
<td>75.00</td>
</tr>
<tr>
<td>150</td>
<td>0°1'30&quot;</td>
<td>4,350.25</td>
<td>-22.50</td>
<td>0.00</td>
<td>0°1'30&quot;</td>
<td>0°1'30&quot;</td>
<td>25.00</td>
<td>50.00</td>
<td>100.00</td>
</tr>
<tr>
<td>175</td>
<td>0°1'45&quot;</td>
<td>3,747.50</td>
<td>-35.60</td>
<td>0.00</td>
<td>0°1'45&quot;</td>
<td>0°1'45&quot;</td>
<td>33.33</td>
<td>66.67</td>
<td>150.00</td>
</tr>
<tr>
<td>200</td>
<td>0°2'00&quot;</td>
<td>3,164.75</td>
<td>-50.00</td>
<td>0.00</td>
<td>0°2'00&quot;</td>
<td>0°2'00&quot;</td>
<td>41.67</td>
<td>83.33</td>
<td>225.00</td>
</tr>
<tr>
<td>225</td>
<td>0°2'15&quot;</td>
<td>2,613.75</td>
<td>-65.63</td>
<td>0.00</td>
<td>0°2'15&quot;</td>
<td>0°2'15&quot;</td>
<td>50.00</td>
<td>100.00</td>
<td>300.00</td>
</tr>
<tr>
<td>250</td>
<td>0°2'30&quot;</td>
<td>2,123.40</td>
<td>-82.81</td>
<td>0.00</td>
<td>0°2'30&quot;</td>
<td>0°2'30&quot;</td>
<td>58.33</td>
<td>116.67</td>
<td>450.00</td>
</tr>
<tr>
<td>275</td>
<td>0°2'45&quot;</td>
<td>1,682.16</td>
<td>-102.00</td>
<td>0.00</td>
<td>0°2'45&quot;</td>
<td>0°2'45&quot;</td>
<td>66.67</td>
<td>133.33</td>
<td>600.00</td>
</tr>
<tr>
<td>300</td>
<td>0°3'00&quot;</td>
<td>1,302.48</td>
<td>-123.81</td>
<td>0.00</td>
<td>0°3'00&quot;</td>
<td>0°3'00&quot;</td>
<td>75.00</td>
<td>150.00</td>
<td>750.00</td>
</tr>
<tr>
<td>325</td>
<td>0°3'15&quot;</td>
<td>1,002.25</td>
<td>-147.50</td>
<td>0.00</td>
<td>0°3'15&quot;</td>
<td>0°3'15&quot;</td>
<td>83.33</td>
<td>166.67</td>
<td>900.00</td>
</tr>
<tr>
<td>350</td>
<td>0°3'30&quot;</td>
<td>803.33</td>
<td>-173.81</td>
<td>0.00</td>
<td>0°3'30&quot;</td>
<td>0°3'30&quot;</td>
<td>91.67</td>
<td>183.33</td>
<td>1050.00</td>
</tr>
<tr>
<td>375</td>
<td>0°3'45&quot;</td>
<td>642.04</td>
<td>-202.00</td>
<td>0.00</td>
<td>0°3'45&quot;</td>
<td>0°3'45&quot;</td>
<td>100.00</td>
<td>200.00</td>
<td>1200.00</td>
</tr>
<tr>
<td>400</td>
<td>0°4'00&quot;</td>
<td>500.92</td>
<td>-233.81</td>
<td>0.00</td>
<td>0°4'00&quot;</td>
<td>0°4'00&quot;</td>
<td>108.44</td>
<td>216.88</td>
<td>1350.00</td>
</tr>
<tr>
<td>425</td>
<td>0°4'15&quot;</td>
<td>381.03</td>
<td>-268.50</td>
<td>0.00</td>
<td>0°4'15&quot;</td>
<td>0°4'15&quot;</td>
<td>116.67</td>
<td>233.33</td>
<td>1500.00</td>
</tr>
</tbody>
</table>

**Formula for computing deflection angles \( \alpha \) and \( \beta \) ahead and back to other points on spiral when \( TS_5 \) set up is at a point on spiral.**

\[
\alpha = \frac{1}{2} a L_{11} (L_{11} - L_1) + \frac{1}{2} a (L_{11} - L_1)^2
\]

\[
\beta = \frac{1}{2} a L_{11} (L_{11} - L_1) - \frac{1}{2} a (L_{11} - L_1)^2
\]

**Note:**

- For additional data and formulas related to the use of transition spirals refer to standard drawings No. D 3-1 & D 3-2.
- For super-elevation refer to D 2-1 & D 2-2.

### Arizona State Highway Department

**Transition Spiral Table for \( \alpha = 1 \)**

Recommended for 70 MPH design speed.
### Tabulation of Spiral Functions as Related to \( t \) Set Up at TS. When \( \alpha = 1/8 \)

| Length From TS. Alongs Spiral in Feet 100L | \( D \) | \( R \) (Corresponding Circular Arc Radius in Feet \( = \frac{5727.55}{D} \)) | \( D \) | \( t \) (in Feet \( = \frac{501}{\alpha^2} \)) | \( \Delta^* \) | \( \phi^* \) (Deflection From TS Only) in Feet | \( \phi^* \) (Deflection From Point on Spiral \( = \frac{501}{\alpha^2} \)) | \( Y \) in Feet | \( U \) in Feet | \( C \) (Long Chord in Feet \( = \frac{100L_1}{\alpha} \)) in Feet | \( X \) in Feet | \( Y \) in Feet |
|------------------------------------------|------|--------------------------------|------|-----------------|------|-----------------|-----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| 0  0°00'   INFINITY          0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 25  0°20'  17,168.74 | 6,594.37 | 0.01 | 12.50 | 0°02'30" | 0°02'30" | 0°02'30" | 0°02'30" | 16.67 | 25.00 | 100.00 | 174.99 | 2.08 |
| 50  0°40'  5,729.58 | 2,864.79 | 0.04 | 25.00 | 0°10'00" | 0°10'00" | 0°10'00" | 0°10'00" | 33.33 | 50.00 | 150.00 | 224.99 | 4.22 |
| 75  1°20'  4,297.19 | 1,958.95 | 0.19 | 37.50 | 0°22'30" | 0°22'30" | 0°22'30" | 0°22'30" | 50.00 | 75.00 | 224.99 | 324.51 | 13.30 |
| 100  2°00'  3,437.75 | 1,253.44 | 0.33 | 50.00 | 0°40'00" | 0°40'00" | 0°40'00" | 0°40'00" | 66.67 | 100.00 | 275.00 | 424.99 | 20.42 |
| 125  2°40'  2,864.79 | 1,014.28 | 0.52 | 62.50 | 1°02'30" | 1°02'30" | 1°02'30" | 1°02'30" | 83.33 | 116.67 | 324.99 | 372.29 | 20.42 |
| 150  3°20'  2,455.63 | 1,000.96 | 0.83 | 75.00 | 1°30'00" | 1°30'00" | 1°30'00" | 1°30'00" | 100.00 | 150.00 | 372.29 | 372.29 | 20.42 |
| 175  3°40'  2,148.59 | 899.99 | 1.10 | 87.50 | 2°00'00" | 2°00'00" | 2°00'00" | 2°00'00" | 116.67 | 174.99 | 424.99 | 424.99 | 20.42 |
| 200  4°20'  1,958.95 | 833.33 | 1.39 | 100.00 | 2°30'00" | 2°30'00" | 2°30'00" | 2°30'00" | 133.33 | 224.99 | 575.99 | 575.99 | 20.42 |
| 225  5°00'  1,715.66 | 759.09 | 1.68 | 112.50 | 3°00'00" | 3°00'00" | 3°00'00" | 3°00'00" | 150.00 | 275.00 | 726.99 | 726.99 | 20.42 |
| 250  5°20'  1,562.61 | 694.44 | 1.97 | 125.00 | 3°30'00" | 3°30'00" | 3°30'00" | 3°30'00" | 166.67 | 324.99 | 877.99 | 877.99 | 20.42 |
| 275  5°40'  1,433.40 | 645.90 | 2.26 | 137.50 | 4°00'00" | 4°00'00" | 4°00'00" | 4°00'00" | 183.33 | 374.99 | 1028.99 | 1028.99 | 20.42 |
| 300  6°20'  1,322.21 | 596.38 | 2.55 | 150.00 | 4°30'00" | 4°30'00" | 4°30'00" | 4°30'00" | 200.00 | 424.99 | 1179.99 | 1179.99 | 20.42 |
| 325  6°40'  1,227.77 | 547.85 | 2.84 | 162.50 | 5°00'00" | 5°00'00" | 5°00'00" | 5°00'00" | 216.67 | 524.99 | 1330.99 | 1330.99 | 20.42 |
| 350  7°20'  1,145.92 | 501.00 | 3.13 | 175.00 | 5°30'00" | 5°30'00" | 5°30'00" | 5°30'00" | 233.33 | 624.99 | 1491.99 | 1491.99 | 20.42 |
| 375  7°50'  1,082.57 | 456.25 | 3.42 | 187.50 | 6°00'00" | 6°00'00" | 6°00'00" | 6°00'00" | 250.00 | 724.99 | 1652.99 | 1652.99 | 20.42 |

### Formula for Computing Deflection Angles \( \phi \) and \( \phi^* \)

When TS set up is at a point on spiral, \( \phi \) and \( \phi^* \) angles are computed in degrees and decimal parts.

\[
\alpha = \frac{1}{2} \alpha_1 \left( l_1 - l_2 \right) + \frac{1}{8} \alpha \left( l_3 - l_2 \right)^2
\]

\[
\phi = \frac{1}{2} \alpha_1 \left( l_1 - l_2 \right) - \frac{1}{8} \alpha \left( l_3 - l_2 \right)^2
\]

### Note:

For additional data and formulae related to the use of transition spirals, refer to standard drawings no. D 3-1 & D 3-2. For superelevation refer to D 2-1 & D 2-2.

**Transition Spiral Table for \( \alpha = 1/8 \)**

Recommended for 65 M.P.H. design speed.

[Signature]
### TABULATION OF SPIRAL FUNCTIONS AS RELATED TO A SET UP AT TS, WHEN \( \alpha = 1\% \)

<table>
<thead>
<tr>
<th>LENGTH FROM TS ALONG SPIRAL IN FEET</th>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUMULATING DEGREE OF CURVATURE</td>
<td>0%</td>
<td>10%</td>
<td>20%</td>
<td>30%</td>
<td>40%</td>
<td>50%</td>
<td>60%</td>
<td>70%</td>
<td>80%</td>
<td>90%</td>
<td>100%</td>
</tr>
<tr>
<td>CIRCULAR ARC RADIUS</td>
<td>0%</td>
<td>10%</td>
<td>20%</td>
<td>30%</td>
<td>40%</td>
<td>50%</td>
<td>60%</td>
<td>70%</td>
<td>80%</td>
<td>90%</td>
<td>100%</td>
</tr>
<tr>
<td>RADIAL OFFSET</td>
<td>0%</td>
<td>10%</td>
<td>20%</td>
<td>30%</td>
<td>40%</td>
<td>50%</td>
<td>60%</td>
<td>70%</td>
<td>80%</td>
<td>90%</td>
<td>100%</td>
</tr>
<tr>
<td>RADIUS OF SPIRAL</td>
<td>0%</td>
<td>10%</td>
<td>20%</td>
<td>30%</td>
<td>40%</td>
<td>50%</td>
<td>60%</td>
<td>70%</td>
<td>80%</td>
<td>90%</td>
<td>100%</td>
</tr>
<tr>
<td>DEFLECTION ANGLE</td>
<td>0%</td>
<td>10%</td>
<td>20%</td>
<td>30%</td>
<td>40%</td>
<td>50%</td>
<td>60%</td>
<td>70%</td>
<td>80%</td>
<td>90%</td>
<td>100%</td>
</tr>
<tr>
<td>DEFLECTION FROM TS ONLY</td>
<td>0%</td>
<td>10%</td>
<td>20%</td>
<td>30%</td>
<td>40%</td>
<td>50%</td>
<td>60%</td>
<td>70%</td>
<td>80%</td>
<td>90%</td>
<td>100%</td>
</tr>
<tr>
<td>DEVIATION OF SPIRAL</td>
<td>0%</td>
<td>10%</td>
<td>20%</td>
<td>30%</td>
<td>40%</td>
<td>50%</td>
<td>60%</td>
<td>70%</td>
<td>80%</td>
<td>90%</td>
<td>100%</td>
</tr>
</tbody>
</table>

**FORMULA FOR COMPUTING DEFLECTION ANGLES \( \alpha \) AND \( \beta \)**

**NOTE:** FOR ADDITIONAL DATA AND FORMULAE RELATED TO THE USE OF TRANSITION SPIRALS REFER TO STANDARD DRAWINGS NO. D 3-1 & D 3-2. FOR SUPERELEVATION REFER TO D 2-1 & D 2-2.

### TRANSITION SPIRAL TABLE FOR \( \alpha = 1\% \)

**RECOMMENDED FOR 60 MPH DESIGN SPEED**

**CALCULATED AND DRAWN APRIL 1966**

**ENGINEERED BY D 3-8**

**CHECKED BY D 3-9**

**APPROVED BY D 3-10**

**RECOMMENDED FOR 60 MPH DESIGN SPEED**

**CALCULATED AND DRAWN APRIL 1966**

**ENGINEERED BY D 3-8**

**CHECKED BY D 3-9**

**APPROVED BY D 3-10**
### TABULATION OF SPIRAL FUNCTIONS AS RELATED TO θ SET UP AT T.S. WHEN α = 2

| LENGTH FROM T.S. ALONG SPIRAL IN FEET | RADIUS OF CURVATURE (IN FEET) | θ | RADIUS OF CURVATURE (IN FEET) | θ | RADIUS OF CURVATURE (IN FEET) | θ | RADIUS OF CURVATURE (IN FEET) | θ | RADIUS OF CURVATURE (IN FEET) | θ | RADIUS OF CURVATURE (IN FEET) | θ |
|--------------------------------------|--------------------------------|---|--------------------------------|---|--------------------------------|---|--------------------------------|---|--------------------------------|---|--------------------------------|---|--------------------------------|
| 0                                    | 0                              | 0 | 0                              | 0 | 0                              | 0 | 0                              | 0 | 0                              | 0 | 0                              | 0 |
| 25                                   | 0°30'                          | 11,459.14 | -                            | 12.50 | 0°03'55"                      | 0°01'51" | 0°02'30"                      | 8.33 | 0°05'05"                      | 0°06'30" | 25.00 | 0°06'30" | 25.00 | 0°06'30" |
| 50                                   | 1°00'                          | 5,728.58  | .02                           | 25.00 | 0°45'01"                      | 0°45'01" | 0°45'01"                      | 16.67 | 33.33            | 50.00 | 0°10'10" | 50.00 | 0°10'10" |
| 75                                   | 2°30'                          | 3,819.72  | .66                           | 37.50 | 0°53'11"                      | 0°51'11" | 0°53'11"                      | 25.00 | 50.00            | 75.00 | 0°20'30" | 75.00 | 0°20'30" |
| 100                                  | 2°00'                          | 2,866.79  | -                             | 50.00 | 0°15'00"                      | 0°15'00" | 0°15'00"                      | 33.33 | 66.67            | 100.00 | 0°30'00" | 100.00 | 0°30'00" |
| 125                                  | 2°20'                          | 2,291.03  | .28                           | 62.50 | 0°33'55"                      | 0°33'55" | 0°33'55"                      | 41.67 | 83.33            | 125.00 | 1°00'10" | 125.00 | 1°00'10" |
| 150                                  | 2°25'                          | 1,908.86  | .43                           | 75.00 | 0°25'15"                      | 0°25'15" | 0°25'15"                      | 50.00 | 100.00           | 150.00 | 1°30'00" | 150.00 | 1°30'00" |
| 175                                  | 2°30'                          | 1,673.02  | .78                           | 87.43 | 0°33'45"                      | 0°33'45" | 0°33'45"                      | 58.35 | 116.67           | 175.00 | 1°45'30" | 175.00 | 1°45'30" |
| 200                                  | 2°40'                          | 1,432.40  | 1.16                          | 99.98 | 0°15'00"                      | 0°15'00" | 0°15'00"                      | 66.70 | 133.33           | 200.00 | 2°00'30" | 200.00 | 2°00'30" |
| 225                                  | 2°30'                          | 1,273.24  | 1.66                          | 112.47 | 0°53'25"                      | 0°53'25" | 0°53'25"                      | 75.07 | 150.07           | 225.00 | 2°30'00" | 225.00 | 2°30'00" |
| 250                                  | 3°00'                          | 1,145.32  | 2.27                          | 124.95 | 6°15'00"                      | 6°15'00" | 6°15'00"                      | 83.44 | 166.76           | 250.00 | 3°00'30" | 250.00 | 3°00'30" |
| 275                                  | 3°30'                          | 1,041.74  | 3.02                          | 137.42 | 7°33'45"                      | 7°33'45" | 7°33'45"                      | 91.64 | 183.49           | 275.00 | 3°30'30" | 275.00 | 3°30'30" |
| 300                                  | 4°00'                          | 954.93    | 3.93                          | 146.85 | 8°00'00"                      | 8°00'00" | 8°00'00"                      | 100.26 | 200.26           | 300.00 | 4°00'30" | 300.00 | 4°00'30" |
| 325                                  | 6°30'                          | 681.47    | 4.59                          | 162.32 | 10°33'45"                     | 10°33'45" | 10°33'45"                     | 108.73 | 217.70           | 325.00 | 6°30'30" | 325.00 | 6°30'30" |
| 350                                  | 7°00'                          | 612.51    | 5.25                          | 174.72 | 12°00'00"                     | 12°00'00" | 12°00'00"                     | 117.72 | 235.44           | 350.00 | 7°00'30" | 350.00 | 7°00'30" |
| 375                                  | 7°30'                          | 763.94    | 6.77                          | 187.12 | 14°00'45"                     | 14°00'45" | 14°00'45"                     | 125.78 | 250.78           | 375.00 | 7°30'30" | 375.00 | 7°30'30" |

**FORMULA FOR COMPUTING DEFLECTION ANGLES θ AND θ₁ AHEAD AND BACK TO OTHER POINTS ON SPIRAL WHEN θ SET UP IS AT A POINT ON SPIRAL:**

\[ \theta = \frac{\theta_{\text{front}} \cdot \theta_{\text{back}}}{\theta_{\text{front}} + \theta_{\text{back}}} \]

**FOR ADDITIONAL DATA AND FORMULAE RELATED TO THE USE OF TRANSITION SPIRALS REFER TO STANDARD DRAWINGS NO. 3-1 & 3-2. FOR SUPERELEVATION REFER TO 3-1 & 3-2.**

**TRANSITION SPIRAL TABLE FOR CL = 2**

**RECOMMENDED FOR 55 MPH DESIGN SPEED**

**CALCULATED AND DRAWN APRIL 1961**

**CHECKED BY FINNEY & PLAN**

**APPROVED BY**
**Tabulation of Spiral Functions as Related to a Set Up at Ts, When $\alpha = 2\frac{1}{2}$**

<table>
<thead>
<tr>
<th>Length From Ts Along Spiral in Feet</th>
<th>R</th>
<th>O</th>
<th>$\Delta\alpha$</th>
<th>Deviation Angle</th>
<th>$\Delta$</th>
<th>Deflection from Point on Spiral to Point on Ts in Feet</th>
<th>Deflection from Point on Spiral to Ts in Feet</th>
<th>$\Delta l$</th>
<th>Long Cord in Feet</th>
<th>$\Delta l_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>10</td>
<td>0°15'</td>
<td>29.518.32</td>
<td>-</td>
<td>5.00</td>
<td>0°00'45&quot;</td>
<td>0°00'15&quot;</td>
<td>0°00'30&quot;</td>
<td>3.33</td>
<td>6.67</td>
<td>10.00</td>
</tr>
<tr>
<td>20</td>
<td>0°30'</td>
<td>11.465.16</td>
<td>-</td>
<td>10.00</td>
<td>0°00'90&quot;</td>
<td>0°00'45&quot;</td>
<td>0°00'60&quot;</td>
<td>6.67</td>
<td>13.33</td>
<td>20.00</td>
</tr>
<tr>
<td>30</td>
<td>0°45'</td>
<td>7.639.44</td>
<td>-</td>
<td>15.00</td>
<td>0°00'135&quot;</td>
<td>0°00'60&quot;</td>
<td>0°00'90&quot;</td>
<td>10.00</td>
<td>20.00</td>
<td>30.00</td>
</tr>
<tr>
<td>40</td>
<td>1°00'</td>
<td>5.729.58</td>
<td>-</td>
<td>20.00</td>
<td>0°00'180&quot;</td>
<td>0°00'90&quot;</td>
<td>0°00'120&quot;</td>
<td>13.33</td>
<td>26.67</td>
<td>40.00</td>
</tr>
<tr>
<td>50</td>
<td>1°15'</td>
<td>4.583.66</td>
<td>-</td>
<td>25.00</td>
<td>0°00'225&quot;</td>
<td>0°00'120&quot;</td>
<td>0°00'150&quot;</td>
<td>16.67</td>
<td>33.33</td>
<td>50.00</td>
</tr>
<tr>
<td>60</td>
<td>1°30'</td>
<td>3.819.72</td>
<td>-</td>
<td>30.00</td>
<td>0°00'270&quot;</td>
<td>0°00'150&quot;</td>
<td>0°00'180&quot;</td>
<td>20.00</td>
<td>40.00</td>
<td>60.00</td>
</tr>
<tr>
<td>70</td>
<td>1°45'</td>
<td>3.297.05</td>
<td>-</td>
<td>35.00</td>
<td>0°00'315&quot;</td>
<td>0°00'180&quot;</td>
<td>0°00'210&quot;</td>
<td>23.33</td>
<td>46.67</td>
<td>70.00</td>
</tr>
<tr>
<td>80</td>
<td>2°00'</td>
<td>2.678.47</td>
<td>-</td>
<td>40.00</td>
<td>0°00'360&quot;</td>
<td>0°00'210&quot;</td>
<td>0°00'240&quot;</td>
<td>26.67</td>
<td>53.33</td>
<td>80.00</td>
</tr>
<tr>
<td>90</td>
<td>2°15'</td>
<td>2.100.30</td>
<td>0.24</td>
<td>45.00</td>
<td>0°00'405&quot;</td>
<td>0°00'240&quot;</td>
<td>0°00'270&quot;</td>
<td>30.00</td>
<td>60.00</td>
<td>90.00</td>
</tr>
<tr>
<td>100</td>
<td>2°30'</td>
<td>1.591.43</td>
<td>0.48</td>
<td>50.00</td>
<td>0°00'450&quot;</td>
<td>0°00'270&quot;</td>
<td>0°00'300&quot;</td>
<td>33.33</td>
<td>66.67</td>
<td>100.00</td>
</tr>
<tr>
<td>110</td>
<td>2°45'</td>
<td>1.125.64</td>
<td>0.72</td>
<td>55.00</td>
<td>0°00'495&quot;</td>
<td>0°00'300&quot;</td>
<td>0°00'330&quot;</td>
<td>36.67</td>
<td>83.33</td>
<td>110.00</td>
</tr>
<tr>
<td>120</td>
<td>3°00'</td>
<td>0.695.81</td>
<td>0.96</td>
<td>60.00</td>
<td>0°00'540&quot;</td>
<td>0°00'330&quot;</td>
<td>0°00'360&quot;</td>
<td>40.00</td>
<td>100.00</td>
<td>120.00</td>
</tr>
<tr>
<td>130</td>
<td>3°15'</td>
<td>0.389.51</td>
<td>1.20</td>
<td>65.00</td>
<td>0°00'585&quot;</td>
<td>0°00'360&quot;</td>
<td>0°00'390&quot;</td>
<td>43.33</td>
<td>116.67</td>
<td>130.00</td>
</tr>
<tr>
<td>140</td>
<td>3°30'</td>
<td>0.207.56</td>
<td>1.44</td>
<td>70.00</td>
<td>0°00'630&quot;</td>
<td>0°00'390&quot;</td>
<td>0°00'420&quot;</td>
<td>46.67</td>
<td>133.33</td>
<td>140.00</td>
</tr>
<tr>
<td>150</td>
<td>3°45'</td>
<td>0.120.27</td>
<td>1.68</td>
<td>75.00</td>
<td>0°00'675&quot;</td>
<td>0°00'420&quot;</td>
<td>0°00'450&quot;</td>
<td>50.00</td>
<td>150.00</td>
<td>150.00</td>
</tr>
<tr>
<td>160</td>
<td>4°00'</td>
<td>0.061.14</td>
<td>2.00</td>
<td>80.00</td>
<td>0°00'720&quot;</td>
<td>0°00'450&quot;</td>
<td>0°00'480&quot;</td>
<td>53.33</td>
<td>166.67</td>
<td>160.00</td>
</tr>
<tr>
<td>170</td>
<td>4°15'</td>
<td>0.030.57</td>
<td>2.24</td>
<td>85.00</td>
<td>0°00'765&quot;</td>
<td>0°00'480&quot;</td>
<td>0°00'510&quot;</td>
<td>56.67</td>
<td>183.33</td>
<td>170.00</td>
</tr>
<tr>
<td>180</td>
<td>4°30'</td>
<td>0.017.62</td>
<td>2.48</td>
<td>90.00</td>
<td>0°00'810&quot;</td>
<td>0°00'510&quot;</td>
<td>0°00'540&quot;</td>
<td>60.00</td>
<td>200.00</td>
<td>180.00</td>
</tr>
<tr>
<td>190</td>
<td>4°45'</td>
<td>0.011.62</td>
<td>2.72</td>
<td>95.00</td>
<td>0°00'855&quot;</td>
<td>0°00'540&quot;</td>
<td>0°00'570&quot;</td>
<td>63.33</td>
<td>216.67</td>
<td>190.00</td>
</tr>
</tbody>
</table>

**Formula for Computing Deflection Angles $\alpha$ and $\Delta\alpha$**  

$\alpha = \frac{1}{2} l_1 \left(1 - l + l_2\right) + \frac{1}{6} a(l_1 - l_2)^2$  

$\Delta\alpha = \frac{1}{2} l_1 \left(1 - l + l_2\right) - \frac{1}{6} a(l_1 - l_2)^2$  

**Note:**  
For additional data and formulae related to the use of transition spirals refer to standard drawings No. D 3-1 & D 3-2 for super elevation D 2-3.  

**Transition Spiral Table for $\alpha = 2\frac{1}{2}$**

**Recommended for 50 M.P.H. Design Speed**

**Calculations made April 1931 by Lyle Middushima - Highway Designer**

**Traced by:** L.A.P.  
**Checked by:**  
**Approved by:**  
**3-10**

**Arizona State Highway Department Plans Division**

**Rev.**
### Tabulation of Spiral Functions as Related to \( k \) Set Up at T.S., When \( \alpha = 5 \)°

<table>
<thead>
<tr>
<th>Length from T.S. along Spiral in Feet</th>
<th>( R ) Circular Curvature in Feet</th>
<th>( D ) Cylindrical Curvature in Feet</th>
<th>( t ) in Feet</th>
<th>( \Delta t ) in Feet</th>
<th>( \Delta \alpha ) in Degrees</th>
<th>( \Delta \alpha ) Deflection from Point on Spiral ( t ) Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>0.15</td>
<td>11,459</td>
<td>1</td>
<td>0.975</td>
<td>10</td>
<td>0.9478</td>
</tr>
<tr>
<td>20</td>
<td>1°00</td>
<td>5,729</td>
<td>10</td>
<td>0.060</td>
<td>10</td>
<td>0.0681</td>
</tr>
<tr>
<td>30</td>
<td>2°00</td>
<td>3,818</td>
<td>15</td>
<td>0.036</td>
<td>10</td>
<td>0.0629</td>
</tr>
<tr>
<td>40</td>
<td>3°00</td>
<td>2,664</td>
<td>20</td>
<td>0.024</td>
<td>10</td>
<td>0.0586</td>
</tr>
<tr>
<td>50</td>
<td>4°00</td>
<td>2,291</td>
<td>25</td>
<td>0.020</td>
<td>10</td>
<td>0.0536</td>
</tr>
<tr>
<td>60</td>
<td>5°00</td>
<td>1,909</td>
<td>30</td>
<td>0.016</td>
<td>10</td>
<td>0.0489</td>
</tr>
<tr>
<td>70</td>
<td>6°00</td>
<td>1,637</td>
<td>35</td>
<td>0.012</td>
<td>10</td>
<td>0.0449</td>
</tr>
<tr>
<td>80</td>
<td>7°00</td>
<td>1,423</td>
<td>40</td>
<td>0.010</td>
<td>10</td>
<td>0.0415</td>
</tr>
<tr>
<td>90</td>
<td>8°00</td>
<td>1,273</td>
<td>45</td>
<td>0.008</td>
<td>10</td>
<td>0.0385</td>
</tr>
<tr>
<td>100</td>
<td>9°00</td>
<td>1,145</td>
<td>50</td>
<td>0.005</td>
<td>10</td>
<td>0.0359</td>
</tr>
<tr>
<td>110</td>
<td>10°00</td>
<td>1,041</td>
<td>55</td>
<td>0.002</td>
<td>10</td>
<td>0.0337</td>
</tr>
<tr>
<td>120</td>
<td>11°00</td>
<td>954</td>
<td>60</td>
<td>0.001</td>
<td>10</td>
<td>0.0317</td>
</tr>
<tr>
<td>130</td>
<td>12°00</td>
<td>881</td>
<td>65</td>
<td>0.001</td>
<td>10</td>
<td>0.0300</td>
</tr>
<tr>
<td>140</td>
<td>13°00</td>
<td>818</td>
<td>70</td>
<td>0.000</td>
<td>10</td>
<td>0.0285</td>
</tr>
<tr>
<td>150</td>
<td>14°00</td>
<td>763</td>
<td>75</td>
<td>0.000</td>
<td>10</td>
<td>0.0272</td>
</tr>
<tr>
<td>160</td>
<td>15°00</td>
<td>716</td>
<td>80</td>
<td>0.000</td>
<td>10</td>
<td>0.0260</td>
</tr>
<tr>
<td>170</td>
<td>16°00</td>
<td>674</td>
<td>85</td>
<td>0.000</td>
<td>10</td>
<td>0.0250</td>
</tr>
<tr>
<td>180</td>
<td>17°00</td>
<td>636</td>
<td>90</td>
<td>0.000</td>
<td>10</td>
<td>0.0241</td>
</tr>
<tr>
<td>190</td>
<td>18°00</td>
<td>603</td>
<td>95</td>
<td>0.000</td>
<td>10</td>
<td>0.0233</td>
</tr>
<tr>
<td>200</td>
<td>19°00</td>
<td>572</td>
<td>100</td>
<td>0.000</td>
<td>10</td>
<td>0.0228</td>
</tr>
<tr>
<td>210</td>
<td>20°00</td>
<td>545</td>
<td>105</td>
<td>0.000</td>
<td>10</td>
<td>0.0224</td>
</tr>
<tr>
<td>220</td>
<td>21°00</td>
<td>520</td>
<td>110</td>
<td>0.000</td>
<td>10</td>
<td>0.0220</td>
</tr>
<tr>
<td>230</td>
<td>22°00</td>
<td>498</td>
<td>115</td>
<td>0.000</td>
<td>10</td>
<td>0.0217</td>
</tr>
<tr>
<td>240</td>
<td>23°00</td>
<td>479</td>
<td>120</td>
<td>0.000</td>
<td>10</td>
<td>0.0214</td>
</tr>
<tr>
<td>250</td>
<td>24°00</td>
<td>460</td>
<td>125</td>
<td>0.000</td>
<td>10</td>
<td>0.0211</td>
</tr>
<tr>
<td>260</td>
<td>25°00</td>
<td>440</td>
<td>130</td>
<td>0.000</td>
<td>10</td>
<td>0.0209</td>
</tr>
<tr>
<td>270</td>
<td>26°00</td>
<td>424</td>
<td>135</td>
<td>0.000</td>
<td>10</td>
<td>0.0207</td>
</tr>
<tr>
<td>280</td>
<td>27°00</td>
<td>409</td>
<td>140</td>
<td>0.000</td>
<td>10</td>
<td>0.0205</td>
</tr>
<tr>
<td>290</td>
<td>28°00</td>
<td>394</td>
<td>145</td>
<td>0.000</td>
<td>10</td>
<td>0.0203</td>
</tr>
<tr>
<td>300</td>
<td>29°00</td>
<td>381</td>
<td>150</td>
<td>0.000</td>
<td>10</td>
<td>0.0201</td>
</tr>
</tbody>
</table>

### Formula for Computing Deflection Angles \( \alpha \) on Spiral Ahead and Back to Other Points on Spiral When \( k \) Set Up Is at a Point on Spiral \( \alpha \) and \( \Delta \alpha \) Angles Are Computed in Degrees and Decimal Parts

\[
\alpha = \frac{\pi}{180} \left( L_2 - L_1 \right) + \frac{\pi}{180} \left( L_2 - L_1 \right)^2
\]

\[
\Delta \alpha = \frac{\pi}{180} \left( L_2 - L_1 \right) - \frac{\pi}{180} \left( L_2 - L_1 \right)^2
\]

---

**Note:**
- For additional data and formulas related to the use of transition spirals, refer to standard drawings No. D-3-1 & D-3-2.
- For super-elevation, refer to D-2-1 & D-2-2.

**Arizona State Highway Department Plans Division**

**Transition Spiral Table for \( \alpha = 5 \)°**

**Recommended for 40 MPH Design Speed**

**Calculated Drawn April 1974**

**By Leslie W. Smith, Highway Designer**

**Standard Drivng No.**

**Traced by L. M. D.**

**Approved by Deputy Highway Commissioner**

---

**D 3-12**
<table>
<thead>
<tr>
<th>Transition Spiral Table For</th>
<th>ARIZONA STATE HIGHWAY DEPARTMENT</th>
<th>TRANSITION SPIRAL TABLE FOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q = Rate of Increase in Degrees of Curvature Per 100 Feet on Spiral</td>
<td>C = Long Good X 90°/C = Long Good X 90°</td>
<td>C = Long Good X 90°/C = Long Good X 90°</td>
</tr>
<tr>
<td>D = G = Cumulating Degree of Curvature on Spiral Beginning at Point T</td>
<td>D = G = Cumulating Degree of Curvature on Spiral Beginning at Point T</td>
<td>D = G = Cumulating Degree of Curvature on Spiral Beginning at Point T</td>
</tr>
<tr>
<td>TRANSITION Q = 10</td>
<td>TRANSITION Q = 10</td>
<td>TRANSITION Q = 10</td>
</tr>
<tr>
<td>[ \alpha = \frac{1}{2} \left( \beta - \frac{1}{2} \right) \left( \frac{1}{\rho} - \frac{1}{\rho_0} \right) ]</td>
<td>[ \alpha = \frac{1}{2} \left( \beta - \frac{1}{2} \right) \left( \frac{1}{\rho} - \frac{1}{\rho_0} \right) ]</td>
<td>[ \alpha = \frac{1}{2} \left( \beta - \frac{1}{2} \right) \left( \frac{1}{\rho} - \frac{1}{\rho_0} \right) ]</td>
</tr>
</tbody>
</table>
DRAWING SHOWING APPLICATION OF STD. D5-1, DRIVeway ARRANGEMENTS POSSIBLE IN THE CASE OF A MULTIPLE SERVICE STATION.
**DIAGONAL PARKING**

**PARALLEL PARKING**

**3 TRAFFIC LANES**
200 TO 300 VEHICLES PER HOUR

**4 TRAFFIC LANES**
OVER 300 VEHICLES PER HOUR

**2 TRAFFIC LANES**
UNDER 200 VEHICLES PER HOUR

---

**NOTE:**

- THE MINIMUM DIMENSIONS SHOWN ON THIS DRAWING ARE FOR DIFFERENT CONDITIONS OF PARKING AND TRAFFIC LANES. THEY MUST NOT BE CONSTRUED AS DESIRABLE IN THE LIGHT OF MODERN DESIGN STANDARDS BUT RATHER AS MINIMUM REQUIREMENTS FOR EXISTING FACILITIES, TYPICAL OF URBAN DEVELOPMENTS.
- PARKING LANE WIDTHS AND SPACES SHOWN HERE ARE BASED ON MINIMUM REQUIREMENTS FOR PASSENGER VEHICLES AND CONFORM TO A.A.S.H.O. POLICY.

---

**ARIZONA STATE HIGHWAY DEPARTMENT**

**PLANS DIVISION**

**PARKING ON STATE HIGHWAYS**

DRAWN AND TRACED MAY 15, 1941

CHECKED BY:

APPROVED BY:

ENGINEER OF PLANS:

D 6-1
STANDARD NOTATIONS FOR STRUCTURES

STRUCTURES
(Over 20' Clear Span)
Sta. _______ to Sta. _______
New Conc. BOX Bridge Culvert (Sk. __ LT.)
(NO. SPANS) (WIDTH) (HEIGHT) (LENGTH) Rdwy.
See Bridge Sheet(s) & Standard(s)

Sta. _______ to Sta. _______
New CONG. Bridge, __ Cl. Rdwy.
See Bridge Sheet(s) & Standard(s)

Sta. _______ to Sta. _______
In Place _____ Rdwy.
See Bridge Sheet(s) & Standard(s)

STRUCTURES
(20' Clear Span or Less)
Sta. _______ (Sk. __ LT.)
New Conc. BOX Bridge Culvert
(NO. SPANS) (SIZE) (HEIGHT) (LENGTH)
Standard(s)

Sta._______
Conc. Bridge Culvert In Place
Extend Lt. _____ Extend Rt. ______
See Bridge Sheets & Standard(s)

PIES
Sta. _______ (Sk. __ LT.)
New C.M.P. Culvert (SIZE) (LENGTH)
(Hdwl(s), Std. _________

Sta._______
New Cattle Guard _______ Grill Units
Standard _________

FT. ROAD GUARD
Standard _________

Sta. _______ to Sta. _______
Remove ( & Reset at Sta. _______
New _______ Culvert (SIZE) (LENGTH)
(Hdwl(s), Std. _________

Sta._______
NO. SIZE LENGTH C.M.P. Culv. In Place
To Remain (Remove Headwalls)
New Ext. Lt., Ext. Rt. ______
(Hdwl(s), Std. _________

FORDS
Sta. _______ to Sta. _______
New Ford ____ Ft. Long
Standard _________

MISCELLANEOUS

Use No. 6 Guide Lines

ARIZONA HIGHWAY DEPARTMENT
PLANS DIVISION

STRUCTURE NOTATIONS

DRAWN CH CHECKED AP PROVED PLAN NO.
Feb 1946 Feb 1946
D7-2

REV.
<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATE OR NATIONAL LINE</td>
<td>COUNTY LINE</td>
</tr>
<tr>
<td>TOWNSHIP OR RANGE LINE</td>
<td>SECTION LINE</td>
</tr>
<tr>
<td>QUARTER SECTION LINE</td>
<td>FOREST OR RESERVATION LINE</td>
</tr>
<tr>
<td>HWY. RIGHT OF WAY LINE</td>
<td>TRANSIT OR SURVEY LINE</td>
</tr>
<tr>
<td>PROFILE GRADE LINE</td>
<td>PROFILE GROUND LINE</td>
</tr>
<tr>
<td>LAND SURVEY CORNERS</td>
<td>TELEPHONE OR TELEGRAPH LINE</td>
</tr>
<tr>
<td>POWER LINE</td>
<td>TRAFFIC SIGN</td>
</tr>
<tr>
<td>ROAD GUARD</td>
<td>GUIDE POSTS</td>
</tr>
<tr>
<td>STANDARD FENCE (BARB. WIRE)</td>
<td>SPECIAL FENCE (FABRIC, WIRE)</td>
</tr>
<tr>
<td>CORR. METAL CULVERTS</td>
<td>REINFORCED CONCRETE CULVERTS</td>
</tr>
<tr>
<td>BRIDGES</td>
<td>CATTLE GUARD</td>
</tr>
<tr>
<td>RIGHT OF WAY MARKER</td>
<td>EXISTING PAVEMENT</td>
</tr>
<tr>
<td>RAILROAD TRACK</td>
<td>TREES AND SHRUBS</td>
</tr>
<tr>
<td>DIKE OR LEVEE</td>
<td>CHANNEL OR DITCH</td>
</tr>
<tr>
<td>UNFENCED PROPERTY</td>
<td>RETAINING WALL</td>
</tr>
<tr>
<td>DROP INLET</td>
<td>GUY POLE</td>
</tr>
<tr>
<td>BANK PROTECTION</td>
<td>RAILROAD WARNING SIGN</td>
</tr>
<tr>
<td>SIDE ROAD TURNOUT</td>
<td>MANHOLE</td>
</tr>
<tr>
<td>SURVEY MON. COVER</td>
<td>NEW MIX. BIT. SURFACE</td>
</tr>
<tr>
<td>NEW P.C. CONCRETE</td>
<td>RELAID SALV. M.B. SURFACE</td>
</tr>
<tr>
<td>AGGREGATE BASE</td>
<td>COARSE</td>
</tr>
<tr>
<td>FINE</td>
<td>SELECT MATERIAL</td>
</tr>
</tbody>
</table>