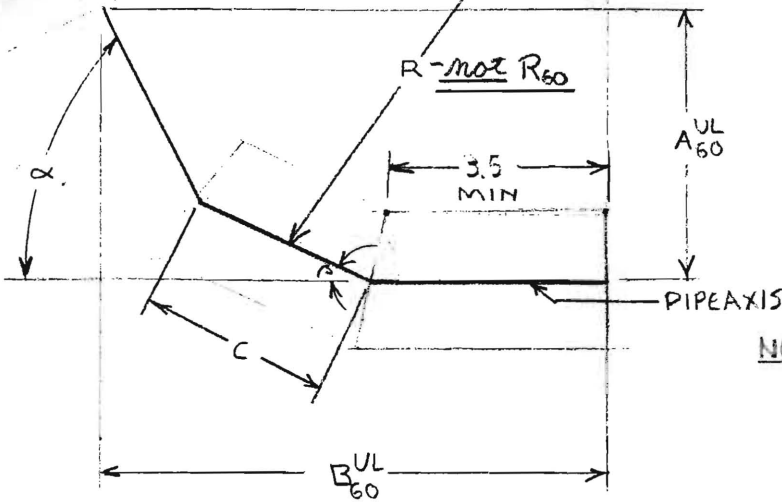


10/9/02

60° EB DEVELOPMENT

FIG. 1



angles are degrees unless noted.

α = NOMINAL ANGLE (E.G. 60°) angle from straight

$\beta = \alpha/2$

PROBLEM: TRY TO USE MIDDLE LEG LENGTH FROM 90° ELBOW ON 60° ELBOW (DEFINED BY UL DRAWING). MUST HAVE 3.5 MIN. LEG TO MANUFACTURE PART.

NEED: ID, TYPE, ANGLE (α)

the following dimensions are UL MINIMUM. finished pipe must be larger.

TYPE S, A, N

$$A_{60} = .25(ID) + 4.8$$

$$B_{60} = .434(ID) + 8.293$$

A & B equations were derived from UL drawings which give min. dimensions (+6, -0).

TYPE D

$$A_{60} = .25(ID) + 5.8$$

$$B_{60} = .433(ID) + 10.044$$

R will become irrelevant when using C_{90} from 90° ELBOW.

may use 60° for 46-60, and use 90° dim for 61-90°.

TYPE B & V

$$A_{60} = .25(ID) + 6.35$$

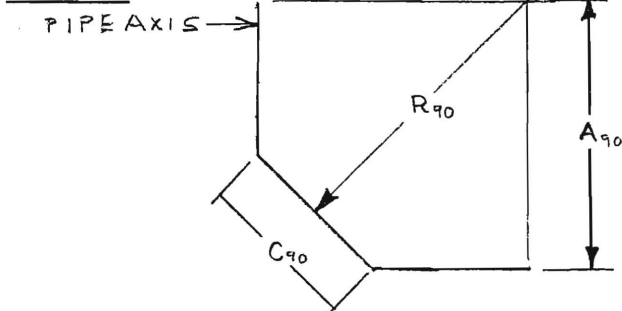
$$B_{60} = .433(ID) + 11.005$$

pos. open up 90° and see if it fits UL def. geom. for 60°

first, try to use same C value as the 90° elbow. see if fits constraints. (C_{90})

90° ELBOW

FIG. 2



NEED: TYPE & ID. (arguments).

TYPE A, S, N.

$$A = (ID/2) + 7$$

(below called A_{90})

$$R = (ID/2) + 7.83$$

(below called R_{90})

TYPE B

$$A = (ID/2) + 9$$

$$R = (ID/2) + 10.66$$

CONT'D

(CONT'D)

TYPE D

$A = (10/2) + 10$

$R = (10/2) + 12.07$

TYPE V

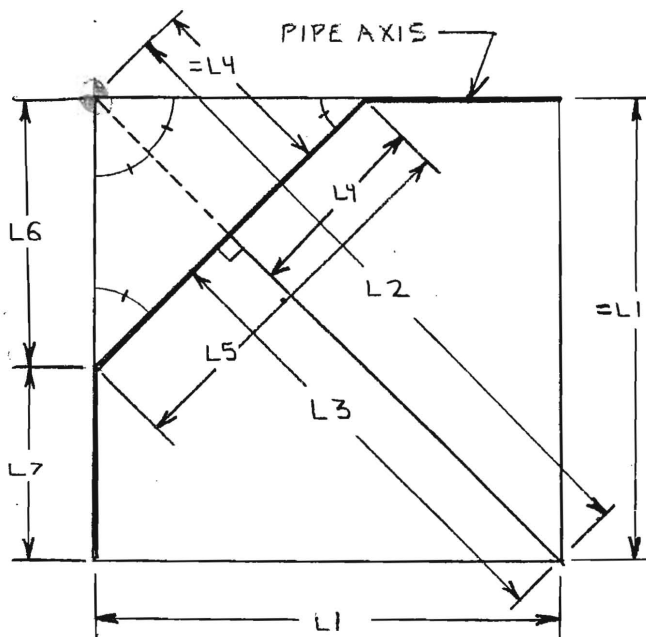
$A = (10/2) + 8$

$R = (10/2) + 8.83$

dimension C_{90} generalized for all types:

$C_{90} = 2(A_{90} (1/\cos(45)) - R_{90})$ from L5 below:

FIG. 3



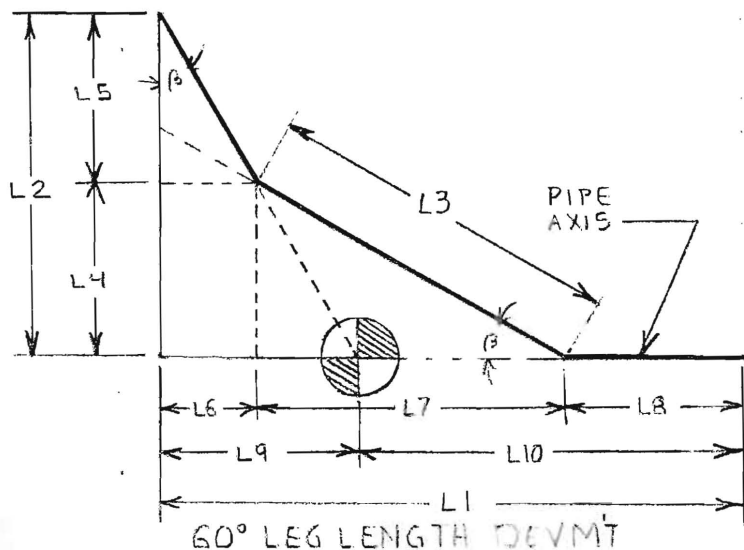
- $L1 = \text{GIVEN} = A_{90}$ see above
- $L2 = L1 (1/\cos(45))$
- $L3 = \text{GIVEN} = R_{90}$ see above
- $L4 = L2 - L3$
- $\rightarrow L5 = 2(L4)$ this is C_{90}
- $L6 = L4 (1/\cos(45))$
- $L7 = L1 - L6$

note: can use $\sec(\theta) = 1/\cos(\theta)$ if available.

90° ELBOW DIMENSIONAL DEVMT.

we now have A_{90} , R_{90} , & C_{90} . need to build 60° EB using C_{90} for the middle leg.

FIG. 4



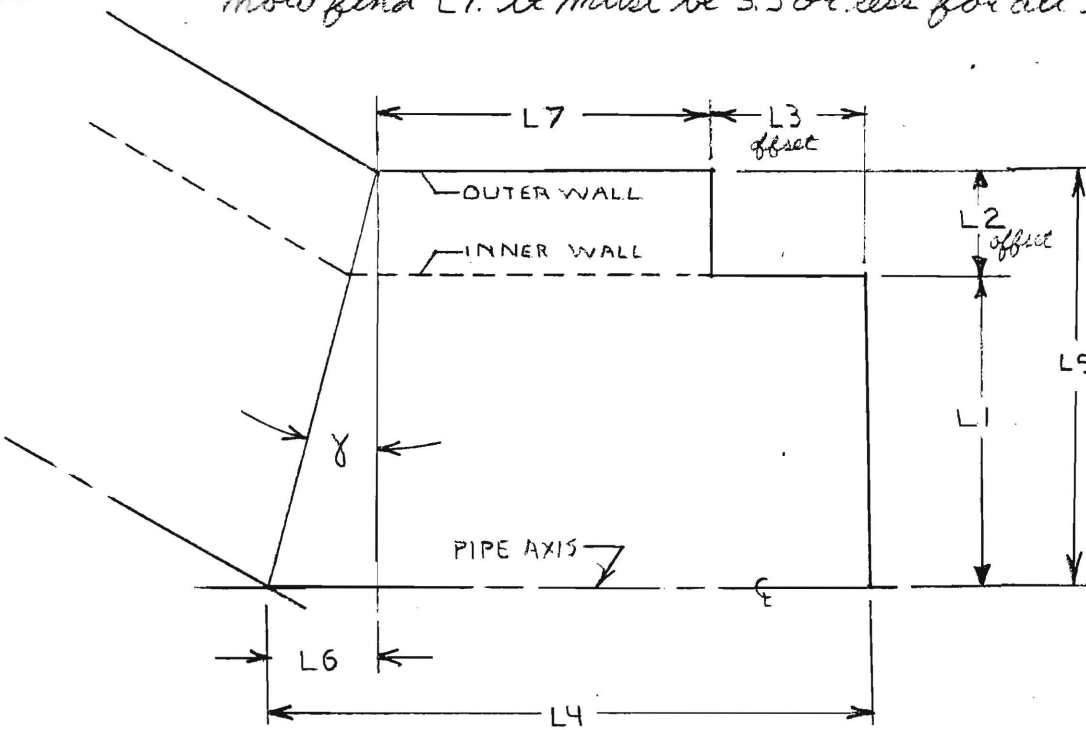
- $L1 = \text{GIVEN} = B_{60}$ see above
- $L2 = \text{GIVEN} = A_{60}$ see above
- $L3 = \text{GIVEN} = C_{90}$ see above
- $L4 = L3 (\sin(\beta))$ [$\beta = \text{see above}$]
- $L5 = L2 - L4$
- $L6 = L5 (\tan(\beta))$
- $L7 = L3 (\cos(\beta))$
- $L8 = L1 - L7 - L6$

10/10/02

CONT'D

FIG.5

now find L7. it must be 3.5 or less for all types



- $L1 = ID/2$
- $L2 = \text{BY TYPE:}$
 - A = 1.0
 - B = 2.0
 - D = 4.0
 - N = 0.0
 - S = 1.0
 - V = 1.5
- $L3 = \text{BY TYPE:}$
 - A = .850
 - B = .850
 - D = .850
 - N = 0.0
 - S = .850
 - V = 2.40

- $L4 = \text{GIVEN} = \text{FIG.4, } L8$
- $L5 = L1 + L2$
- $L6 = L5 (\tan(\gamma))$
- $L7 = L4 - L3 - L6$

center leg should be ok because it was used in 90°, which is lighter.

middle wall on triple wall is ok if outer wall is.

RESULT: • FAILS IN ALL CASES. (SEE SPREADSHEET).

- CANNOT USE 90° ELBOW DIMS. FOR 60° ELBOW (W/UL CONSTRAINED).
- MUST HAVE ELBOW FOR 45°-60° (UL LISTED) (NEW 60° DIMS) *see below*
- & AN ELBOW 60°-90°. (NOT UL LISTED) (OLD 90° DIMS (2 DIFFERENT ELBOWS, 1 UL 1 NOT UL))

REMEDY: • FOR ANGLES 46°-60°, MAKE NEW ELBOW.

- MUST KEEP 3.5 MIN. DIM,
- MUST KEEP UL DWG. A₆₀ & B₆₀ *see P1.*

• FOR ANGLES 61°-90°, USE OLD 90° DIMS + ONLY OPEN ANGLE UP. (KEEP LEG LENGTH).

first, develop 60° elbow w/ new constraints:

60° ELBOW (TO MAKE 45°-60° ELBOWS)

- ~~USE A60 & B60 FROM P1~~ over constrains geom.
- ~~MAINTAIN 3.50 MIN. LEG LENGTH.~~ (S.P.I. models assume this ±.020)
- ~~USE B60 FROM P1~~
- USE A60 & B60 & R60 All FROM S.P.I. (MODELS USED FOR UL DRAWINGS.)

A60 = SEE P.1
 B60 = SEE P.1
 R60 = BY TYPE:
 A = ID/2 + 7
 B = ID/2 + 8
 D = ID/2 + 9
 N = ID/2 + 7
 S = ID/2 + 7
 V = B

"R", according to S.P.I., is the radius of the circle that is tangent to the centerline of the gorges.

VIZ:

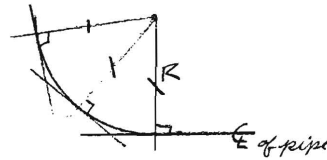


FIG. 6

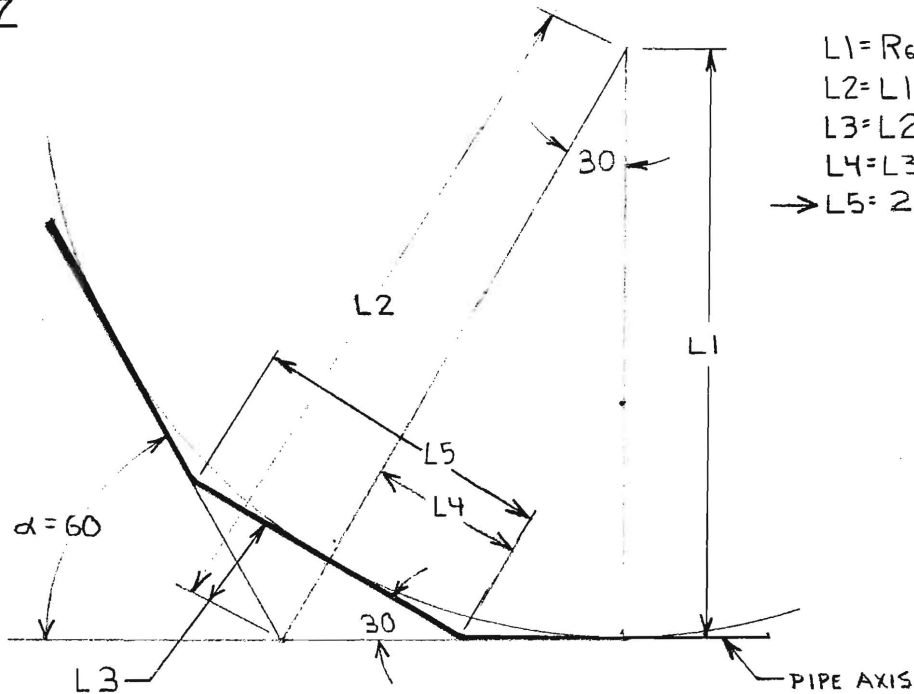
use type "B"? YES

10/15/02

FIRST, FIND LEG LENGTHS. USE ONLY 60° α FOR LENGTHS.

will later find start/end points that will vary with angle, will not vary leg lengths w/ angle.
 this method takes a 60° elbow and "opens" it up, keeping lengths (45°-60°)

MIDDLE LEG:
FIG. 7

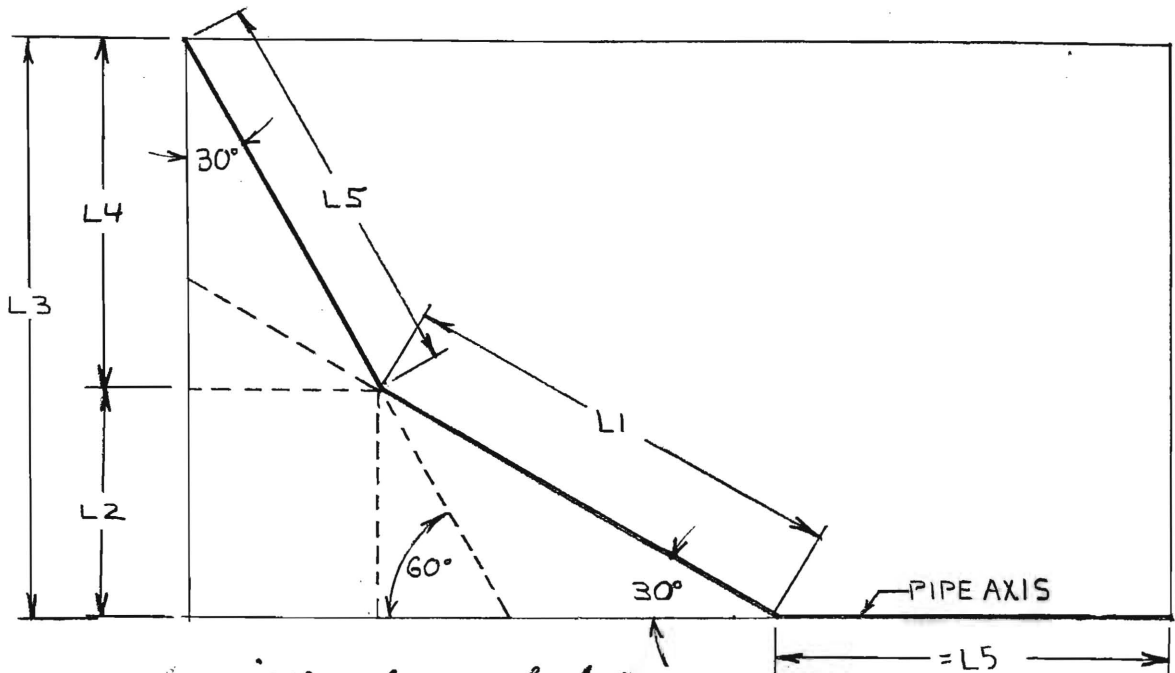


L1 = R60 see above (this page).
 L2 = L1 / COS(30) see NOTE 1
 L3 = L2 - L1
 L4 = L3 / TAN(30)
 → L5 = 2(L4) middle leg

NOTE 1: USE 60° α FOR LENGTHS.

↓ CONT'D

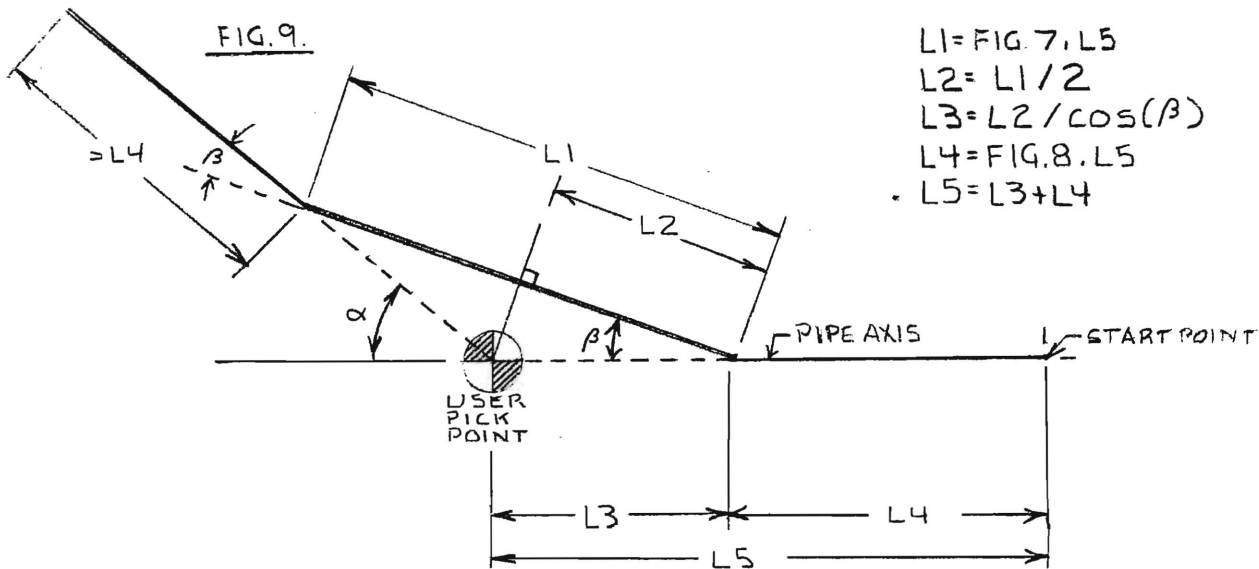
FIG. 8
LEGS 1 & 2 (SAME LENGTH).



use 60° angle to calculate lengths.

$L1 = \text{FIG. 7, } L5$
 $L2 = L1 \sin(30)$
 $L3 = A \cos \theta \text{ see p.1}$
 $L4 = L3 - L2$
 $\rightarrow L5 = L4 / \cos(30) \text{ leg length}$

NOW THAT WE HAVE LEG LENGTHS, FIND START POINT TO DRAW ELBOW.



$L1 = \text{FIG. 7, } L5$
 $L2 = L1 / 2$
 $L3 = L2 / \cos(\beta)$
 $L4 = \text{FIG. 8, } L5$
 $L5 = L3 + L4$

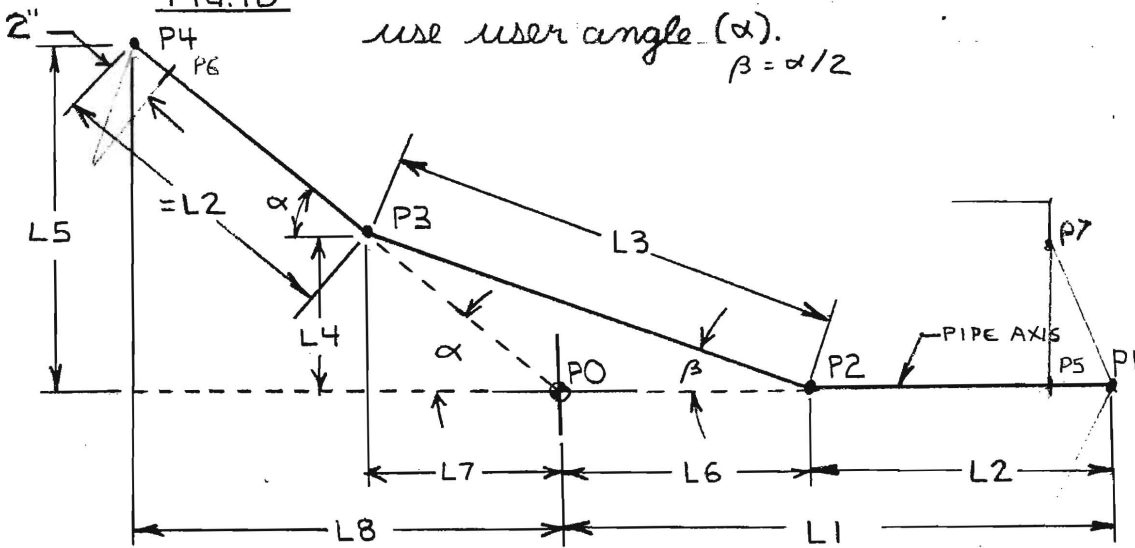
$\alpha = \text{ANGLE FROM STRAIGHT}$
 $\beta = \alpha / 2$
 (use user angles to get points)

↓ CONT'D

FIND POINTS TO PLOT PIPE AXIS.

FIG.10

use user angle (α).
 $\beta = \alpha/2$



$$\begin{aligned} L1 &= \text{FIG. 9}, L5 \\ L2 &= \text{FIG. 9}, L4 \\ L3 &= \text{FIG. 9}, L1 \\ L4 &= L3(\sin(\beta)) \\ L5 &= L4 + L2(\sin(\alpha)) \\ L6 &= L1 - L2 \\ L7 &= L3(\cos(\beta)) - L6 \\ L8 &= L5 / \tan(\alpha) \end{aligned}$$

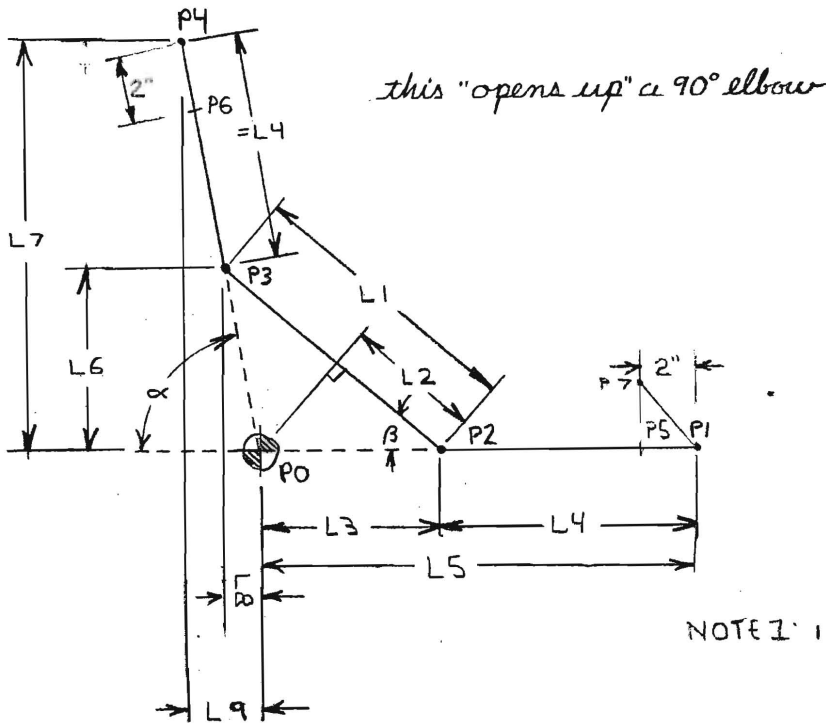
- P0 = USER PICK POINT
- P1 = L1, 0
- P2 = L6, 0
- P3 = L7, L4
- P4 = L8, L5
- P5 = (L1 - 2), 0
- P6 = (L8 - 2(\cos(\alpha)), L5 - 2(\sin(\alpha)))
- P7 = (L1 - 2), 10/2

90° ELBOW (TO MAKE 61°-90° ELBOWS) (adjustable 90°).

ALREADY HAVE LENGTHS (FIG. 3, P2).

FIND POINTS TO PLOT PIPE AXIS.

FIG. 11



this "opens up" a 90° elbow

$$\begin{aligned} L1 &= \text{FIG. 3}, L5 \\ L2 &= L1 / 2 \\ L3 &= L2 / \cos(\beta) \\ L4 &= \text{FIG. 3}, L7 \\ L5 &= L3 + L4 \\ L6 &= L1(\sin(\beta)) \\ L7 &= L6 + L4(\sin(\alpha)) \\ L8 &= L1(\cos(\beta)) - L3 \\ L9 &= L7 / \tan(\alpha). \text{ see note 1} \end{aligned}$$

- P0 = USER PICK POINT.
- P1 = L5, 0
- P2 = L3, 0
- P3 = L8, L6
- P4 = L9, L7
- P5 = (L5 - 2), 0

NOTE 1: IF $\alpha = 90$, $L9 = 0$.
 $P6 = (L9 - 2(\cos(\alpha)), (L7 - 2(\cos(\alpha)))$
 $P7 = (L5 - 2), 10/2$

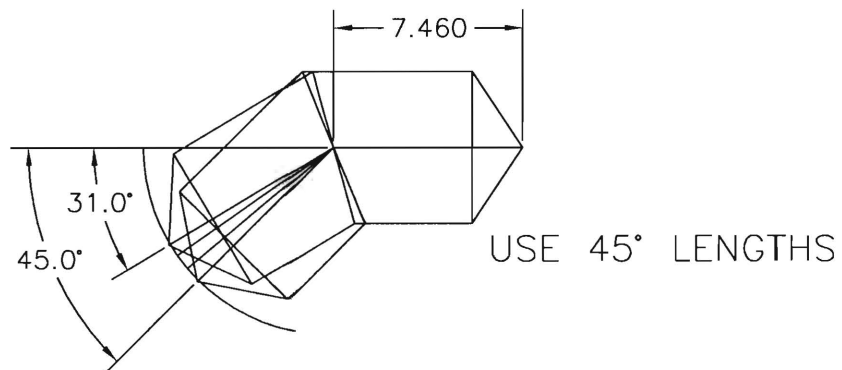
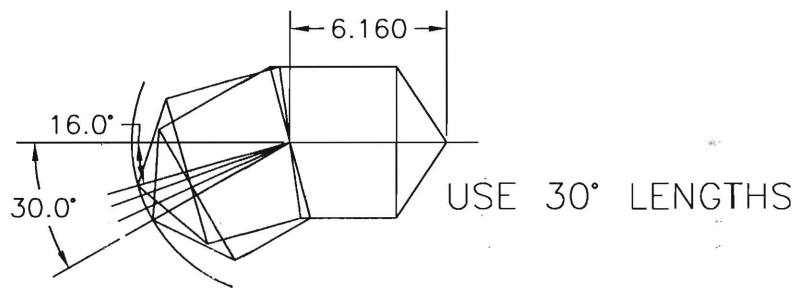
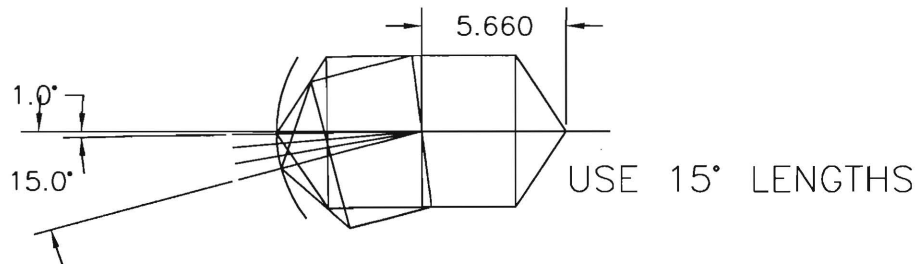
SUMMARY:

- 1°-15° ELBOWS - USE 15° LENGTHS
- 16°-30° ELBOWS - USE 30° LENGTHS
- 31°-45° ELBOWS - USE 45° LENGTHS
- 46°-60° ELBOWS - USE 60° LENGTHS
- 61°-90° ELBOWS - USE 90° LENGTHS.

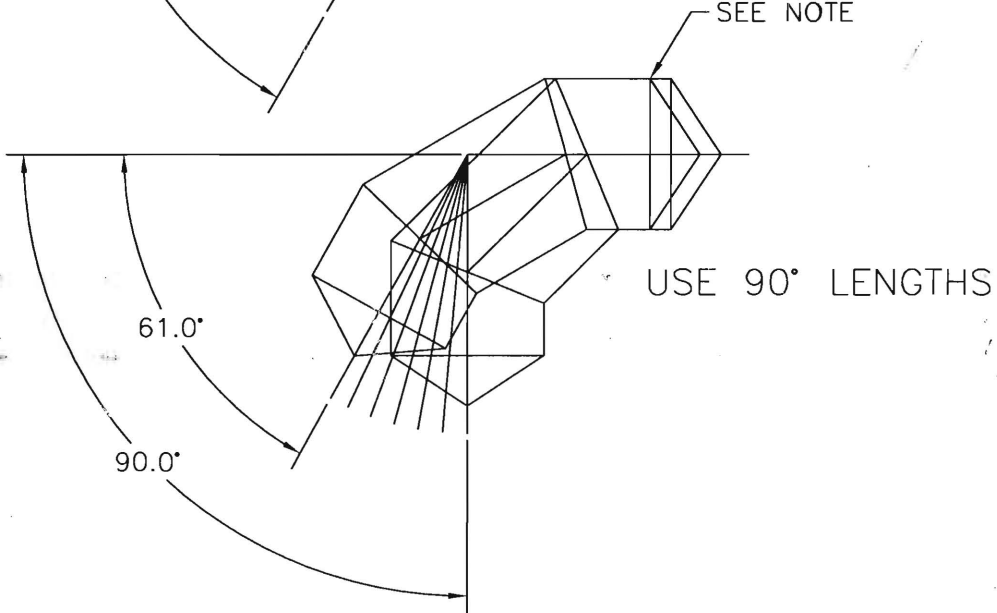
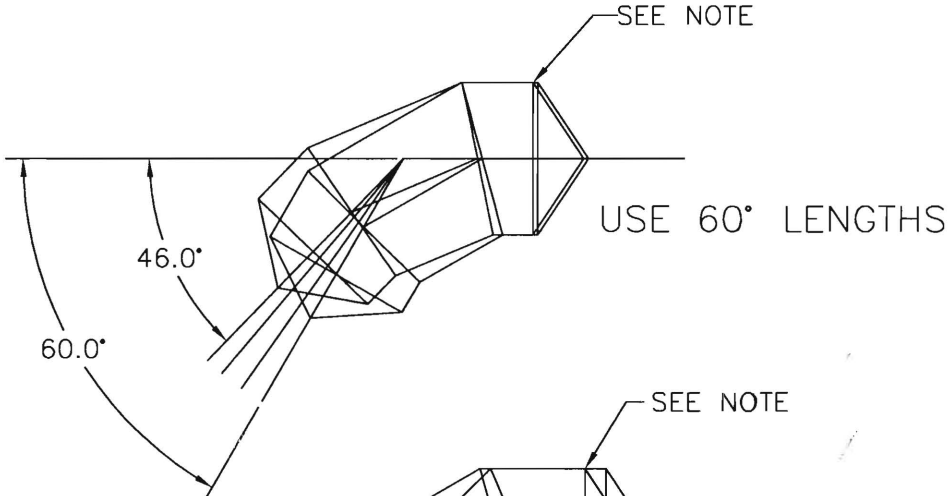
note: 2 gore elbows do not need special development.

see above
 see above

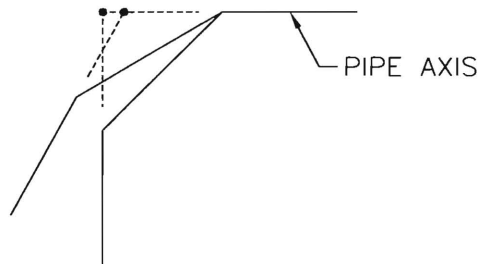
2 GORE ELBOWS



3 GORE ELBOWS



NOTE: FOR 3 GORE ELBOWS, LENGTHS REMAIN THE SAME, BUT WHEN ANGLE CHANGES, CENTER POINT CHANGES TOO.




```

(defun c:eb()(c:elbow))
(defun c:elbow(/ bp xd yd ans d a b typ rholdmode)
  (setq attnote nil)
  (setq rholdmode (getvar "osmode"));RH ADDED 080801
  (if (c:setampco)
    (progn
      (command "undo" "be")

      (command "point" "0,0,0")
      (setq ucsent (entlast))
    ; (command "ucs" "w")
      (setq bpt (getpoint "\nSelect Base point:"))
      (setlpt bpt)
      (setq xd (trans (setq xdt (getpoint bpt "\nSelect X direction:")) 1 0)
      )
      (setq yd (trans (setq ydt (getpoint bpt "\nSelect Y direction:")) 1 0)
      )
      (setq bp (trans bpt 1 0))
      (if vdia
        (progn
          (setq ans (getint (strcat "\nWhat is Dia?<" (rtos vdia 2 2) ">")))
          (if (/= ans nil)(setq d ans)(setq d vdia))
        )
        (setq d (getint "\nWhat is Dia?"))
      )
      (setq ans
        (strcase
          (substr
            (getstring (strcat "\nReset vent dia to" (itoa d) "?"))
            1 1)
          )
        )
      (if (= ans "Y")(setq vdia d)
      ; (setq ans (getint (strcat "\nWhat is branch Dia?<" (itoa(fix d)) ">")))
      ; (if (/= ans nil)(setq d2 ans)(setq d2 d))
        (setq oldmode (getvar "osmode"))
        (setvar "osmode" 0)
        (command "ucs" "3" bpt xdt ydt);align ucs with user pick points
        (setvar "osmode" oldmode)

;RH101602 Decide what the working angle is
        (setq SpecialYN "")
        (while (and (/= typ 90)(/= typ 120)(/= typ 135)(/= typ 150)(/= typ 165)
        )(/= (strcase SpecialYN) "Y"))
        (setq typ (rtd (angle (trans bp 0 1) (trans yd 0 1))))
        (princ "\nAngle<")(princ (- 180 typ))
        (setq ans (getreal ">:"))
        (if ans (setq typ (- 180 ans)))
        (if (and (/= typ 90)(/= typ 120)(/= typ 135)(/= typ 150)(/= typ 165))
          (progn
            (setq SpecialYN (getstring "Non-standard angle. \nDo you want to create a special elbow? Y,N <Y>: "))
            (if (= SpecialYN "") (setq SpecialYN "Y"))
          )
        )
      )
      )
;RH101602 If we are working with a special angle, we need to round it to
the nearest degree
;and pick a nominal angle to get lengths from.

```

