GTE LENKURT ELECTRIC (CANADA) LTD.

DATE: APRIL 17, 1978

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PROVISIONAL PROCESS SPECIFICATION & CHANGE NOTICE

SPECIFICATION TITLE

BEND ALLOWANCES & BLANK DEVELOPMENT (SHEET METAL)

DESCRIPTION:

To standardize the methods of computing the bend allowance and subsequently the blank development of sheet metal parts

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CHANGES / REASONS:

CROSS REFERENCE:

RES 13455

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SUBJECT: BEND ALLOWANCES & BLANK DEVELOPMENT (SHEET METAL)

PURPOSE: To standardize the methods of computing the bend allowances and subsequently the blank development of sheet metal parts.

1. GENERAL

1.1 When bending sheet metal, some allowance must be made for the material required for each bend. The length of "equivalent straight" stock (bend allowance) must be computed for each bend and added to the straight sections to obtain the total length (developed length) of the material before bending. The required bend allowance is dependent on the thickness and nature of the material and the bend radius. The applicable basic fomulas are given below for different classifications of materials.

a. For 90° bends in, soft copper, and soft brass:

$$\text{Bend allowance (BA)} = (0.55 \times T) + (1.57 \times R)$$

b. For 90° bends in half-hard brass and half hard copper aluminum:

$$\text{Bend allowance (BA)} = (0.64 \times T) + (1.57 \times R)$$

c. For 90° bends in cold rolled steel and stainless steel:

1.2 For "Angles of Bend" other than 90°, calculate the bend allowance for 90° and multiply by the required angle divided by 90. The "Angle of Bend" is defined as the angle through which the material is to be bent, not necessarily that angle specified on the drawing.

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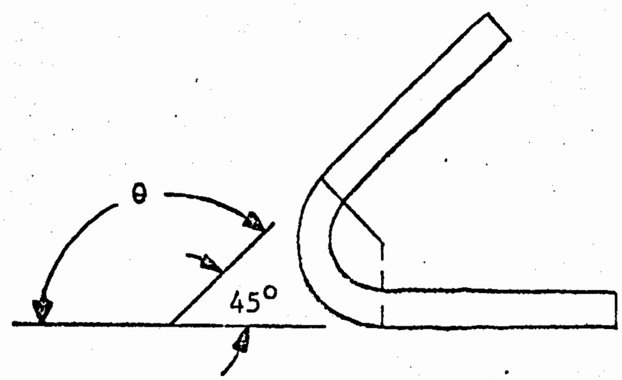

EXAMPLE:

$\theta = 135^{\circ}$

$BA_{\theta} = BA \times \frac{135}{90}$

1.3 The abbreviations employed in this process specification are defined as follows:

D.L.	Developed Length
B.A.	Bend Allowance (90°Bend)
T	Material Thickness (as specified on the RM specification)
R	Bend Radius (if specified as a fraction, R must be taken to the nearest .001" for calculation purposes).
B.A.θ	Bend Allowance (for bends other than 90°bends).
A, B,	Outside dimensions of part

1.4 Three methods of computing Developed Lengths for 90° bends which will produce identical results are provided in this technical standard. In every case, the fomulae for Developed Length are given by:

a. Methods 1 & 2:

$$D.\ L. = (A + B) - (2T + 2R) + BA$$

b. Method 3:

$$D.\ L. = (A + B) - 2T + C$$
where $C = BA - 2R$

1.5 Refer to the Machinists Handbook (13th Edition or later) for radii and material thickness dimensions not provided in this technical standard. If the tables or formula from the Machinists Handbook are employed, the same procedures as specified in this process specification shall apply.

2. PROCEDURE

2.1 90° Bends

a. The following example (Figure 2) is illustrated for the three approved methods of calculation:

.1 90° Bends con't

Example:

a. Material 18ga cold-rolled steel (.048)

b. Bend Radius: 1/16" (.062)

c. Bend Angle: 90°

Note:

Radius is taken to nearest .001" and thickness (.048) conforms to RM specification.

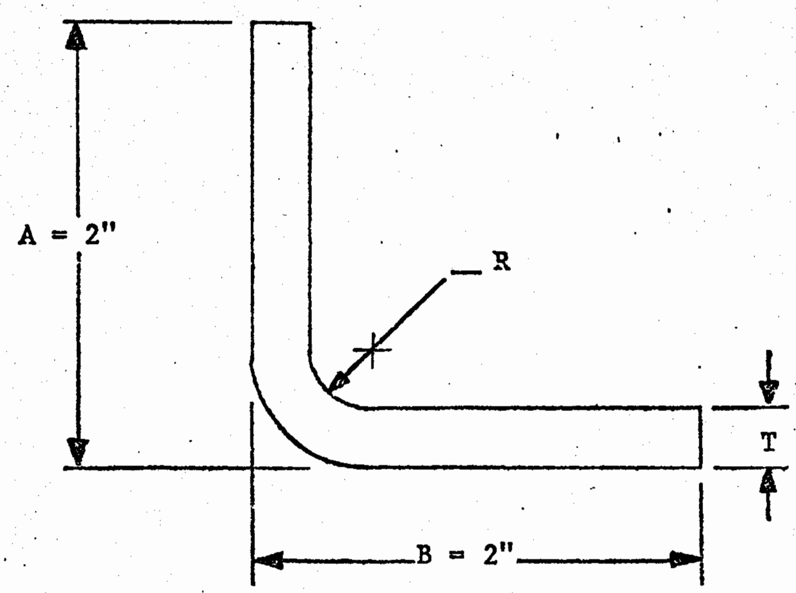

FIG. 2

Method 1:

The bend allowance is calculated directly from one of the three basic formula This method is applicable to any given radius and material thickness. It, therefore, should always be used when the specified thickness and radius on the drawing differs from those shown in the tables.

2.1 Method 1: con't

Application:

Applying the basic fomula for cold-rolled steel, we have:-

BA = (0.71 x T) + (1.57 x R)

= 0.71 x .048 + 1.57 x .062

= .034 + .097

= 0.131 Bend Allowance

Substituting into the formula for developed length:-

DL = (A + B) - (2T + 2R) + BA

= (2 + 2) - (2 (.048) + 2 (.062)) + .131

DL = 3.910 ins.

Method 2:

This method is essentially identical to Method 1, except that the bend allowance figures have been tabulated for a range of material thickness and bend radii. There is one table for each of the three basic material classifications. These tables should only be used when the specified radius on the drawing is identical to that radius shown in the tables. In addition, the material thickness per RM specificaton must be employed in conjunction with the table and it may be necessary to interpolate:

Application:

From Table 3 for cold-rolled steel, we find BA - .131 (for .048 material, 1/16 radius). Substituting into the formula for developed length:-

DL = (A + B) - (2T + 2R) + BA

= (2 + 2) - (2 (.048) + 2 (.062)) + .131

DL = 3.910 ins.

Method 3:

This is the simplest method available as the developed length can be calculated directly from the tabulated constants. However, it should be emphasized that this method is applicable to 90^{o} bends only. Again, where the specified material thickness and radius on the drawing differ from those shown in the

2.1 Method 3: con't

tables, it may be necessary to employ the basic formula (Method 1). Since, this method is more convenient, it is recommended for all applications where possible. The tables have been tabulated to cover the material thickness and radii now in general use.

Note: The constant C may be a minus quantity in certain applications.

Application:

From the table for cold-rolled steel, .048 thick and 1/16 radius, we have:-

C = + .006

Substituting into the formula for developed length:

DL = A + B - 2T + C where C = BA - 2R

= 2 + 2 - .096 + .006

DL = 3.910 ins.

2.2 Offsets (Joggles)

a) General

Due to lack of detail on most drawings and lack of definition in the forming of offsets on small sheet metal parts the standard methods for predetermining developed length cannot be applied. While it is possible by employing detailed mathematics to calculate this length accurately for all radii, thicknesses and offsets it is more practical to lay a few ground rules and employ a simple formula. The term "offset" as it is applied here indicates an amount less than the sum of twice the radius plus one thickness of material otherwise standard bend allowance formulas can be used.

b) Formula

DL = A + B + T + O+ 10% (T+O)

To implement this formula apply the following abbreviations to the sketch illustrated below.

A = Required flat proportion indicated on drawing.
B = F = (A+C)
C = T + 2R (If not indicated on drawing)
F = Finished size indicated on drawing

2.2 b) Formula con't

O = Offset indicated on drawing
R = Radius = 1/2 offset. (If not indicated on drawing)
T = Material thickness indicated on drawing
DL = Developed length

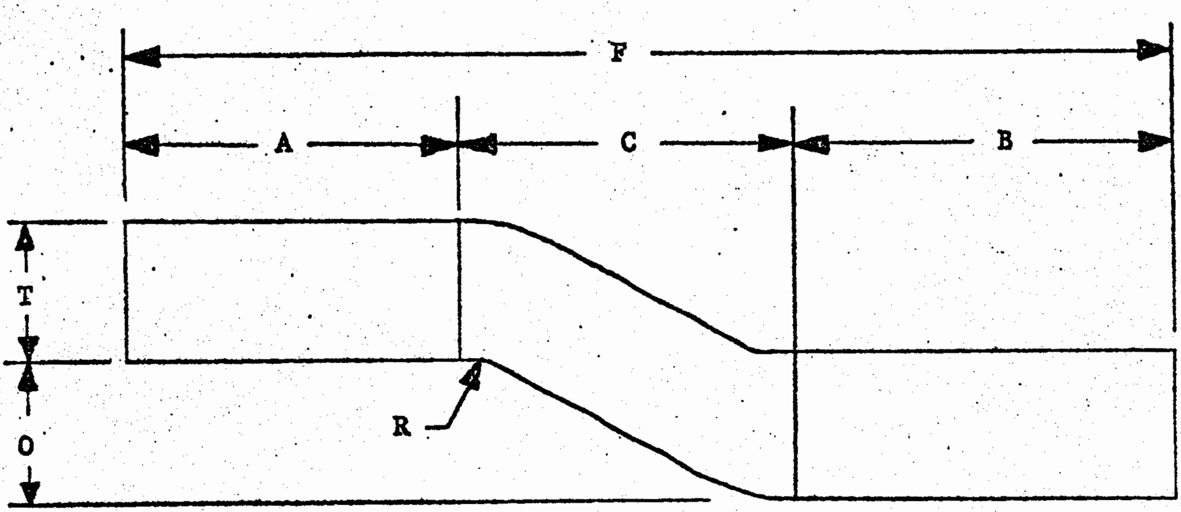

FIG. 3

As noted above the radius must be equal to half the offset as an increase or decrease in this dimension results in an equivalent increase or decrease in the bend allowance for the average offset.

If used as indicated, the above formula is accurate within .005". If greater accuracy is required use standard mathematical processes.

Example:

Substitute known Quantities:

A = .375
F = 1.250
T = .075
O = .062
R = .031
C = .075 + .062 = .137
B = 1.250 - (.375 + .137) = .738
DL = .375 + .738 + .075 + .062 + .014 = 1.264

2.3 Bend Allowance For Sharp Bends

Less than 1/64" radius

Here again the standard formulas previously discussed cannot be applied. In this case the developed length is determined by computing the length along the neutral plane. For details and examples see pages 15 and 16.

TABLE 1: BEND ALLOWANCE TABLE FOR METHOD NO. 2 (SOFT COPPER & SOFT BRASS)

RADIUS R OF BEND, INCHES	THICKNESS T OF MATERIAL, INCH								
	1/64	1/32	3/64	1/16	5/64	3/32	1/8	5/32	3/16
1/32	0.058	0.066	0.075	0.083	0.092	0.101	0.118	0.135	0.152
3/64	0.083	0.091	0.100	0.108	0.117	0.126	0.143	0.160	0.177
1/16	0.107	0.115	0.124	0.132	0.141	0.150	0.167	0.184	0.201
3/32	0.156	0.164	0.173	0.181	0.190	0.199	0.216	0.233	0.250
1/8	0.205	0.213	0.222	0.230	0.239	0.248	0.265	0.282	0.299
5/32	0.254	0.262	0.271	0.279	0.288	0,297	0.314	0.331	0.348
3/16	0.303	0.311	0.320	0.328	0.337	0.346	0.363	0.380	0.397
7/32	0.353	0.361	0.370	0.378	0.387	0.396	0.413	0.430	0.447
1/4	0.401	0.409	0.418	0.426	0.435	0.444	0.461	0.478	0.495

NOTE: Approximations cannot be used. The dimension for "RADIUS" must always be taken to the nearest .011" and the dimension for "THICKNESS" must agree with the RM Specification.

TABLE 2: BEND ALLOWANCE TABLE FOR METHOD NO. 2 (HALF-HARD SHEET COPPER, HALF-HARD BRASS SOFT STEEL & ALUMINIUM)

RADIUS R OF BEND, INCHES	THICKNESS T OF MATERIAL, INCH								
	1/64	1/32	3/64	1/16	5/64	3/32	1/8	5/32	3/16
1/32	0.059	0.069	0.079	0.089	0.099	0.109	0.129	0.149	0.169
3/64	0.084	0.094	0.104	0.114	0.124	0.134	0.154	0.174	0.194
1/16	0.108	0.118	0.128	0.138	0.148	0.158	0.178	0.198	0.218
3/32	0.157	0.167	0.177	0.187	0.197	0.207	0.227	0.247	0.267
1/8	0.260	0.216	0.226	0.236	0.246	0.256	0.276	0.296	0.316
5/32	0.255	0.264	0.275	0.285	0.295	0.305	0.325	0.347	0.365
3/16	0.304	0.314	0.324	0.334	0.344	0.354	0.374	0.394	0.414
7/32	0.354	0.364	0.374	0.384	0.394	0.404	0.424	0.444	0.464
1/4	0.402	0.412	0.422	0.432	0.442	0.452	0.472	0.492	0.512

NOTE: Approximations cannot be used. The dimension for "RADIUS" must always be taken to the nearest .001" and the dimension for "THICKNESS" must agree with the RM Specification.

TABLE 3: BEND ALLOWANCE TABLE FOR METHOD NO. 2 (STAINLESS STEEL, COLD ROLLED STEEL)

RADIUS R OF BEND, INCHES	THICKNESS T OF MATERIAL, INCH								
	1/64	1/32	3/64	1/16	5/64	3/32	1/8	5/32	3/16
1/32	0.060	0.071	0.082	0.093	0.104	0.116	0.138	0.160	0.182
3/64	0.085	0.096	0.107	0.118	0.129	0.141	0.163	0.185	0.207
1/16	0.109	0.120	0.131	0.142	0.153	0.165	0.187	0.209	0.231
3/32	0.158	0.169	0.180	0.191	0.202	0.214	0.236	0.258	0.280
1/8	0.207	0.218	0.229	0.240	0.251	0.263	0.285	0.307	0.329
5/32	0.256	0.267	0.278	0.289	0.300	0.312	0.334	0.356	0.378
3/16	0.305	0.316	0.327	0.338	0.349	0.361	0.383	0.405	0.427
7/32	0.355	0.366	0.377	0.388	0.399	0.411	0.433	0.455	0.477
1/4	0.403	0.414	0.425	0.436	0.447	0.459	0.481	0.503	0.525

NOTE: Approximations cannot be used. The dimension for "RADIUS" must always be taken to the nearest .001" and the dimension for "THICKNESS" must agree with the RM Specification.

TABLE 4: CONSTANT TABLES FOR METHOD NO. 3

MATERIAL	GAUGE	THICKNESS	RADIUS	CONSTANT	IBM NUMBER
COPPER	20 oz.	.027	1/32	+.004	101-03127-01
1/2	24	.032	1/32	+.007	-03132-01
HARD	16	.065	1/32	+.029	-03362-85
	16	.065	1/16	+.014	-85

TABLE 4 (A)

STEEL	26	.020	1/32	+.001	101-02192-13
C.R.S.	24	.025	1/32	+.004	-12
	22	.032	1/32	+.009	-10
	20	.036	1/32	+.013	-09
	20	.036	3/64	+.004	-09
	18	.048	1/32	+.020	-04
	18	.048	3/64	+.013	-04
	18	.048	1/16	+.006	-04
	16	.060	1/32	+.031	-06
	16	.060	3/64	+.024	-06
	16	.060	1/16	+.017	-06
	14	.075	1/32	+.040	-05
	14	.075	3/64	+.033	-05
	14	.075	1/16	+.026	-05
	14	.075	3/32	+.013	-05
	13	.090	1/16	+.037	-02
	13	.090	3/32	+.024	-02

TABLE 4 (B)

TABLE 4 (B) con't

MATERIAL	GAUGE	THICKNESS	RADIUS	CONSTANT	IBM NUMBER
STEEL	13 oz.	.090	1/8	+.010	101-02192-02
	14	.104	1/16	+.044	
C.R.S.	11	.120	1/16	+.058	
	11	.120	3/32	+.045	
	11	.120	1/8	+.031	
	1/8	.125	1/8	+.035	102-00217-55

NOTE: Approximations cannot be used. The dimension for "RADIUS" must always be taken to the nearest .001 and the dimension for "THICKNESS" must agree with the RM Specification.

C = BA - 2R

CONSTANT TABLES FOR METHOD NO.3

MATERIAL	GAUGE	THICKNESS	RADIUS	CONSTANT	IBM NUMBER
ALUMINUM	24 oz.	.020	1/32	-.001	101-01520-01
	20	.032	1/32	+.007	-06
	18	.040	1/32	+.011	-07
	16	.050	1/32	+.018	-02
	14	.063	1/32	+.026	-03
	14	.063	1/16	+.013	-03
	14	.063	1/8	-.014	-03
	13	.074	1/32	+.025	
	12	.080	1/32	+.037	-04
	12	.080	1/16	+.023	-04
	12	.080	1/8	-.003	-04
	1/8	.125	1/32	+.065	101-01795-01
	1/8	.125	1/16	+.053	-01
	1/8	.125	3/32	+.041	-01
	1/8	.125	1/8	+.026	-01
	11	.090	1/32	+.039	
	11	.090	1/16	+.026	
	11	.090	3/32	+.013	

CONSTANT TABLES FOR METHOD NO.3 con't

NOTE: Approximations cannot be used. The dimension for "RADIUS" must always be taken to the nearest .001 and the dimension for thickness must agree with the RM Specification.

TABLE 4 (C)

MATERIAL	GAUGE	THICKNESS	RADIUS	CONSTANT	IBM NUMBER
BRASS	22 oz.	.025	1/32	+.003	101-04300-05
1/2	20	.032	1/32	+.007	-02
HARD	18	.040	1/32	+.012	-03
	18	.040	3/64	+.005	-03
	14	.046	1/32	+.029	-04
	14	.064	3/64	+.020	-04
	14	.064	1/16	+.013	-04
	11	.094	1/16	+.033	-07
	1/8	.125	1/16	+.053	101-71815-01
	1/8	.125	3/32	+.040	-01
	3/16	.187	3/32	+.080	-02
	3/16	.187	1/8	+.066	-02

TABLE 4 (D)

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MATERIAL	GAUGE	THICKNESS	RADIUS	CONSTANT	IBM NUMBER
STAINLESS	24 oz.	.025	1/32	+.004	101-02450-09
STEEL	20	.036	1/32	+.013	-02
	18	.048	1/32	+.020	-03
	18	.048	3/64	+.013	-03
	16	.060	1/32	+.031	-06
	16	.060	3/64	+.024	-06
	16	.060	1/16	+.017	-06
		.075	3/64	+.034	
	13	.090	3/64	+.044	-04
	13	.090	1/16	+.037	-04
	13	.090	3/32	+.024	-04
	11	.120	1/16	+.058	-05
	11	.120	3/32	+.045	-05
	11	.120	1/8	+.031	-05
	3/16	.188	3/32	+.093	-07
	3/16	.188	1/8	+.079	-07

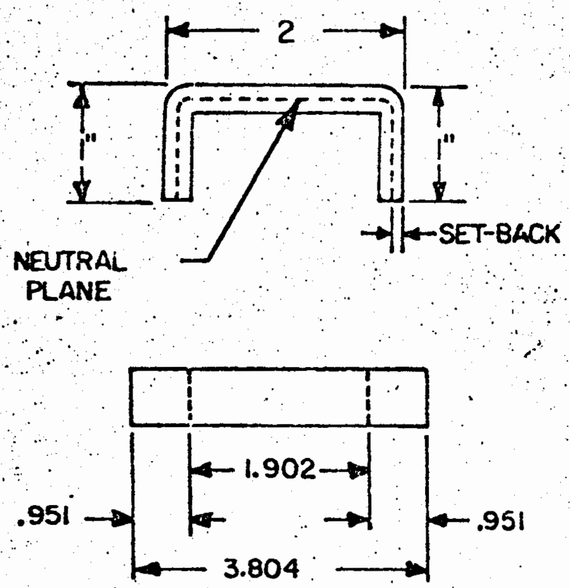
NOTE: Approximations cannot be used. The dimension for "RADIUS" must always be taken to the nearest .001 and the dimension for "THICKNESS" must agree with the RM Specification.

TABLE 4 (E)

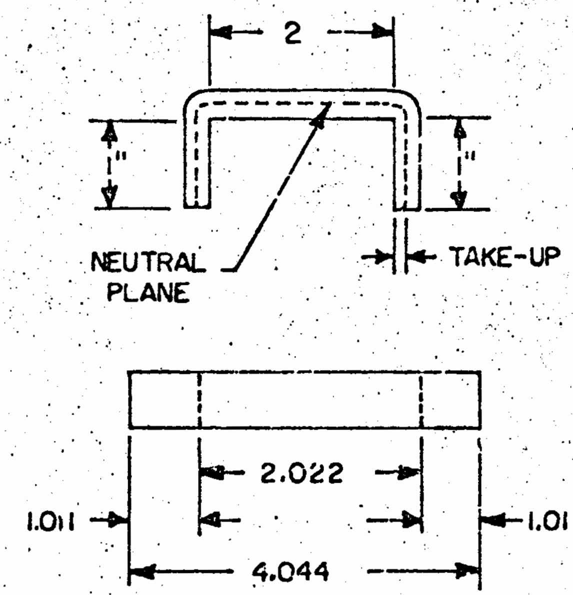
SHARP BENDS LESS THAN 1/64 RADIUS

EXAMPLES: 060 C.R.S., .049 SET-BACK, .011 TAKE-UP, NO RADIUS.

OUTSIDE DIMENSIONS



INSIDE DIMENSIONS



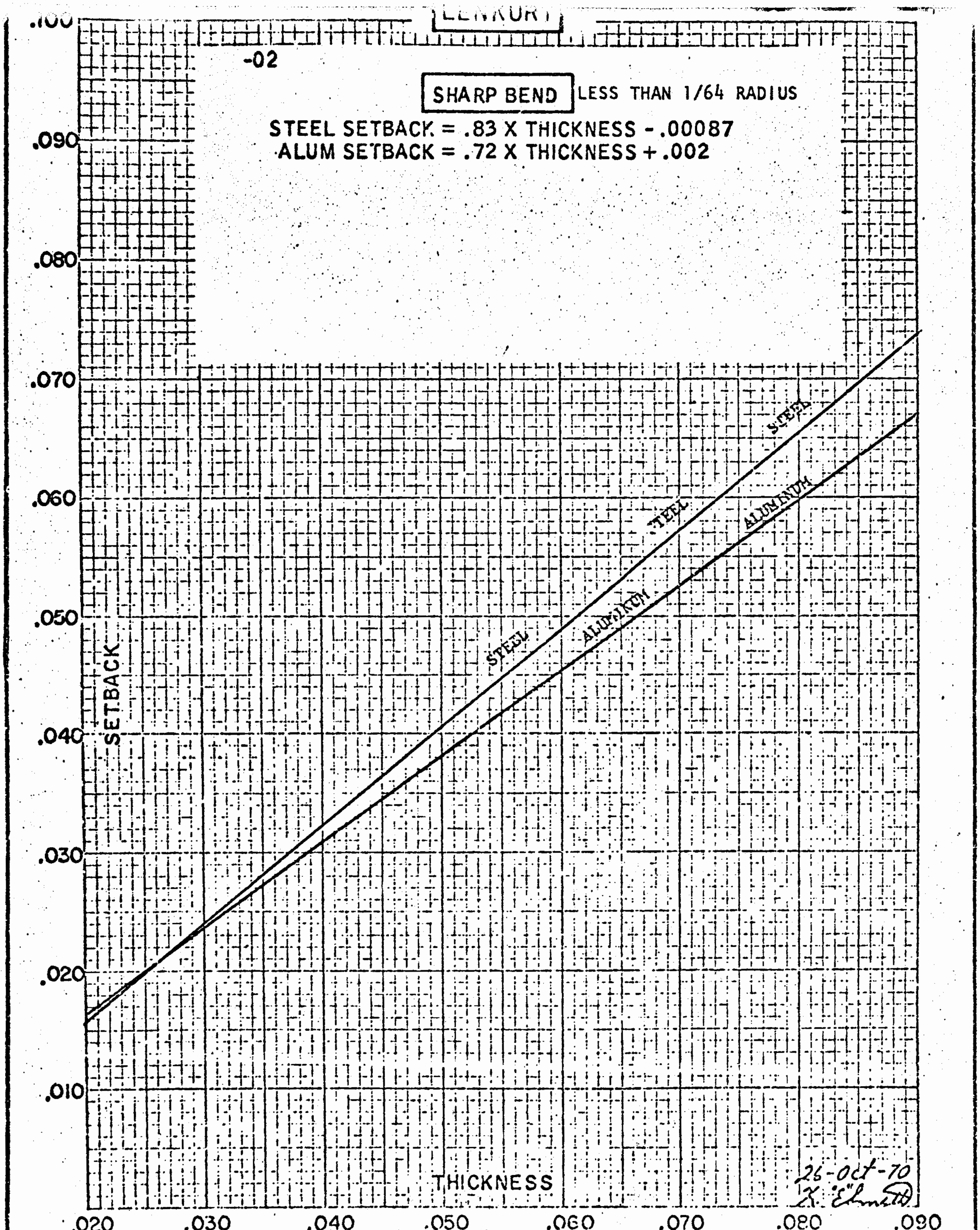
NEUTRAL PLANE: THEORETICAL POINT WHICH NEITHER STRETCHES OR COMPRESSES.

SET-BACK: APPROXIMATELY 80% OF MATERIAL THICKNESS FROM OUTSIDE FACE OF BEND TO NEUTRAL PLANE. SET-BACK IS SUBTRACTED FROM DIMENSION.

TAKE-UP: APPROXIMATELY 20% OF MATERIAL THICKNESS FROM INSIDE FACE OF BEND TO NEUTRAL PLANE. TAKE-UP IS ADDED TO DIMENSION.

SOLUTIONS TO EXAMPLES:

1" −.049 = .951	1" +.011 = 1.011
2" −2(.049) = 1.902	2" +2(.011) = 2.022
1" −.049 = .951	1" +.011 = 1.011
3.804 DEVELOPED LENGTH	4.044 DEVELOPED LENGTH



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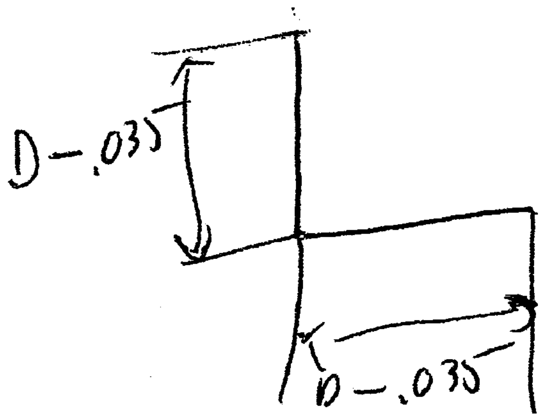
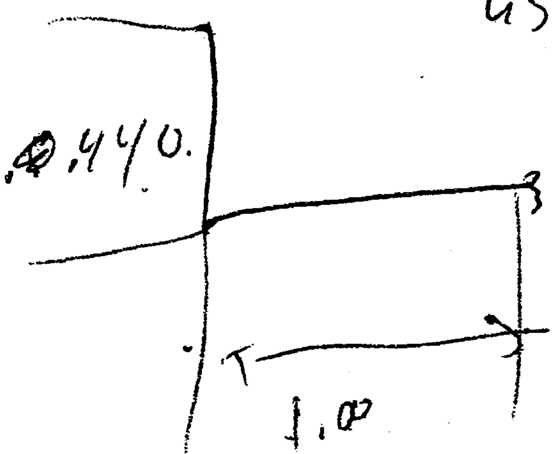


TO make 90° Bend
and have both sides
correct cut

metal -.060- .040. short
- measure edge .035 short

Using lip reference



for - .440 lip + 1 side
cut 1.370-1.380
metal