Inspections, Compliance, Enforcement, and Criminal Investigations

Circular Temperature Recording Chart Measurements

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DEPT. OF HEALTH, EDUCATION, AND WELFARE PUBLIC HEALTH SERVICE FOOD AND DRUG ADMINISTRATION *ORA/ORO/DEIO/IB*	**Date: 2/20/87 Number: 45 Related Program Areas: All Programs**

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ITG SUBJECT: CIRCULAR TEMPERATURE RECORDING CHART MEASUREMENTS

INTRODUCTION

Circular temperature recording charts are used in a broad variety of firms from food canneries to medical device manufacturers to drug manufacturers. Investigators currently use draftman's dividers to measure chord (straight line, point-to-point) instead of arc (curve) distances to check process time. There is no easy way to measure arcs in investigational work. Firms also use dividers or stamped metal gauges to do the same chord measurements. When an investigator wants to set dividers to a 25 minute chord, for instance, he/she normally checks the setting by spanning 2 (on charts with 10 minute markings) or 3 (on charts with 15 minute markings) estimated 25 minute chords to come up with an even marked time (50 and 75 minutes on 10 and 15 minute marked charts, respectively). He/she repeats the process until successful. Once the dividers come up on the even markings, the investigator assumes the dividers are properly set. However, estimating odd times such as 13, 19, or 23 minutes is difficult using this method.

In addition to the previous problem, a one minute time difference is only about 0.014 inch on a typical Taylor OP524 chart. Introducing a 0.014 inch error by making 15 spans or misstamping a gauge is easy to envision.

Another problem is the extreme difficulty in extrapolating times from known chord lengths. An investigator cannot calculate a 17 minute chord distance accurately, given either longer (20, 30 minutes) or shorter (10, 15 minutes) chord distances, because of the simple fact that two chords representing shorter times (i.e., 10 minutes each) have a combined length longer than a 20 minute chord.

These chord problems are compounded when a firm uses different process temperatures, handles multiple products and/or containers, or uses different temperature recording charts.

COMPUTER-CALCULATED CHORDS

The geometry for determining the arc or chord length of a circle is shown in Appendix 1. A computer can be used to generate reference tables of chord lengths related to times for any circular recording chart at any temperature. An investigator only needs to know: (1) the number of hours on the chart, and (2) the diameter of the circle for the particular temperature desired. Geometric theory is based on the fact that a radius bisecting a chord creates two equal right triangles.

APPLICATION

It is suggested that personnel modify the attached computer programs which were written in Microsoft BASIC. Program Listing 1, written for a Tandy 200 laptop portable computer, is compatible on most microcomputers. Program Listing 2 was written for a TRS-80 Model 1 computer. Both programs should run on IBM-PCs unchanged (except possibly for adding spaces where required by GWBASIC). The programs can be adapted to any district computer by knowledgeable personnel. Test the resultant programs by using values from a 24 hour Taylor OP600 chart. The diameter of a circle for 240 degrees F is 7.929 inches. Results should be 0.017299 for 1 minute, 0.034596 for 2 minutes, 0.051895 for 3 minutes, 0.172970 for 10 minutes, and 2.052180 for 120 minutes. Program Listing 2 can be used to print reference tables while Program Listing 1 is primarily a demonstration program. The most useful application of the programs would be to develop reference tables and maintain them in EI files. Once a blank chart is collected and expected

process temperatures are run through Program Listing 2, the resultant tables (similar to Table 1 attached) can be kept in EI files and photocopies can be taken to inspection sites. Another possible application is to take laptop computers to inspection sites. A computer used in conjunction with a dot matrix printer can also generate chord gauges on paper similar to the metal gauges made in cannery machine shops.

Questions about the geometric theory or computer programming can be addressed to DEIO/IB, (301)443-3340.

CIRCLE DIAGRAM [4]

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(image size 11KB)[6]

Appendix 1. Geometric Theory (Diagram not available)

1. An isosceles triangle is formed by connecting a chord (C) with the center of a circle. Call (A) the angle in the center of the circle.
2. A line through the center of the circle, perpendicular to the chord, bisects the chord and its arc.
3. Since the bisecting line is perpendicular to the chord, each half of the original triangle is a right triangle.
4. Each right triangle formed above has a small angle equal to A/2 Let A/2 = a.
5. Therefore Sin a = C/2 divided by the radius (R) or, Sin a = C/2R = C/D where D is the diameter of the circle.
6. Solving for the chord, C = D Sin a. The chord represents the time which the investigator measures with dividers.
7. We want to make chord values equal to minutes. It is simplest to standardize on the fact that there are 360 degrees in a circle. If we assign one minute equal one degree to angle A and its chords, there are 720 angle a's (degrees) in the circle. Thus, we create a formula where a (minutes) = a (degrees) divided by 2, or more apprpriately t (minutes) = a (degrees)/2.
8. We must also consider a factor to correct different chart values to minutes because while there are 360 minutes on a 6 hour chart, there are 720 minutes on a 12 hour chart and 1440 minutes on a 24 hour chart. From these figures, factor F = 6/H where H is the number of hours on the chart.
9. Combining the above two formulas, t (minutes) = a (degrees) 1/2. Placing this in step 6 above, we get chord = diameter Sin (3t/H) or C = D Sin (3t/H). This is the formula used in Program Listings 1 and 2.

Program Listing 1

```
1 REM DARRELL LEE, SALT LAKE CITY RESIDENT POST FTS 588-5285
10 DIM C(360): K = .0174533: CLS : REM DIMENSIONS VARIABLES,
INSERTS RADIAN CORRECTION FACTOR (K)
100 INPUT "Enter chart name and number"; CH$
110 INPUT "Enter no. hours on chart"; H
120 F = H / 3: REM F IS CORRECTION FACTOR
130 INPUT "Enter target temperature for chord lengths"; TE
140 PRINT "Enter diameter of"; TE; : INPUT " degree circle
    in inches or millimeters"; D
150 IF D > 15 THEN M$ = "millimeter" ELSE M$ = "inch"
160 INPUT "Is this correct (y/n)"; A$
170 IF LEFT$(A$, 1) = "y" OR LEFT$(A$, 1) = "Y" THEN 200 ELSE 100
200 PRINT "Table of times with corresponding chord lengths
    for a(n) "; CH$;
    " chart at "; TE; " degrees (a"; D; M$; " diameter circle)."
210 PRINT : PRINT "Minutes ";
220 IF M$ = "millimeter" THEN S$ = "s" ELSE S$ = "es"
230 PRINT M$; S$: PRINT
```

```
240 FOR T = 1 TO 120 STEP 4
250 FOR TT = T TO T + 3
260 C(TT) = D * SIN(K * TT / F)
270 NEXT TT
280 PRINT T; C(T): PRINT T + 1; C(T + 1): PRINT T + 2;
    C(T + 2): PRINT T + 3; C(T + 3)
290 NEXT T
```

Program Listing 2

```
10 ' REPORT CHART PLANNER
20 ' RUNS ON RADIO SHACK TRS-80 COMPUTER. MODIFY FOR OTHER COMPUTERS
NOT USING MICRSOFT BASIC.
30 CLEAR 2000 35 LPRINT CHR$(3): REM PRINTER COMMAND RESETS PAGE
40 DIM C(360): K = .0174533:
   A$ = "### ###.###### ### ###.###### ### ###.
   ###### ### ###.###### ### ###.######"
50 ' K = RADIAN CORRECTION FACTOR. NOT USED IF COMPUTER CALUCULATES
SINE USING DEGREES.
60 CLS
70 FOR I = 1 TO 8: PRINT : NEXT I
80 PRINT "********** RETORT CHART PLANNER        **********"
90 FOR I = 1 TO 500: NEXT: FOR I = 1 TO 6: PRINT : NEXT I
100 PRINT "        ***** DARRELL LEE                  ****"
110 PRINT "        * 2073 E. GYRFALCON DR.            *"
120 PRINT "        * SANDY. UT 84092                  *"
130 PRINT "        * SALT LAKE CITY RESIDENT POST     *"
140 PRINT "        * ROOM 1033 ADMINISTRATION BLDG.   *"
150 PRINT "        * 1745 WEST 1700 SOUTH             *"
160 PRINT "        * SALT LAKE CITY. UT 84104         *"
170 PRINT "        *********************************"
180 PRINT : PRINT
190 FOR I = 1 TO 1000: NEXT I
200 INPUT "ENTER RETORT CHART MANUFACTURER'S NUMBER
    (IE. TAYLOR OP 524)"; O$
210 INPUT "ENTER NUMBER OF HOURS ON RETORT CHART (6,12,24)"; H
220 F = H / 3
260 INPUT "ENTER TARGET TEMPERATURE FOR CHORD LENGTHS"; TE
270 PRINT "ENTER DIAMETER OF"; TE; : INPUT "DEGREE CIRCLE
    IN INCHES OR MILLIMETERS"; D
280 IF D > 15 THEN M$ = "MM. ": GOTO 300
290 M$ = "INCH " 300 LPRINT "TABLE OF TIMES WITH CORRESPONDING
    CHORD LENGTHS FOR A(N) ": LPRINT
310 LPRINT O$:' CHART AT";TE; "DEGREES (A";D;M$;"DIAMETER CIRCLE)":LPRINT
320 LPRINT "FOR ADDITIONAL CUSTOM MADE DATA TABLES CONTACT
DARRELL LEE AT SALT LAKE CITY RESIDENT POST.": LPRINT : LPRINT : LPRINT
330 FOR T = 1 TO 120 STEP 4
340 FOR TT = T TO T + 3
350 C(TT) = D * SIN(K * TT / F): NEXT TT
360 LPRINT USINGGA$; T, C(T), T + 1, C(T + 1),
    T + 2, C(T + 2), T +3, C(T + 3)
370 NEXT T
380 INPUT "DO YOU WISH TO PRINT ANOTHER TABLE"; Q$
390 IF LEFT$(Q$, 1) = "Y" THEN 30 ELSE END
```

Table 1. Chart Example

TABLE OF TIMES WITH CORRESPONDING CHORD LENGTHS FOR A(N) TAYLOR OP600 CHART AT 240 DEGREES
(A 7.929 INCH DIAMETER CIRCLE) FOR ADDITIONAL CUSTOM MADE DATA TABLES CONTACT DARRELL LEE A⌐

SALT LAKE CITY RESIDENT POST

Time (min)	Chord(in)	Time (min)	Chord(in)	Time (min)	Chord(in)	Time (min)	Chord(in)
1	0.017299	2	0.034596	3	0.051895	4	0.069193
5	0.086491	6	0.103787	7	0.121084	8	0.138580
9	0.155675	10	0.172970	11	0.190264	12	0.207557
13	0.224849	14	0.242140	15	0.259429	16	0.276718
17	0.294006	18	0.311292	19	0.328575	20	0.345858
21	0.363140	22	0.380418	23	0.397696	24	0.414972
25	0.432245	26	0.449517	27	0.466787	28	0.484054
29	0.501319	30	0.518582	31	0.535842	32	0.553099
33	0.570354	34	0.587607	35	0.604856	36	0.622102
37	0.639346	38	0.656587	39	0.673824	40	0.691058
41	0.708289	42	0.725516	43	0.742741	44	0.759961
45	0.777178	46	0.794391	47	0.811601	48	0.828807
49	0.846008	50	0.863206	51	0.880400	52	0.897588
53	0.914774	54	0.931955	55	0.949130	56	0.966302
57	0.983470	58	1.000630	59	1.017790	60	1.034940
61	1.052090	62	1.069230	63	1.086370	64	1.103500
65	1.120630	66	1.137750	67	1.154870	68	1.171980
69	1.189090	70	1.206190	71	1.223280	72	1.240370
73	1.257450	74	1.274530	75	1.291600	76	1.308660
77	1.325720	78	1.342770	79	1.359820	80	1.366860
81	1.393890	82	1.410910	83	1.417930	84	1.444950
85	1.461950	86	1.478950	87	1.49540	88	1.512930
89	1.529900	90	1.546870	91	1.563830	92	1.580790
93	1.597740	94	1.614680	95	1.631610	96	1.648530
97	1.665450	98	1.682360	99	1.699260	100	1.716150
101	1.733040	102	1.749910	103	1.766780	104	1.783640
105	1.800490	106	1.817330	107	1.834160	108	1.850990
109	1.867810	110	1.884610	111	1.901410	112	1.918200
113	1.934980	114	1.951750	115	1.968510	116	1.985260
117	2.002010	118	2.018740	119	2.035460	120	2.052180

NOTE: Darrell Lee is now a National Expert in Computers and is located in the SAN-DO office.

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