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AUTH.NAME AUTHOR AFFILIATION
UTLEY,E.E. Carolina Power & Light Co.
RECIP.NAME RECIPIENT AFFILIATION
VARGA,S.A. Operating Reactors Branch 1

SUBJECT: Forwards util responses to NRC 800301 questions entitled, "Clarification of Sept 27 Ltr to Licensees re Demonstration of Operability of Purge & Vent Valves," & Allis-Chalmers test rept which provides supporting info to responses. *pcc RDT*

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	I&E	06	2	2	NRC PDR	02	1	1
	OR ASSESS BR	10	1	1	RAD ASSESS BR11		1	1
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CP&L
Carolina Power & Light Company

December 24, 1980

File: NG-3514(R)

Serial No.: NO-80-1913

Office of Nuclear Reactor Regulation
ATTENTION: Mr. Steven A. Varga, Chief
Operating Reactors Branch No. 1
United States Nuclear Regulatory Commission
Washington, D. C. 20555

H. B. ROBINSON STEAM ELECTRIC PLANT UNIT NO. 2
DOCKET NO. 50-261
LICENSE NO. DPR-23
CONTAINMENT PURGING AND VENTING DURING NORMAL OPERATION

Dear Mr. Varga:

Enclosed please find Carolina Power & Light Company's (CP&L) response to NRC questions provided on February 1, 1980 entitled, "Clarification of September 27 Letter to Licensees Regarding Demonstration of Operability of Purge and Vent Valves." This response also includes a copy of an Allis-Chalmers document entitled "Test Report on an Allis-Chalmers 6" Streamseal Butterfly Valve in Air Concerning Nuclear Containment Isolation Valves," which provides supporting documentation for our responses.

Should you have any further questions or comments, please contact my staff.

Yours very truly,

E. E. Utley
Executive Vice President
Power Supply and
Engineering & Construction

A034
S
1/1

DCS/jc (1918)
Enclosures

cc: Mr. J. D. Neighbors (NRC)

8012300671

P

411 Fayetteville Street • P. O. Box 1551 • Raleigh, N. C. 27602

ENCLOSURE 1

Response to NRC Questions Entitled "Clarification of September 27 Letter to Licensees Regarding Demonstration of Operability of Purge and Vent Valves"

Item 1

The containment conditions during a DBA were obtained from the FSAR. Ramp pressure and temperature were then plotted (Addendum #1) against time. Valve closing time is 2 seconds. A second curve was then plotted displaying ramp pressure versus angle of closure during the 2-second closure time (Addendum #2). The disc angle of opening was then compared to containment pressure (P_1). P_1 was then considered inlet pressure to the valve. The test program recorded inlet pressures and corresponding pressure drops (ΔP) at 10 psig intervals in most cases. If the containment pressure in a given instance fell between two recorded test pressures, a value of ΔP for the case would be obtained by linear interpolation between them. The same approach was used in calculating the torque coefficient (C_T) once the inlet pressures had been established.

Gas density and temperature were not considered, as temperature does not affect the disc torsional loading under operating conditions except as it affects containment pressure; the value for that pressure being given with the pressure ramp plot. Refer to the attached data sheets (Addendum #3) to determine pressure drop and torque coefficient along with applied torque for any given disc angle for a particular valve.

Item 2

The dynamic torque coefficients used in determining developed torque were obtained by direct testing of a 6" butterfly valve in a wind tunnel facility at Langley Air Force Base. The test included three different valve disc designs, containing three different thicknesses to diameter (t/d) ratios. The t/d ratio exercises a direct influence over developed torque and is a constant over the range of valve sizes. A discussion of this relationship is included in the Allis-Chalmers Containment Isolation Valve Test Report (Enclosure 2) under (1) Procedure, (2) Test Results, and (3) Conclusions. As the t/d

ratio effects a constant influence on torque coefficients over the full range of valve sizes, this ratio was the basis used in selection of the pertinent test data for a given valve analysis. Mathematical analysis was used in determining the performance of individual valves in Carolina Power & Light Robinson Plant based on data obtained during Air Force Wind Tunnel testing of a similar 6" valve. The ability to upscale information derived from the 6" valve tests is given by geometric similiarity in design between all valves of this type. This approach has been proven many times in the past by experiment in both the laboratory and the field by Allis-Chalmers engineering personnel in performance evaluation of the entire STREAMSEAL product line using various fluid media. The ruling factor governing torque performance for this butterfly valve design is the disc thickness to disc diameter (t/d) ratio. This ratio has a direct bearing on the magnitude of the applied torque directed to the valve shaft and operated upon by the valve actuator. In determining actual valve performance for a given installation, the t/d ratio of the valve in question is first calculated. The ratio remains fairly constant for all valve sizes; therefore, comparison can be made between the 6" test valve and all other valves of similar construction. Three t/d ratios were tested with the 6" valve covering the range of disc designs manufactured by Allis-Chalmers. For a given instance, an actual valve t/d ratio is determined and compared with t/d ratios given in the test report. The next higher t/d ratio is selected, if a direct match is not possible, thereby yielding a conservative value for torques calculated in this process. After the t/d ratio is determined, the other details of valve position (type of installation, expected differential pressures, and appropriate test number) are determined, the calculation procedure is continued as outlined in the Torque Calculation paragraph and following paragraphs in the test report (pg. 5).

Item 3

Installation effects as to orientation, disc position, inlet and outlet conditions, etc., were all provided for in the test program. A discussion of each of these parameters is outlined in Allis-Chalmers test report under Procedure. For any given valve installation, appropriate test data was used based on valve installation, orientation and disc position. Determination of these variables would then allow selection of an appropriate test number to determine valve performance. See (1) Procedure and (2) Torque Calculations in Allis-Chalmers test report to determine the method of test selection.

Item 4

Valve closure rate was a given value and was considered constant from 90° open to closed. The containment pressure response profile was compared to valve closure rate by means of a curve plot, angle of closure versus increasing containment pressure (see Addendum #2).

The lag time between received signal and initial valve movement was accounted for in that the 2-second closure time is the time between signal generation and valve full closure.

Item 5

The predicted ΔP capability versus the vane angle of opening have been tabulated on the data sheets enclosed (see Addendum #3).

Maximum ΔP capability is the pressure rating of the valve; for the 42" BFV, the operating pressure rating is 50 psig, but proof of design test pressure (maximum without structural failure) would be 100 psig differential across the valve. For the 6" BFV, 150 psig is maximum operating pressure, with 300 psig differential being the maximum for proof of design test purposes.

Item 6

Valves were designed and constructed according to AWWA C504 applicable at time of construction. All components were sized according to tabulated data requirements listed in the AWWA specification.

86714-3	42" shaft dia.:	2-7/8" 304SS
77042-4	42" taper pins:	416 H.T. SS #10 x 6" lg.
87085-4	6" shaft dia.:	1" 304SS
39917-4	6" taper pins	1/4" x 1-1/4" lg. - 416

CUSTOMER	DATE	SHEET
CAROLINA POWER & LIGHT	11-20-80	1 OF

SUBJECT	PRELIM.	FINAL
VALVE TAG NOS. V12-6 THRU -9		✓

DRAWING NUMBER — LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS — FORM 6715-1

CALCULATED BY: SCHWARZ

6. VALVE SHAFT STRESSES:

DURING THE VALVE STROKE, THE SHAFT IS SUBJECTED TO DIRECT SHEAR DUE TO THE PRESSURE DROP AND TO TORSIONAL SHEAR DUE TO THE REQUIRED CLOSING TORQUE, CREATED BY THE SEATING TORQUE.

THE THEORY OF COMBINED STRESSES STATES:

$$\sigma = S_1 + S_2 = S_D + S_T = \frac{F}{A} \pm \frac{T}{Z_p}$$

WHERE: σ = RESULTANT STRESS. REF.: FAIRES PARA 8.2, 8

S_D = STRESS DUE TO DIRECT SHEAR

S_T = TORSIONAL STRESS.

FOR BFV SHAFTS

$$S_D = \frac{F}{A} = \frac{\pi/4 \times D^2 \times \Delta P}{2 A_s}$$

WHERE: D = DISC DIAMETER (IN)

ΔP = PRESSURE DROP (PSI)

A_s = SHAFT DIA (IN²)

CUSTOMER CP&L

SUBJECT

DRAWING NUMBER

DATE

SHEET 2 OF

PRELIM. FINAL

CALCULATED BY SCHWARZ

LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

AND:

$$S_T = \frac{T \times 12}{Z_P}$$

WHERE: T = MAX APPLIED TORQUE (IN-LB.)

SHAFT: Z_P = POLAR SECTION MODULUS (IN^3).

$$Z_P = \frac{\pi D^3}{16}$$ FOR ROUND SECTIONS

∴

$$\sigma = \frac{\pi/4\, D^2 \Delta P}{2A_S} + \frac{T \times 12}{Z_P}$$

FOR 42" VALVES:

D = 40.88 IN ϕ.

$A_S = \frac{\pi}{4}(2.88)^2 = 6.51\ IN^2$ $\qquad \frac{\pi/4\,(40.88)^2 \Delta P}{2(6.51)} = 100.8\Delta P$

$Z_P = \frac{\pi(2.88)^3}{16} = 4.69\ IN^3$ $\qquad \frac{T \times 12}{4.69} = 2.56\,T.$

$$\sigma = 100.8\,\Delta P + 2.56\,T.$$

$\Delta P = 17$ psi $\qquad \sigma = 100.8 \times 17 + 2.56 \times 2200$

T = 3400 ft lbs (Max. Theoretical) $\quad \sigma$ = 1345 psi FOR 2 SEC CLOSE

T = 2200 ft lbs (seating Torque)

8

CUSTOMER CP&L | DATE - | SHEET 3 OF

SUBJECT | PRELIM. | FINAL

DRAWING NUMBER | LITHO IN U.S.A.—A-C | CALCULATED BY SCHWARZ

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

FOR TYPE 304 STAINLESS STEEL, MAX $S_D + S_T$ = 9000psi.

MAX ΔP ALLOWABLE:

σ = 9000 psi MAX.

$$\Delta P = \frac{9000 - 2.56 \times 2200}{100.8}$$

ΔP = 33.4 psi — DURING CLOSING.

FOR 6" VALVES.

D = 6 IN ϕ

D_s = 1" ϕ; A_s = .786 IN^2

Z_p = .196 IN^3

T = 93 ftlbs (Max. Theoretical)

T = 25 ftlbs (seating Torque)

$$\sigma = \frac{\pi/4\,(6)^2\,\Delta P}{2(.786)} + \frac{25 \times 12}{4.56}$$

$$\sigma = 17.98\,\Delta P + 65.78.$$

ΔP = 17 psi σ = 371 psi — 2 sec. close

MAX ΔP; σ = 9000 psi

$$\Delta P = \frac{9000 - 65.78}{17.98} = 497 \text{ psi}$$ {During closing

CUSTOMER | DATE | SHEET 4 OF
SUBJECT | PRELIM. | FINAL
DRAWING NUMBER | LITHO IN U.S.A.-A-C | CALCULATED BY

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

AT MAXIMUM CONTAINMENT PRESSURE:

$\Delta P = 42$ psi

FOR 42" VALVES

$$\sigma = 100.8 \times 42 + 2.56 * 2200$$

$$\sigma = 9865.6 \text{ psi}$$

YIELD STRESS IN SHEAR FOR 304 SS MAT'L = $S_y/2$ = 15KSI

THE ABOVE CALCULATION INDICATES THAT EVEN UNDER MAXIMUM DBA CONDITIONS THE EXTREME SHAFT FIBERS DO NOT APPROACH YIELD STRESS (FACTOR OF SAFETY: 1.52:1.) THEREFORE THE VALVES WILL MAINTAIN STRUCTURAL INTEGRITY EVEN IF FOR SOME REASON THEY DO NOT CLOSE IN THE REQUIRED 2 SECS.

Item 7 - Omitted by the NRC

Item 8 - Omitted by the NRC

Item 9

A. Containment pressure rise effects on the actuators' ability to evacuate control air pressure have not been considered in determining the margin of torque capacity to close the valve. However, by plotting the required operating torque to close the valve, against the instantaneous operator torque, it becomes obvious that the operator has much greater capacity (approximately 3:1) than that required to close the valve under emergency conditions.

B. The actuator bleed configuration allows the instrument air to vent to the containment vessel atmosphere, through solenoid valves, from the high pressure side of the actuator piston. Similar low pressure side vents are provided for the actuator piston ensuring a pressure balance across the piston via venting to the containment vessel. This feature serves to negate the effects of back-pressure on venting rate. Vents on the isolation valve outside containment vent to atmosphere.

Item 10 - Not applicable.

Item 11 - Not applicable.

Item 12

The valve operators at H. B. Robinson 2 have sufficient torque capacity to open and close the valves under containment ramp pressures, without limiting the amount of valve travel. CP&L will install stops, however, to limit the radiological consequences of an accident while purging. The operator torque margin for a given valve is listed on the enclosed

data sheets (Addendum #3). Seating torque are listed on the bottom of the tabulated data sheets. All operators have adequate torque to seat the valves.

Item 13

At no time does the maximum torque developed by the valve exceed the maximum torque rating of the operators. Refer to curve plots for individual operator torque capacities. All the operators have a comfortable margin of safety above the maximum operating torque.

Item 14

The maximum torque value applied to the valves is within the standard operating range of the valve actuator; therefore normal torque settings for limit switches, torque override devices, etc., apply in the normal fashion.

Item 15

No electric motor operators are used in the valve assemblies under consideration.

Item 16

No handwheels are provided on these actuators.

Item 17, Item 19, Item 20

No environmental testing or analysis was performed on these specific valves prior to shipment to the customer.

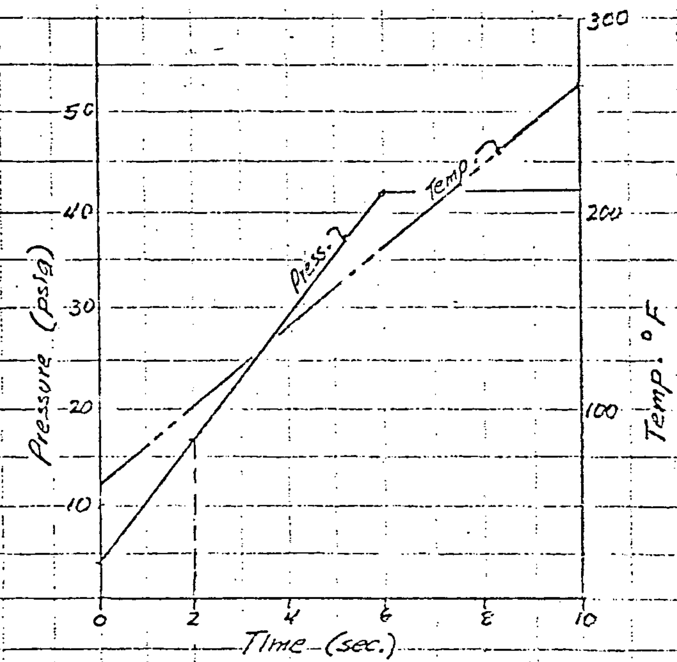
However, all the valves were constructed in accordance with specified Nuclear Standards in effect at the time of manufacture.

Item 18 - Omitted by the NRC

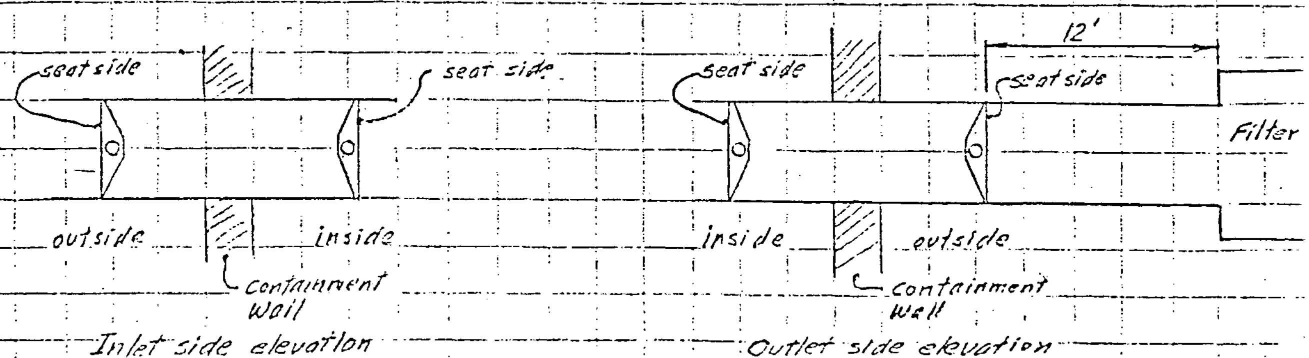
Item 21

The valve seat leakage is constantly monitored by plant PPS and maintenance is performed as needed to either adjust or replace the seating segments. Periodic cycling is not done on the 42" purge valves above Cold Shutdown. The Pressure Relief 6" valves are cycled as needed to control CV pressure.

The solenoid valves inside CV which control the air to/from these valves were replaced with environmentally qualified models. The elastomeric components of these solenoid valves will be replaced on four year cycles as committed to in our response to IE Bulletin 79-01B.

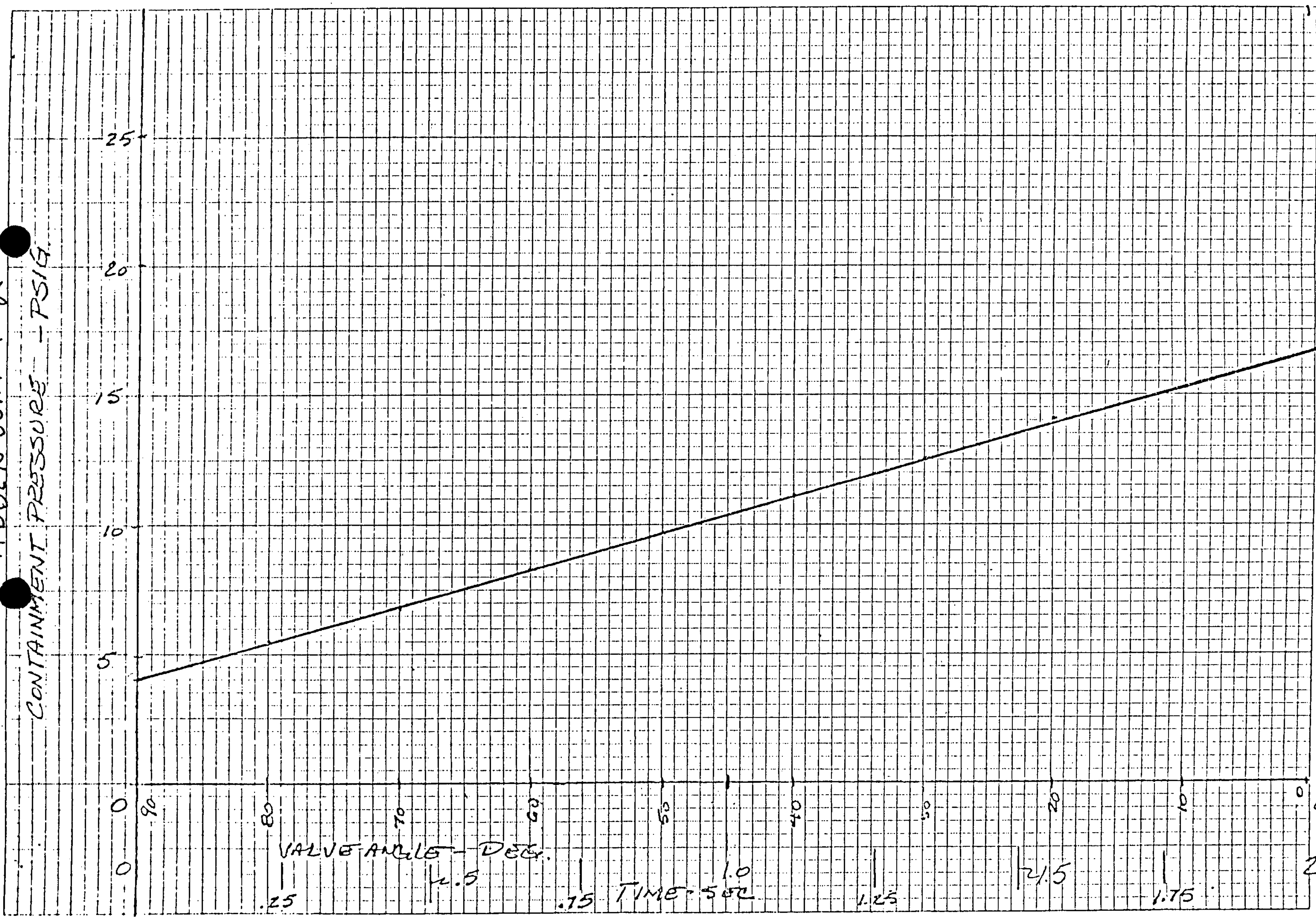


When containment press. reaches 4 psig valve receives signal to close. Valve closing time is 2 seconds. Pressure ramp is 4 psig to 42 psig in 6 seconds. Temperature ramp is ambient to 265°F in 10 seconds. According to the attached graph, the valve would theoretically close against a max. press. of ≈ 17 psig.



6" & 42" Valves in similar mounting conditions

ADDENDUM #2



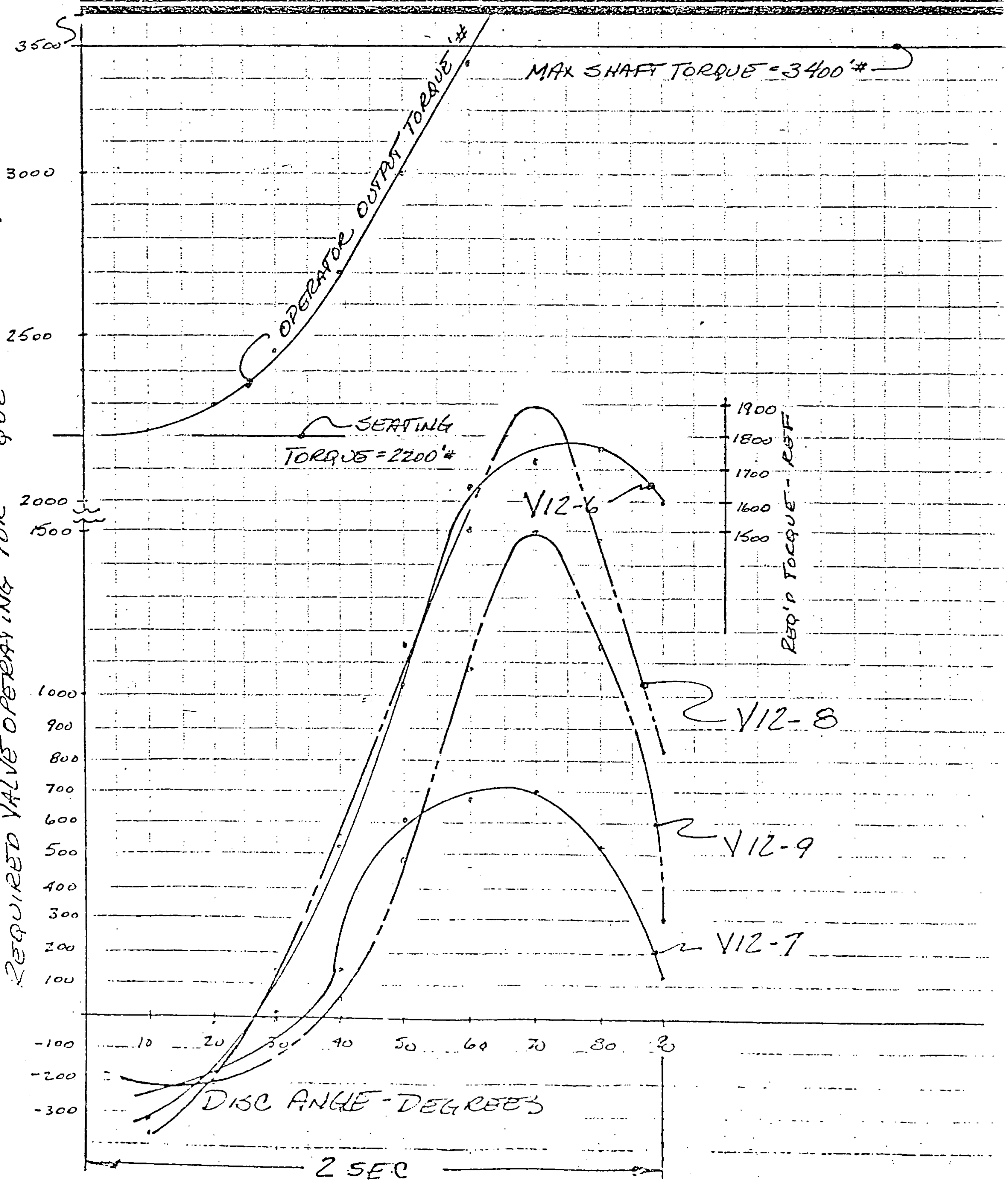
CONTAINMENT PRESSURE - PSIG
25
20
15
10
5
0
90
80
70
60
50
40
30
20
10
0
VALVE ANGLE - DEG.
.25
.5
.75
1.0
1.25
1.5
1.75
2
TIME - SEC

ADDENDUM # 5, A

CUSTOMER CAROLINA POWER / ROBINSON / PL.	DATE 2-15-80	SHEET ___ OF ___	
SUBJECT 42" PURGE VALVES - V12-6/9	PRELIM.		FINAL ✓
DRAWING NUMBER			CALCULATED BY P.R. SCHWARZ

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS · LITHO IN U.S.A.—A-C · FORM 6715-1



VALVE NO. V12-6

Carolina Power & Light - 42" BFV 2-15-80
Ramp Pressure vs. Angle 0 sec. Delay $^t/d$ = .12
Test #26. Pmax = 16.7 psig. @ 2 sec.
Operator Type Cyl./Spring. Max Torque 4440'#

°OPEN	SEC.	P_1	ΔP	C_T	T_D'#	T_b'#	T_o'#	OPER. T'#
90	0	4.0	1.4	27.6	1662	28	1690	4440
80	.22	5.5	2.05	19.7	1736	41	1777	4143
70	.44	6.8	2.25	17.7	1712	45	1757	3763
60	.66	8.2	4.8	7.6	1569	96	1664	3368
50	.88	9.6	7.3	2.8	879	146	1024	3005
40	1.11	11.1	9.1	.86	337	181	518	2700
30	1.33	12.5	10.5	-.45	-203	209	6.2	2464
20	1.55	13.9	11.2	-.45	-217	223	6.6	2304
10	1.77	15.3	12.5	-1.07	-575	249	-326	2234
0	2.0	16.7						

MAX SHAFT TORQUE 3400'#. SHAFT DIA. = 2 7/8"
$T_D = 43\ C_T\ \Delta P$.
$T_b = 19.94\ \Delta P$.
$T_o = T_D + T_b$.

VALVE NO. V12-7

Carolina Power & Light - 42" BFV 2-14-80
Ramp Pressure vs. Angle 0 sec. Delay $^t/d$ = .12
Test #25. Pmax = 16.7 psig. @ 2 sec.
Operator Type Cyl./Spring. Max Torque 4440'#

°OPEN	SEC.	P_1	ΔP	C_T	T_D'#	T_b'#	T_o'#	OPER. T'#
90	0	4.0	.5	5.4	116.1	9.97	126.1	4440
80	.22	5.5	.55	21.5	507	10.96	518	4143
70	.44	6.8	1.5	10.4	669	29.9	699	3763
60	.66	8.2	2.25	6.54	631	45	676	3368
50	.88	9.6	6.25	1.80	482	125	607	3005
40	1.11	11.1	8.7	-.30	-112	173	62	2700
30	1.33	12.5	10.5	-.50	-225	209	-16	2464
20	1.55	13.9	11.56	-.82	-406	231	-176	2304
10	1.77	15.3	12.50	-.88	-472	249	-222	2234
0	2.0	16.7						

MAX SHAFT TORQUE 3400'#. SHAFT DIA = 2 7/8"

$T_D = 43\ C_T\ \Delta P.$

$T_b = 19.94\ \Delta P.$

$T_o = T_D + T_b.$

VALVE NO. V12-8

Carolina Power & Light - 42" BFV 2-15-80
Ramp Pressure vs. Angle 0 sec. Delay $t/d = .12$
Test #27. Pmax = 16.7 psig. @ 2 sec.
Operator Type Cyl./Spring. Max Torque 4440'#

°OPEN	SEC.	P_1	ΔP	C_T	T_D'#	T_b'#	T_o'#	OPER. T'#
90	0	4.0	.5	37.6	808.4	10	818	4440
80	.22	5.5	1.0	34.1	1466	20	1486	4143
70	.44	6.8	1.5	28.4	1832	30	1862	3763
60	.66	8.2	3.25	10.28	1437	65	1501	3368
50	.88	9.6	6.8	3.4	994	136	1130	3005
40	1.11	11.1	7.0	1.4	421	140	561	2700
30	1.33	12.5	8.5	-.1	-37	170	133	2464
20	1.55	13.9	9.5	-.9	-368	189	-178	2304
10	1.77	15.3	12.5	-1.1	-591	249	-342	2234
0	2.0	16.7						

MAX SHAFT TORQUE 3400'#. SHAFT DIA = 2 7/8"

$T_D = 43\ C_T \Delta P.$

$T_b = 19.94\ \Delta P.$

$T_o = T_D + T_b.$

VALVE NO. V12-9

Carolina Power & Light - 42" BFV 2-15-80
Ramp Pressure vs. Angle 0 sec. Delay $^t/_d$ = .12
Test #28. Pmax = 16.7 psig. @ 2 sec.
Operator Type Cyl./Spring. Max Torque 4440'#

°OPEN	SEC.	P_1	ΔP	C_T	T_D'#	T_b'#	T_o'#	OPER. T'#
90	0	4.0	1.0	6.74	289	19.9	309	4440
80	.22	5.5	2.05	12.8	1128	41	1169	4143
70	.44	6.8	2.86	11.8	1451	57	1508	3763
60	.66	8.2	5.8	3.9	973	116	1088	3368
50	.88	9.6	7.9	.98	333	158	491	3005
40	1.11	11.1	9.6	-.06	-25	191	167	2700
30	1.33	12.5	10	-.45	-194	199	5.9	2464
20	1.55	13.9	11.5	-.89	-440	229	-211	2304
10	1.77	15.3	12.4	-.43	-229	247	18	2234
0	2.0	16.7						

MAX SHAFT TORQUE 3400'#. SHAFT DIA = 2 7/8"
$T_D = 43\ C_T\ \Delta P$.
$T_b = 19.94\ \Delta P$.
$T_o = T_D + T_b$.

ADDENDUM #3B

CUSTOMER	DATE	SHEET OF
Carolina Power / Robinson Plant	2-20-80	

SUBJECT	PRELIM.	FINAL
6" BFV'S - V12-10/11.		✓

DRAWING NUMBER		CALCULATED BY
	ENGINEERING CALCULATION SHEET	P. SCHWARZ.

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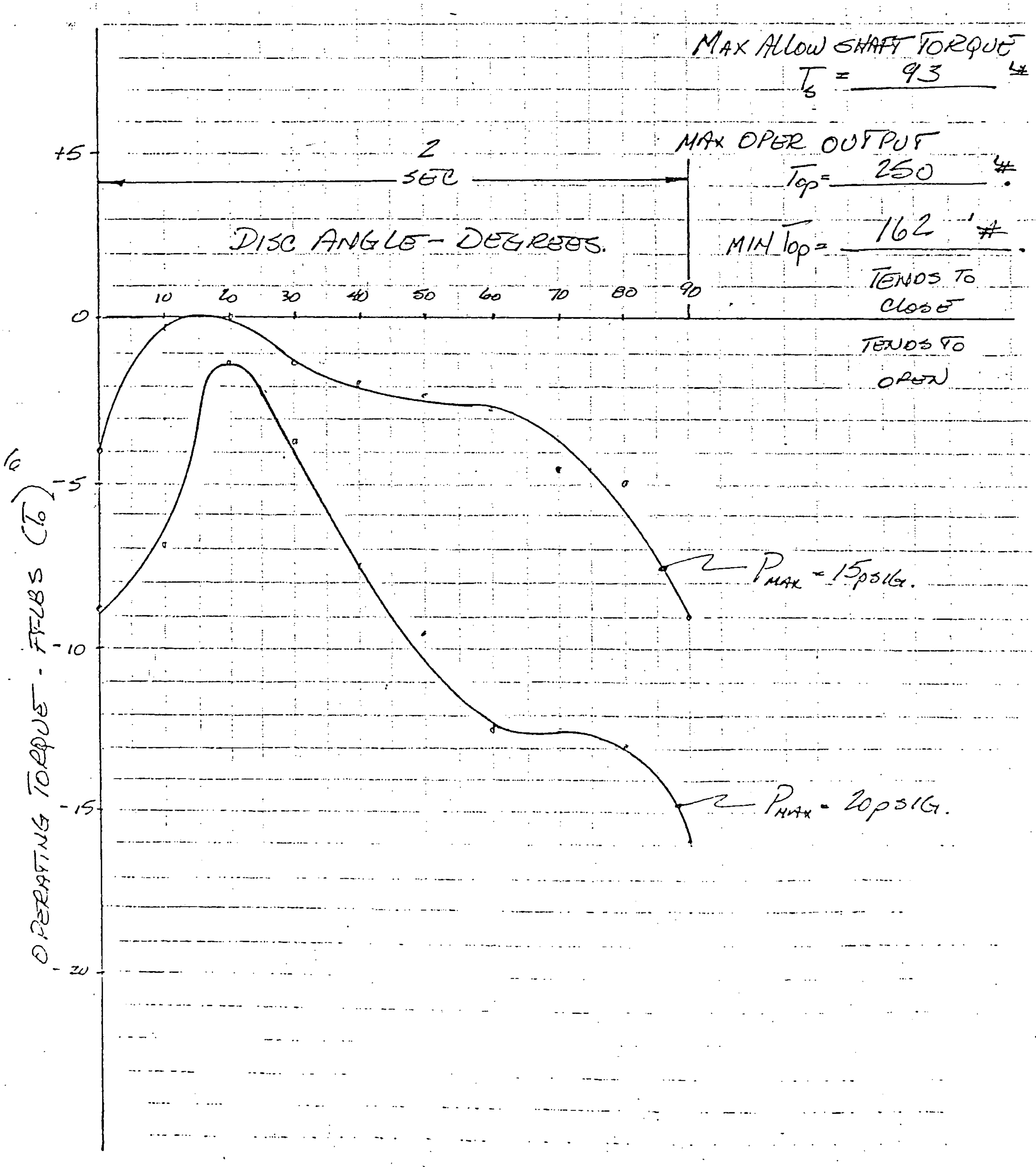


VALVE NO. V12-10/11

Carolina Power & Light - 6" BFV — 12-09-80
Ramp Pressure vs. Angle   0 sec. Delay
Test #21. Pmax = 15 psig.   t/d = .29
Operator Type Cyl./Spring. Max Torque 250'#

°OPEN	SEC.	P_1	ΔP	C_T	T_D'#	T_b'#	T_o'#	OPER. T'#
90	0	7.5	3	-25.1	-9.4	.42	-8.98	250.0
80	.22	8.0	4	-11.0	-5.5	.56	-4.94	240.2
70	.44	10.0	7	-6.3	-5.5	.99	-4.51	230.4
60	.66	11.0	8	-3.9	-3.9	1.13	-2.77	220.6
50	.88	12.5	10	-3.1	-3.9	1.41	-2.49	210.8
40	1.11	14.0	12	-2.4	-3.6	1.70	-1.90	201.1
30	1.33	14.5	13.5	-1.8	-3.1	1.90	-1.2	191.3
20	1.55	15.0	15	-1.1	-2.0	2.12	+.12	181.5
10	1.77	15.0	15	-1.3	-2.4	2.12	-.3	171.7
0	2.0	15.0	15	-3.1	-5.9	-	-	162.0

MAX SHAFT TORQUE 93'#. SHAFT DIA = 1"

$T_D = 125\ C_T\ \Delta P.$

$T_b = .141\ \Delta P.$

$T_o = T_D + T_b.$

VALVE NO. V12-10/11

Carolina Power & Light - 6" BFV 12-09-80

Ramp Pressure vs. Angle 0 sec. Delay

Test #21. Pmax = 20 psig. t/d = .29

Operator Type Cyl./Spring. Max Torque 250'#

°OPEN	SEC.	P_1	ΔP	C_T	T_D'#	T_b'#	T_o'#	OPER. T'#
90	0	10.0	4.5	-29.3	-16.5	.64	-15.86	250.0
80	.22	10.5	5.5	-20.1	-13.8	.78	-13.02	240.2
70	.44	14.0	10.0	-11.0	-13.8	1.41	-12.39	230.4
60	.66	15.0	12.0	-9.2	-13.8	1.70	-12.10	220.6
50	.88	16.5	14.5	-6.5	-11.8	2.04	-9.76	210.8
40	1.11	18.0	16.5	-4.5	-9.8	2.32	-7.50	201.1
30	1.33	19.0	18.0	-2.8	-6.3	2.54	-3.76	191.3
20	1.55	20.0	19.5	-1.6	-3.9	2.75	-1.15	181.5
10	1.77	20.0	20.0	-3.9	-9.8	2.82	-6.98	171.7
0	2.0	20.0	20.0	-4.7	-11.8	-	-8.80	162.0

MAX SHAFT TORQUE 93'#. SHAFT DIA = 1"

$T_D = 125\ C_T\ \Delta P.$

$T_b = .141\ \Delta P.$

$T_o = T_D + T_b.$

ADDENDUM #5C

CUSTOMER: Carolina Power / Robinson Plant

DA

SHEET OF

SUBJECT: 6" BFV'S - V12-12/13

PRELIM. | FINAL ✓

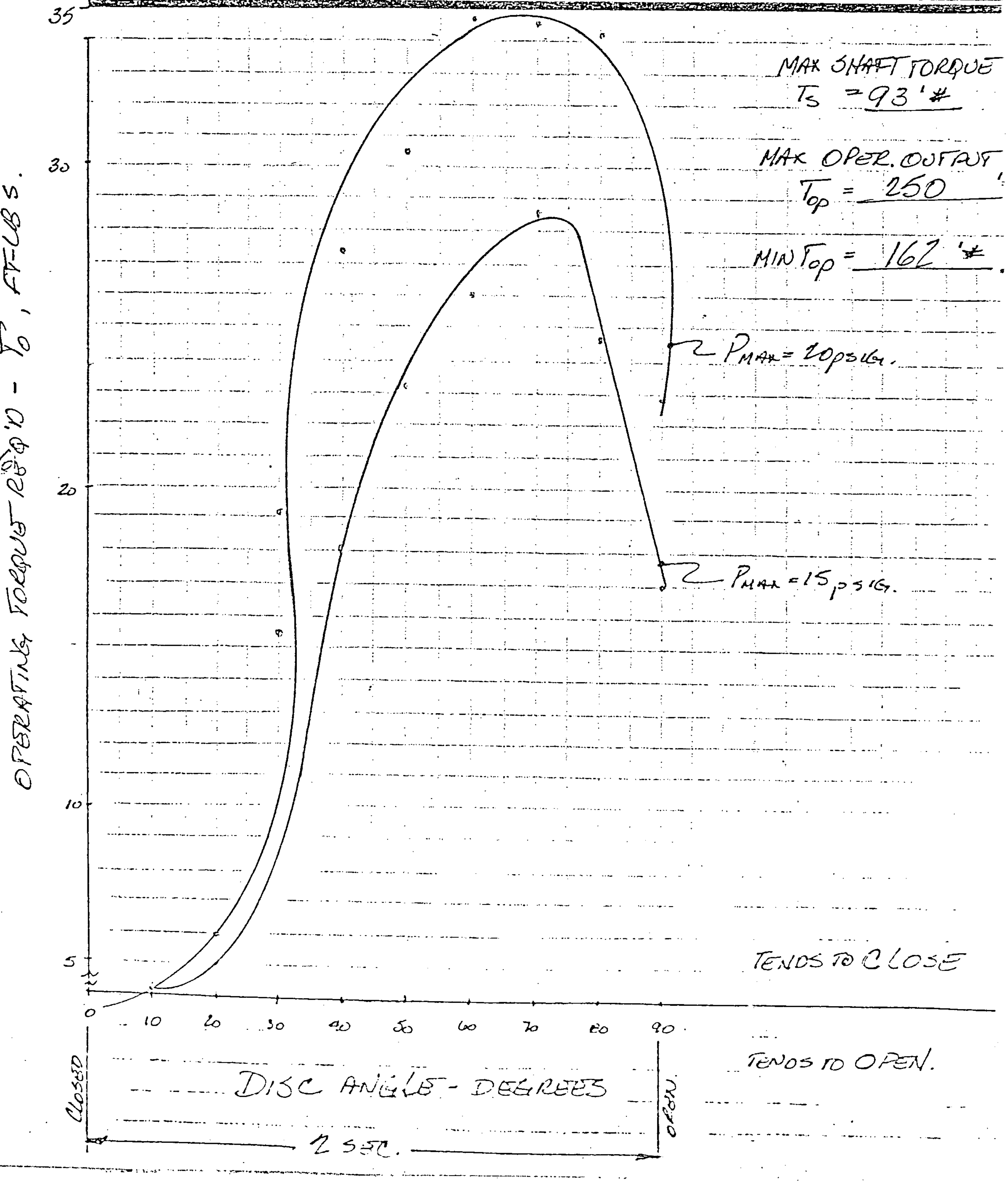
DRAWING NUMBER

LITHO IN U.S.A.—A-C

CALCULATED BY: P. Schwarz

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1



VALVE NO. V12-12/13

Carolina Power & Light - 6" BFV 12-09-80
Ramp Pressure vs. Angle 0 sec. Delay
Test #22. Pmax = 15 psig. t/d = .29
Operator Type Cyl./Spring. Max Torque 250'#

°OPEN	SEC.	P_1	ΔP	C_T	T_D'#	T_b'#	T_o'#	OPER. T'#
90	0	6.5	3.5	37.7	16.5	.5	17.0	250.0
80	.22	9.0	6.0	33.1	24.8	.8	25.6	240.2
70	.44	9.0	6.5	33.8	27.5	.92	28.5	230.4
60	.66	10.0	8.0	24.8	24.8	1.13	25.9	220.6
50	.88	11.0	9.5	18.5	22.0	1.34	23.3	210.8
40	1.11	12.0	11.0	12.0	16.5	1.55	18.1	201.1
30	1.33	13.0	12.0	9.2	13.8	1.70	15.5	191.3
20	1.55	13.0	13.0	1.9	3.1	1.83	4.9	181.5
10	1.77	13.0	13.0	-1.9	-3.1	1.83	1.3	171.7
0	2.0	13.0	13.0	-1.9	-3.1	—	—	162.0

MAX SHAFT TORQUE 93'#. SHAFT DIA = 1"

$T_D = 125\ C_T\ \Delta P.$

$T_b = .141\ \Delta P.$

$T_o = T_D + T_b.$

VALVE NO. V12-12/13

Carolina Power & Light - 6" BFV 12-09-80
Ramp Pressure vs. Angle 0 sec. Delay
Test #22. Pmax = 20 psig. t/d = .29
Operator Type Cyl./Spring. Max Torque 250'#

°OPEN	SEC.	P_1	ΔP	C_T	T_D'#	T_b'#	T_o'#	OPER. T'#
90	0	10.0	6.0	29.3	22	.85	22.8	250.0
80	.22	13.0	10.0	26.4	33	1.41	34.4	240.2
70	.44	14.0	11.5	23.0	33	1.62	34.6	230.4
60	.66	15.0	13.0	20.3	33	1.83	34.8	220.6
50	.88	18.0	16.0	14.0	28	2.26	30.3	210.8
40	1.11	19.0	17.5	11.3	24.8	2.50	27.3	201.1
30	1.33	19.5	18.5	7.1	16.5	2.61	19.1	191.3
20	1.55	20.0	20.0	1.2	3.1	2.82	5.9	181.5
10	1.77	20.0	20.0	-1.2	-3.1	2.82	.3	171.7
0	2.0	20.0	20.0	-1.2	-3.1	-	-	162.0

MAX SHAFT TORQUE 93'#. SHAFT DIA = 1"
$T_D = 125\ C_T\ \Delta P.$
$T_b = .141\ \Delta P.$
$T_o = T_D + T_b.$

TEST REPORT ON AN ALLIS-CHALMERS

6" STREAMSEAL BUTTERFLY VALVE IN AIR

CONCERNING NUCLEAR CONTAINMENT ISOLATION VALVES

A-C
VER-0209

12/17/79

RECEIVED
DEC 26 '79
Robinson Plant
C P & L Co.

Test Report on an Allis-Chalmers 6" STREAMSEAL Butterfly Valve in Air concerning Nuclear Containment Isolation Valves

Philip G. Schwarz 12/21/79
Prepared by

R. H. Zeiders 12/21/79
Approved by

D. L. Goldman (sjg) 12/21/79
Approved by

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6/6086

Contents

Introduction:

The purpose of this program was to observe and document the performance of an Allis-Chalmers Streamseal 6" Butterfly Valve. The testing performed was under specified air pressure conditions, to determine torque coefficients applicable to this type of valve. The test program is intended to serve as a model for larger valves manufactured by Allis-Chalmers, presently installed in various installations around the country. The coefficients thus developed by the testing method may then be applied to the larger on-site valves to determine the required actuator capacity under dynamic conditions, and to determine shaft stress levels.

The test procedure was designed to obtain data concerning four areas of investigation:

1. Valve closure rate versus time under dynamic conditions. IE: Constant or variable closure rate.

2. Flow direction through valve. How valve performance and shaft torques are affected by flow direction, & ΔP across the valve. What effects the change in pressure across the valve has on performance, and if actual conditions conform to prior published performance data for valve sizing.

3. The effect of the piping system on the valve installations. How the existence of piping, elbows, sudden enlargements, affects valve performance, closure times and shaft stresses.

4. The effect of valve disc and shaft orientation to the fluid mixture egressing from the containment.

Summary:

The information contained within this report is the result of a series of test runs performed on an Allis-Chalmers 6" Streamseal Butterfly Valve, in response to utility inquiries regarding various valves installed in Nuclear Power plants. With the information contained herein, an accurate assessment of a given Allis-Chalmers butterfly design in isolation containment service may be obtained within the range of specified inlet pressures. The uppermost concern in this analysis is the determination that both valve actuator and shaft size are adequate to perform as required during pressure conditions specified by the utility. A series of tests were performed over a range of inlet pressures from 60 psig to 10 psig. Through data collection and calculation, a tabulation of torque coefficients (C_T) was obtained, that enabled prediction of valve torques for the same pressure conditions, for any size Allis-Chalmers butterfly valve of the same disc thickness/diameter ratio and of similar design. Application of the C_T value will yield a maximum applied shaft torque and will allow comparison of maximum allowable shaft torques and actuator capacities under specified inlet conditions.

Procedure:

The procedure outlined below describes the testing and evaluation of one Allis-Chalmers Streamseal Butterfly Valve, equipped with a Limitorque Electric Motor Actuator Model No. H0BC/SMC-04 with a minimum rated output of 150 ft-lbs. at 5.2 seconds for 90 degrees rotation. The valve was tested by mounting it in the blow-down stack of the Low Pressure Turbulence Tunnel installation located at NASA Facility Langley Research Center, Hampton, VA. All data was collected by monitoring incoming signals transmitted to equipment located in the adjacent tunnel control room.

Testing consisted of data gathering with the valve secured in two mounting installations, various valve positions relative to the elbow centerline, and with three types of valve configurations incorporating distinct disc thickness ratios. Refer to Figs. 7&8 for comparative thickness. This approach allowed study of valve performance under various expected mounting profiles, to obtain the maximum amount of information within the capacity of the test facility.

The procedure intended to present the valve with similar conditions as experienced by valves installed in the actual facilities. As variations in performance for butterfly valves are known to be affected by valve mounting configuration, valve position in the line, and disc thickness, the valve was mounted in a series of positions relative to the air stream as outlined below:

A. Elbow in/pipe out installation

1. Flat Face Upstream

    a. Shaft in plane with elbow
    b. Shaft 90° out of plane of elbow

2. Curved Face Upstream

    a. Shaft in plane
    b. Shaft 90° out of plane

The above series of test positions were performed for the standard full thickness disc. For 6-20" BFV's all 150 lb. rated t/d=.29. Two thinner t/d ratios (t/d=.17, and t/d=.12) represent alternate valve constructions as dictated by the pressure rating of the full-scale valves installed in the field, for valves above 20" dia.

An elbow inlet/pipe outlet installation was dictated by the physical constraints of the test area (See Fig. No. A), and by cognizance that certain installations would present piping configurations less than an ideal straight pipe in/

straight pipe out arrangement. Therefore it was considered appropriate for purposes of the test program that an elbow inlet installation represented a worse-case situation, thereby covering most conditions expected to be experienced in the field. It is known that different torque behavior will be experienced by the valve, as a function of disc angle of attack to the flowstream, with an elbow inlet installation, due to flow separation as the fluid curves about the inner radius of the elbow. In addition to changes in torque characteristics relating to flow separation near elbow, the flow through an elbow will require an acceleration of the fluid on the outside radius in an attempt to keep pace with the fluid on the inside radius. This effect causes a velocity difference across the cross section of the elbow, and hence a pressure difference occurs in the elbow. Also, this test program confirmed that a higher torque will be experienced by the valve shaft when the curved side of the disc (body seat downstream) is facing the upstream side of the flow. The forces on the valve shafting were minimized when the flat (body seat upstream) face of the disc was installed upstream, along with the shafts inplane with the elbow radius. See Figs 9 & 10. An offset disc exhibits the above characteristics due to the assymetry of profile that the disc presents to the flowstream. Unlike a lens type disc with a symmetrical profile and consequent unidirectional torsional loading, an offset disc will apply a distinctly positive or negative rotational loading to the shaft depending on whether the disc geometry presented to the flowstream will be the curved side of the disc upstream (body seat downstream) or the flat side upstream (body seat upstream). This effect will tend to make the disc attempt to close in the case of the curved side being upstream, or conversely tends to open with the flat face upstream. Torque coefficients generated from this data will exhibit a positive sign when the valve tends to close, and a negative sign when the valve tends to open. See Figs. 9 & 11.

The testing procedure consisted of obtaining a maximum pressure level of 60 psig with the tunnel pressurization system, opening the tunnel shut-off valve, (See Fig. A) and subjecting the test valve to tunnel pressure with the test valve disc in the open position (90°).

While the test valve was under pressure conditions, a series of three open to close cycles were performed. The valve was then returned to the open position, and the tunnel pressure allow to decay to the next 10 psig pressure increment, where the triple cycling was again performed. In this manner the valve was tested, while recording data, until tunnel pressure had decayed to below 10 psig. A series of data plots were obtained for each pressure level. For each disc thickness and shaft/elbow plane relationship, a test number was assigned. Disc thickness is expressed as a t/d ratio meaning the ratio of the disc thickness to the disc diameter. This expression then identifies a particular profile that a disc would present to the flowstream in the wide open position. The test number identified valve disc geometry and method of valve installation (See Addendum I From this data, a shaft torque for a given ΔP was calculated for a given inlet pressure, and therefore a corresponding C_T for the condition was obtained. All three disc ratios were tested in this manner.

Measured Variables:

Five variables pertaining to shaft torque calculation were measured and recorded during the testing process. (Refer to Appendix # I for typical examples of recorded data). The initial variable of interest was the pressure drop across the valve, therefore an upstream pressure variable P_{T_1}, and a downstream pressure variable P_{T_2} were recorded. For both pressure variables, static and velocity head (total line pressure) (expressed mathematically

$$\text{Pressure} \quad P = P_S + \rho \frac{V^2}{2g}, \text{ where } P_S = \text{static}$$

$$\text{pressure and } \rho \frac{V^2}{2g} = \text{dynamic pressure}$$

or velocity head were measured. Points of pickup were at the extreme upstream end of the elbow flange for upstream pressure P_1, and midway along the length (5 diameters) of exit pipe for downstream pressure P_2. Pressure pick-up was by means of double orifice totaling pitot tubes (Prandtl type) leading to strain-gage diaphragm type pressure transducers located sufficient distance from the point of pickup to minimize distortion due to system vibration.

Secondly, torque measurement as a function of flow velocity (or valve disc angle) was a requirement. Therefore strain gages of good commercial quality were mounted on the shafts in an area between the valve disc and the valve actuator. The strain gauges were connected in a temperature compensated wheatstone bridge network to the strip chart recorder amplifier, calibrated to obtain microstrain readings corresponding to a unit torsional deflection of 420 microstrain per inch of chart recorder deflection. By previous calculation, it was determined that for 304 stainless steel with a torsional yield strength of 15000 psi, a maximum permissable torsional deflection of 615 microstrain could be obtained before exceeding the theoretical yield limit. The 615 microstrain correspond to a chart recorder excursion of 1.5 inches, and in no test case was that value exceeded. The 615 microstrain value is a constant for all shafting diameters, and was approached only with the smallest necked down shaft diameter (1/2"). Necking the shaft was required in this small size valve, so as to accomodate the smaller t/d ratios investigated in the test program within the physical limitations of the valve body and disc. In all cases however, even with the greatest pressure drop (ΔP) across the valve, and therefore the highest velocities influencing torsional loading on the disc/shaft assembly, no excessive torque conditions were experienced. This effect can therefore apply indirectly to larger valves with larger shaft diameters as it expresses itself as a change in magnitude of the final calculated C_T value. The microstrain relationship is expressed in terms of the applied torque,

$$\text{IE:} \quad E = \frac{T}{E_S \, \pi \, R^3}; \text{ where}$$

E = microstrain (inches x 10^{-6})

T = in-lbs.

E_S = Torsional modulus for stainless steel = 12×10^6 psi

R = Shaft Radius in inches.

Solving for torque yields: $T = .393\ E\ D^3$; where the shaft diameter D is expressed in feet; and the value of E may be determined by reading the microstrain plot.

Thirdly, a temperature probe was connected just downstream of the P_1 pressure pickup to enable temperature readings in °F to be recorded. It was felt that recording temperature during valve cycling would be pertinent, if it became necessary to calculate mass flow across the valve for any given pressure drop. Therefore the fourth channel (T) was recorded and is noted in the data listings (See Fig. A).

Fourth, a position potentiometer, as an integral part of the motor actuator, was connected to the recorder amplifier, and a plot of 90° open to close, valve disc rotation was recorded. This plot enabled a relationship between position versus the other measured variables to be recorded, thereby tying together all variables as an expression of disc angle. It then becomes a relatively simple task to read pressure drop, torsional loading and temperature change as a function of position angle.

Torque Calculations:

The standard formula for applied dynamic torque for butterfly valves:

$$T_d = C_T \times D^3 \times \Delta P \qquad \text{EQ. 1.}$$

where: T_d = Dynamic value torque in ft-lbs.

C_T = Torque coefficient determined from test data.

ΔP = Total pressure drop measured acorss valve (psi).

D = Valve bore diameter (ft.)

Valve torque coefficients (C_T) were compute by solving the above formula for C_T, and by utilizing test data for valves of T_d (ft-lbs.) and ΔP (psi). Therefore, C_T values for the 6" Streamseal valve may be expressed:

$$C_T = \frac{T_d}{\left(\frac{6}{12}\right)^3 \Delta P} = \frac{8\ T_d}{\Delta P} \qquad \text{EQ. 2.}$$

Therefore, by utilizing C_T values calculated from test data, and plugging in appropriate pressure.and dimensional values in

EQ. 1 an accurate value for the dynamic torque for a known pressure drop may be obtained. Pressure drops used in calculating torque in a specific application may be obtained from the test data as long as inlet pressure corresponds with the inlet pressure of the valve in question.

To obtain total dynamic torque in a specific instance, bearing torque (T_b) must also be considered. Although not a big factor at high values of inlet pressure (P_{T1}), it begins to figure significantly for low values of inlet pressure, and may even become the dominating factor for low inlet pressure values. Bearing torques are to be considered in light of disc behavior under pressure conditions in a given application. Depending on disc orientation in the line, bearing torque will be subtractive as a function of the disc tending to close ($+C_T$) or additive if the disc tends to open ($-C_T$) under flow conditions.

Bearing torque is calculated thus:

$$T_b = 4.71 \times D^2 \times d \times f \times \Delta P$$

where: T_b = Bearing torque (ft-lbs.)

D = Valve dia (ft.)

d = Shaft dia. (in.)

f = Friction Coefficient (.12 for bronze)

ΔP = Pressure drop (psi)

Total torque applied to the shaft therefore is the algebraic sum of the dynamic torque plus the bearing torque. This torque value is the quantity required to overcome forces operating on both the valve disc and the shaft. The total torque required to move the disc against a given inlet pressure is a function of a number of variables operating simultaneously: Disc Angle, Pressure Drop, Disc Geometry (t/d ratio), Shaft Diameter, Shaft Disc orientation relative to upstream piping components, and degree of pressure recovery downstream of the valve. Pressure recovery downstream of the valve was determined during testing, as presenting a less severe loading to the disc structure than the methods employed in this program, and therefore was not included as it was considered that the methods employed presented a worst case situation to applications encountered in the field.

Calculating Torque Values for Field Applications:

Procedure for calculating torque values for larger valves Ref to Appendix 1.

1. Determine t/d ratio for valve: $\frac{\text{Disc Thickness (in.)}}{\text{Disc Diameter (in.)}}$

2. Select appropriate Test No. based on:

   a.) t/d ratio
   b.) Valve Shaft Position
   c.) Curved or Flat Upstream Disc Face.

3. Determine maximum ΔP across valve.

4. Select appropriate plot based on ΔP above.

5. Determine C_T values for disc angles.

6. Apply torque formula: $T_d = C_T \times D^3 \times \Delta P$ for each disc angle.

7. Calculate Bearing Torque: $T_b = 4.71 x D^2 x d x \Delta P_b$ for each disc angle.

   NOTE: ΔP_b = Pressure drop noted on curve plot data sheet for each disc angle.

8. Obtain total torques for each disc angle.

9. Refer to AWWA Std. C504 for maximum operating shaft torques.

10. Determine operator output torques for each disc angle.

In comparing operator output torques to total dynamic valve torques, consideration should be given to both operator capacity and to maximum shaft capacity. In most cases, the governing variable will be the ability of the actuator to control the dynamic forces applied to the disc and shaft.

Test Results:

Valve inlet pressures for this series of tests were established at 75 psia (60.3 psig). Subsequently, readings were taken at 10 psig intervals, until 10 psig inlet pressure readings were obtained. Analysis of the data for the thickest disc (t/d=.29) subjected to these pressure conditions indicate that torques obtained from inlet pressures ranging from 60 psig to 10 psig, will fall well below the maximum rated torque of 100 ft. lbs. for the valve shaft. This indicates that larger valves based on this design may be expected to behave likewise. Torque characteristics observed under air flow conditions exhibited similar plot profiles as those previously published for water data, thereby verifying as valid the original design approach to the method of valve sizing.

Test results also indicate that a thicker disc will produce a greater torsional loading on the shaft due to greater aerodynamic effects acting on the disc surface. The apparent camber of the disc surface influences the magnitude of the rotational moment similar to the lift of an airfoil. Smaller t/d ratios exhibited less tendency for the disc to load the shaft under flow conditions. Disc face geometry will also

greatly influence the torsional loading on the shaft. Consistently lower torque values were observed with the flat face of the disc located on the upstream side (when closed) of the valve. Higher torques were observed when the curved face of the disc was presented to the upstream flow. As expected, peak torques were experienced by the valve in all cases when the valve achieved an angle of approximately 70°-75° open, with the shaft torque diminishing as the disc approached 0° open.

Another consideration that must be taken into account in determining peak shaft torques, is the relative position of the shaft to the plane of an upstream fitting or elbow. An increase in applied shaft torque was observed when the valve was mounted at 90° to the plane of the elbow on the inlet side. See Fig. 12.

As is characteristic of butterfly valves, the disc will exhibit a tendency to close or to open under flow conditions, as mentioned above. If the curved face of the valve disc is facing upstream the valve will tend to close, and conversely, if the flat face is upstream the valve will tend to open. With the lower t/d ratios, torque reversal will occur in most instances, especially for higher values of pressure drop. C_T values generated calculation incorporating these torque figures will indicate the tendency for the valve to close by being positive (+) when tending to close, and negative (-) when tending to open.

Conclusions

The test program has demonstrated that torque characteristics exhibited by the streamseal butterfly valve are very dependent on a number of considerations. Initially, a determination of the location of the valve relative to upstream conditions must be evaluated. The existence of an elbow or other interference in flow direction, in the immediate upstream vicinity, will be a factor in determining the placement of the shafts relative to the plane of the elbow. A reduction of shaft torque due to flow separation will be achieved by placing the valve shaft centerlines in the same plane as the elbow radii.

Second, upstream facing disc geometry is important, as it too has a direct bearing on the intensity of the torque applied to the shaft. Curved side facing upstream will apply a greater torque to close the valve than if the flat side of the disc were facing upstream.

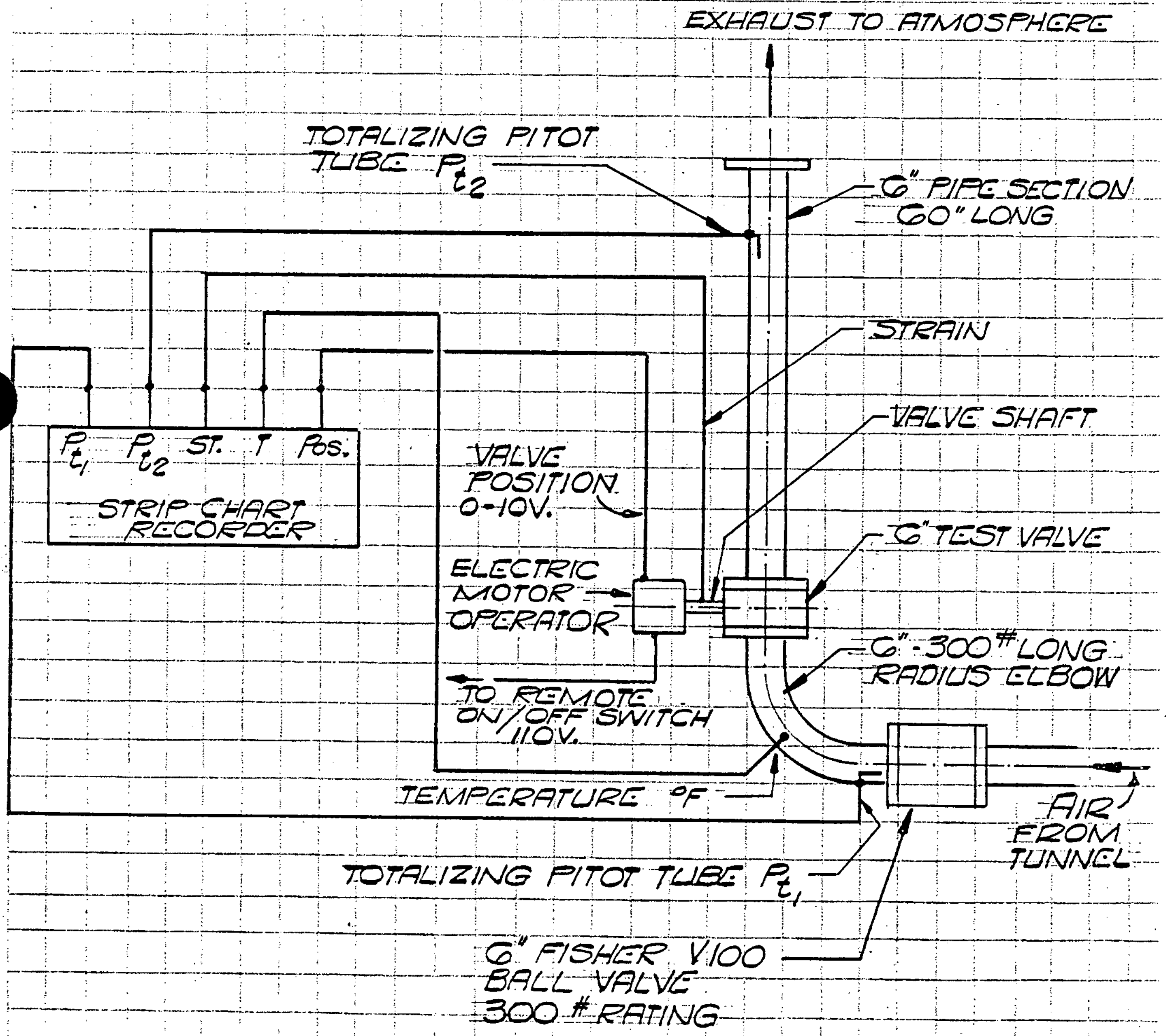
Third, as was previously known the t/d ratio influences the magnitude of the applied shaft torque, whereas the thicker the disc cross section, the greater the aerodynamic effects and consequent increase in applied torque. The t/d ratio also gives a clue as to the relative shaft diameter. That becomes important when determining the bearing torque, as a greater shaft diameter necessitates a greater disc cross section. Shaft diameters must be considered not only for the ability to withstand dynamic forces, but must also be sized with respect

to static shear forces under full load shut-off conditions. Hence an ideal t/d ratio is one that optimizes the minimum aerodynamic effects of the disc cross section to adequate shaft diameters supporting both static and dynamic loads.

In consideration of the above, it is indicated that the worst case, with the highest applied shaft torque under any given pressure drop would be when the valve is close mounted to an elbow, at right angles to the plane of the radius and installed with the curved side upstream. Decreasing levels of shaft torque are indicated as each of the above parameters (Refer to Fig. 12) are changed or modified until the lowest level of shaft torque is attained when the shafts are in plane to the elbow, and the flat side of the disc is facing upstream (Refer to Fig 9). Therefore a pertinent recommendation would be to mount the butterfly valves in question as described in the latter case above whenever possible. A further conclusion can be made, that for a specific application accurate calculation of torques under existing conditions and recalculation of expected torques when the conditions are modified can be effected by employing the data given by curve plot, tabulation and formulas given in this report.

CUSTOMER NASA/LANGLEY RESEARCH CENTER	DATE 12-20-79	SHEET I OF 1	
SUBJECT 6" BUTTERFLY VALVE AIR TESTS		PRELIM.	FINAL
DRAWING NUMBER	LITHO IN U.S.A.—A-C ENGINEERING CALCULATION SHEET ALLIS-CHALMERS FORM 6715-1	CALCULATED BY GILGORE	

SCHEMATIC OF TEST SET UP ELEVATION



Appendix I

STREAMSEAL 6" BFV Valve Tests

Test #	t/d	Upstream Face	Inlet Pressure PSIA (Range)	Valve Inst.	Valve Position	Fig. No.
21	.29	Flat	75-25	Pin/Pout	In Plane	9
22	.29	Curved	75-25	Pin/Pout	In Plane	11
23	.29	Curved	75-25	Pin/Pout	90° to RT.	12
24	.29	Flat	75-25	Pin/Pout	90° to RT.	10
25	.12	Flat	75-25	Pin/Pout	In Plane	9
26	.12	Curved	75-25	Pin/Pout	In Plane	11
27	.12	Curved	75-25	Pin/Pout	90° to RT.	12
28	.12	Flat	75.4-25	Pin/Pout	90° to RT.	10
29	.17	Flat	75-28	Pin/Pout	In Plane	9
30	.17	Curved	75-28	Pin/Pout	In Plane	11
31	.17	Curved	76.4-28	Pin/Pout	90° to RT.	12
32	.17	Flat	75.4-28	Pin/Pout	90° to RT.	10

CUSTOMER Air Flow Tests NASA/Langley Research Center	DATE Nov. & Dec. 1979	SHEET 1 OF 7	
SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model	PRELIM.	FINAL	
DRAWING NUMBER	LITHO IN U.S.A.—A-C	CALCULATED BY WHG	

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 21 ✓

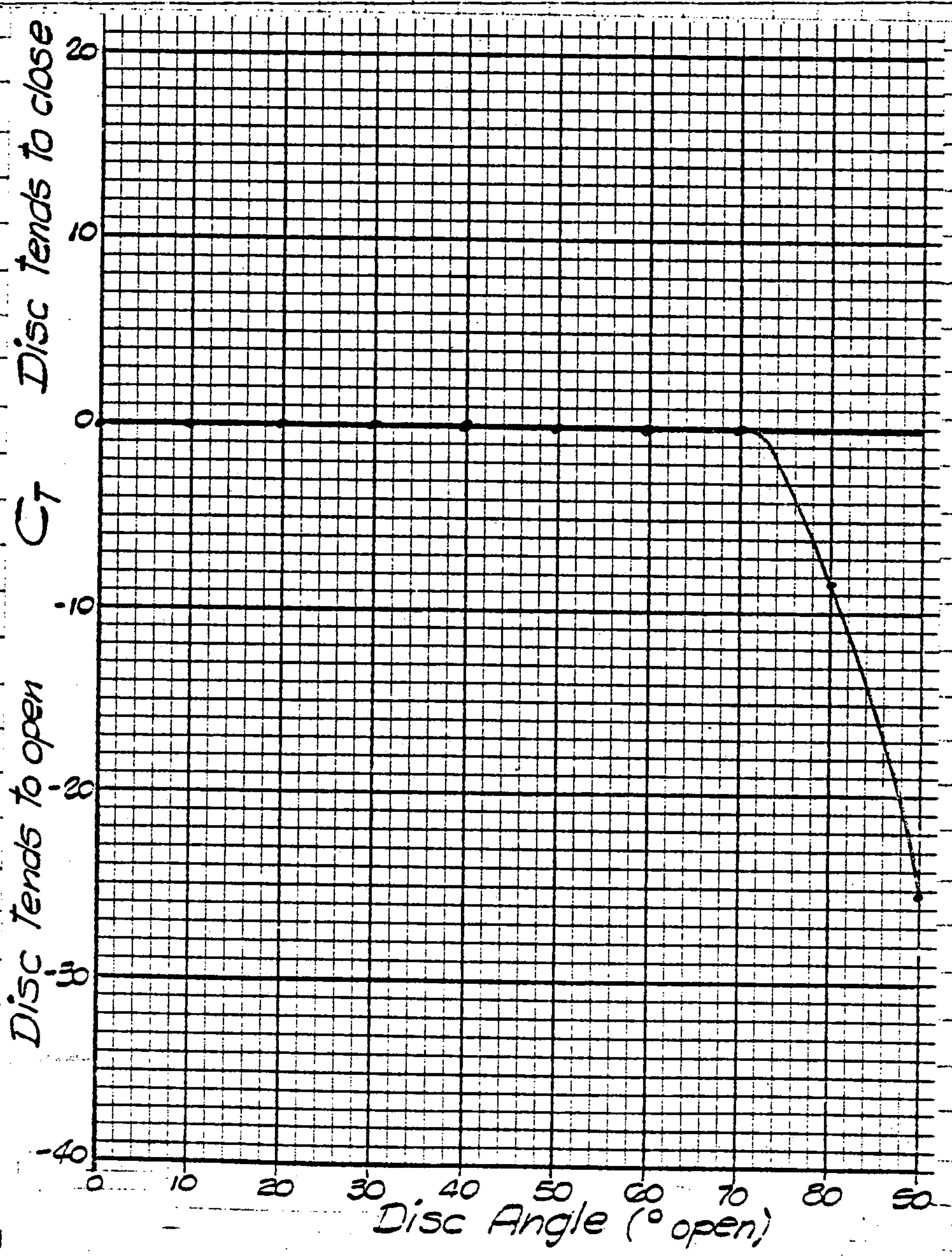
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 10 PSIG Valve orientation ref. Figure 9

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER	DATE	SHEET
Air Flow Tests NASA/Langley Research Center	Nov. & Dec. 1979	2 of 7

SUBJECT	PRELIM.	FINAL
Allis-Chalmers 6" Streamseal Butterfly Valve Model		

DRAWING NUMBER

LITHO IN U.S.A.-A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY WHG

Test No. 21

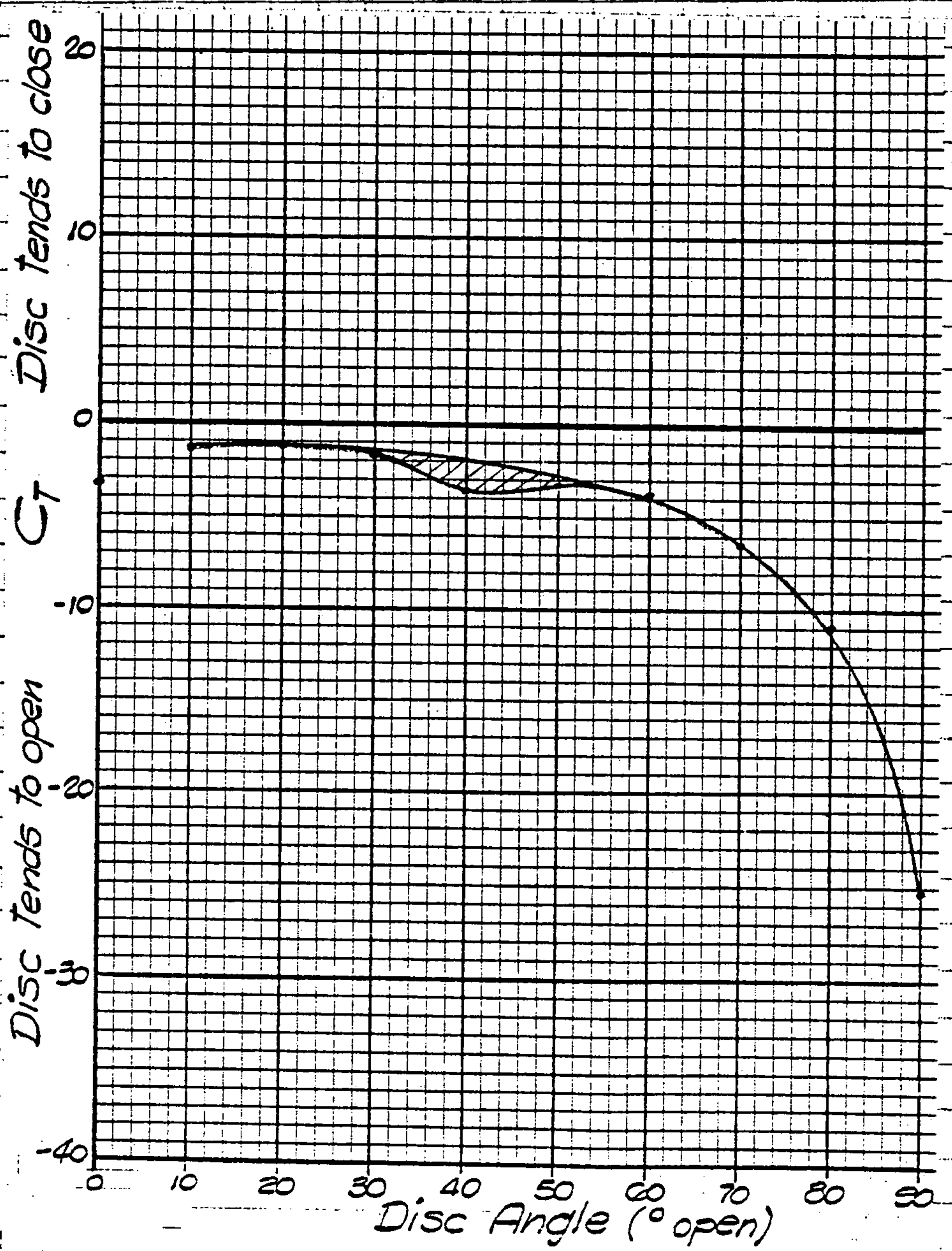
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 15 PSIG Valve orientation ref. Figure 9

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 21 P_{T_1} = 10 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	5	3	2	-6.3	-25.2	7.1
80	5.5	2.5	3	-3.1	-8.3	8.4
70	6	2	4	0	0	9.8
60	7.5	1.5	6	0	0	11.1
50	8.5	1	7.5	0	0	11.8
40	9.5	1	8.5	0	0	12.5
30	10	0	10	0	0	13.2
20	10	0	10	0	0	13.8
10	10	0	10	0	0	13.8
0	10	0	10	0	0	13.8

Test 21 15 PSI

90	7.5	4.5	3	-9.4	-25.1	6.4
80	8	4	4	-5.5	-11.0	7.8
70	10	3	7	-5.5	-6.3	9.8
60	11	3	8	-3.9	-3.9	11.8
50	12.5	2.5	10	-3.9	-3.1	12.5
40	14	2	12	-5.5	-3.7	13.2
30	14.5	1	13.5	-3.1	-1.8	13.8
20	15	0	15	-2.0	-1.1	14.5
10	15	0	15	-2.4	-1.3	15.2
0	15	0	15	-5.9	-3.1	15.2

CUSTOMER	DATE	SHEET
Air Flow Tests NASA/Langley Research Center	Nov. & Dec. 1979	3 of 7

SUBJECT	PRELIM.	FINAL
Allis-Chalmers 6" Streamseal Butterfly Valve Model		

DRAWING NUMBER

LITHO IN U.S.A.—A-C

CALCULATED BY WHG

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 21

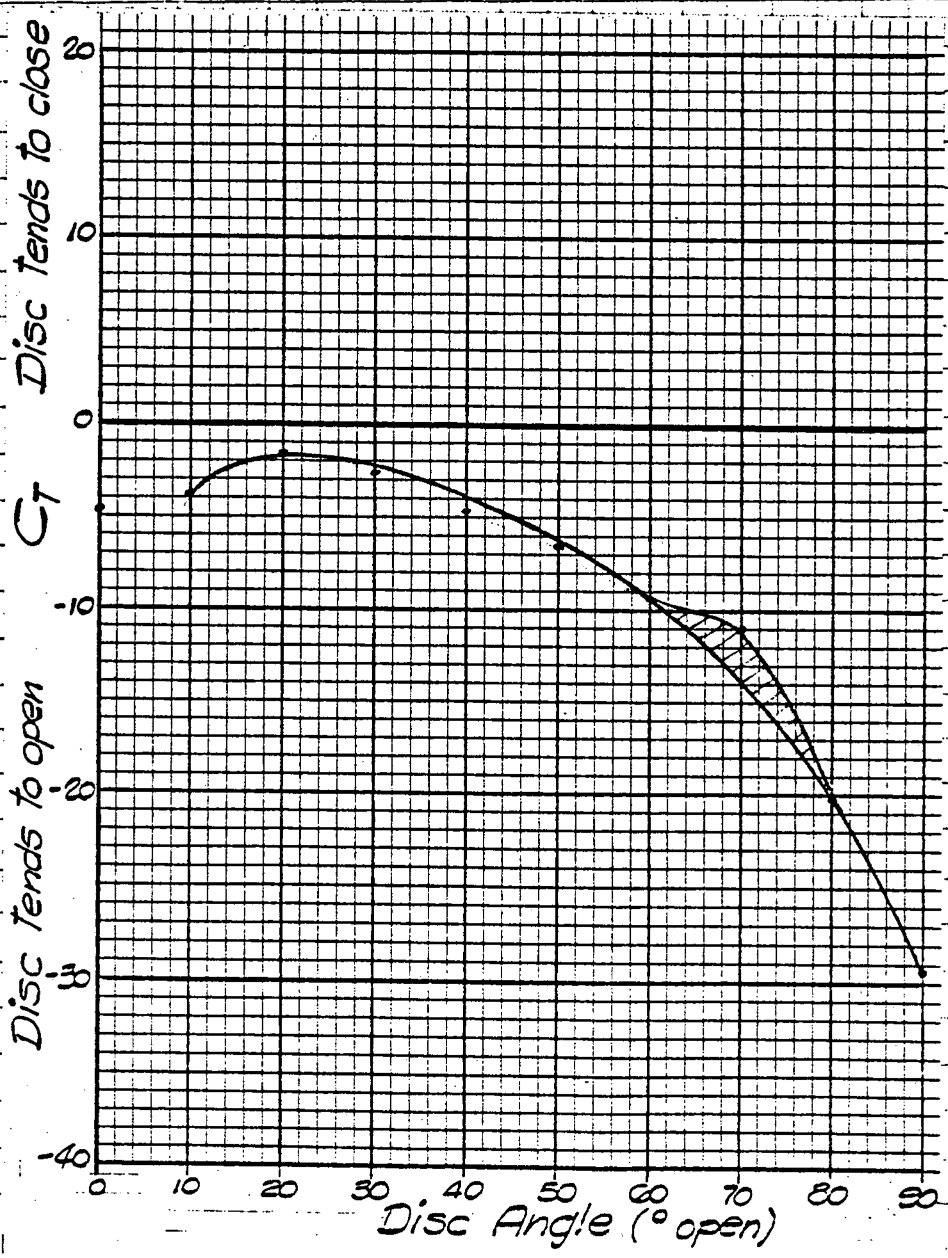
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 20 PSIG Valve orientation ref. Figure 9

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER: Air Flow Tests NASA/Langley Research Center	DATE: Nov. & Dec. 1979	SHEET 4 OF 7
SUBJECT: Allis-Chalmers 6" Streamseal Butterfly Valve Model	PRELIM.	FINAL
DRAWING NUMBER	CALCULATED BY WHG	

LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 21

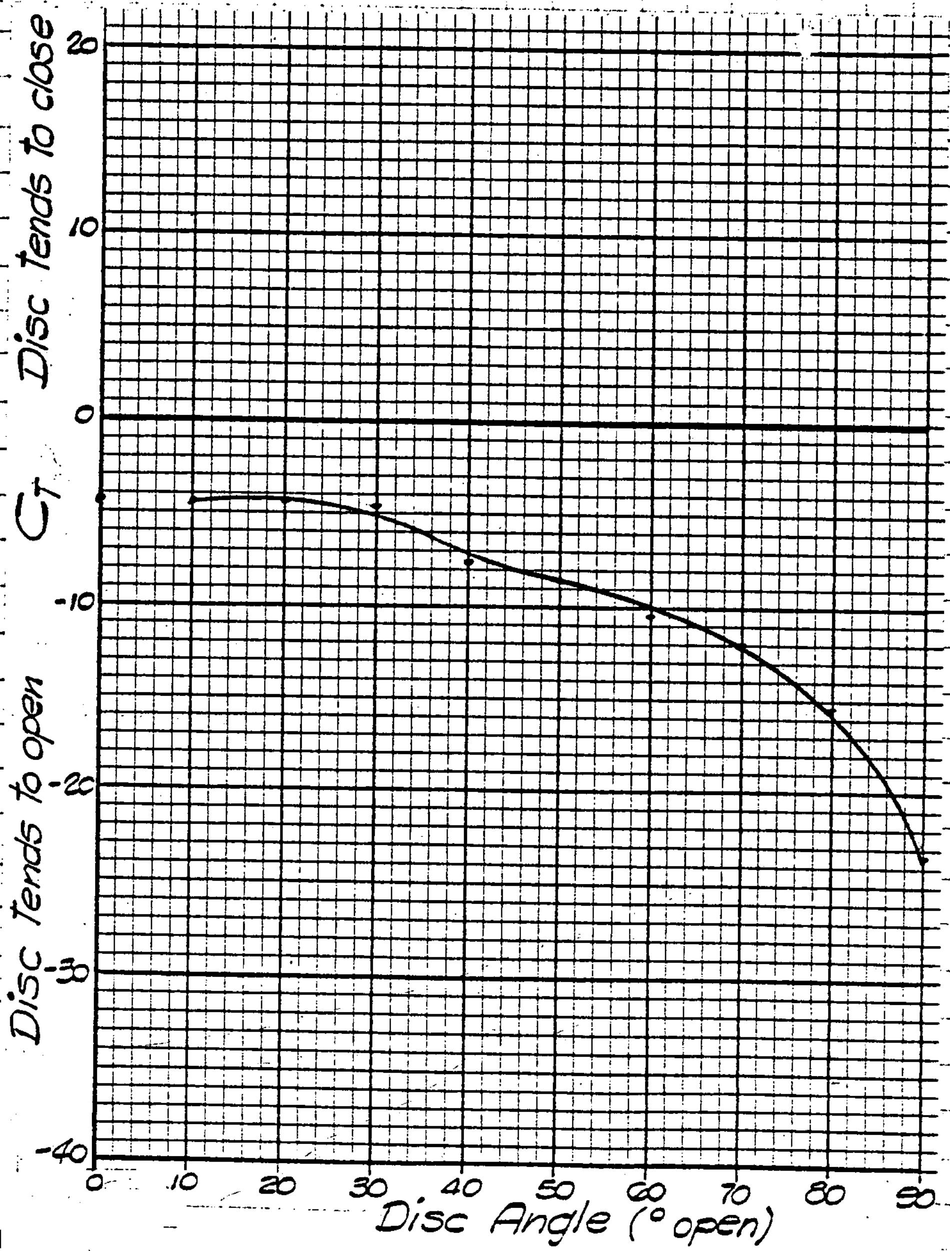
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 30PSIG Valve orientation ref. Figure 9

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in PSI.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 21 20 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	10	5.5	4.5	-16.5	-29.3	7.8
80	10.5	5	5.5	-13.8	-20.1	8.4
70	14	4	10	-13.8	-11.0	10.5
60	15	3	12	-13.8	-9.2	11.8
50	16.5	2	14.5	-11.8	-6.5	13.8
40	18	1.5	16.5	-9.8	-4.5	15.2
30	19	1	18	-6.3	-2.8	16.5
20	20	.5	19.5	-3.9	-1.6	17.2
10	20	0	20	-9.8	-3.9	17.9
0	20	0	20	-11.8	-4.7	17.9

Test 21 30 PSI

90	17.5	7	10.5	-30.7	-23.4	13.2
80	20	7	13	-24.8	-15.3	13.8
70	22.5	6	16.5	-24.8	-12.0	16.5
60	25	5	20	-25.9	-10.4	18.5
50	28.5	4	24.5	-25.9	-8.5	19.9
40	29	3	26	-24.8	-7.6	21.2
30	30	2	28	-16.5	-4.7	21.9
20	31	1	30	-15.7	-4.2	22.6
10	31	1	30	-16.5	-4.4	22.6
0-	31	1	30	-16.5	-4.4	22.6

CUSTOMER	DATE	SHEET
Air Flow Tests NASA/Langley Research Center	Nov. & Dec. 1979	5 OF 7

SUBJECT	PRELIM.	FINAL
Allis-Chalmers 6" Streamseal Butterfly Valve Model		

DRAWING NUMBER

LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY WHG

Test No. 21

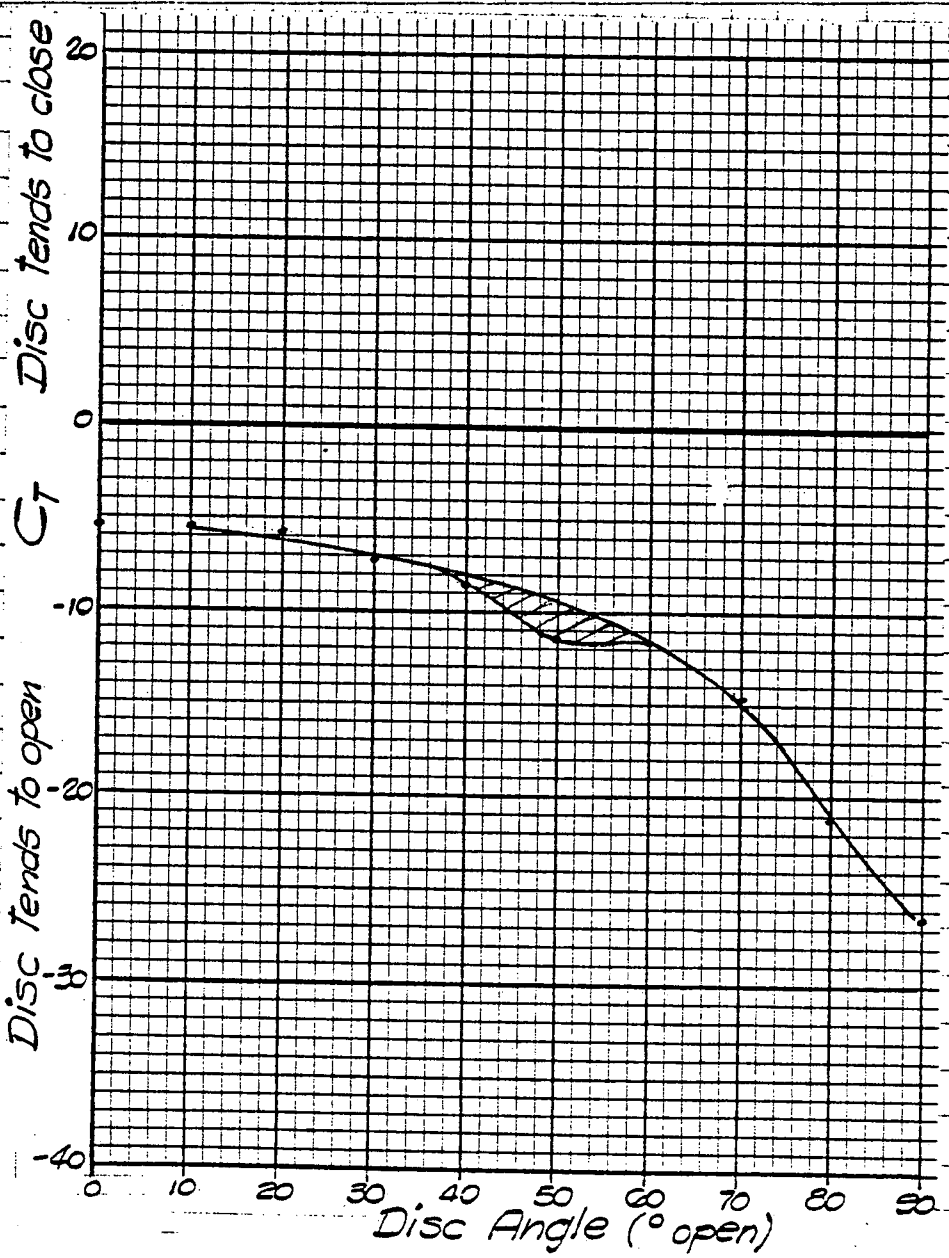
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 40 PSIG Valve orientation ref. Figure 9

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER	DATE	SHEET
Air Flow Tests NASA/Langley Research Center	Nov. & Dec. 1979	6 of 7

SUBJECT	PRELIM.	FINAL
Allis-Chalmers 6" Streamseal Butterfly Valve Model		

DRAWING NUMBER — LITHO IN U.S.A.—A-C — CALCULATED BY WHG

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS — FORM 6715-1

Test No. 21

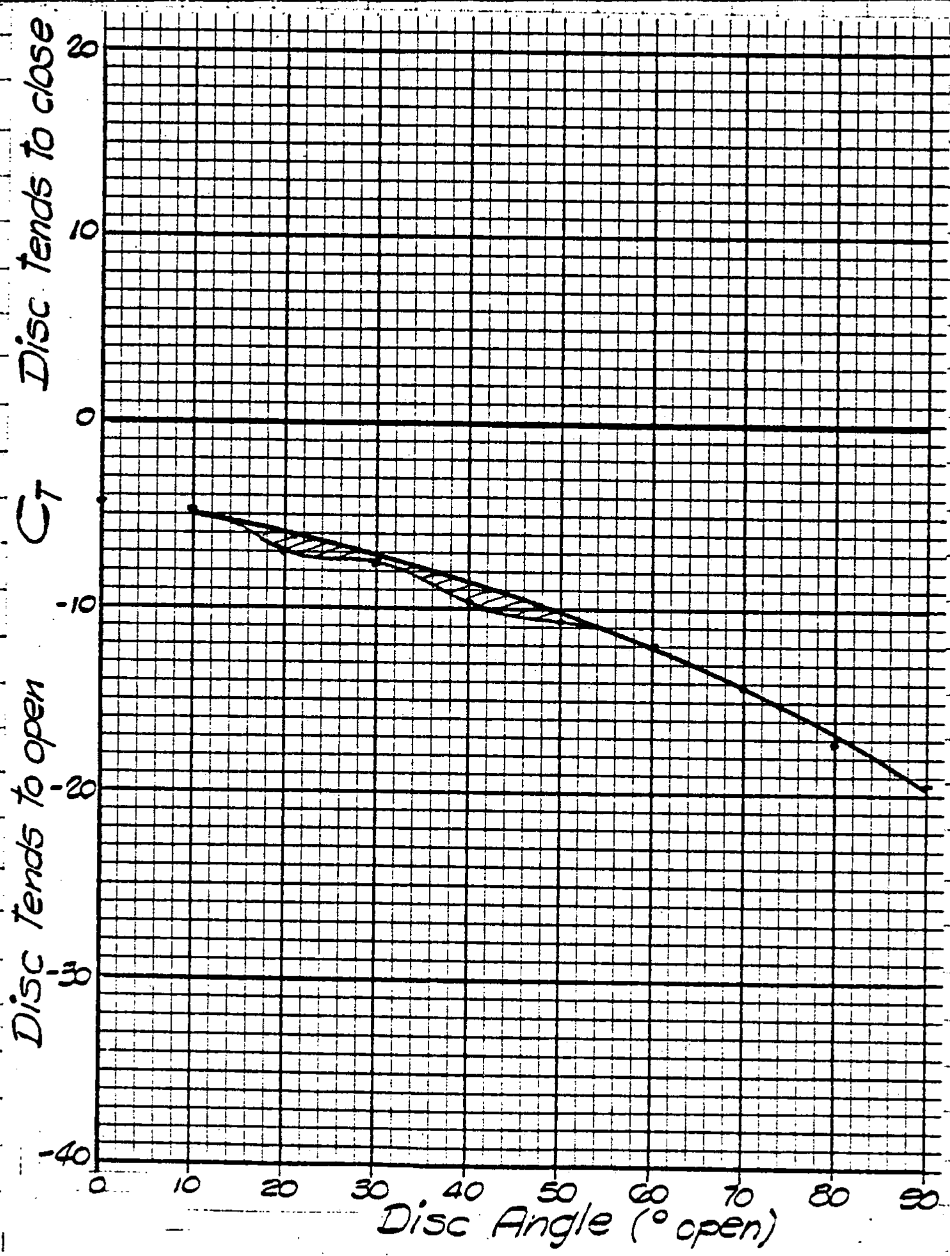
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 50 PSIG Valve orientation ref. Figure 9

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 21 40 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	25	12.5	12.5	-41.3	-26.4	20.6
80	25	12.5	12.5	33.0	-21.1	21.9
70	30	12	18	-33.0	-14.7	23.9
60	30.5	8	22.5	-33.0	-11.7	25.3
50	35	6	29	-41.3	-11.4	28.0
40	35	4	31	-33.0	-8.5	29.3
30	35.5	4	31.5	28.1	-7.1	30.7
20	38	4	34	-24.8	-5.8	31.3
10	40	3	37	-24.8	-5.4	31.3
0	40	2	38	-24.8	-5.2	31.3

Test 21 50 PSI

90	34.0	16.5	17.5	-42.9	-19.6	32.0
80	33.0	16.0	17.0	-36.3	-17.1	33.3
70	37.5	15.0	22.5	-39.6	-14.1	36.0
60	40.0	12.5	27.5	-41.3	-12.0	38.1
50	43.0	9.0	34.0	-46.2	-10.9	38.7
40	46.0	6.5	39.5	-47.9	-9.7	40.1
30	47.0	5.0	42.0	-39.6	-7.5	40.7
20	47.5	3.5	44.0	-33.0	-6.0	41.4
10	49.0	2.5	46.5	-28.1	-4.8	42.1
0	49.0	1.5	47.5	-24.8	-4.2	42.1

CUSTOMER Air Flow Tests NASA/Langley Research Center	DATE Nov. & Dec. 1979	SHEET 7 OF 7
SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model	PRELIM.	FINAL
DRAWING NUMBER	LITHO IN U.S.A.—A-C	CALCULATED BY WHG

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 21

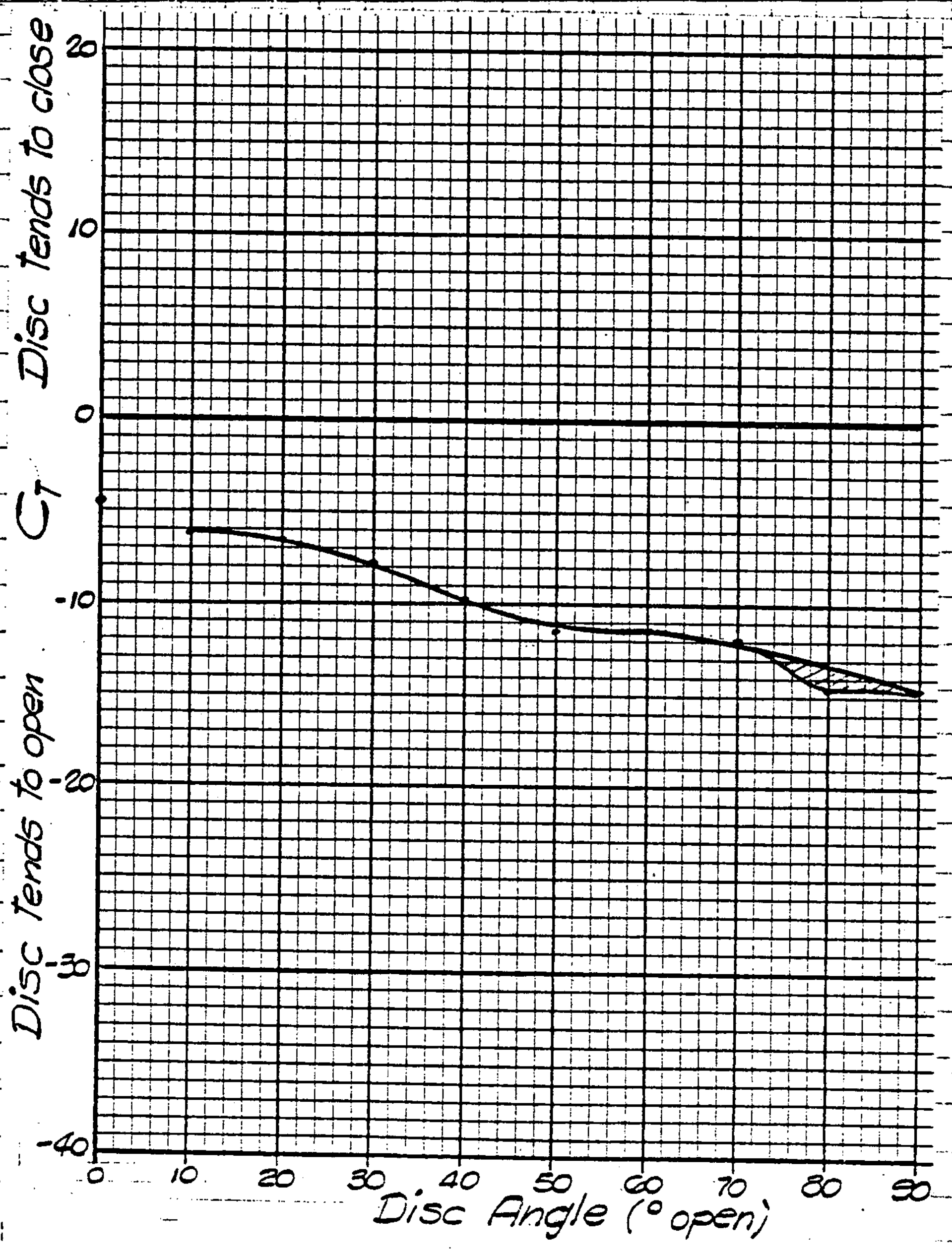
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 60 PSIG Valve orientation ref. Figure 9

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 21 60 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	40	17.5	22.5	-41.3	-14.7	39.4
80	40	17.5	22.5	-41.3	-14.7	40.7
70	45	17.5	27.5	-41.3	-12.0	43.4
60	47.5	12.5	35	-49.5	-11.3	45.5
50	50	10	40	-57.8	-11.6	47.5
40	54	7.5	46.5	-57.8	-9.9	49.5
30	55	5	50	-49.5	-7.9	50.2
20	55	5	50	-41.3	-6.6	50.8
10	55	1	54	-41.3	-6.1	51.5
0	57	0	57	-33.0	-4.6	51.5

CUSTOMER Air Flow Tests NASA/Langley Research Center | DATE Nov. & Dec. 1979 | SHEET 1 OF 7

SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model | PRELIM. | FINAL

DRAWING NUMBER | LITHO IN U.S.A.—A-C | CALCULATED BY WHG

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 22

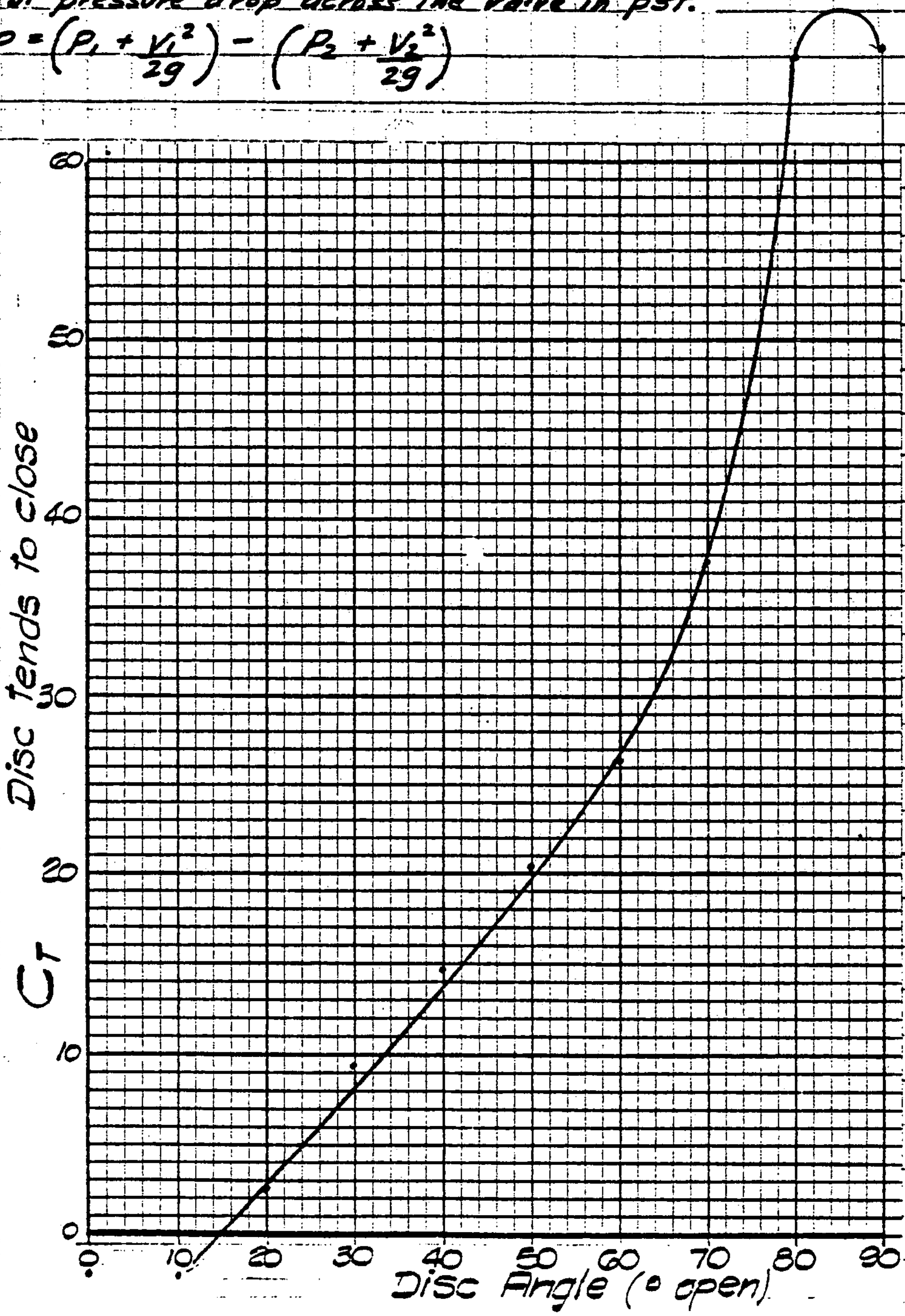
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 10PSIG Valve orientation ref. Figure 11

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER	DATE	SHEET
Air Flow Tests NASA/Langley Research Center	Nov. & Dec. 1979	2 of 7

SUBJECT	PRELIM.	FINAL
Allis-Chalmers 6" Streamseal Butterfly Valve Model		

DRAWING NUMBER — LITHO IN U.S.A.—A-C — CALCULATED BY WHG

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS — FORM 6715-1

Test No. 22

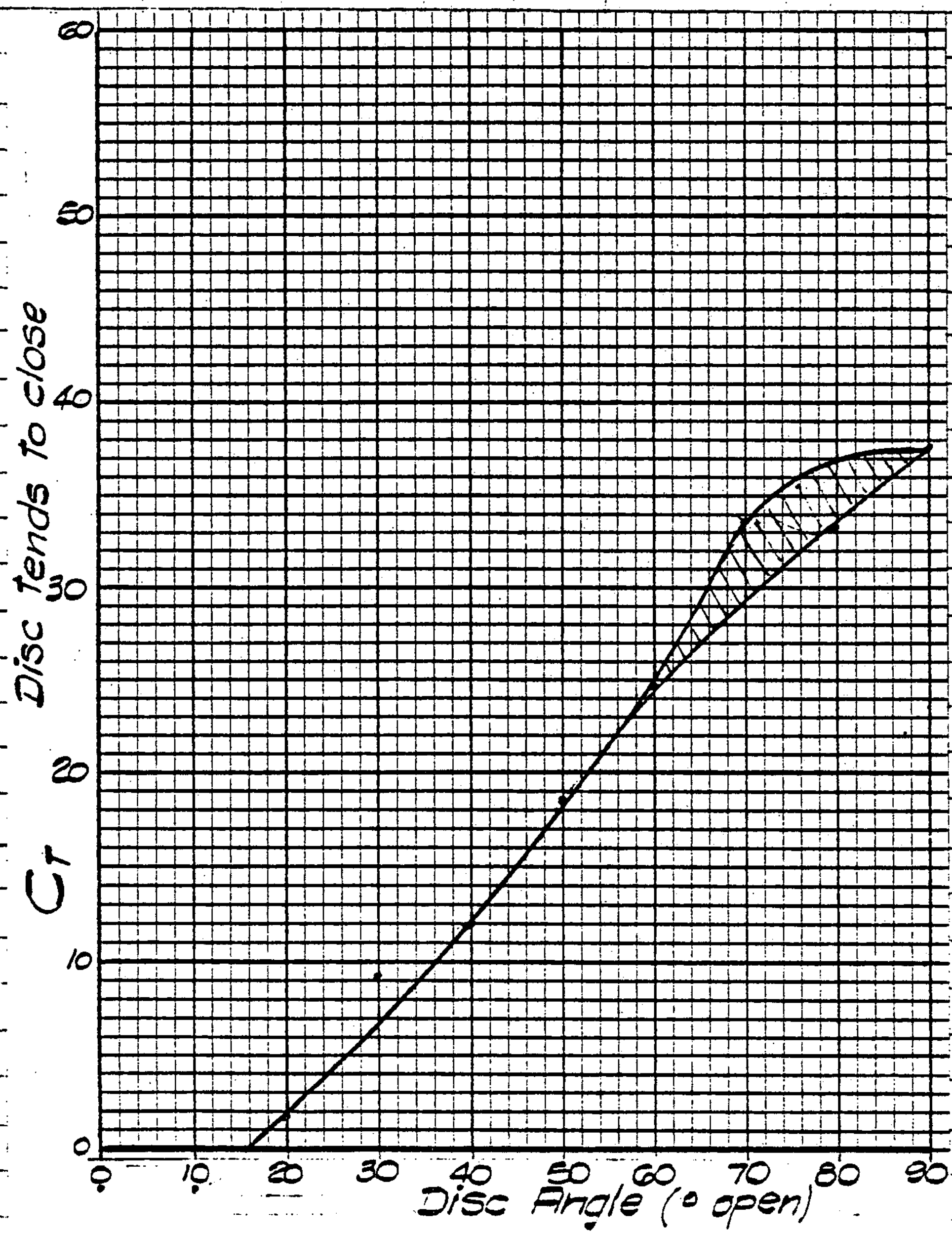
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 15 PSIG Valve orientation ref. Figure 11

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 22 P_{T_1} = 10 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	4	3	1	8.3	66.4	5.1
80	5	3	2	16.5	66	6.4
70	5.5	2	3.5	16.5	37.7	8.4
60	7	2	5	16.5	26.4	10.5
50	8	1.5	6.5	16.5	20.3	11.8
40	9	1	8	14.9	14.9	11.8
30	10	.5	9.5	11.0	9.3	13.2
20	10	.5	9.5	3.1	2.6	13.2
10	10	.5	9.5	-3.1	-2.6	13.2
0	10	0	10	-3.1	-2.5	13.2

Test 22 15 PSI

90	6.5	3	3.5	16.5	37.7	5.1
80	9	3	6	24.8	33.1	6.4
70	9	2.5	6.5	27.5	33.8	8.4
60	10	2	8	24.8	24.8	10.5
50	11	1.5	9.5	22.0	18.5	11.8
40	12	1	11	16.5	12	11.8
30	13	1	12	13.8	9.2	12.5
30	13	0	13	3.1	1.9	12.5
10	13	0	13	-3.1	-1.9	12.5
0	13	0	13	-3.1	-1.9	12.5

CUSTOMER Air Flow Tests NASA/Langley Research Center | DATE Nov. & Dec. 1979 | SHEET 3 OF 7

SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model | PRELIM. | FINAL

DRAWING NUMBER | LITHO IN U.S.A.—A-C | CALCULATED BY WHG

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 22

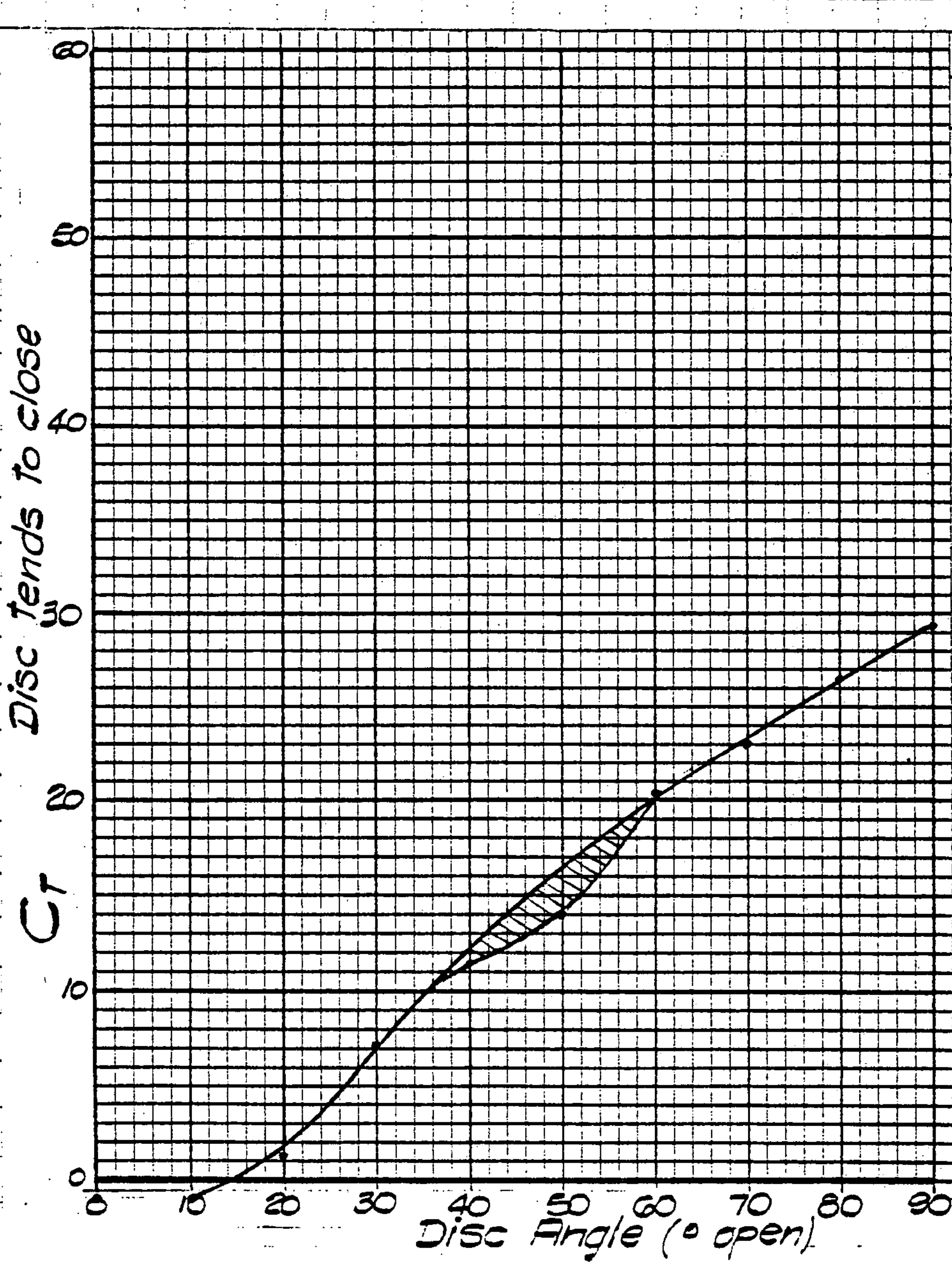
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 20 PSIG   Valve orientation ref. Figure 11

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER Air Flow Tests NASA/Langley Research Center | DATE Nov. & Dec. 1979 | SHEET 4 OF 7

SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model | PRELIM. | FINAL

DRAWING NUMBER | LITHO IN U.S.A.—A-C | CALCULATED BY WHG

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS | FORM 6715-1

Test No. 22

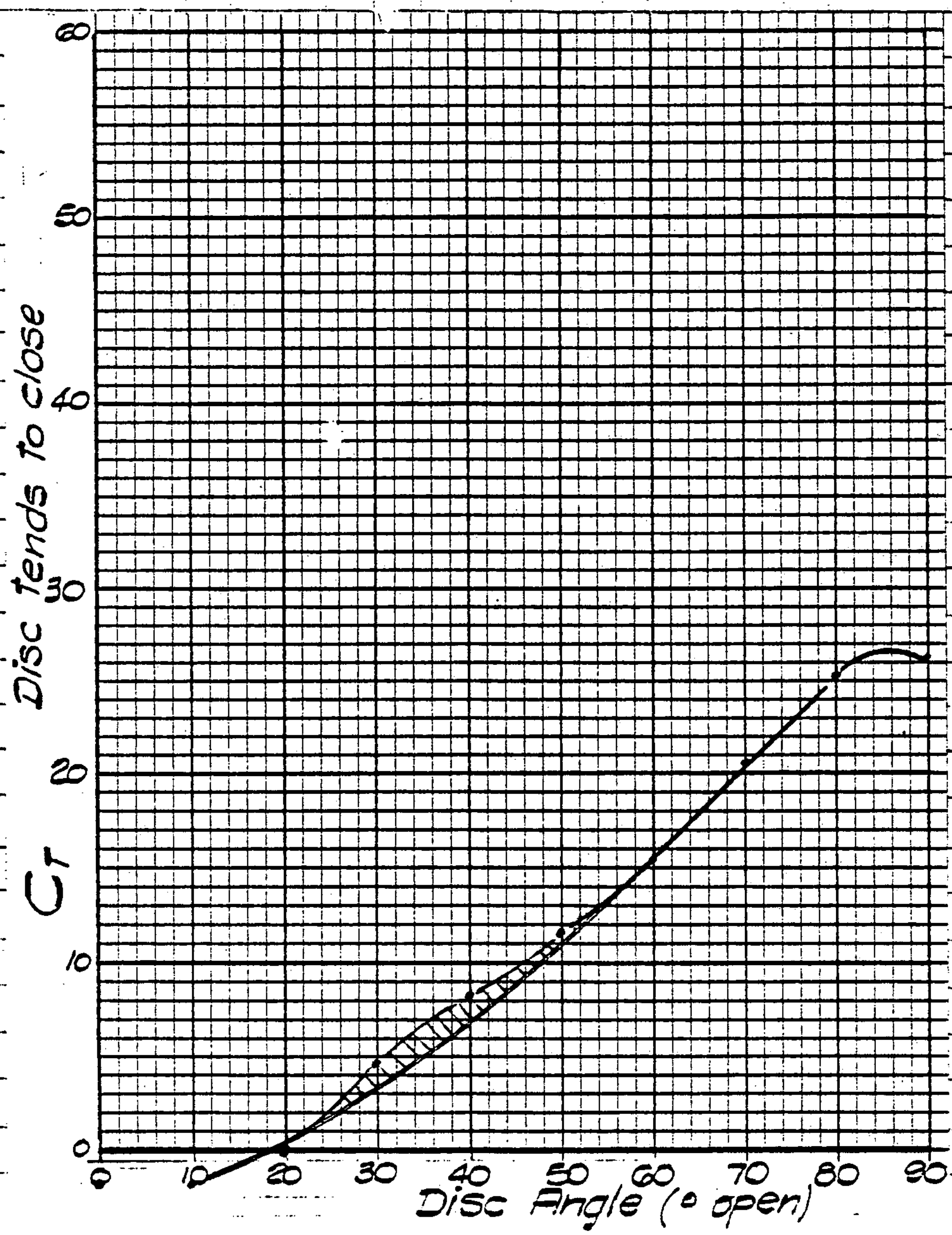
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 30PSIG Valve orientation ref. Figure 11

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 22 20 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	10	4	6	22	29.3	6.4
80	13	3	10	33	26.4	8.4
70	14	2.5	11.5	33	23.0	10.5
60	15	2	13	33	20.3	11.8
50	18	2	16	28	14	13.8
40	19	1.5	17.5	24.8	11.3	15.2
30	19.5	1	18.5	16.5	7.1	15.2
20	20	0	20	3.1	1.2	15.2
10	20	0	20	-3.1	-1.2	15.8
0	20	0	20	-3.1	-1.2	15.8

Test 22 30 PSI

90	17	8	9	29.5	26.2	11.8
80	20	6	14	44.0	25.1	13.2
70	22	5	17	44.0	20.7	15.8
60	24	4	20	38.5	15.4	17.2
50	25.5	3	22.5	33.0	11.7	18.5
40	27	1.5	25.5	25.9	8.1	18.5
30	29	0	29	17.3	4.8	19.2
20	30	0	30	0	0	19.9
10	30	0	30	-7.1	-1.9	19.9
0	30	0	30	-6.3	-1.7	19.9

CUSTOMER	DATE	SHEET
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SUBJECT	PRELIM.	FINAL
Allis-Chalmers 6" Streamseal Butterfly Valve Model		

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LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY WHG

Test No. 22

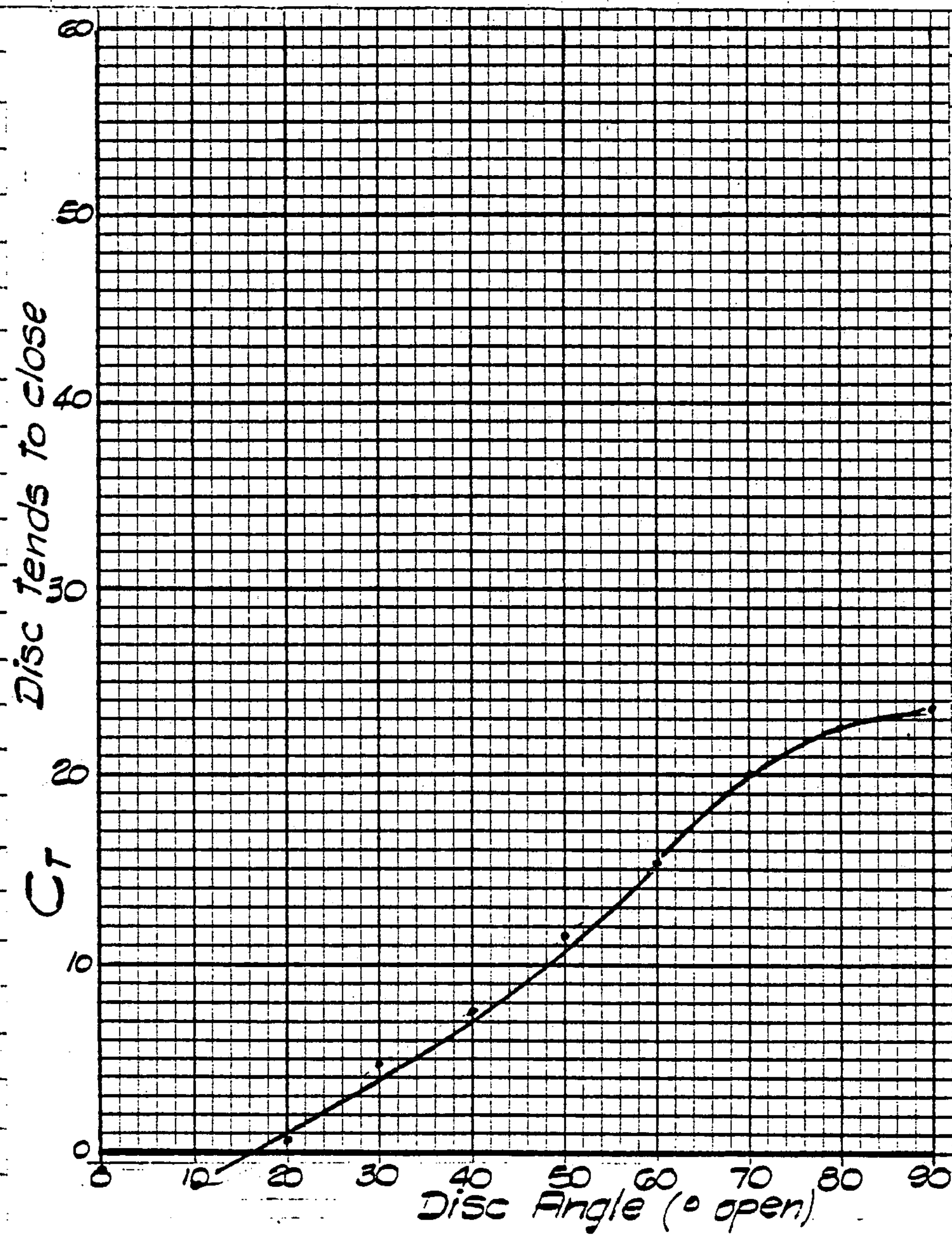
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 40PSIG Valve orientation ref. Figure 11

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER Air Flow Tests NASA/Langley Research Center	DATE Nov. & Dec. 1979	SHEET 6 OF 7
SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model	PRELIM.	FINAL
DRAWING NUMBER	LITHO IN U.S.A.—A-C	CALCULATED BY WHG

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 22

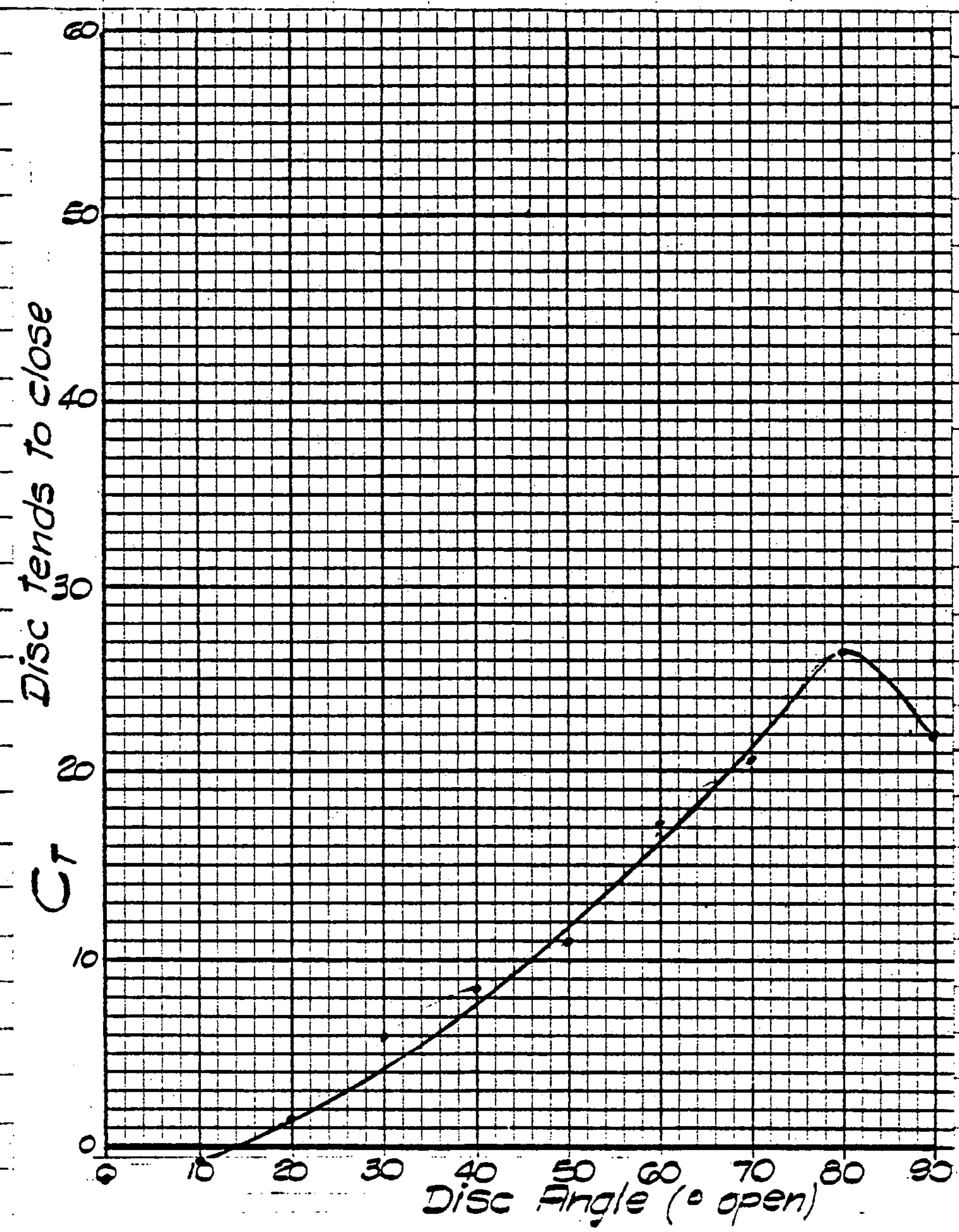
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 50PSIG Valve orientation ref. Figure 11

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 22 40 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	25	12	13	38.5	23.7	19.9
80	29	9.5	19.5	55	22.6	21.9
70	30	8	22	55	20	23.9
60	33	7	26	49.5	15.2	25.3
50	35	5	30	44	11.7	27.3
40	37.5	3	34.5	33	7.7	28.6
30	38	2	36	22	4.9	29.3
20	38	1	37	3.9	.8	30.0
10	39	0	39	-11.0	-2.3	30.0
0	40	0	40	-5.5	-1.1	30.0

Test 22 50 PSI

90	34	16	18	49.5	22	32.0
80	35	15	20	66.0	26.4	33.3
70	38.5	13	25.5	66.0	20.7	35.4
60	38.5	13	25.5	54.6	17.1	37.4
50	44	8	36	49.5	11	38.7
40	45	5	40	41.3	8.3	39.4
30	47	3	44	33.0	6	39.4
20	47.5	2	45.5	8.3	1.5	40.1
10	48	1	47	-5.5	-.9	40.1
0	49	1	48	-8.3	-1.4	40.1

CUSTOMER	DATE	SHEET
Air Flow Tests NASA/Langley Research Center	Nov. & Dec. 1979	7 of 7

SUBJECT	PRELIM.	FINAL
Allis-Chalmers 6" Streamseal Butterfly Valve Model		

DRAWING NUMBER

LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY WHG

Test No. 22

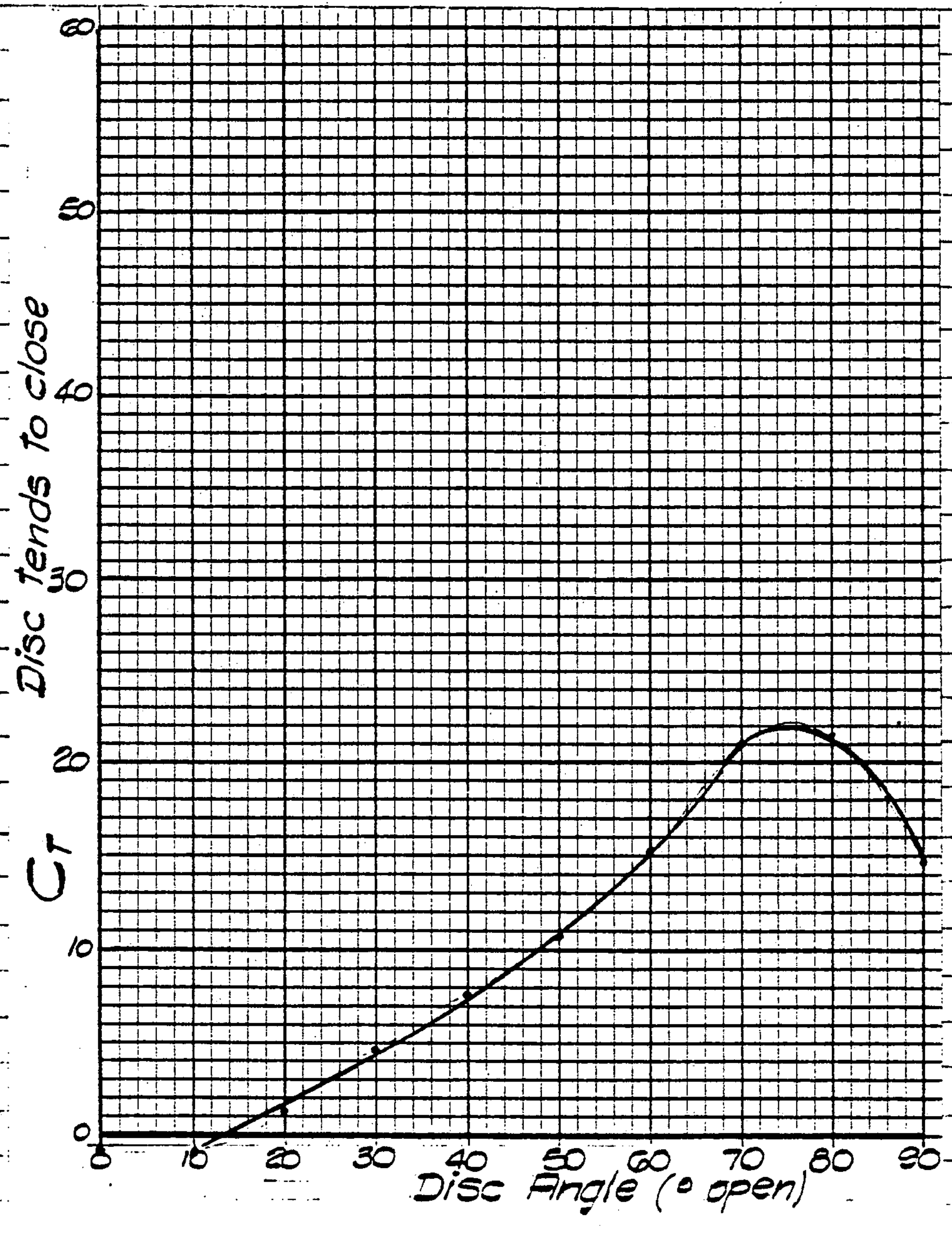
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 60 PSIG Valve orientation ref. Figure 11

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 22 60 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	40.5	17	23.5	57.8	19.7	37.4
80	40	16	24	66.0	22	38.7
70	43.5	15.5	28	66.0	18.9	41.4
60	45	32.5	32.5	66.0	16.2	43.4
50	52.5	10	42.5	57.8	10.9	45.5
40	56	7	49	47.2	7.7	46.1
30	57.5	3.5	54	33.0	4.9	46.8
20	59	3	56	7.9	1.1	46.8
10	59.5	2	57.5	-6.3	-.9	46.8
0	59.5	2	57.5	-9.8	-1.4	46.8

CUSTOMER: Air Flow Tests NASA/Langley Research Center	DATE: Nov. & Dec. 1979	SHEET 1 OF 7	
SUBJECT: Allis-Chalmers 6" Streamseal Butterfly Valve Model		PRELIM.	FINAL
DRAWING NUMBER	ENGINEERING CALCULATION SHEET (LITHO IN U.S.A.—A-C; ALLIS-CHALMERS; FORM 6715-1)	CALCULATED BY WHG	
		Test No. 23	

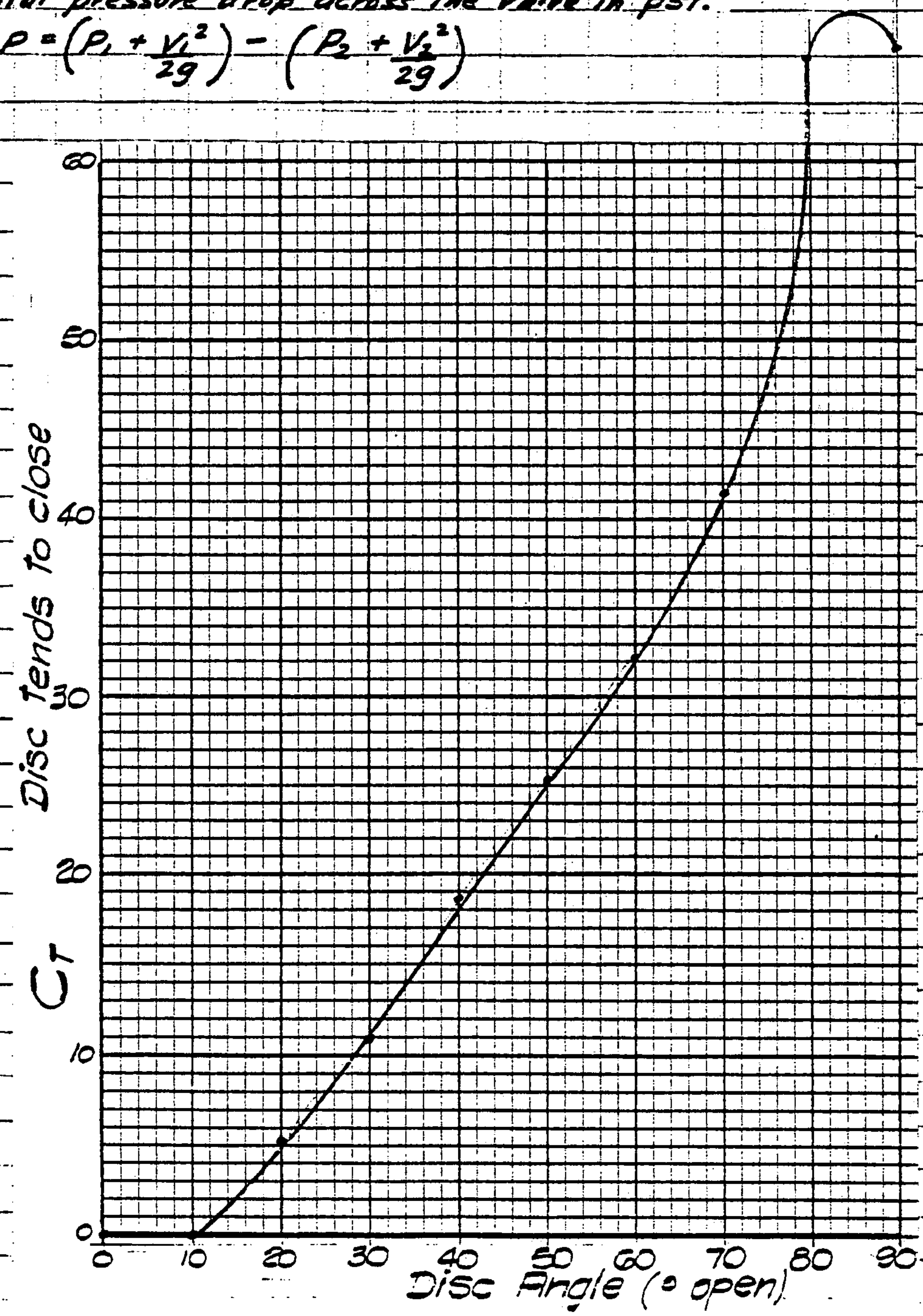
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 10 PSIG Valve orientation ref. Figure 12

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where Td is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER	DATE	SHEET
Air Flow Tests NASA/Langley Research Center	Nov. & Dec. 1979	2 OF 7

SUBJECT	PRELIM.	FINAL
Allis-Chalmers 6" Streamseal Butterfly Valve Model		

DRAWING NUMBER

LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY

Test No. 23

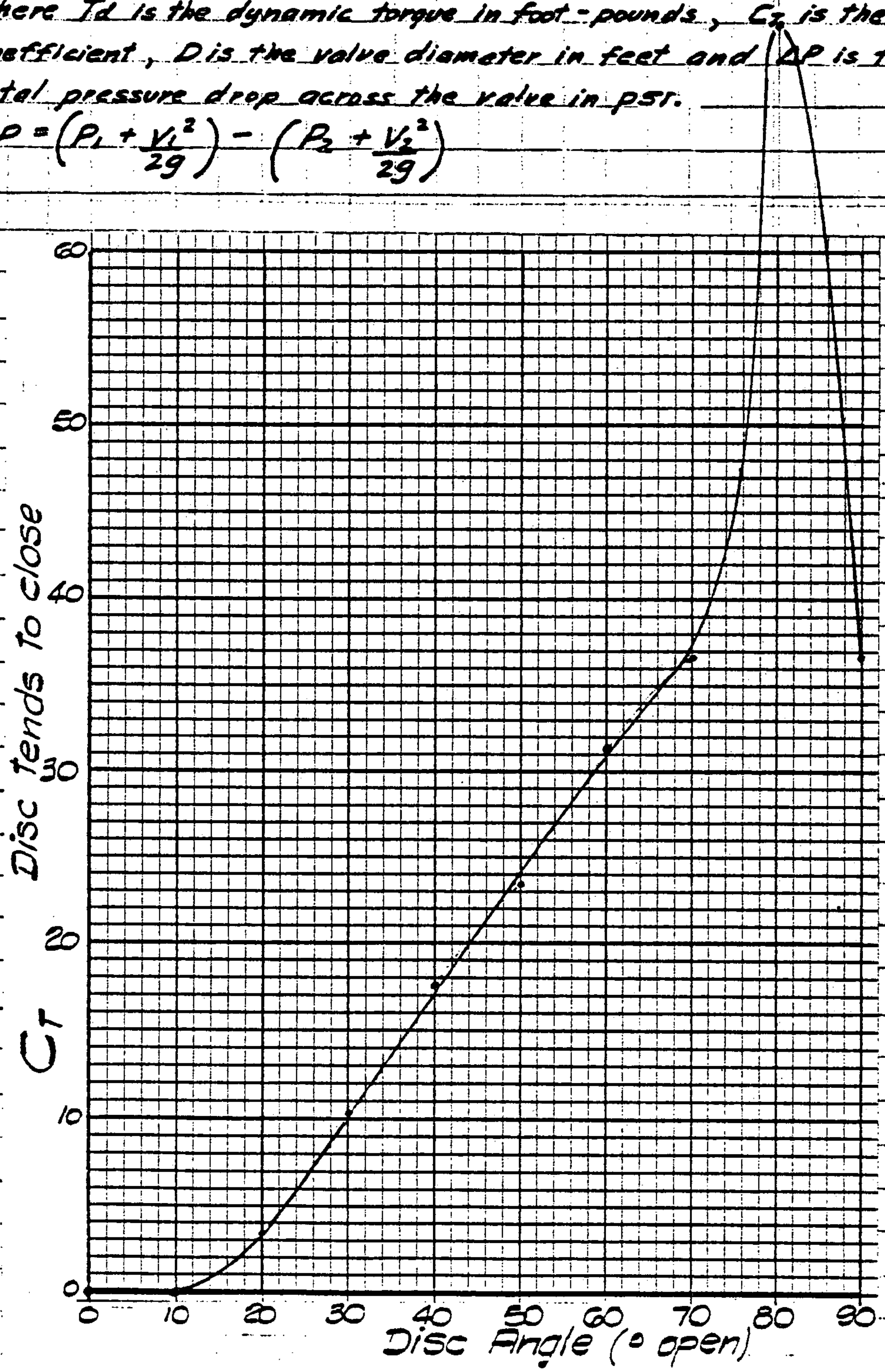
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 15 PSIG Valve orientation ref. Figure 12

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 23 P_{T_1} = 10 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	4	3	1	8.3	66.4	5.1
80	5	3	2	16.5	66.0	5.1
70	5.5	2	3.5	18.1	41.4	8.4
60	6	1.5	4.5	18.1	32.2	10.5
50	7	1.5	5.5	17.3	25.2	11.1
40	8	1	7	16.5	18.9	11.8
30	9	1	8	11.0	11.0	11.8
20	9	.5	8.5	5.5	5.2	11.8
10	10	.5	9.5	0	0	11.8
0	10	.5	9.5	0	0	11.8

Test 23 P_{T_1} = 15 PSI

90	6	3	3	13.8	36.8	5.1
80	7	1	3	27.5	73.3	5.1
70	9	3	6	27.5	36.7	8.4
60	10	3	7	27.5	31.4	10.5
50	11	2.5	8.5	24.8	23.3	11.8
40	12	2	10	22.0	17.6	11.8
30	13	1.5	11.5	14.9	10.4	11.8
20	14	1	13	5.5	3.4	11.8
10	14	1	13	0	0	11.8
0	14	1	13	0	0	11.8

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LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY WHG

Test No. 23

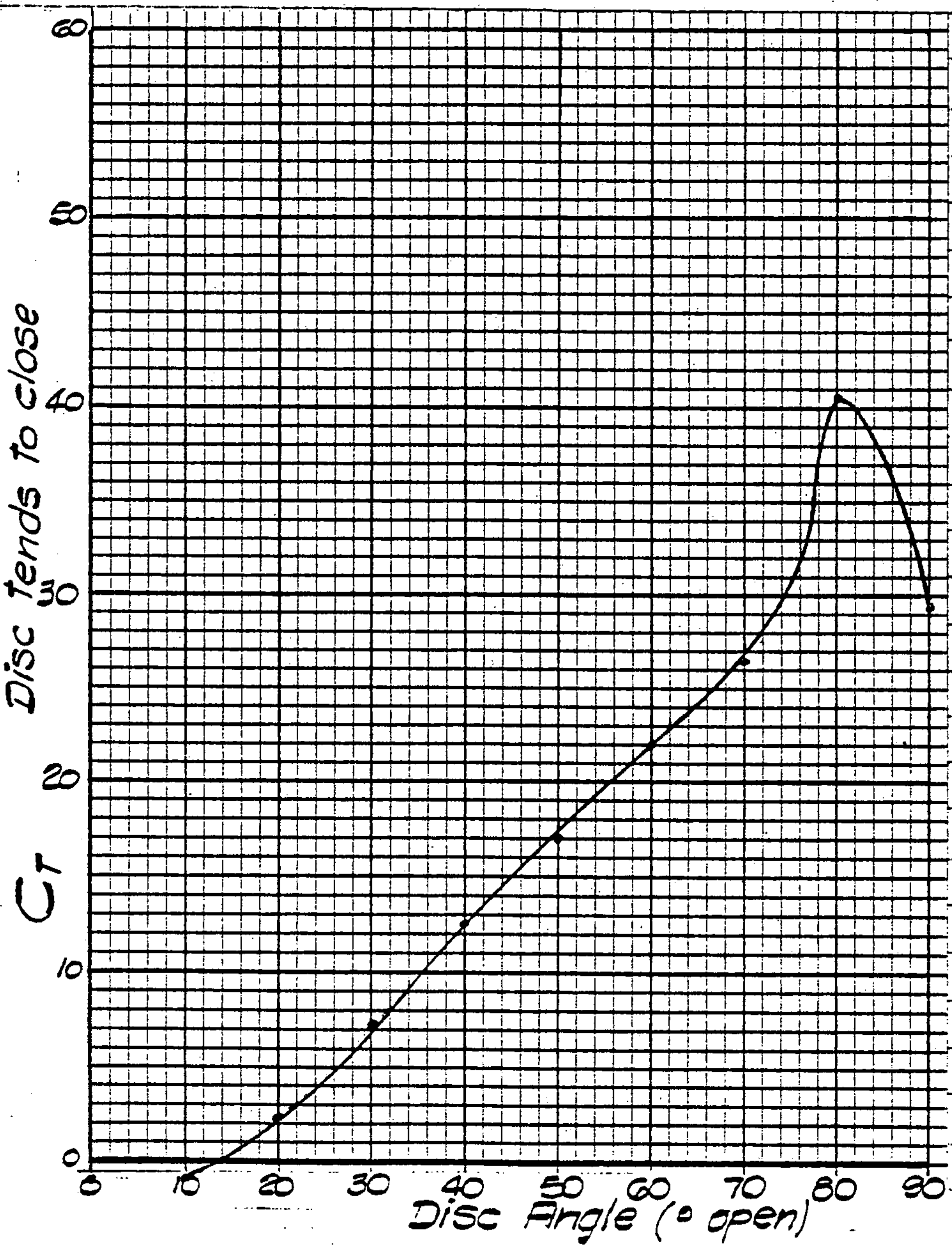
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 20 PSIG Valve orientation ref. Figure 12

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where Td is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



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ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS | FORM 6715-1

Test No. 23

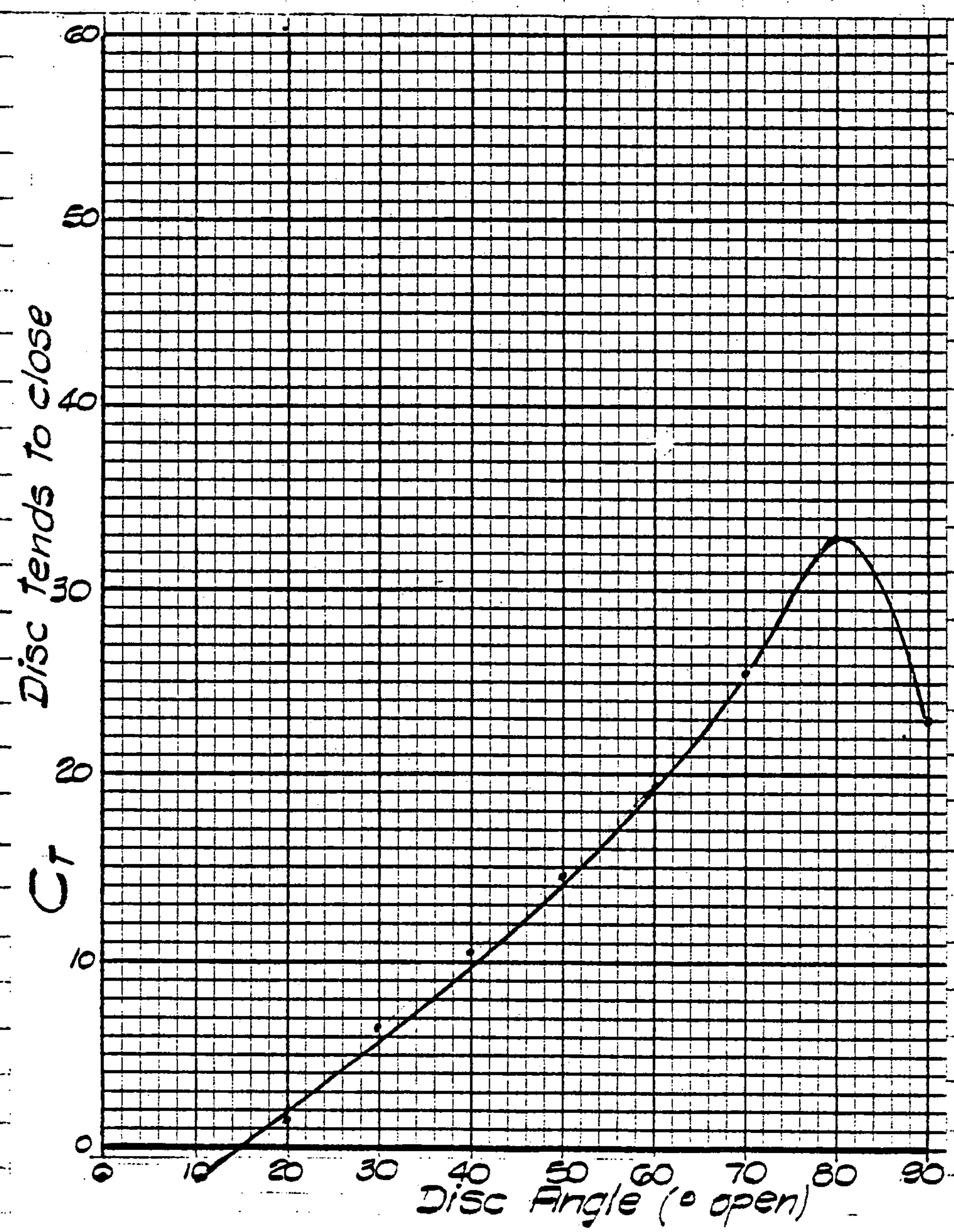
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 30PSIG Valve orientation ref. Figure 12

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 23 $P_{T_1} = 20$ PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	10	4	6	22.0	29.3	5.1
80	12.5	6	6.5	33.0	40.6	7.8
70	14	3.5	10.5	34.6	26.4	9.8
60	15	3	12	33.0	22.0	11.8
50	17.5	2	15.5	33.0	17.0	13.2
40	18.5	1	17.5	27.5	12.6	13.8
30	19	.5	18.5	16.5	7.1	15.2
20	20	0	20	5.5	2.2	15.2
10	20	0	20	-2.8	-1.1	15.2
0	20	0	20	-2.8	-1.1	15.2

Test 23 $P_{T_1} = 30$ PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	19	7.5	11.5	33.0	23.0	11.8
80	20	8	12	49.5	33.0	11.8
70	22	6.5	15.5	49.5	25.5	15.2
60	25.5	5	20.5	49.5	19.3	17.2
50	26	3.5	22.5	41.3	14.7	17.9
40	27.5	2.5	25.0	33.0	10.6	18.5
30	28	1.5	26.5	22.0	6.6	18.5
20	29	1	28	5.5	1.6	18.5
10	29	1	28	-5.5	-1.6	19.2
0	29	1	28	-5.5	-1.6	19.9

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ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 23

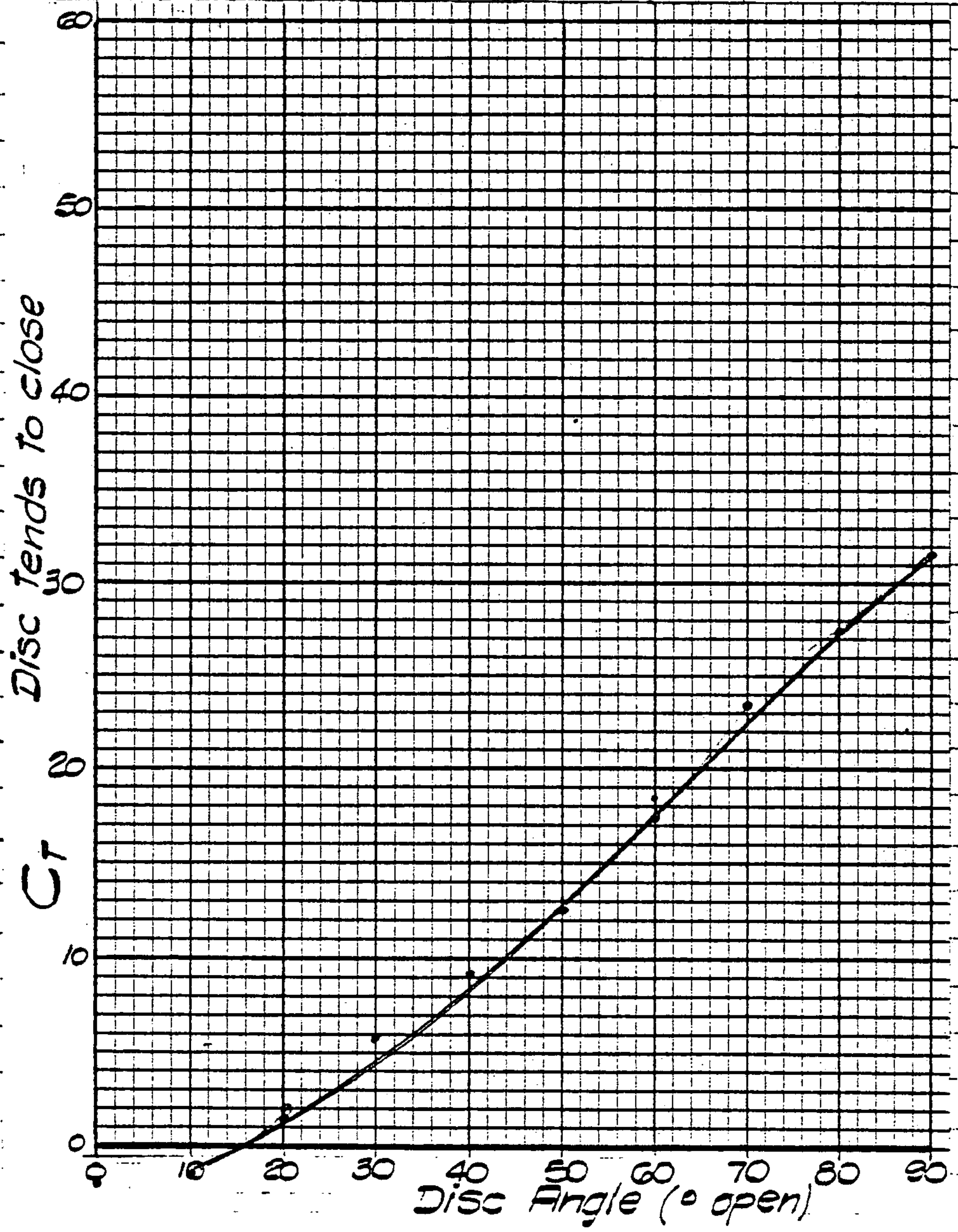
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 40 PSIG Valve orientation ref. Figure 12

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



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ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 23

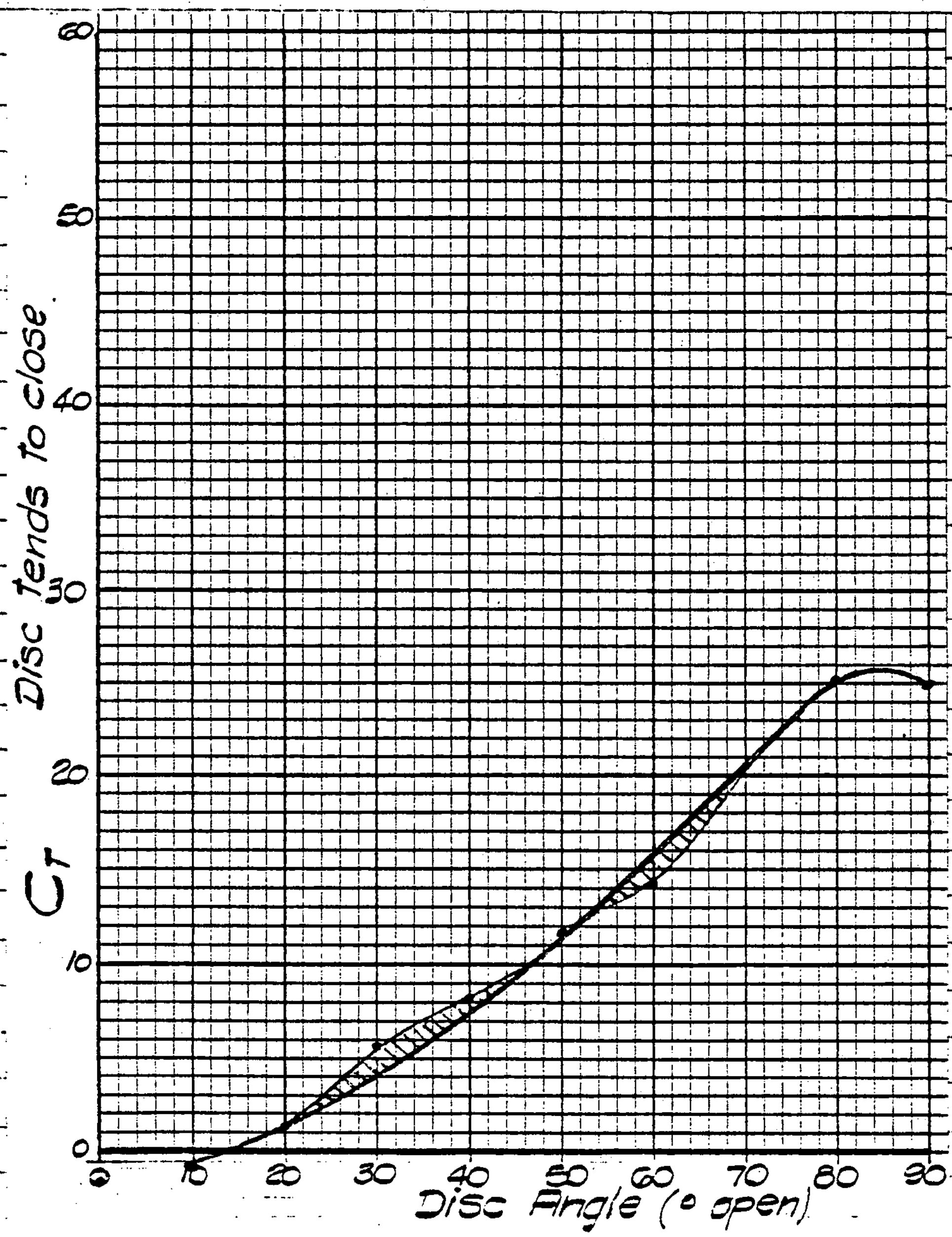
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 50PSIG Valve orientation ref. Figure 12

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 23 P_{T_1} = 40 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	25	12.5	12.5	49.5	31.7	18.5
80	28	11	17	57.8	27.2	20.6
70	30	9.5	20.5	60.5	23.6	22.6
60	34	8.5	25.5	55.0	17.3	23.9
50	37	5.5	31.5	49.5	12.6	25.3
40	38	4	34	38.5	9.1	25.9
30	40	3	37	27.5	5.9	26.6
20	40	2	38	6.7	1.4	27.3
10	40	1	39	-6.7	-1.4	27.3
0	40	1	39	-9.8	-2.0	28.0

Test 23 P_{T_1} = 50 PSI

90	34	15.5	18.5	57.8	25.0	29.3
80	35.5	14.5	21	66.0	25.1	32.0
70	39	13.5	25.5	66.0	20.7	33.3
60	44	10.5	33.5	59.0	14.1	35.4
50	45	8	37	55.0	11.9	36.0
40	46	5	41	41.3	8.1	36.7
30	48	3.5	44.5	33.0	5.9	37.4
20	48.5	2	46.5	7.1	1.2	38.1
10	49	2	47	-5.5	-.9	38.7
0	49	2	47	-8.3	-1.4	38.7

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ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY WHG

Test No. 23

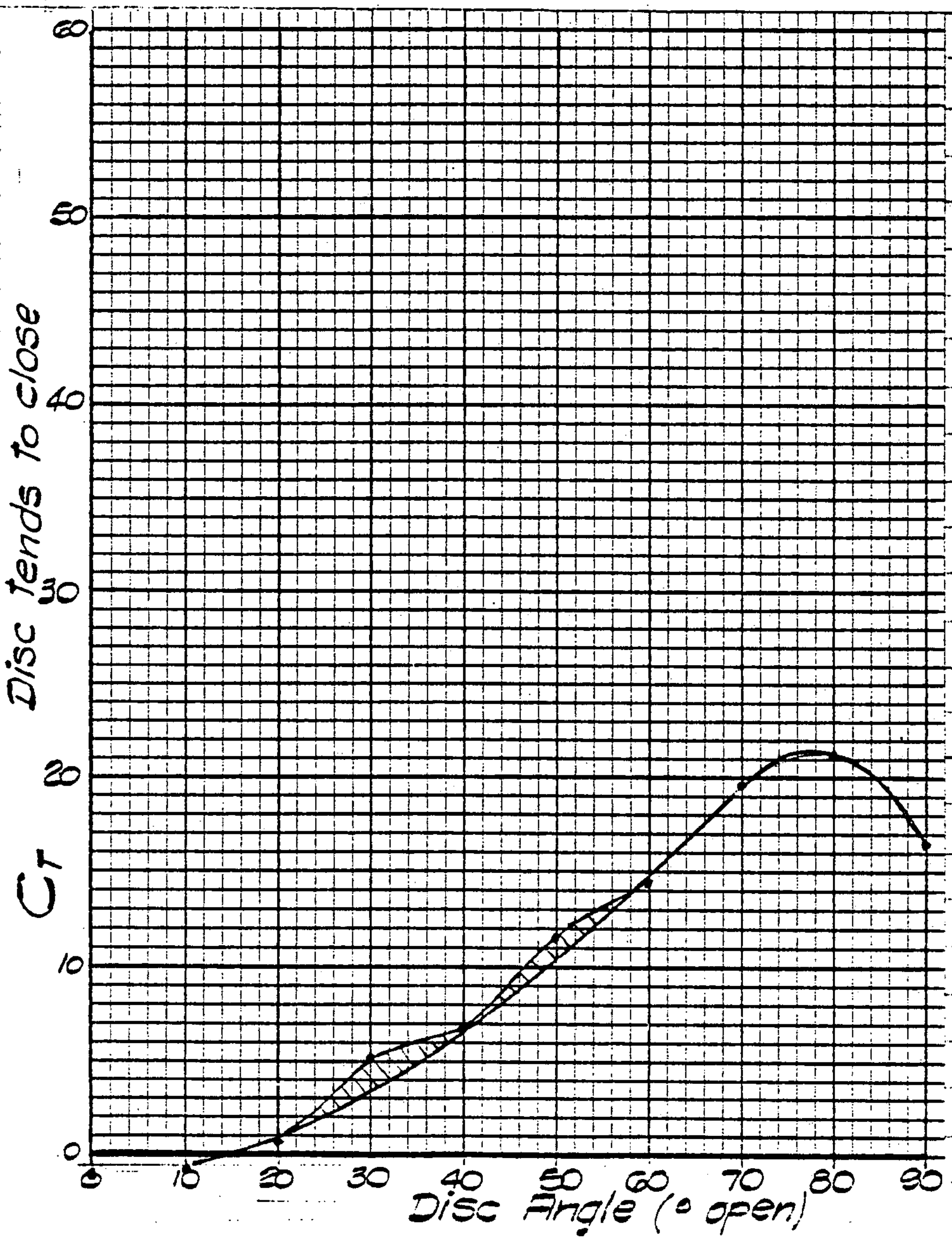
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 60 PSIG Valve orientation ref. Figure 12

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 23 P_{T_1} = 60 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	40	16	24	49.5	16.5	32.0
80	40	15	25	66.0	21.1	34.0
70	41	12	29	71.5	19.7	36.7
60	48	11	37	66.0	14.3	38.7
50	50	8	42	60.5	11.5	40.7
40	54	6	48	41.3	6.9	42.1
30	55	3	52	33.0	5.1	43.4
20	55	2	53	5.5	.8	44.1
10	56	1	55	-5.5	-.8	44.1
0	56	1	55	-8.3	-1.2	44.1

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ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 24 ✓

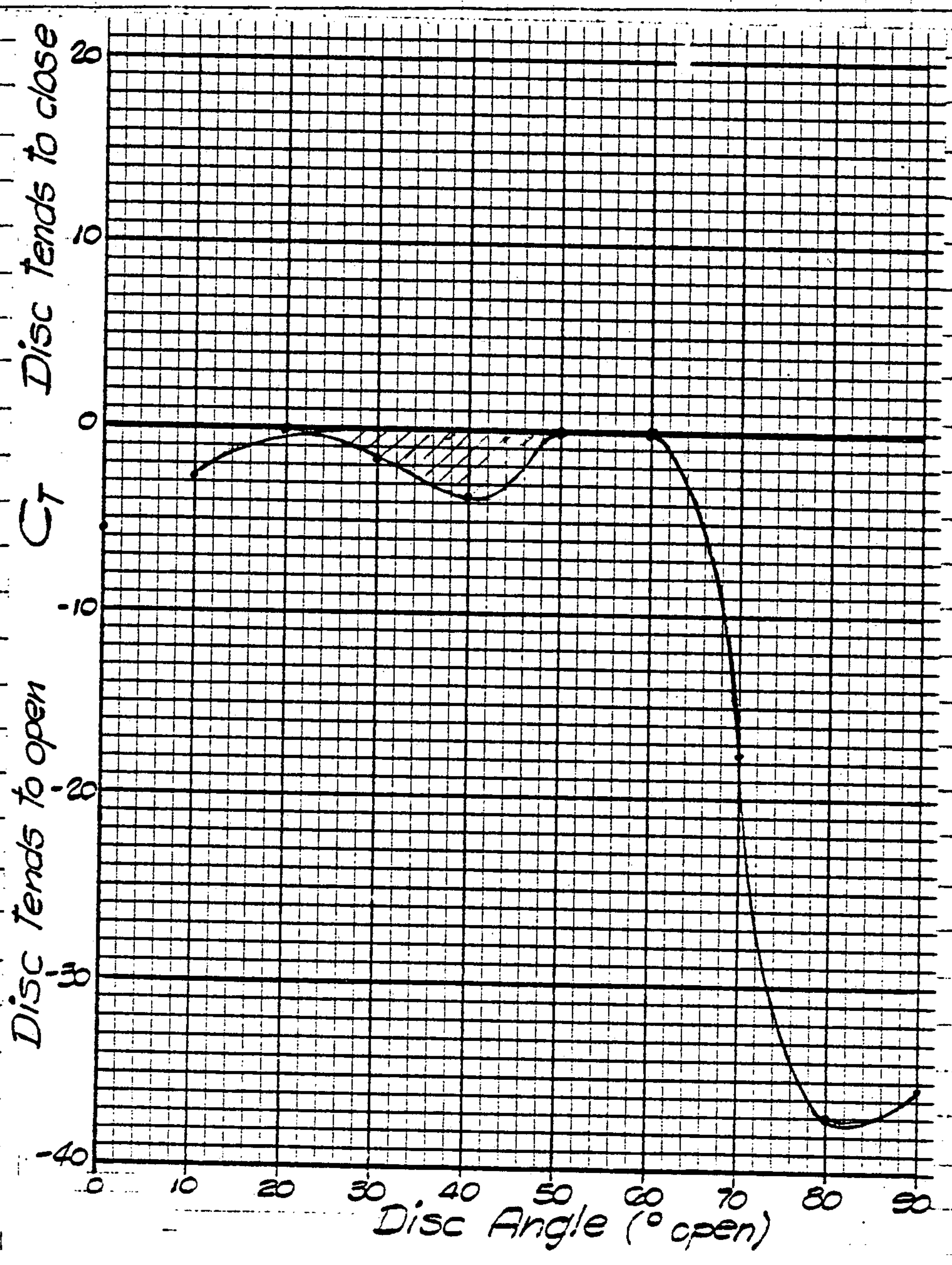
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 10 PSIG Valve orientation ref. Figure 10

Torque equation and coefficient: $Td = C_T \times D^3 \times \Delta P$

where Td is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



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ALLIS-CHALMERS FORM 6715-1

CALCULATED BY WHG

Test No. 24

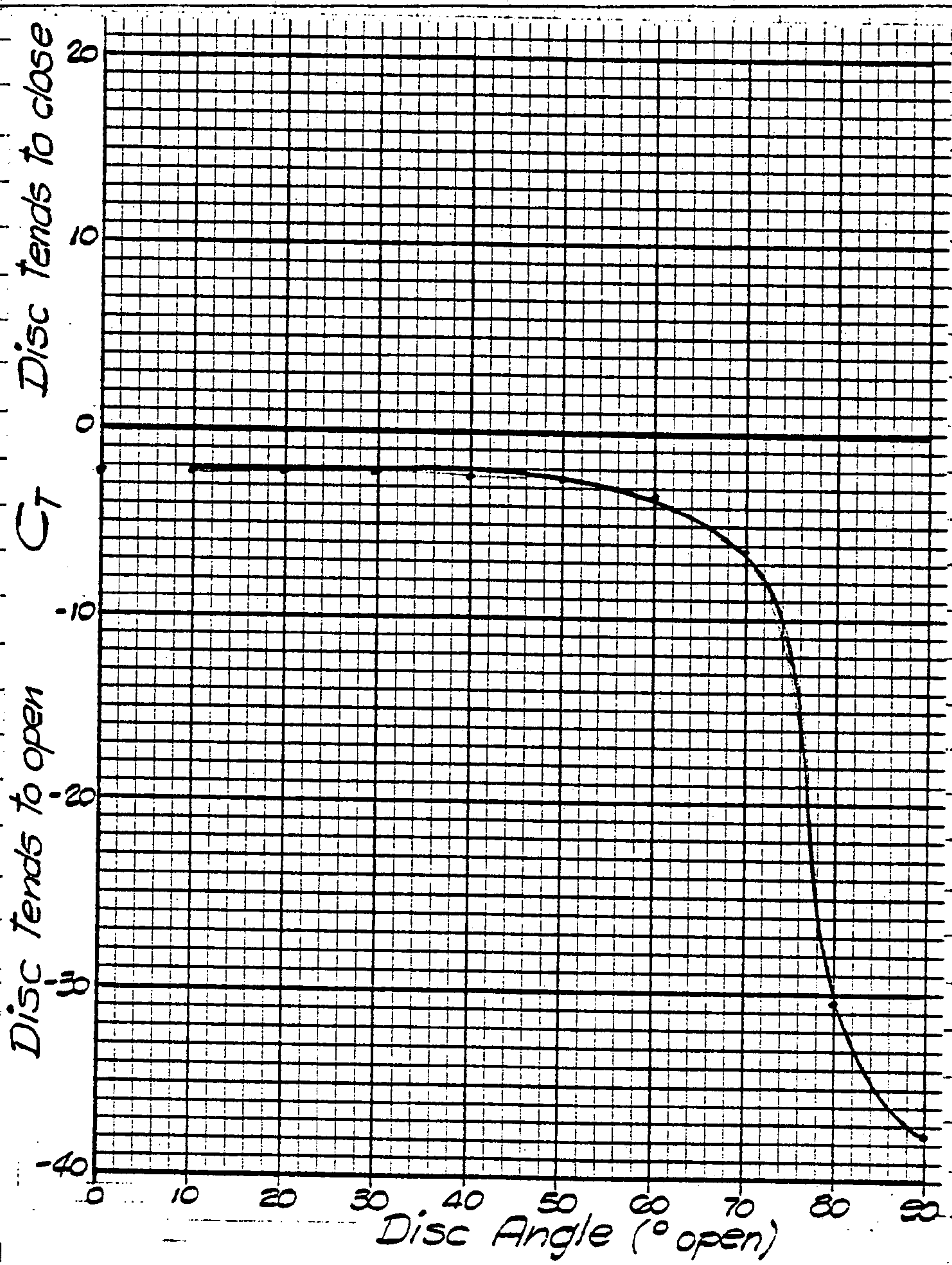
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 15 PSIG Valve orientation ref. Figure 10

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 24 P_{T_1} = 10 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	4	2.5	1.5	-6.6	-35.2	6.4
80	5	2.5	2.5	-11.6	-37.0	6.4
70	5	2.0	3.0	-6.6	-17.6	8.4
60	6	2.0	4.0	0	0	10.5
50	7.5	1.5	6.0	0	0	11.8
40	8	1.0	7.0	-3.3	-3.8	11.8
30	9	1.0	8.0	-1.7	-1.7	13.2
20	10	0.5	9.5	0	0	13.2
10	10	0.5	9.5	-3.3	-2.8	13.2
0	10	0.5	9.5	-6.6	-5.6	13.2

Test 24 P_{T_1} = 15 PSI

90	6	2.5	3.5	-16.5	-37.7	5.8
80	6	2.5	3.5	-13.3	-3.04	7.1
70	9	2.5	3.5	-5.0	-6.2	9.1
60	10	2.0	8.0	-3.3	-3.3	11.8
50	11	1.0	10.0	-3.3	-2.6	12.5
40	12	1.0	11.0	-3.3	-2.4	13.2
30	12.5	0	12.5	-3.3	-2.1	13.2
20	12.5	0	12.5	-3.3	-2.1	13.2
10	12.5	0	12.5	-3.3	-2.1	13.2
0	12.5	0	12.5	-3.3	-2.1	13.2

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ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY WHG

Test No. 24

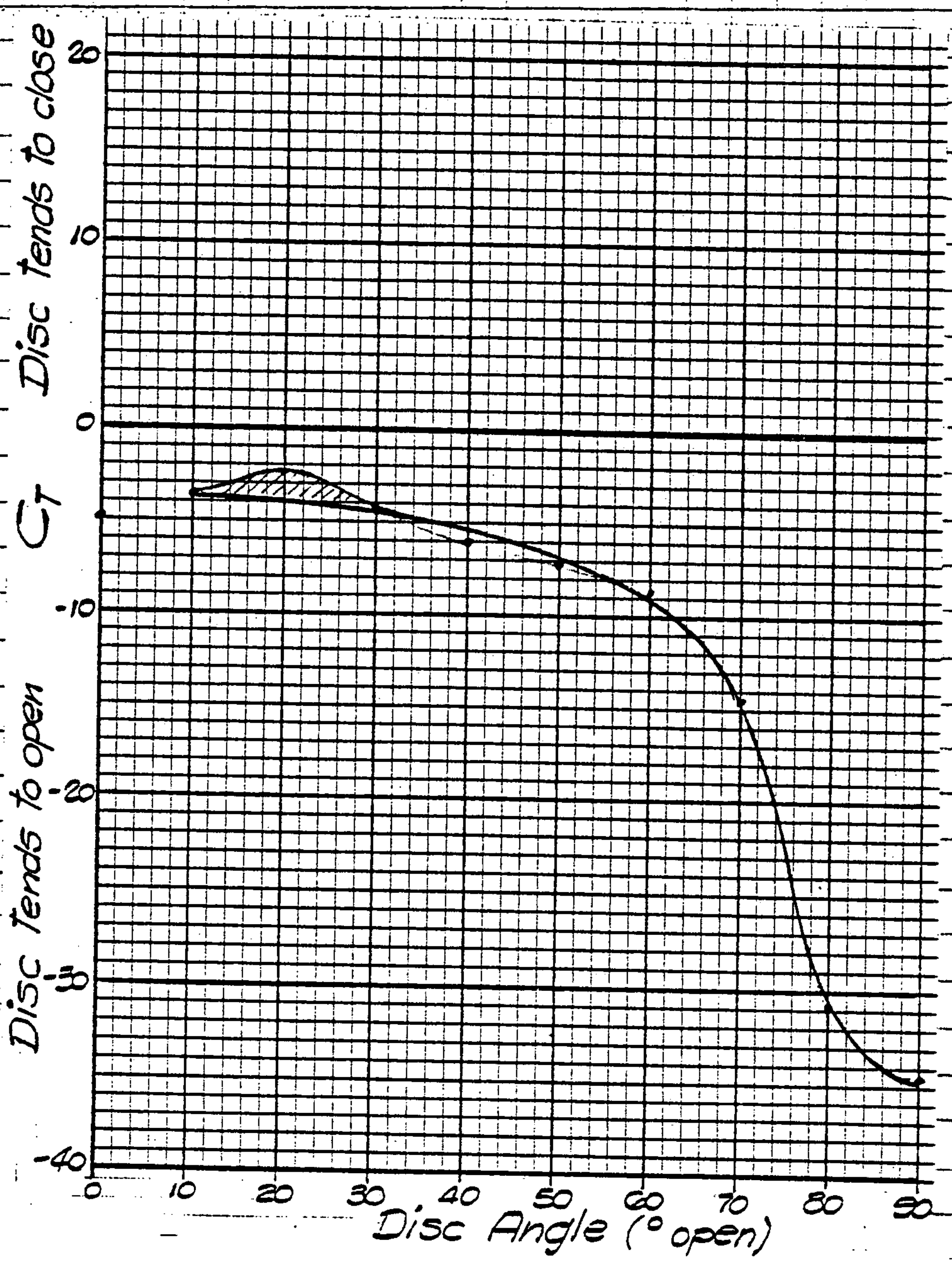
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 20PSIG Valve orientation ref. Figure 10

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where Td is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



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ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 24

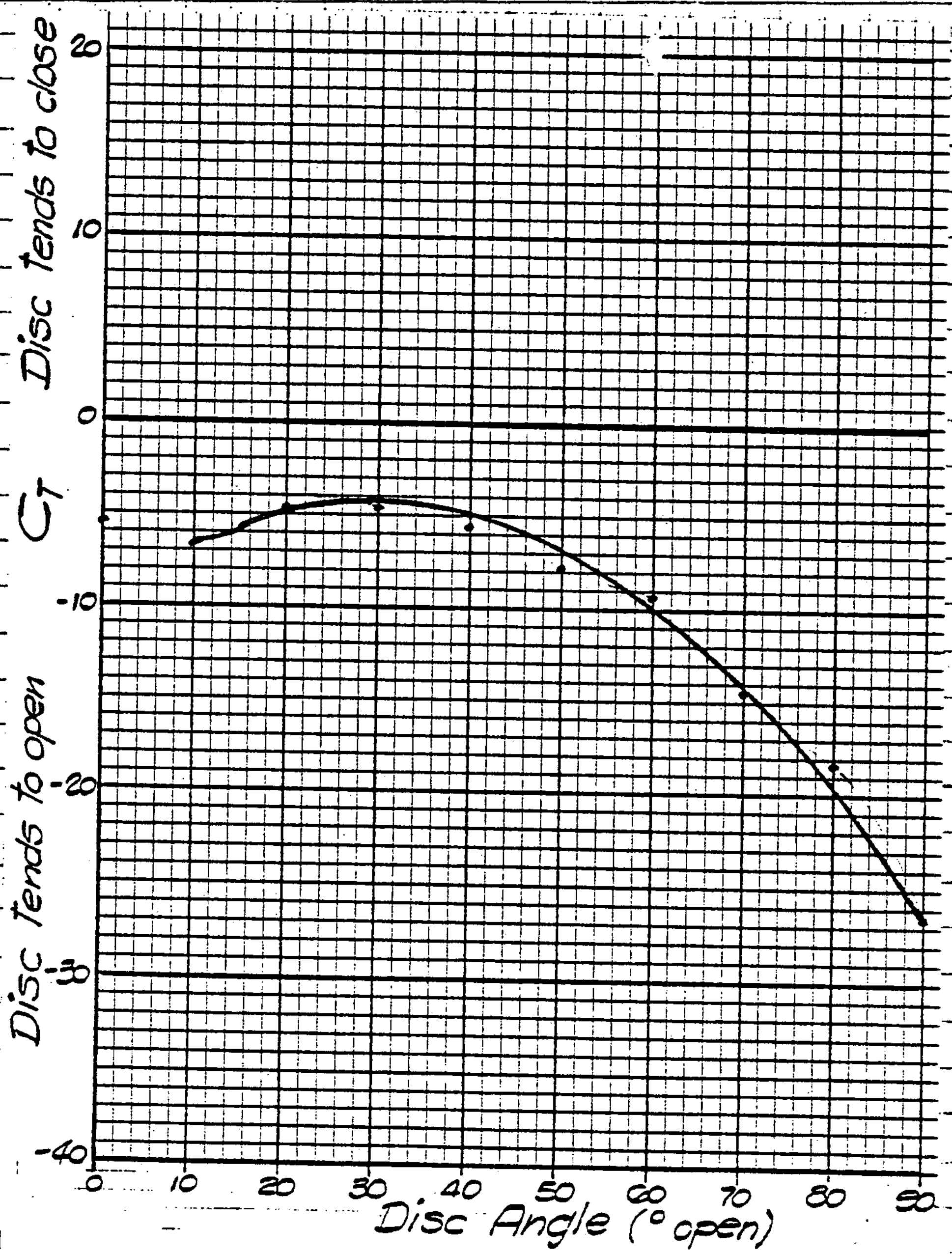
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 30 PSIG Valve orientation ref. Figure 10

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 24 P_{T_1} = 20 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	10.0	5.0	5.0	-21.5	-34.3	6.4
80	10.0	4.0	6.0	-23.1	-30.8	6.4
70	12.5	3.5	9.0	-16.5	-14.7	9.8
60	15.0	3.0	12.0	-13.2	-8.8	11.8
50	15.5	2.5	13.0	-11.6	-7.1	13.2
40	17.5	20.0	15.5	-11.6	-6.0	14.5
30	17.5	1.5	16.0	-8.3	-4.1	15.2
20	18.5	1.0	17.5	-5.0	-2.3	15.2
10	19.5	1.0	18.5	-8.3	-3.6	15.8
0	19.5	0.5	19.0	-11.6	-4.9	15.8

Test 24 P_{T_1} = 30 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	17.5	7.5	10.0	-33.0	-26.5	12.5
80	20.0	5.5	14.5	-33.0	-18.2	15.2
70	21.0	4.5	16.5	-29.7	-14.4	17.2
60	25.0	3.5	21.5	-24.6	-9.2	18.5
50	27.5	2.5	25.0	-24.6	-7.9	19.9
40	30.0	2.0	28.0	-19.8	-5.7	20.6
30	30.0	1.0	29.0	-16.5	-4.6	21.9
20	30.0	1.0	29.0	-16.5	-4.6	21.9
10	30.0	1.0	29.0	-24.8	-6.8	21.9
0	30.0	1.0	29.0	-19.8	-5.5	21.9

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ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY WHG

Test No. 24

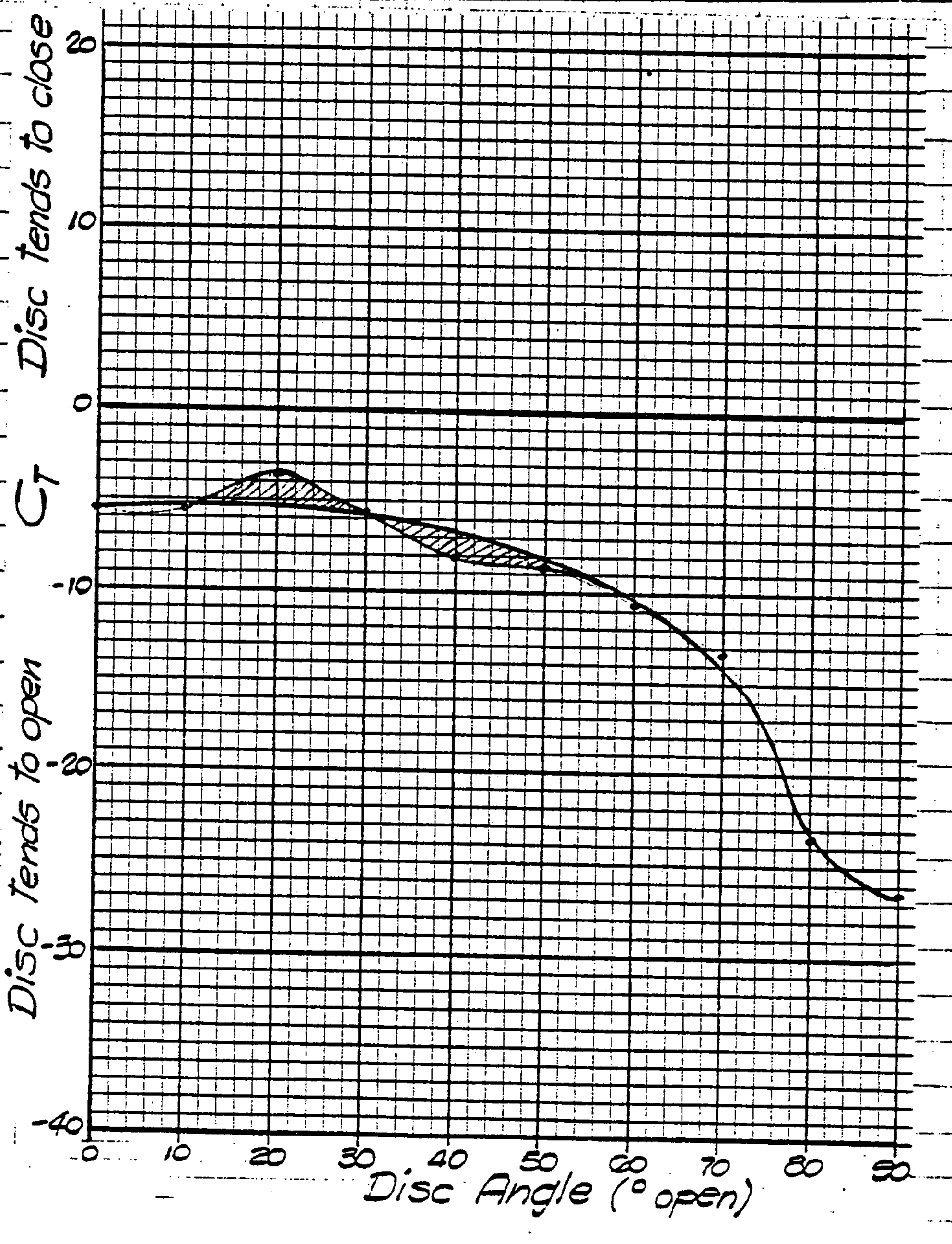
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 40PSIG Valve orientation ref. Figure 10

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



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ALLIS-CHALMERS FORM 6715-1

CALCULATED BY WHG

Test No. 24

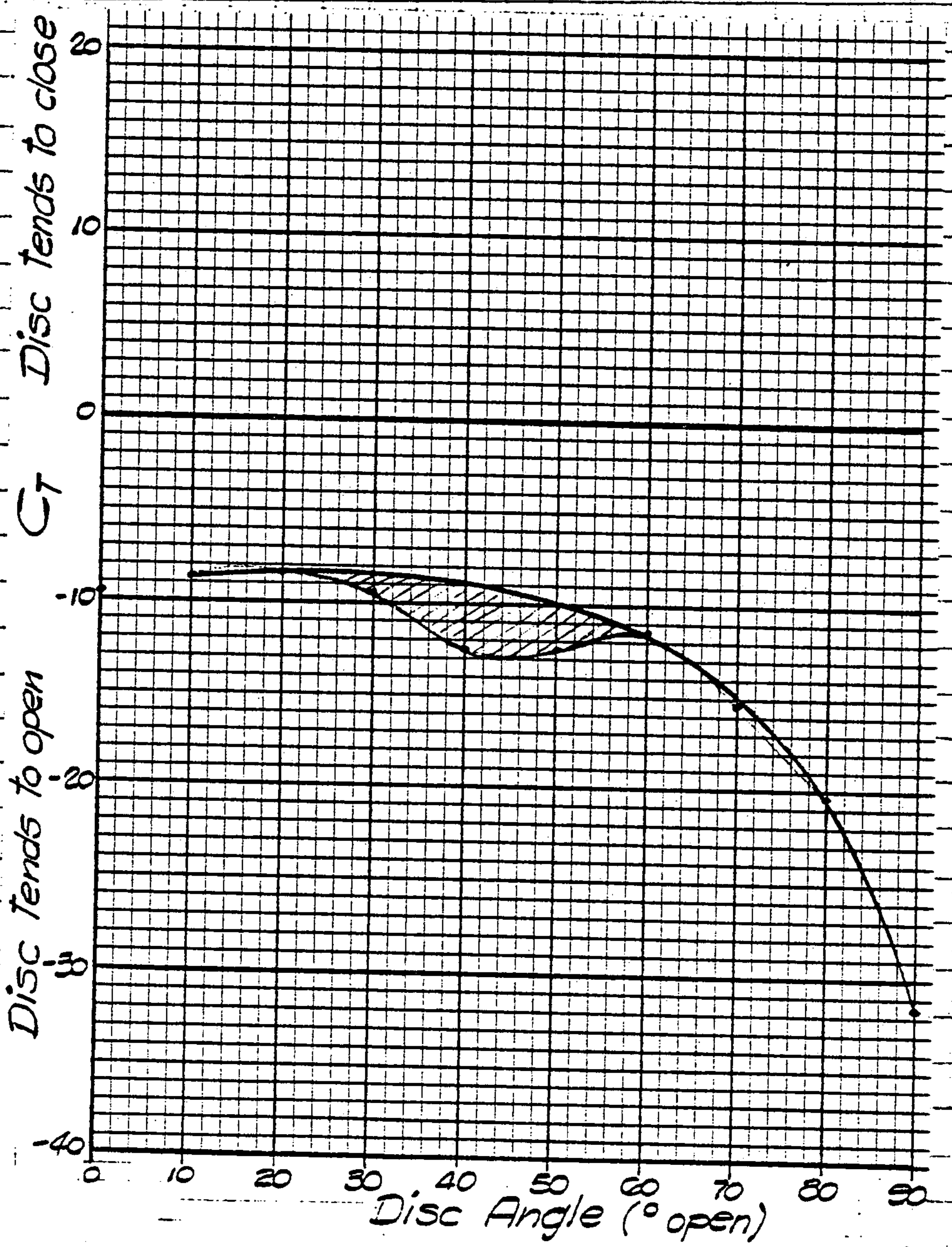
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 50 PSIG Valve orientation ref. Figure 10

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 24 P_{T_1} = 40 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	25	12.5	12.5	-41.3	-26.4	21.2
80	25	11.0	14.0	-41.3	-23.6	21.9
70	30	10.0	20.0	-33.0	-13.2	23.9
60	32	7.5	24.5	-33.0	-10.8	26.6
50	35.0	5.0	30.0	-33.0	-8.8	28.6
40	36.0	3.0	33.0	-33.0	-8.0	30.0
30	37.0	3.0	34.0	-24.8	-5.8	30.7
20	38.0	3.0	35.0	-16.56	-3.8	31.3
10	39.0	3.0	36.0	-24.8	-5.5	32.0
0	39.0	3.0	36.0	-24.8	-5.5	32.0

Test 24 P_{T_1} = 50 PSI

90	30.0	17.5	12.5	-49.5	-31.7	33.3
80	34.0	15.0	19.0	-47.9	-20.2	34.7
70	35.0	12.5	22.5	-42.9	-15.3	36.0
60	40.0	12.5	27.5	-39.6	-11.5	37.4
50	43.5	16.0	27.5	-42.9	-12.5	40.1
40	45.0	17.5	27.5	-42.9	-12.5	41.4
30	47.0	19.0	28.0	-33.0	-9.3	42.1
20	47.5	20.0	27.5	-28.0	-8.2	42.1
10	48.5	21.5	27.0	-29.7	-8.8	42.1
0	48.5	21.5	27.0	-33.0	-9.8	42.1

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DRAWING NUMBER

LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY WHG

Test No. 24

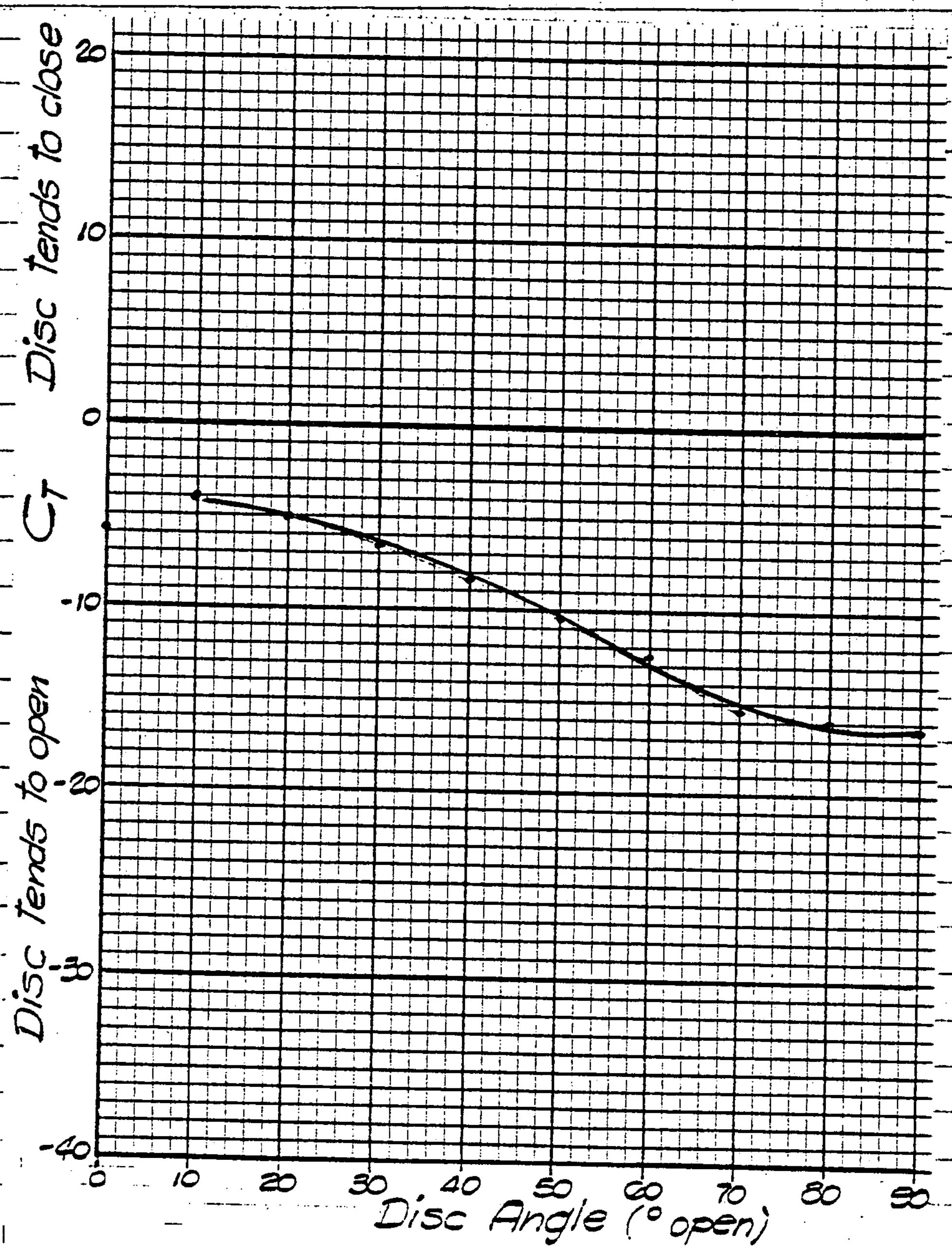
Valve disc thickness to diameter ratio: .29

Initial upstream pressure: 60 PSIG Valve orientation ref. Figure 10

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 24 P_{T_1} = 60 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	40.0	17.5	22.5	-46.2	-16.4	37.4
80	40.0	16.0	24.0	-47.9	-16.0	37.4
70	40.0	15.0	25.0	-47.9	-15.3	38.7
60	42.0	12.5	29.5	-46.2	-12.5	41.4
50	47.5	10.0	37.5	-47.9	-10.2	45.5
40	54.0	6.0	48.0	-49.5	-8.3	46.8
30	55.0	5.0	50.0	-41.3	-6.6	47.5
20	56.0	3.0	53.0	-33.0	-5.0	48.2
10	57.5	1.5	56.0	-28.1	-4.0	48.8
0	57.5	1.5	56.0	-41.3	-5.9	48.8

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LITHO IN U.S.A.-A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY R. Z.

Test No. 25

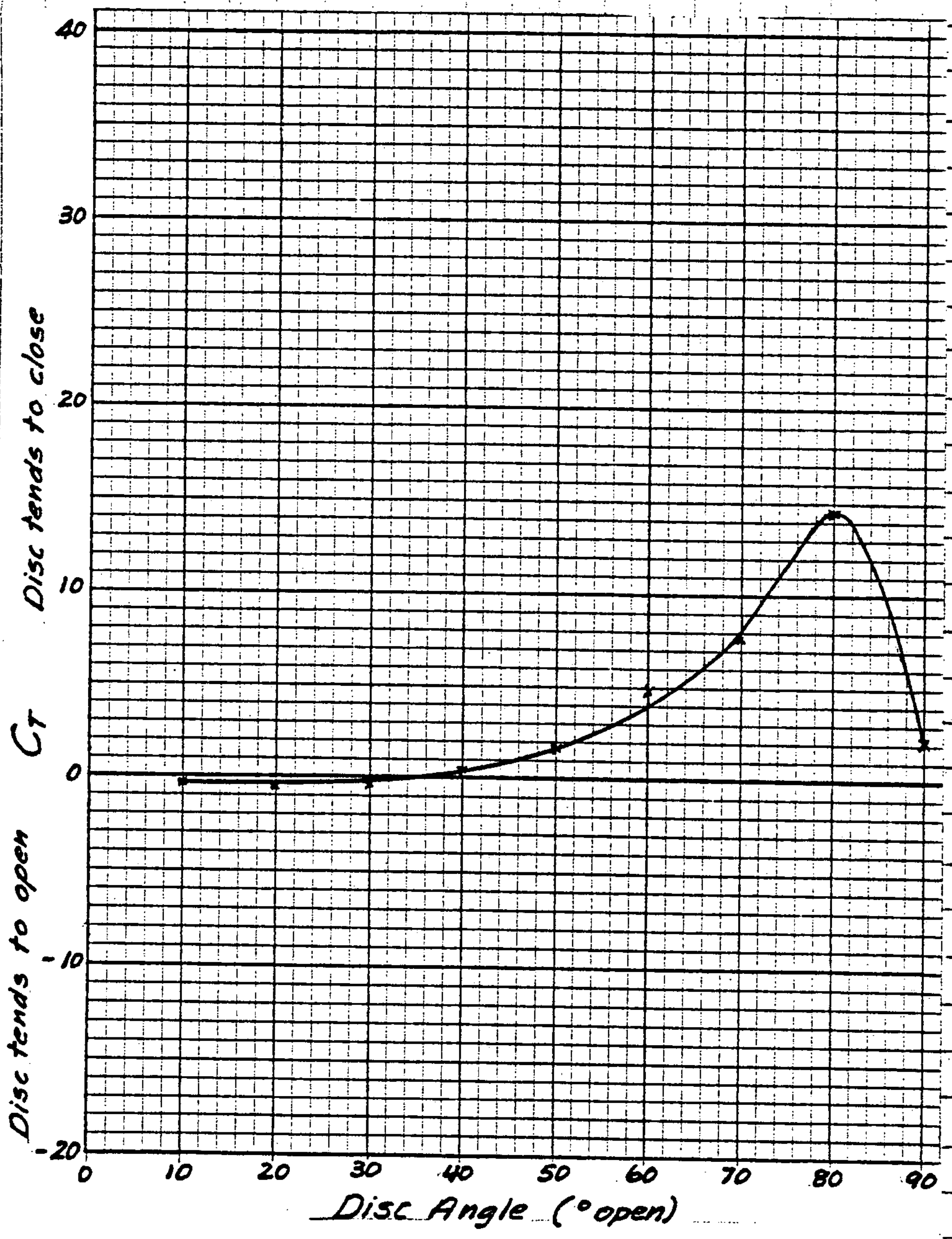
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 10 psig Valve orientation ref. Figure 9

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 25 $P_{T_1} = 10$ PSI

90	5	2.5	2.5	.69	2.21	8.4
80	4	2.5	1.5	2.75	14.67	9.1
70	6	2.5	3.5	3.44	7.86	11.8
60	7	2.5	4.5	2.75	4.89	13.2
50	8	1.5	6.5	1.38	1.70	15.2
40	9	1.0	8.0	-.34	-.34	16.5
30	10	1.0	9.0	-.34	-.30	17.2
20	10	0	10.0	-.59	-.47	17.2
10	10	0	10.0	-.25	-.20	17.2
0	10	0	10.0	-1.72	-1.38	17.2

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Allis-Chalmers 6" Streamseal Butterfly Valve Model

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LITHO IN U.S.A.–A-C

CALCULATED BY R. Z.

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS | FORM 6715-1

Test No. 25

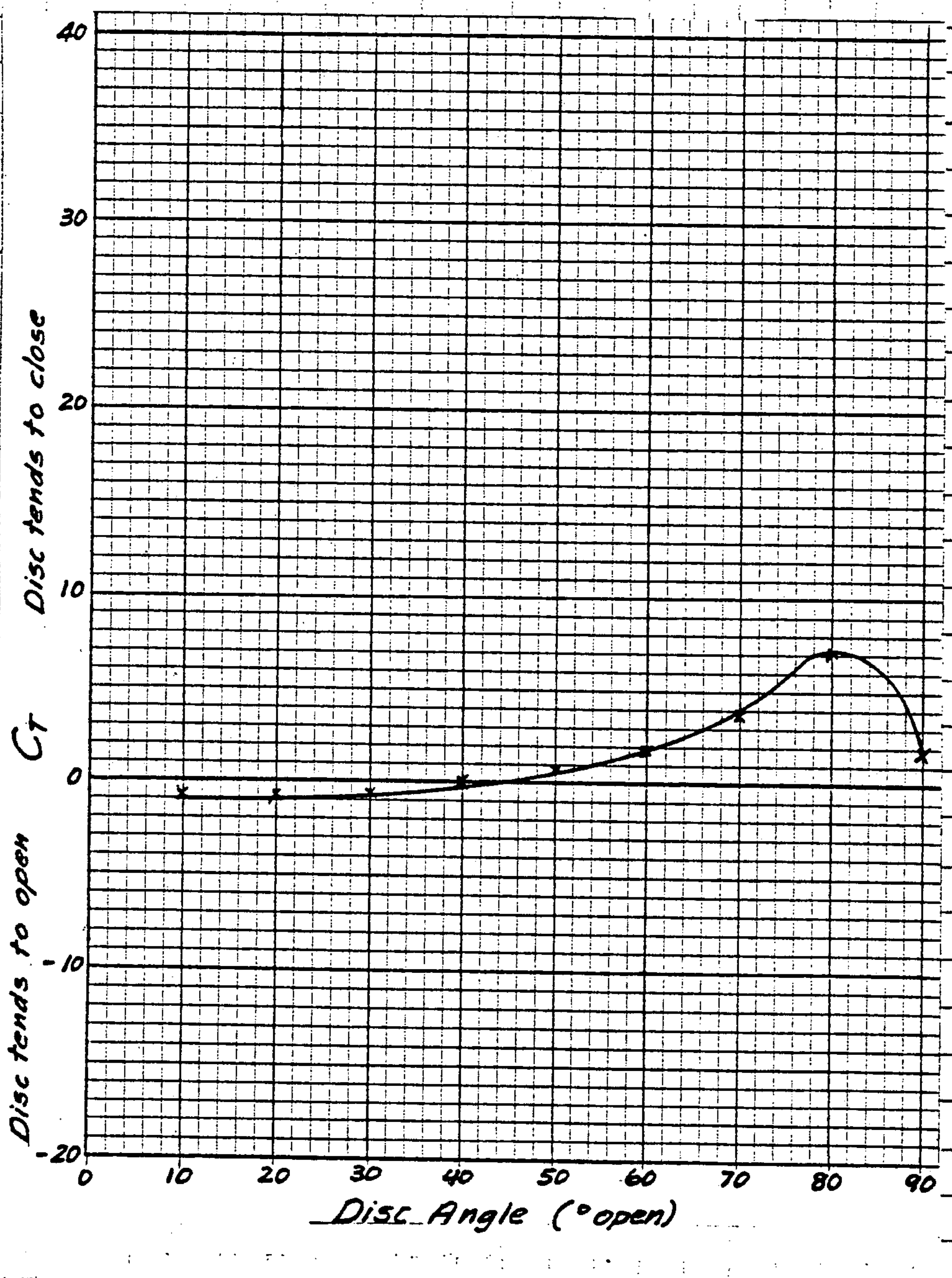
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 15 psig Valve orientation ref. Figure 9

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER	DATE	SHEET
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LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY R. Z.

Test No. 25

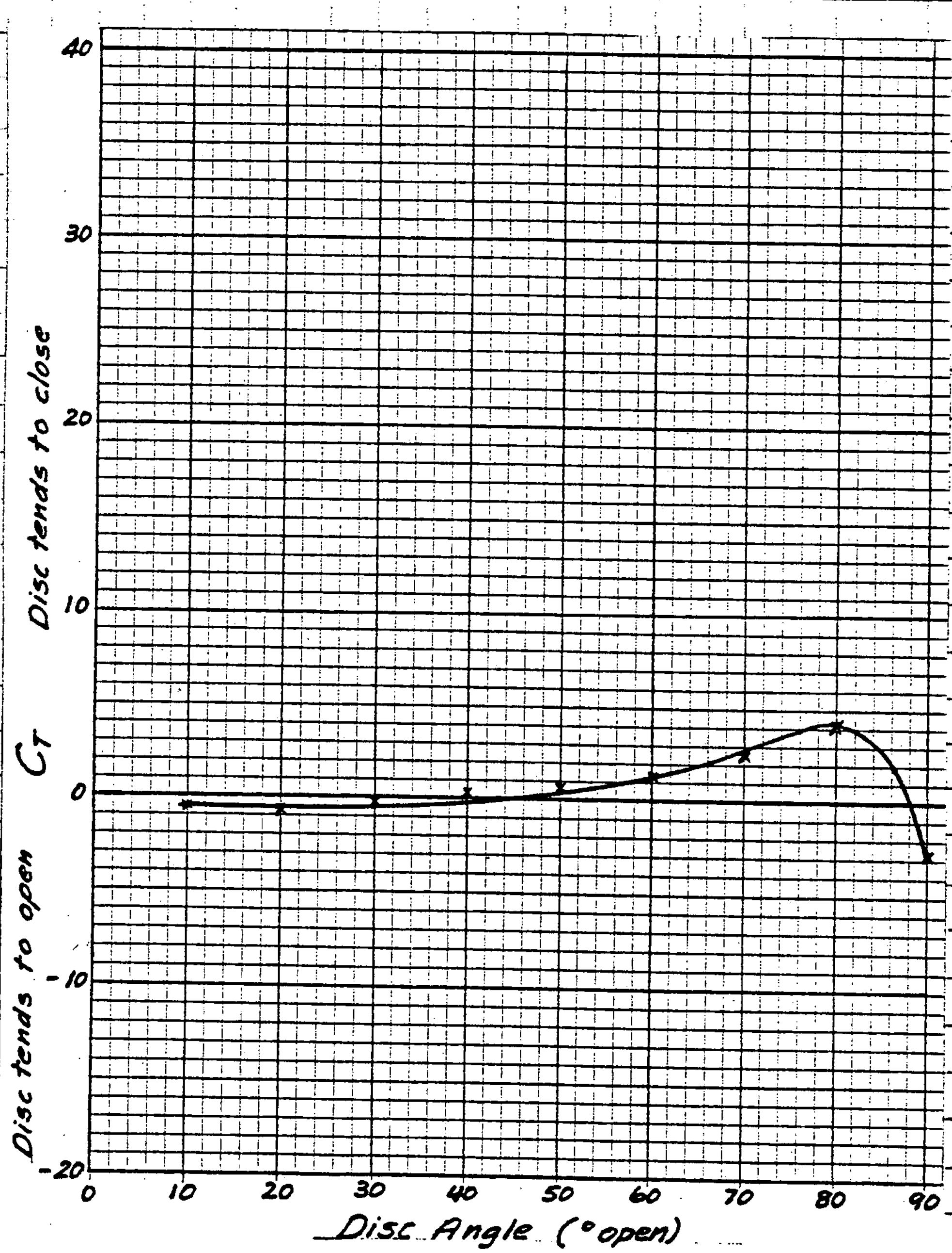
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 20 psig Valve orientation ref. Figure 9

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 25 P_T = 15 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	5.0	2.5	2.5	.69	2.21	5.1
80	6.0	2.5	3.5	3.09	7.06	8.4
70	9.0	2.0	7.0	3.44	3.93	11.1
60	10.0	1.5	8.5	2.06	1.94	12.5
50	11.0	1.0	10.0	1.03	.8	13.8
40	11.5	0.5	11.0	0	0	15.8
30	12.0	0	12.0	-1.03	-.69	16.5
20	12.0	0	12.0	-1.38	-.92	16.5
10	12.0	0	12.0	-1.38	-.92	16.5
0	12.0	0	12.0	-2.06	-1.37	16.5

Test 25 P_T = 20 PSI

90	7.0	4.0	3.0	-1.03	-2.75	5.1
80	10.0	4.0	6.0	3.09	4.12	7.1
70	14.0	3.0	11.0	3.44	2.50	11.8
60	16.0	2.5	13.5	2.06	1.22	15.2
50	17.5	2.0	15.5	1.47	.76	18.5
40	18.0	1.0	17.0	.34	.16	18.5
30	19.0	0.5	18.5	-.34	-.15	18.5
20	20.0	0	20.0	-2.06	-.82	18.5
10	20.0	0	20.0	-1.03	-.41	18.5
0	20.0	0	20.0	-2.36	-.94	18.5

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LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS | FORM 6715-1

CALCULATED BY: R. Z.

Test No. 25

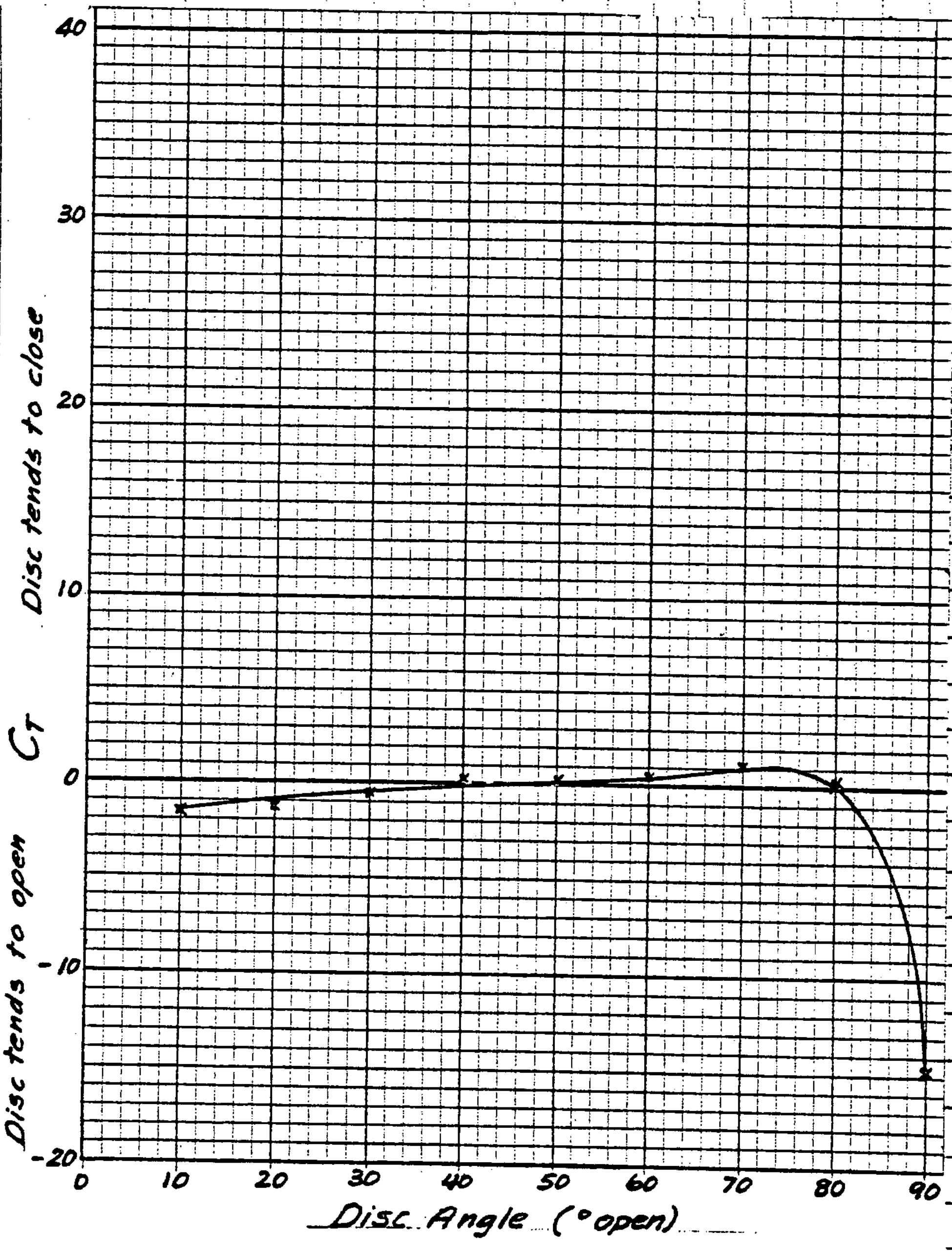
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 30 psig   Valve orientation ref. Figure 9

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



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ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY R. Z.

Test No. 25

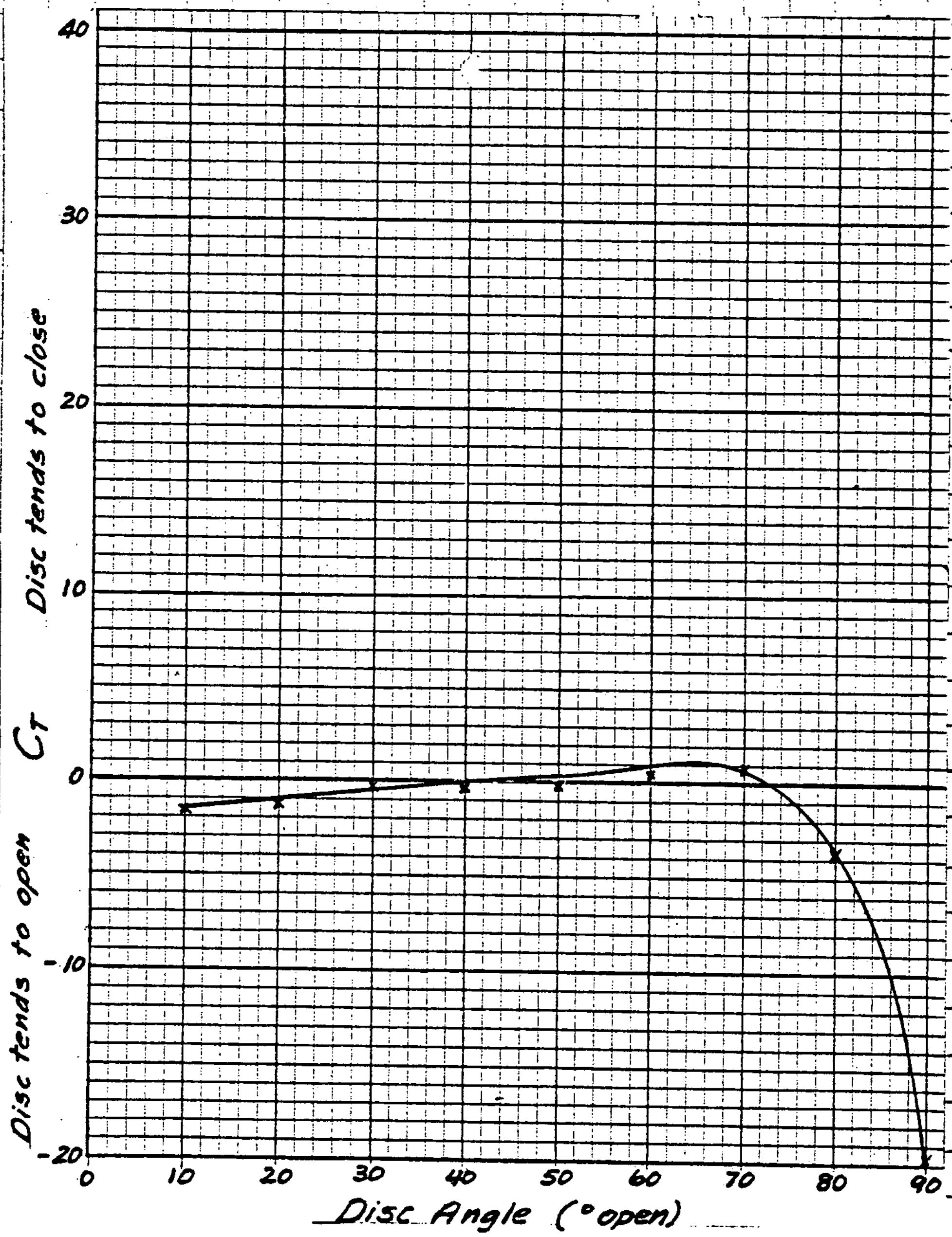
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 40 psig Valve orientation ref. Figure 9

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 25 P_{T_1} = 30 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	12.5	7.5	5.0	-9.28	-14.8	9.8
80	14.0	6.5	7.5	.25	.27	10.5
70	22.0	5.5	16.5	2.41	1.17	17.2
60	25.0	4.5	20.5	1.38	.54	20.6
50	26.5	2.5	24.0	.69	.23	23.3
40	29.0	1.5	27.5	.69	.20	24.6
30	29.0	1.5	27.5	-1.72	-.50	25.3
20	29.0	1.5	27.5	-4.13	-1.20	25.3
10	29.0	1.5	27.5	-5.16	-1.50	25.3
0	29.0	1.5	27.5	-2.06	-.60	25.3

Test 25 P_{T_1} = 40 PSIG

90	18	12	6	-14.8	-19.8	17.9
80	19	11	8	-3.7	-3.7	18.5
70	28	10	18	2.1	.91	21.9
60	33	7	26	1.03	.32	30.0
50	36	4	32	-.4	-.1	32.0
40	38	2.5	35.5	-1.03	-.23	33.3
30	39	2	37	-1.2	-.27	34.0
20	39	1	38	-6	-1.26	34.0
10	39	1	38	-8.25	-1.73	34.0

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DRAWING NUMBER	CALCULATED BY R. Z.	

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS — LITHO IN U.S.A.—A-C — FORM 6715-1

Test No. 25

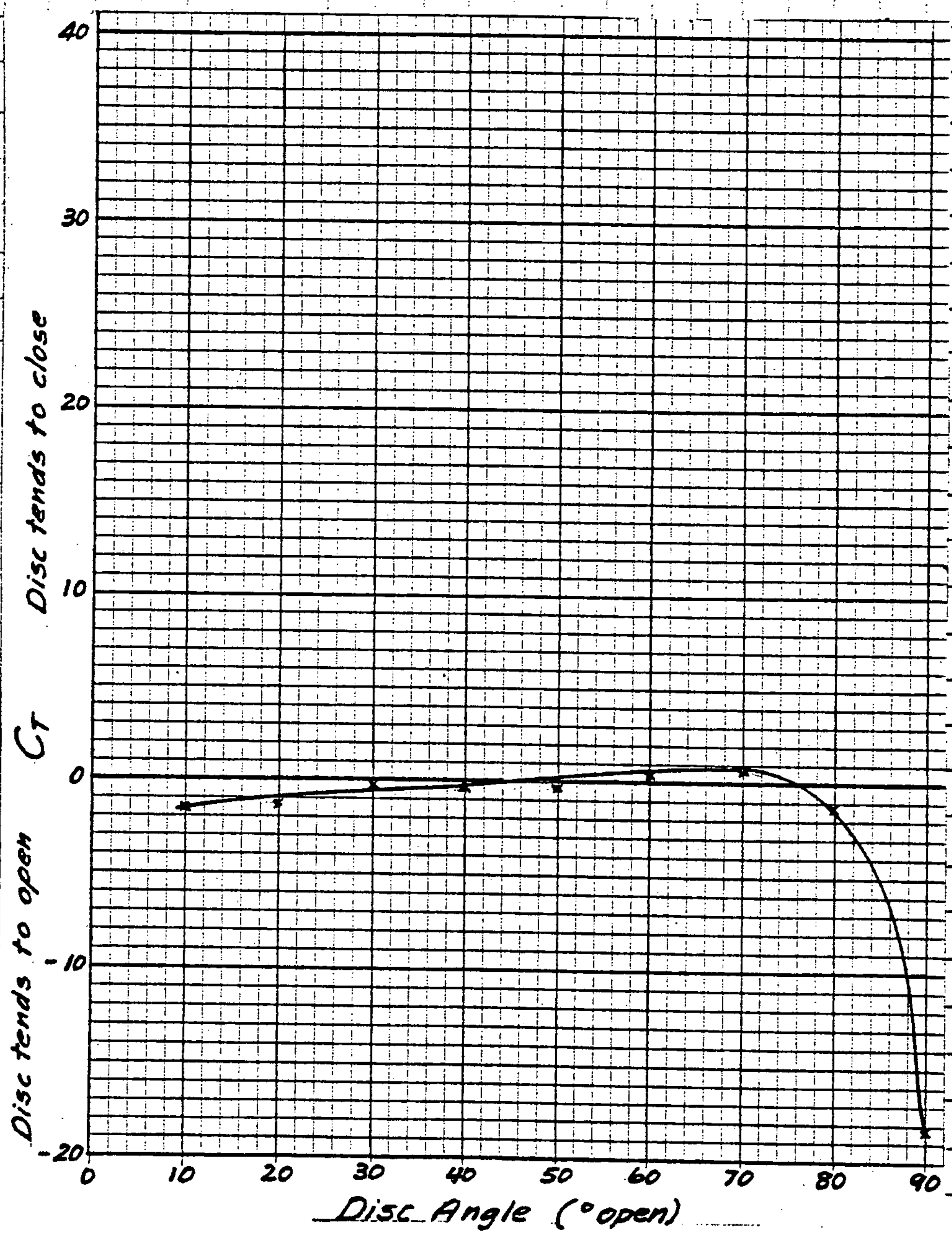
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 50 psig   Valve orientation ref. Figure 9

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER Air Flow Tests NASA/Langley Research Center | DATE Nov. & Dec. 1979 | SHEET 7 OF 7

SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model | PRELIM. | FINAL

DRAWING NUMBER | LITHO IN U.S.A.—A-C | CALCULATED BY R. Z.

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 25

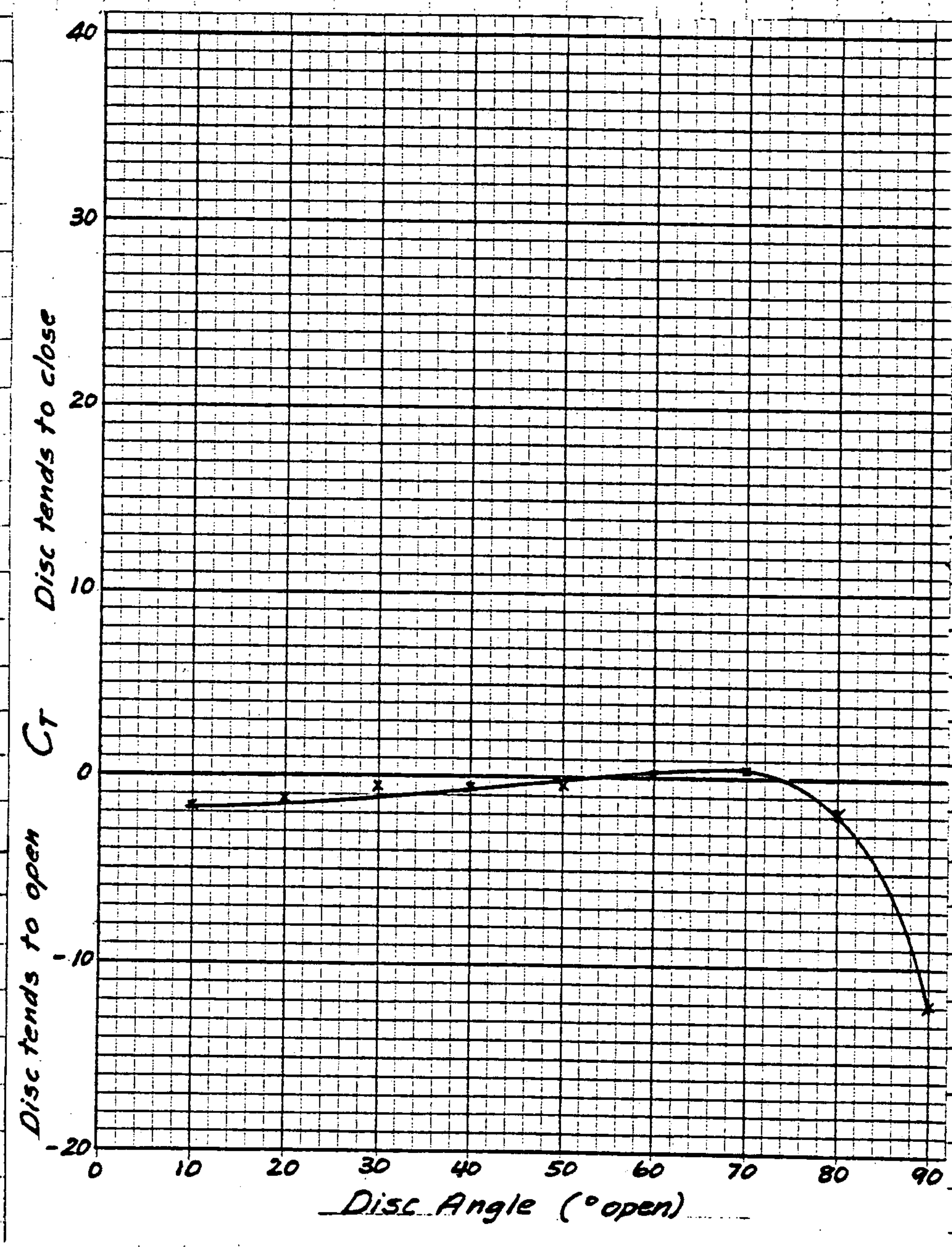
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 60 PSIG Valve orientation ref. Figure 9

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 25 P_{T_1} = 60 PSIG

Disc Angle	P_{T_5}	P_{T_6}	ΔP	T_D	C_T	Temp °F
90	18	12	6	-14.8	-19.8	17.9
90	19	11	8	-3.7	-3.7	18.5
70	28	10	18	2.1	.91	21.9
60	33	7	26	1.03	.32	30.0
50	36	4	32	-.4	-.1	32.0
40	38	2.5	35.5	-1.03	-.23	33.3
30	39	2	37	-1.2	-.27	34.0
20	39	1	38	-6	-1.26	34.0
10	39	1	38	-8.25	-1.73	34.0

Test 25 P_{T_1} = 50 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	24	16.5	7.5	-17.19	-18.34	30.7
80	26	14.5	11.5	-3.09	-2.15	32.0
70	37	13.5	23.5	2.06	.70	38.7
60	42	10.0	32.0	1.03	.26	42.1
50	44	6.5	37.5	-1.03	-.22	45.5
40	47	3.5	43.5	-2.06	-.38	45.5
30	48	2.0	46.0	-1.03	-.18	45.5
20	48	1.0	47.0	-8.25	-1.40	45.5
10	48	1.0	47.0	-9.63	-1.64	45.5
0	48	1.0	47.0	-6.88	-1.17	45.5

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SUBJECT: Allis-Chalmers 6" Streamseal Butterfly Valve Model	PRELIM.	FINAL	
DRAWING NUMBER	LITHO IN U.S.A.—A-C	CALCULATED BY R. G.	

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 26 ✓

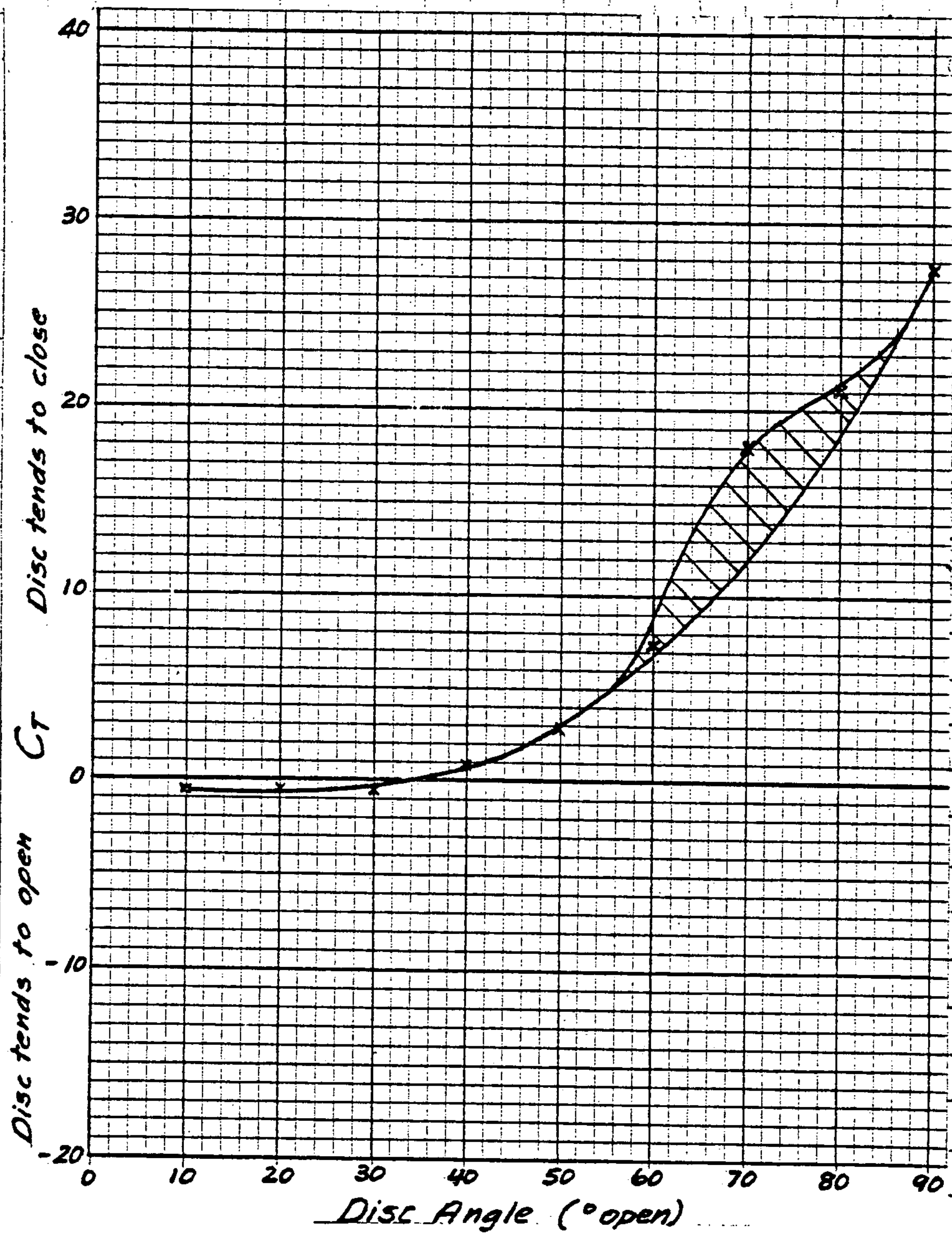
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 10 PSIG Valve orientation ref. Figure 11

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in PSI.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



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Allis-Chalmers 6" Streamseal Butterfly Valve Model		

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ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS — FORM 6715-1

CALCULATED BY R.Z.

Test No. 26

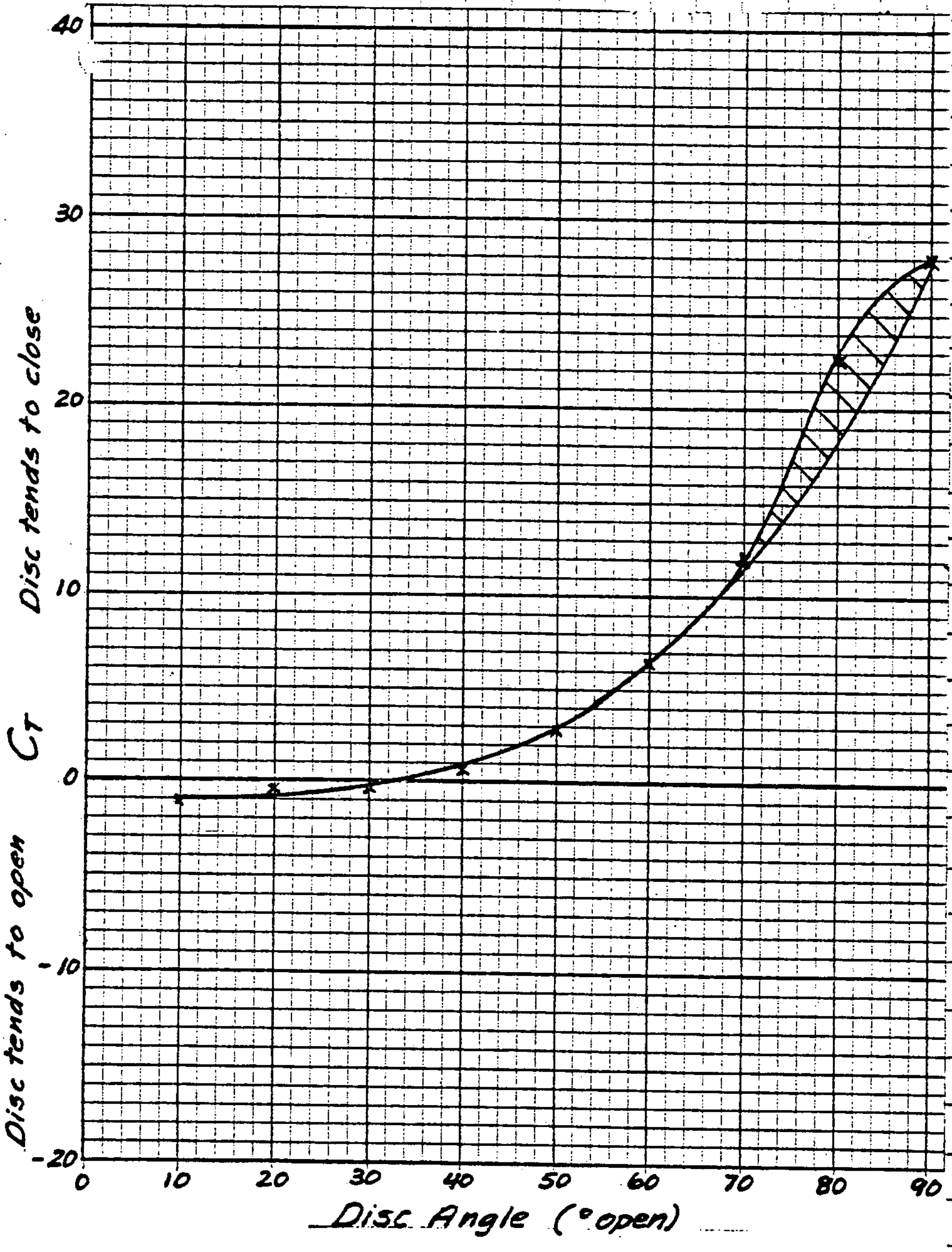
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 15 psig — Valve orientation ref. Figure 11

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 26 P_{T_1} = 10 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	4.0	2.5	1.5	5.2	27.7	9.1
80	4.5	2.0	2.5	6.6	21.1	10.5
70	5.0	2.0	3.0	6.8	18.1	11.8
60	7.0	1.5	5.5	5.0	7.3	13.8
50	8.5	1.0	7.5	2.7	2.9	15.8
40	9.0	0.5	8.5	1.0	0.9	17.2
30	10.0	0	10.0	-0.6	-0.5	17.9
20	10.0	0	10.0	-0.6	-0.5	17.9
10	10.0	0	10.0	-0.8	-0.6	17.9
0	10.0	0	10.0	-2.1	-1.7	17.9

Test 26 P_{T_1} = 15 PSI

90	5.0	3.0	2.0	7.0	28.0	6.4
80	5.5	2.5	3.0	8.5	22.7	7.8
70	8.0	2.5	5.5	8.3	12.1	11.8
60	9.5	2.0	7.5	6.0	6.4	13.8
50	11.0	1.5	9.5	3.5	2.9	15.8
40	12.0	1.0	11.0	1.0	0.7	16.5
30	12.0	1.0	11.0	-0.6	-0.4	17.2
20	12.0	0.5	11.5	-0.6	-0.4	17.2
10	12.5	0.5	12.0	-1.7	-1.1	17.2
0	12.5	0.5	12.0	-3.3	-2.2	17.2

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SUBJECT: Allis-Chalmers 6" Streamseal Butterfly Valve Model

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LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY R. Z.

Test No. 26

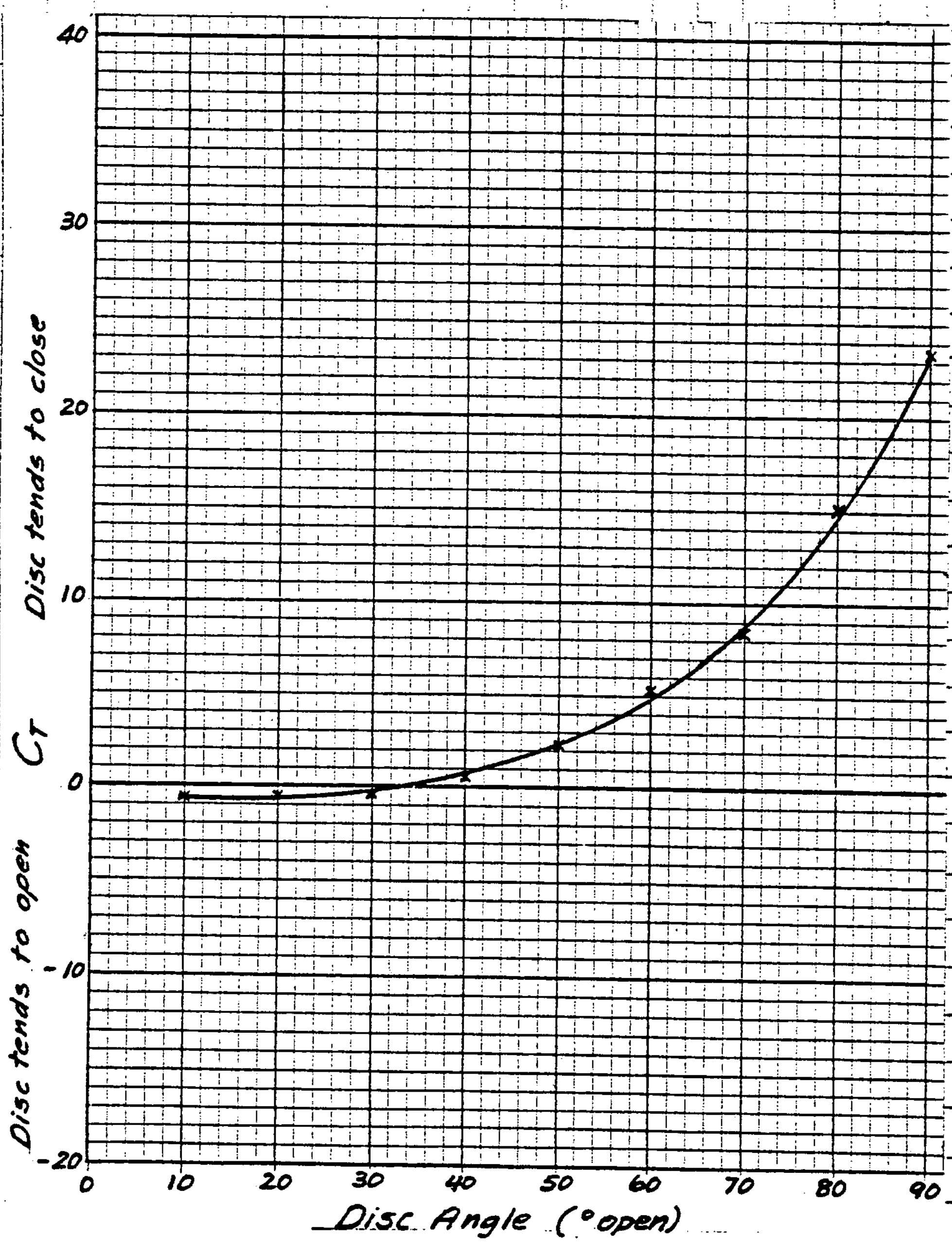
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 20 psig Valve orientation ref. Figure 11

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER Air Flow Tests NASA/Langley Research Center | DATE Nov. & Dec. 1979 | SHEET 4 OF 7

SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model | PRELIM. | FINAL

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ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 26

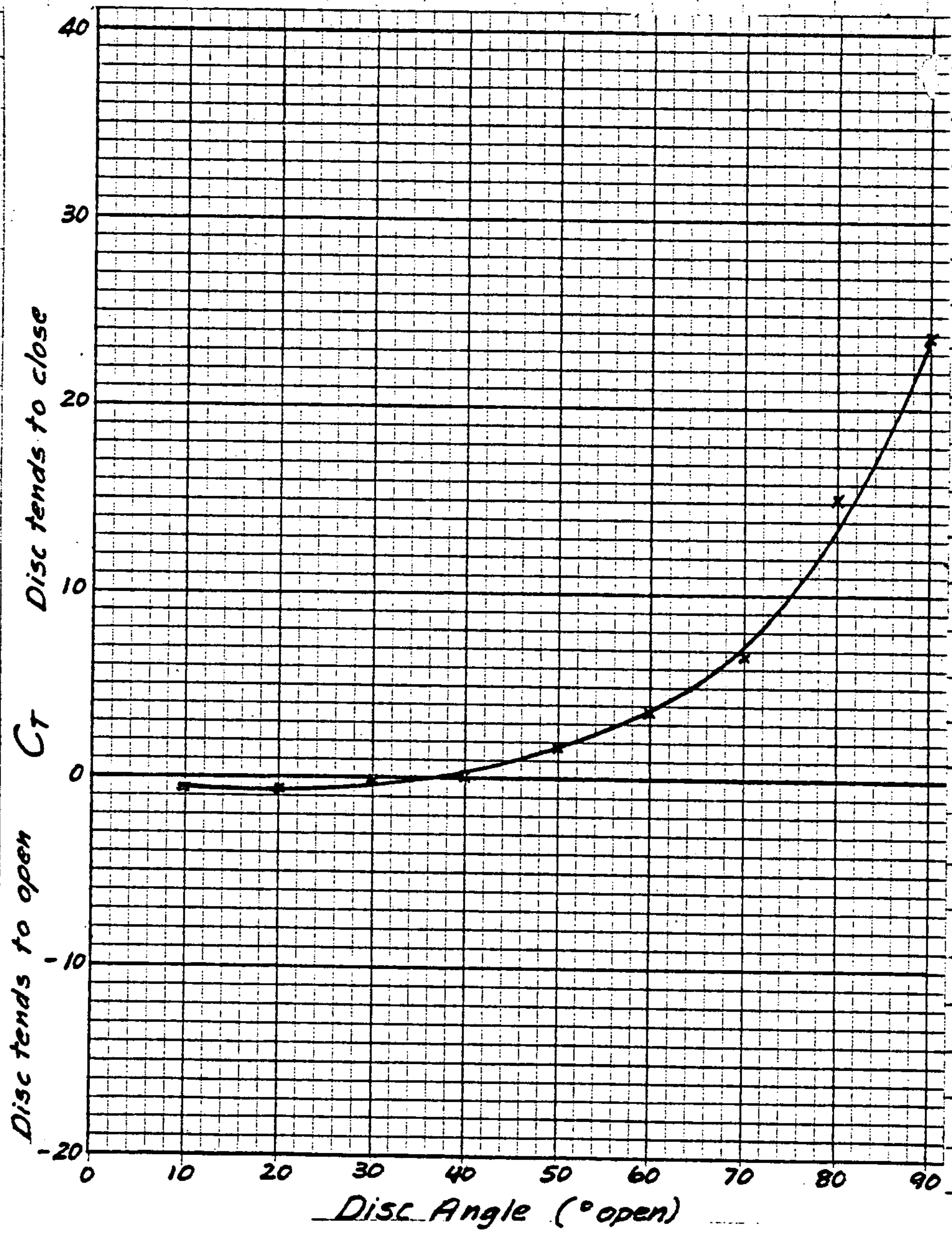
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 30 psig Valve orientation ref. Figure 11

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 26 $P_{T_1} = 20$ PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	7.0	3.5	3.5	10.3	23.5	6.4
80	10.0	3.0	7.0	13.2	15.1	8.4
70	13.5	3.0	10.5	11.1	8.5	11.8
60	15.5	2.5	13.0	8.5	5.2	15.8
50	18.0	2.0	16.0	4.7	2.3	17.9
40	19.0	1.5	17.5	1.2	0.5	18.5
30	19.5	1.0	18.5	-1.0	-0.4	18.5
20	20.0	0.5	19.5	-1.2	-0.5	18.5
10	20.0	0.5	19.5	-1.7	-0.7	18.5
0	20.0	0.5	19.5	-3.5	-1.4	18.5

Test 26 $P_{T_1} = 30$ PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	12.5	7.5	5.0	14.9	23.8	11.8
80	16.0	7.5	8.5	16.1	15.2	13.8
70	22.0	7.0	15.0	12.8	6.8	18.5
60	25.0	3.5	21.5	9.9	3.7	22.6
50	27.5	3.0	24.5	5.6	1.8	23.9
40	29.5	2.5	27.0	0.1	0.03	25.3
30	29.5	2.0	27.5	-0.2	-0.06	25.3
20	29.5	2.0	27.5	-2.5	-0.7	25.3
10	29.5	2.0	27.5	-2.1	-0.6	25.3
0	29.5	2.0	27.5	-6.4	-1.9	25.3

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SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model | PRELIM. | FINAL

DRAWING NUMBER | LITHO IN U.S.A.—A-C | CALCULATED BY R. Z.

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS | FORM 6715-1 | Test No. 26

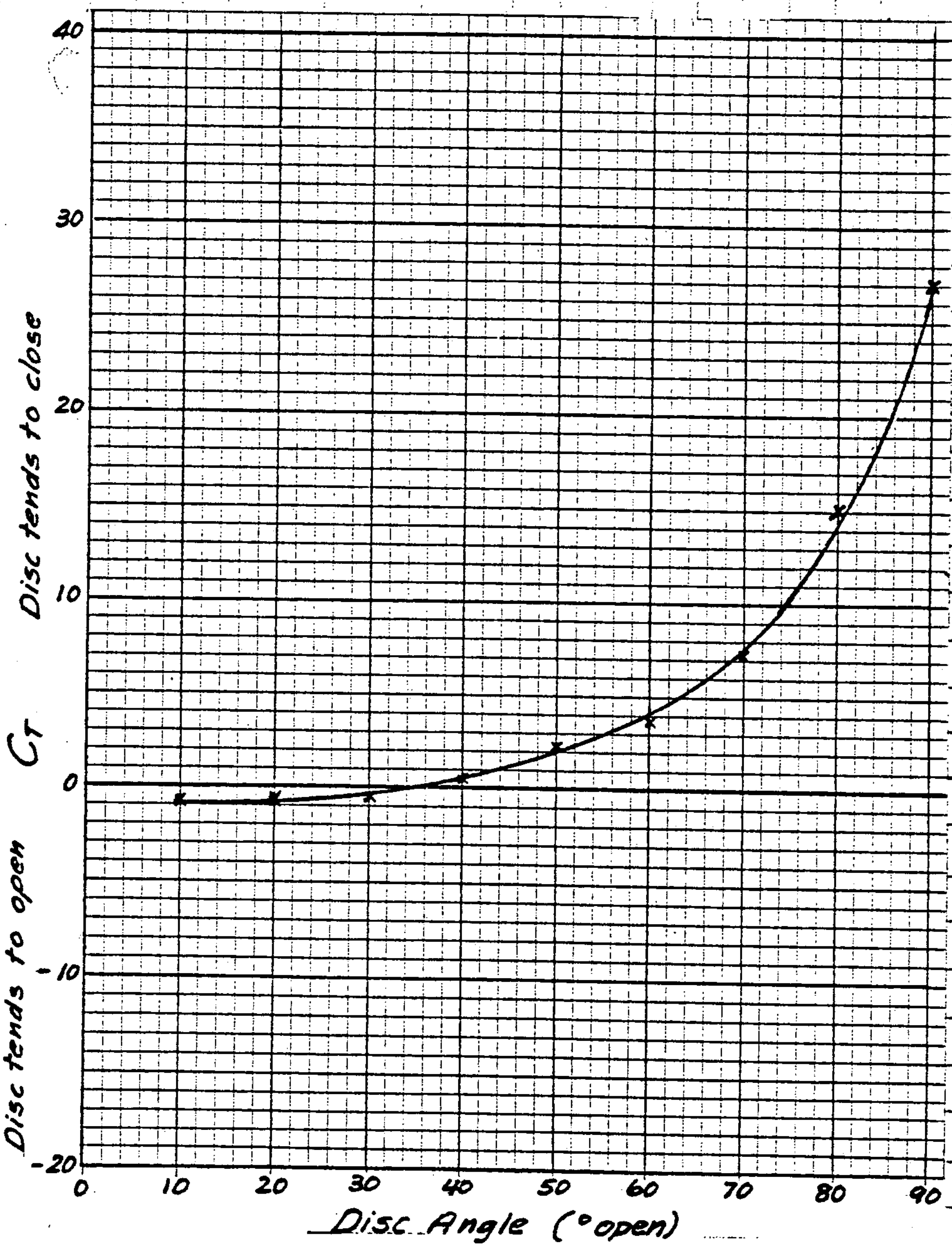
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 40 PSIG Valve orientation ref. Figure 11

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER Air Flow Tests NASA/Langley Research Center | DATE Nov. & Dec. 1979 | SHEET 6 OF 7

SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model | PRELIM. | FINAL

DRAWING NUMBER | LITHO IN U.S.A.—A-C | CALCULATED BY R. Z.

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 26

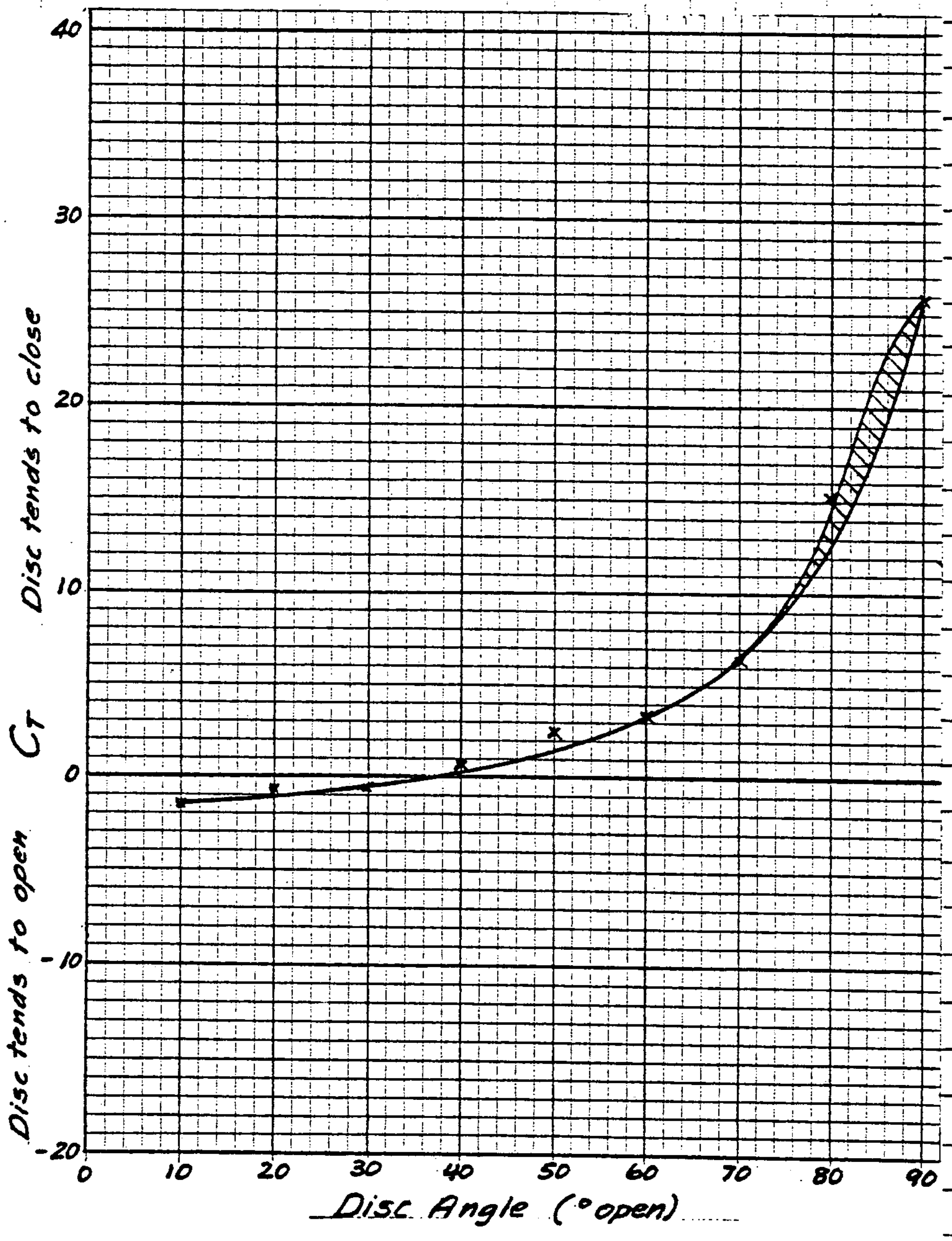
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 50 psig Valve orientation ref. Figure 11

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 26 P_{T_1} = 40 PSIG

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	18	12.5	5.5	18.57	27	19.9
80	22	11	11	20.63	15	21.9
70	28	10	18	16.51	7.34	25.9
60	32.5	7.5	25	11.86	3.79	32.0
50	35	5	30	8.35	2.23	33.3
40	37.5	2.5	35	2.46	.56	34.0
30	38	2.0	36	-2.46	-.55	34.7
20	38	2.0	36	-2.46	-.55	34.7
10	39	1.0	38	-4.13	-.87	34.7
0	40	0	40	-8.25	-1.65	34.7

Test 26 P_{T_1} = 50 PSI

90	24.0	17.0	7.0	22.7	25.9	32.0
80	27.5	15.0	12.5	23.7	15.2	33.3
70	37.0	13.5	23.5	18.6	6.3	38.7
60	42.0	10.0	32.0	13.2	3.3	44.1
50	44.5	17.5	27.0	8.3	2.5	45.5
40	46.0	18.5	27.5	2.3	0.7	46.8
30	47.0	19.0	28.0	-2.5	-0.7	46.8
20	47.0	19.0	28.0	-2.5	-0.7	46.8
10	48.0	20.0	28.0	-5.6	-1.6	46.8
0	48.0	21.0	27.0	-10.3	-3.1	46.8

CUSTOMER	DATE	SHEET
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SUBJECT	PRELIM.	FINAL
Allis-Chalmers 6" Streamseal Butterfly Valve Model		

DRAWING NUMBER

LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY R. Z.

Test No. 26

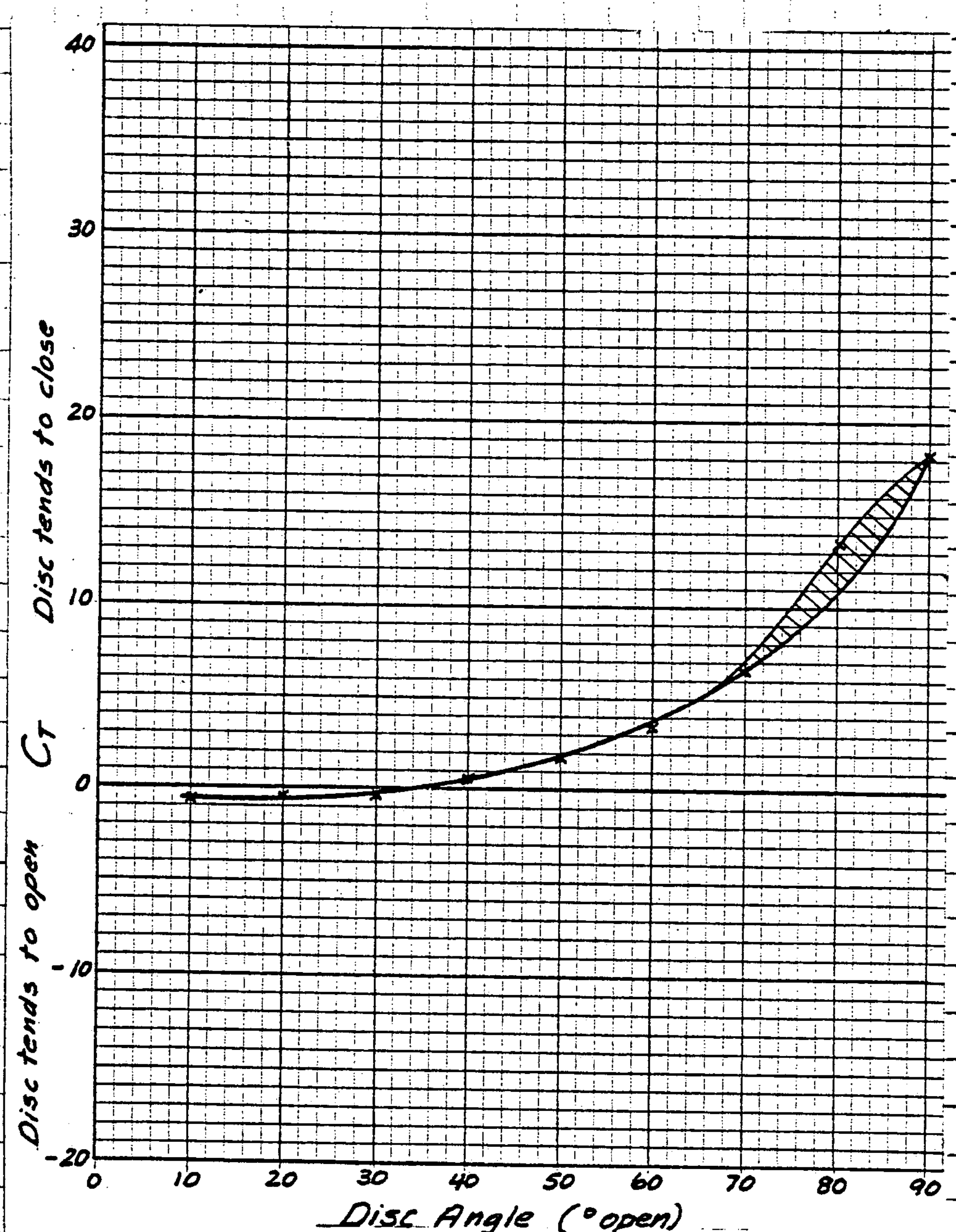
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 60 psig   Valve orientation ref. Figure 11

Torque equation and coefficient: $Td = C_T \times D^3 \times \Delta P$

where Td is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in PSI.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 26 P_{T_1} = 60 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	29.0	18.0	11.0	25.0	18.2	38.7
80	32.5	17.0	15.5	26.2	13.5	41.4
70	41.0	16.0	25.0	20.6	6.6	47.5
60	48.0	12.5	35.5	15.3	3.4	51.5
50	51.5	7.5	44.0	9.9	1.8	52.9
40	54.0	4.0	50.0	3.1	0.5	52.9
30	55.0	2.5	52.5	-2.1	-0.3	53.5
20	55.0	2.0	53.0	-2.7	-0.4	53.5
10	55.0	1.5	53.5	-6.2	-0.9	53.5
0	55.0	1.0	54.0	-10.7	-1.6	53.5

CUSTOMER	DATE	SHEET
Air Flow Tests NASA/Langley Research Center	Nov. & Dec. 1979	1 of 7

SUBJECT	PRELIM.	FINAL
Allis-Chalmers 6" Streamseal Butterfly Valve Model		

DRAWING NUMBER

LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY [illegible]

Test No. 27 ✓

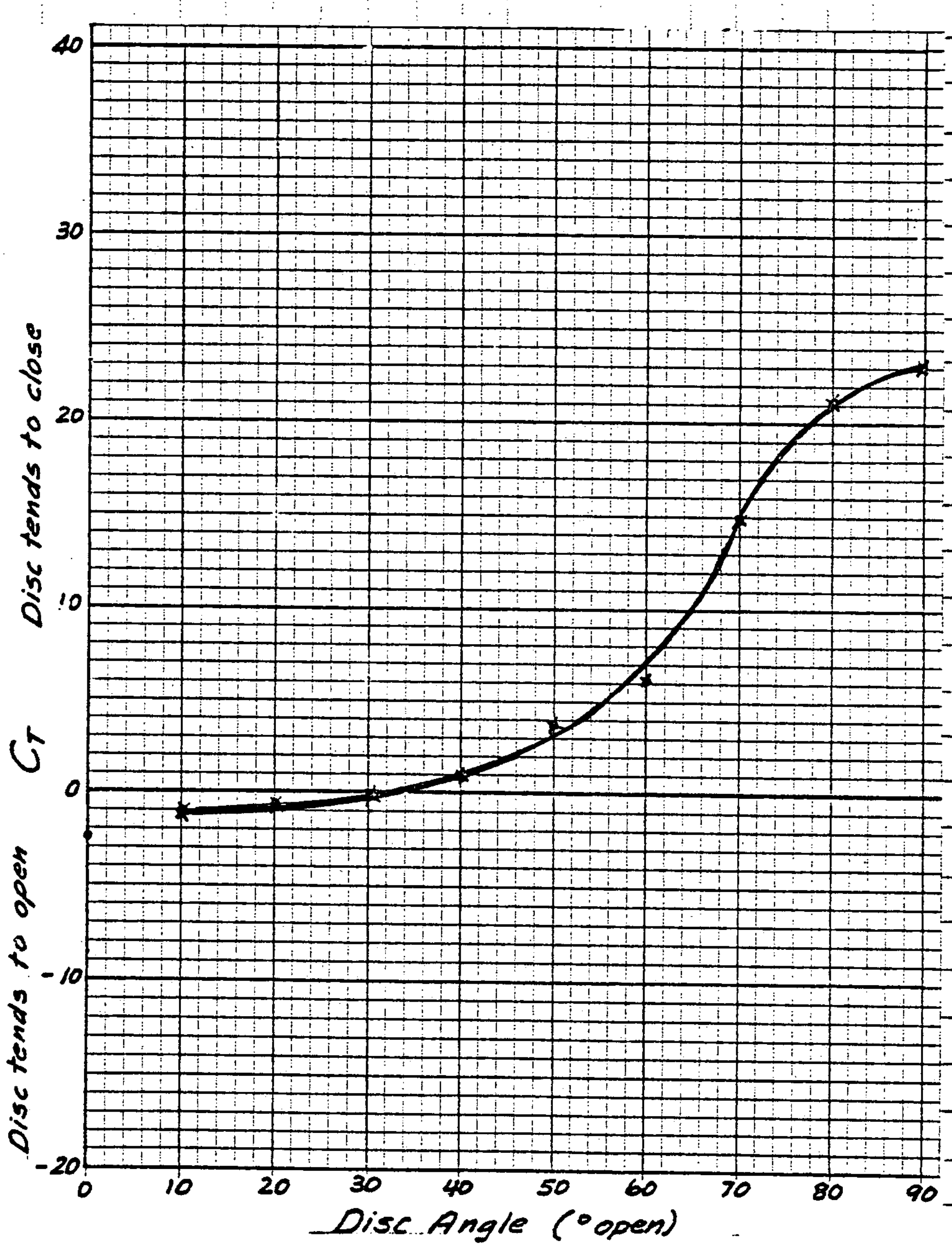
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 10 PSIG Valve orientation ref. Figure 12

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 27 10 PSI

90	5.0	2.5	2.5	7.2	23.1
80	6.0	2.5	3.5	9.3	21.2
70	7.5	2.5	5.0	9.3	14.9
60	10.0	2.0	8.0	6.2	6.2
50	10.5	1.5	9.0	4.1	3.7
40	12.0	1.5	10.5	1.2	0.9
30	12.5	1.0	11.5	-0.1	-0.07
20	12.5	1.0	11.5	-1.0	-0.7
10	12.5	0.5	12.0	-1.7	-1.1
0	12.5	0.5	12.0	3.5	-2.3

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CUSTOMER Air Flow Tests NASA/Langley Research Center | DATE Nov. & Dec. 1979 | SHEET 2 OF 7

SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model | PRELIM. | FINAL

DRAWING NUMBER | LITHO IN U.S.A.—A-C | CALCULATED BY [signature]

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 27

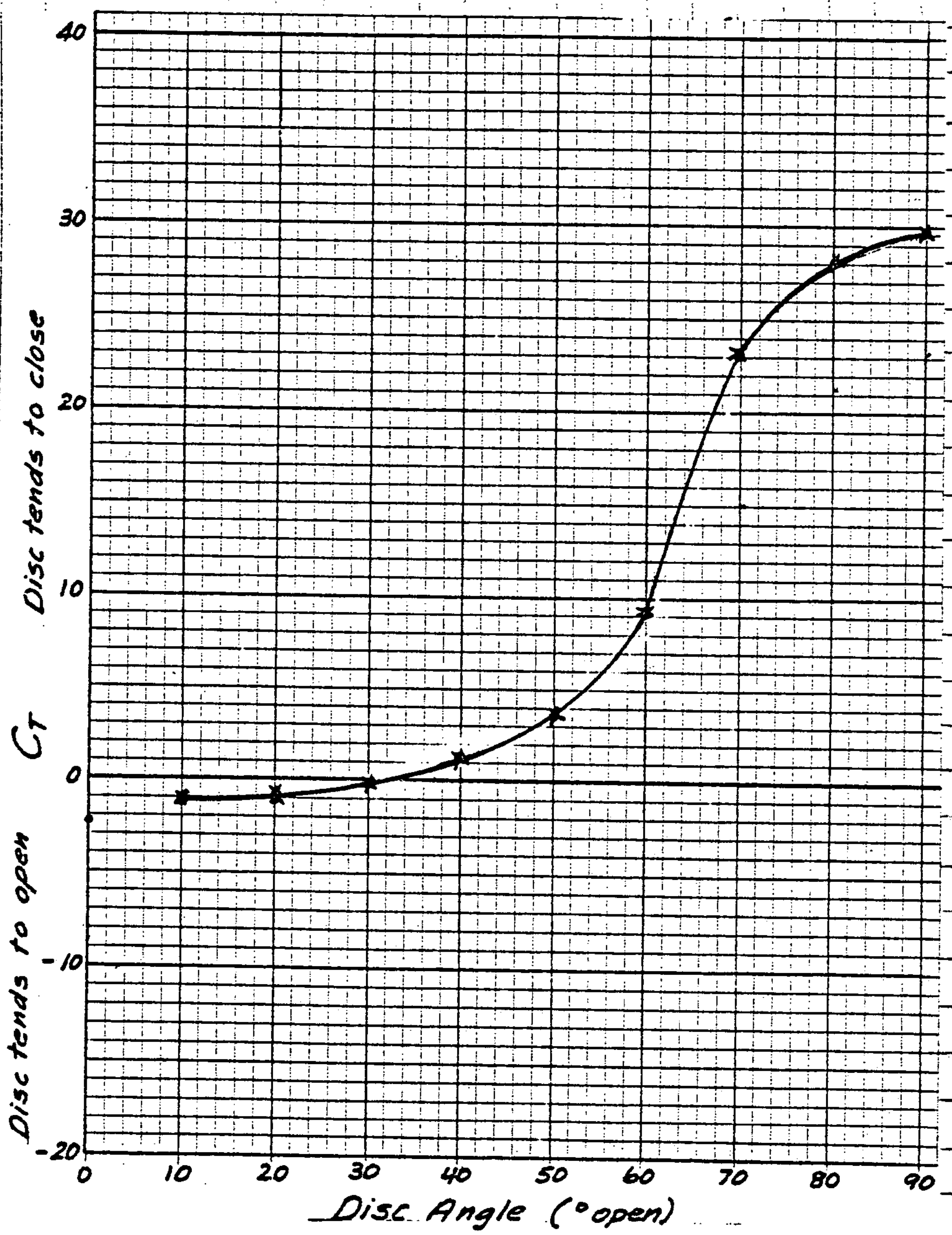
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 15 PSIG Valve orientation ref. Figure 12

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER	DATE	SHEET
Air Flow Tests NASA/Langley Research Center	Nov. & Dec. 1979	SHEET 3 OF 7

SUBJECT	PRELIM.	FINAL
Allis-Chalmers 6" Streamseal Butterfly Valve Model		

DRAWING NUMBER

LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY BHH

Test No. 27

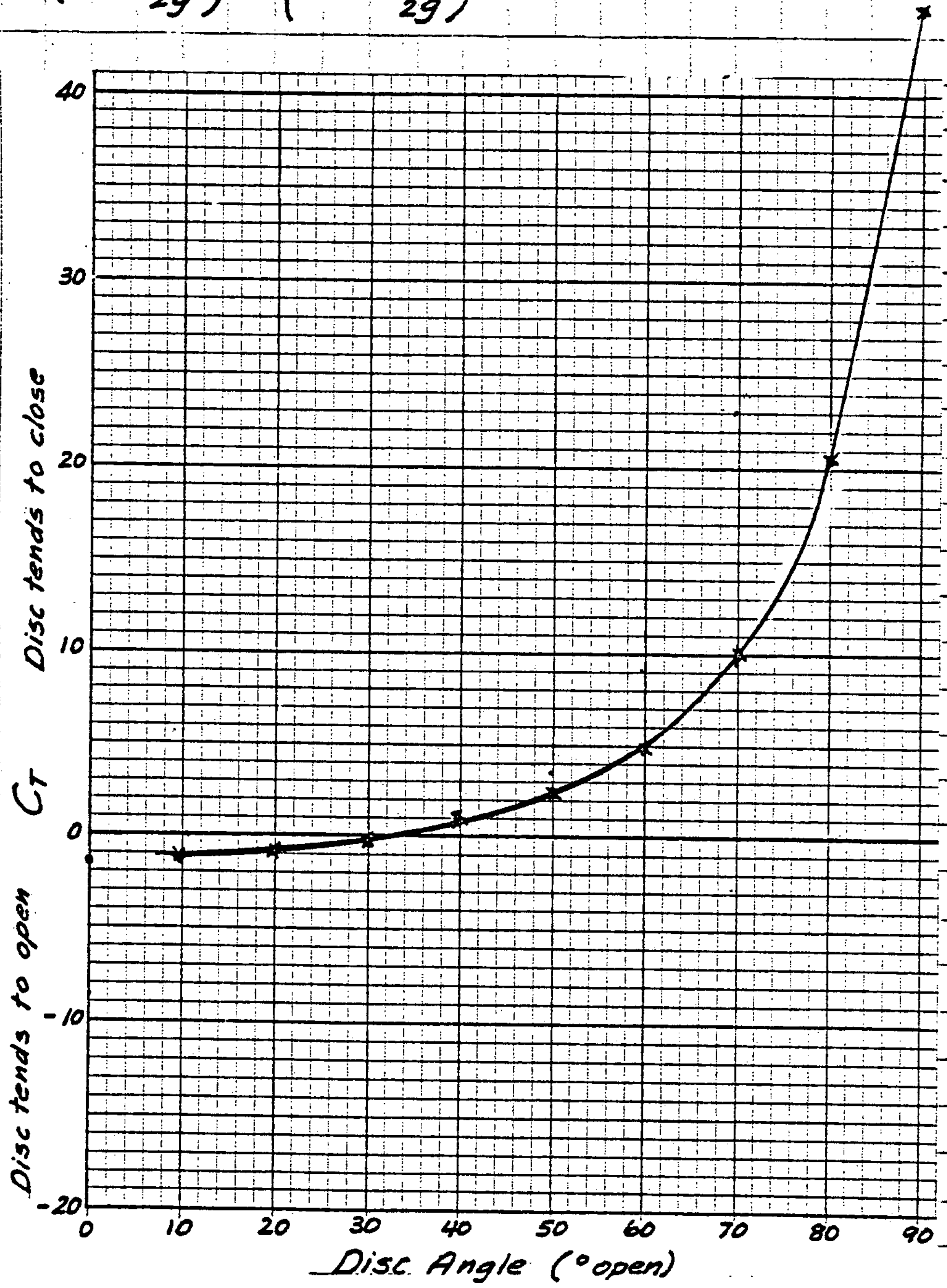
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 20 PSIG Valve orientation ref. Figure 12

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in PSI.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 27 15 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	4.0	2.5	1.5	5.6	29.7	not recorded
80	4.5	2.5	2.0	7.0	28.0	
70	5.0	2.5	2.5	7.2	23.1	
60	6.5	2.0	4.5	5.2	9.2	
50	8.0	1.0	7.0	3.1	3.5	
40	8.0	1.0	7.0	1.2	1.4	
30	9.0	0.5	8.5	-0.1	-0.1	
20	10.0	0.5	9.5	-1.0	-0.9	
10	10.0	0.5	9.5	-1.4	-1.2	
0	10.0	0.5	9.5	-2.7	-2.3	

Test 27 20 PSI

90	7.0	5.0	2.0	11.3	45.2
80	10.0	4.5	5.5	14.0	20.4
70	12.5	3.0	9.5	12.0	10.1
60	16.0	2.5	13.5	8.3	4.9
50	17.5	2.5	15.0	4.7	2.5
40	19.0	1.0	18.0	2.06	0.9
30	19.5	1.0	18.5	-0.4	-0.2
20	20.0	0.5	19.5	-1.9	-0.8
10	20.0	0	20.0	-2.9	-1.2
0	20.0	0	20.0	-3.7	-1.5

CUSTOMER Air Flow Tests NASA/Langley Research Center	DATE Nov. & Dec. 1979	SHEET 4 OF 7	
SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model		PRELIM.	FINAL
DRAWING NUMBER	LITHO IN U.S.A.—A-C **ENGINEERING CALCULATION SHEET** ALLIS-CHALMERS FORM 6715-1	CALCULATED BY [illegible] Test No. 27	

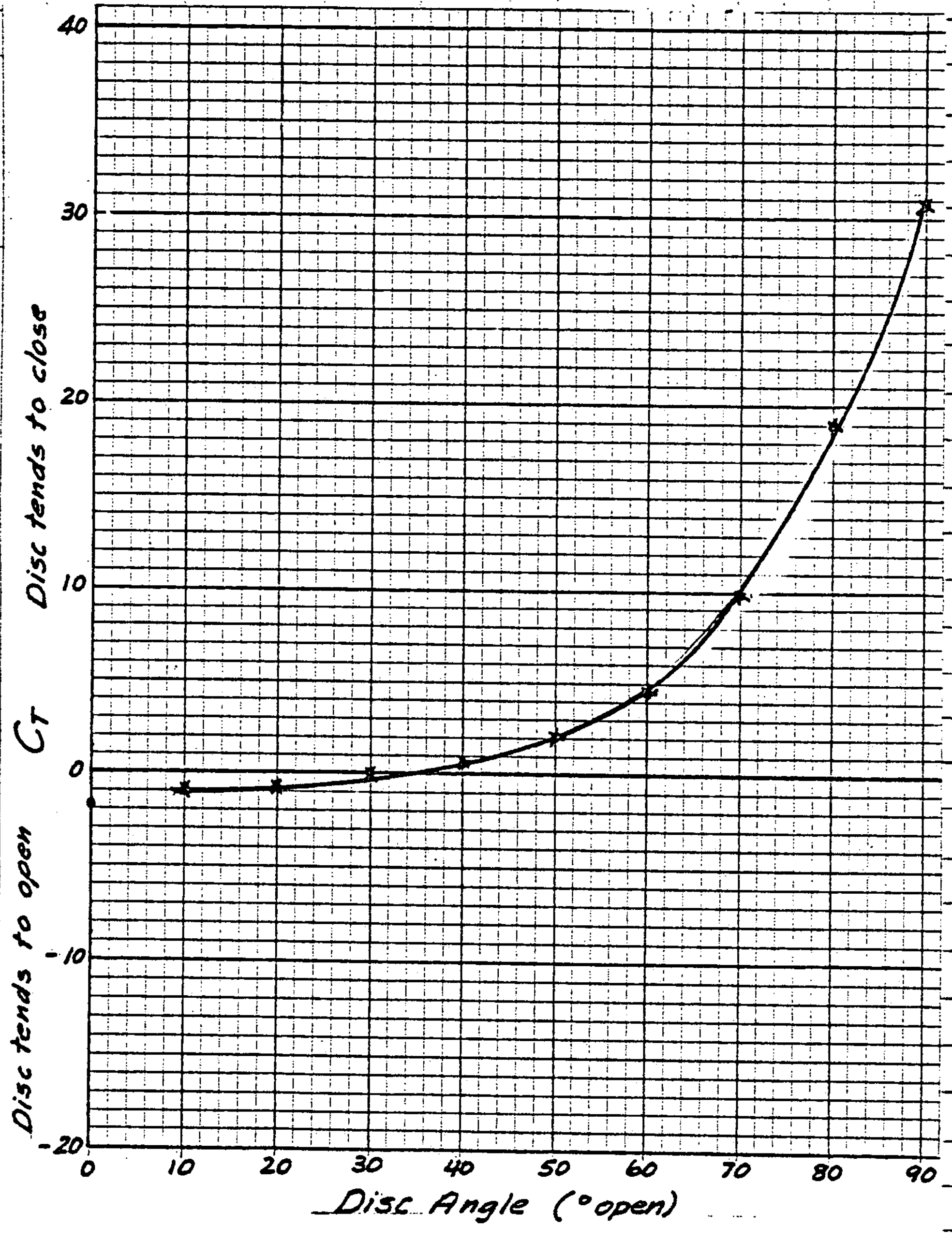
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 30 PSIG   Valve orientation ref. Figure 12

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER	DATE	
Air Flow Tests NASA/Langley Research Center	Nov. & Dec. 1979	SHEET 5 OF 7
SUBJECT: Allis-Chalmers 6" Streamseal Butterfly Valve Model	PRELIM.	FINAL
DRAWING NUMBER	CALCULATED BY	B.H.H.

LITHO IN U.S.A.-A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 27

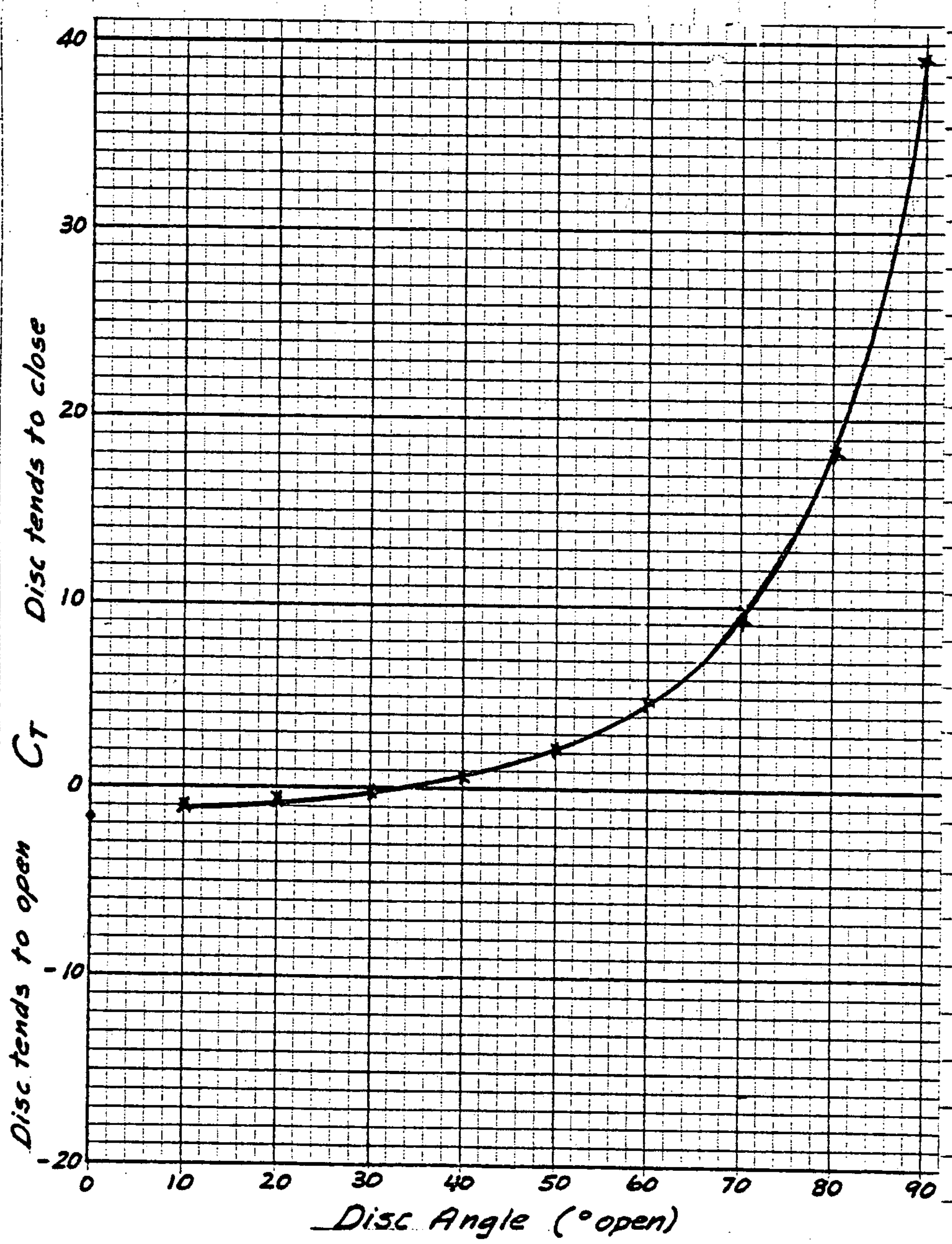
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 40 PSIG Valve orientation ref. Figure 12

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 27 30 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	12.0	8.0	4.0	15.5	30.9	not recorded
80	15.0	7.0	8.0	19.0	19.0	
70	19.0	6.0	13.0	16.1	9.9	
60	25.0	5.0	20.0	11.3	4.5	
50	26.5	2.5	24.0	6.1	2.1	
40	27.5	1.5	26.0	2.1	0.6	
30	28.0	0	28.0	0	0	
20	28.0	0	28.0	-2.5	-0.7	
10	28.0	0	28.0	-2.9	-0.8	
0	28.0	0	28.0	-6.4	-1.8	

Test 27 40 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	19.0	13.0	4.0	19.6	39.2	17.2
80	21.5	11.0	10.5	23.7	18.1	18.5
70	27.5	10.0	17.5	19.8	9.1	23.3
60	32.5	7.5	25.0	15.1	4.8	27.3
50	36.0	5.0	31.0	8.7	2.2	30.0
40	37.5	2.5	35.0	2.9	0.7	31.3
30	38.0	1.5	36.5	-1.0	-0.2	32.0
20	39.0	1.0	38.0	-3.1	-0.7	32.0
10	39.0	0.5	38.5	-4.7	-1.0	32.0
0	39.0	0	39.0	-8.5	-1.7	32.0

CUSTOMER Air Flow Tests NASA/Langley Research Center | DATE Nov. & Dec. 1979 | SHEET 6 OF 7

SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model | PRELIM. | FINAL

DRAWING NUMBER | LITHO IN U.S.A.—A-C | CALCULATED BY BHH

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 27

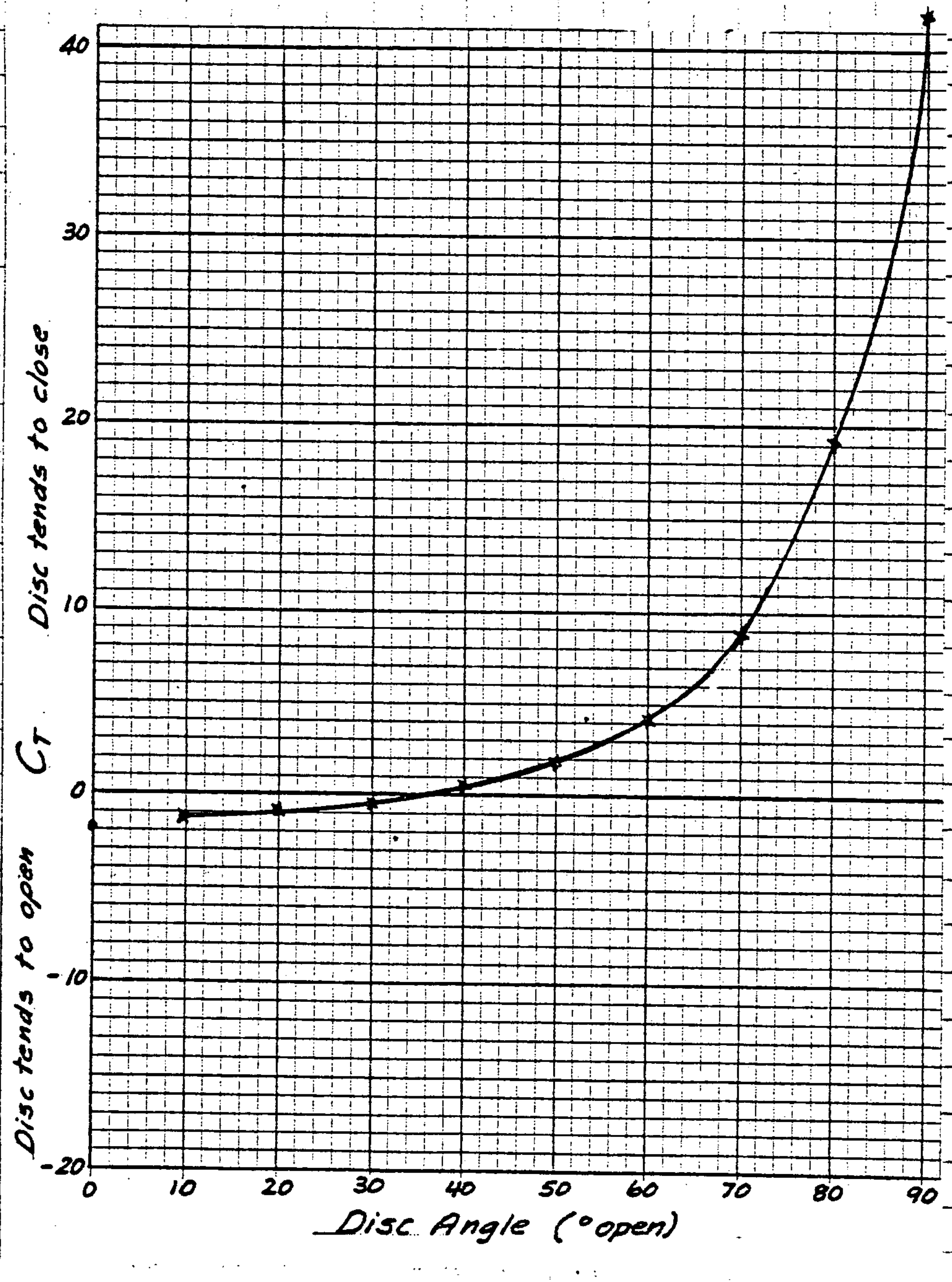
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 50PSIG Valve orientation ref. Figure 12

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER	DATE	
Air Flow Tests NASA/Langley Research Center	Nov. & Dec. 1979	SHEET 7 OF 7
SUBJECT: Allis-Chalmers 6" Streamseal Butterfly Valve Model	PRELIM.	FINAL
DRAWING NUMBER	LITHO IN U.S.A.-A-C	CALCULATED BY [signature]

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 27

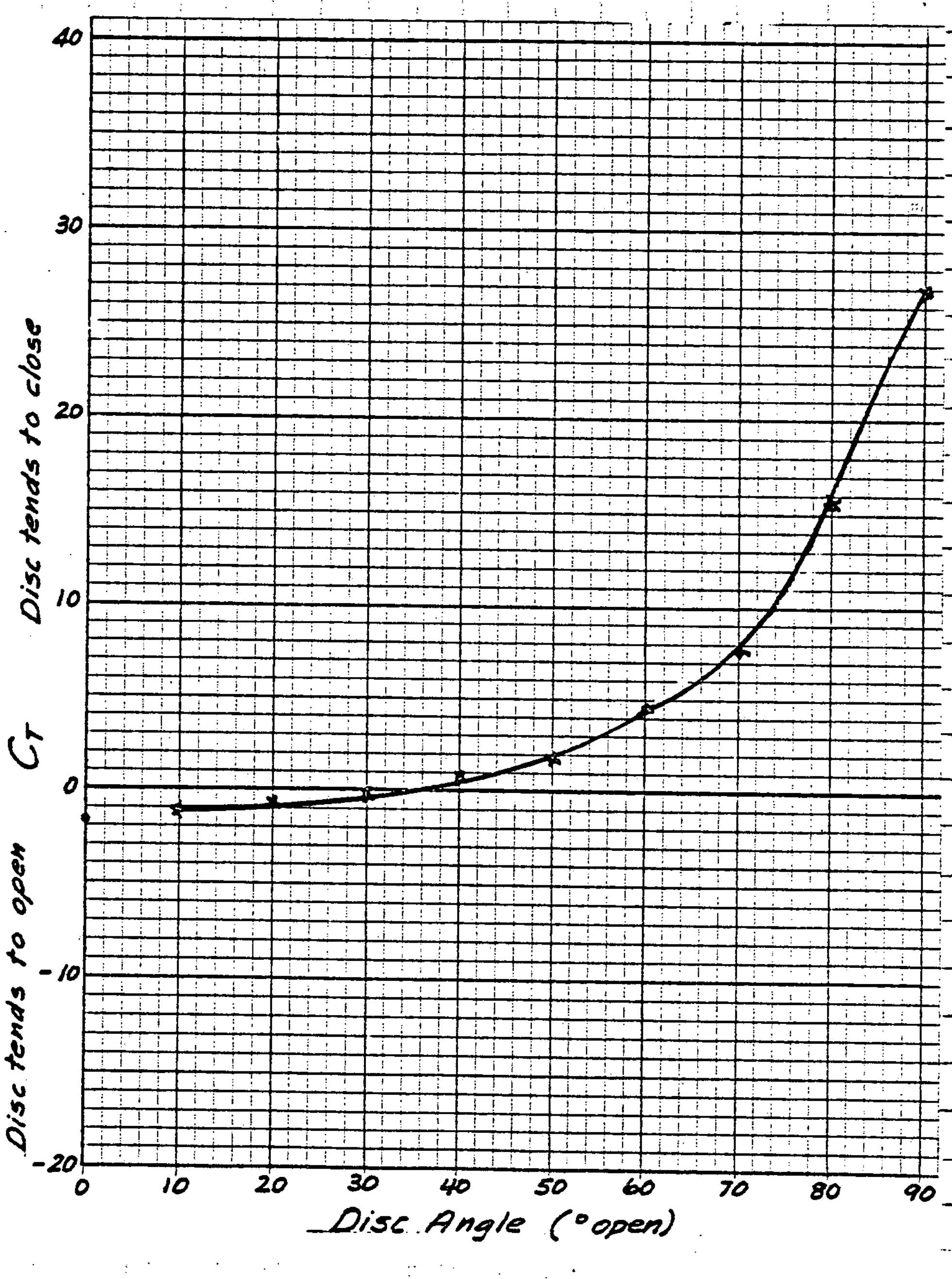
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 60 PSIG Valve orientation ref. Figure 12

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 27 50 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	30.0	25.5	4.5	23.7	42.2	26.6
80	33.0	21.5	11.5	27.6	19.2	28.0
70	40.0	19.0	21.0	23.1	8.8	34.0
60	47.5	15.0	32.5	16.5	4.1	38.1
50	50.0	11.0	39.0	9.3	1.9	39.4
40	52.5	8.5	44.0	3.1	0.6	40.1
30	53.0	8.0	45.0	-2.1	-0.4	40.1
20	53.0	7.5	45.5	-4.5	-0.8	40.1
10	54.0	7.5	46.5	-6.2	-1.1	40.1
0	54.0	7.5	46.5	-10.3	-1.8	40.1

Test 27 60 PSI

90	30.0	22.0	8.0	26.8	26.8	34.7
80	34.0	18.0	16.0	30.9	15.5	37.4
70	43.0	16.0	27.0	25.2	7.5	43.4
60	48.0	13.0	35.0	19.4	4.4	46.0
50	52.0	7.5	44.5	9.9	1.8	48.1
40	54.5	3.5	51.0	3.7	0.6	48.8
30	55.0	2.5	52.5	-1.7	-0.3	48.8
20	55.0	2.0	53.0	-4.7	-0.7	48.8
10	55.0	1.5	53.5	-7.4	-1.1	48.8
0	55.0	0	55.0	-11.6	-1.7	48.8

CUSTOMER Air Flow Tests NASA/Langley Research Center | DATE Nov. & Dec. 1979 | SHEET 1 OF 7

SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model | PRELIM. | FINAL

DRAWING NUMBER | LITHO IN U.S.A.—A-C | CALCULATED BY [signature]

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 28 ✓

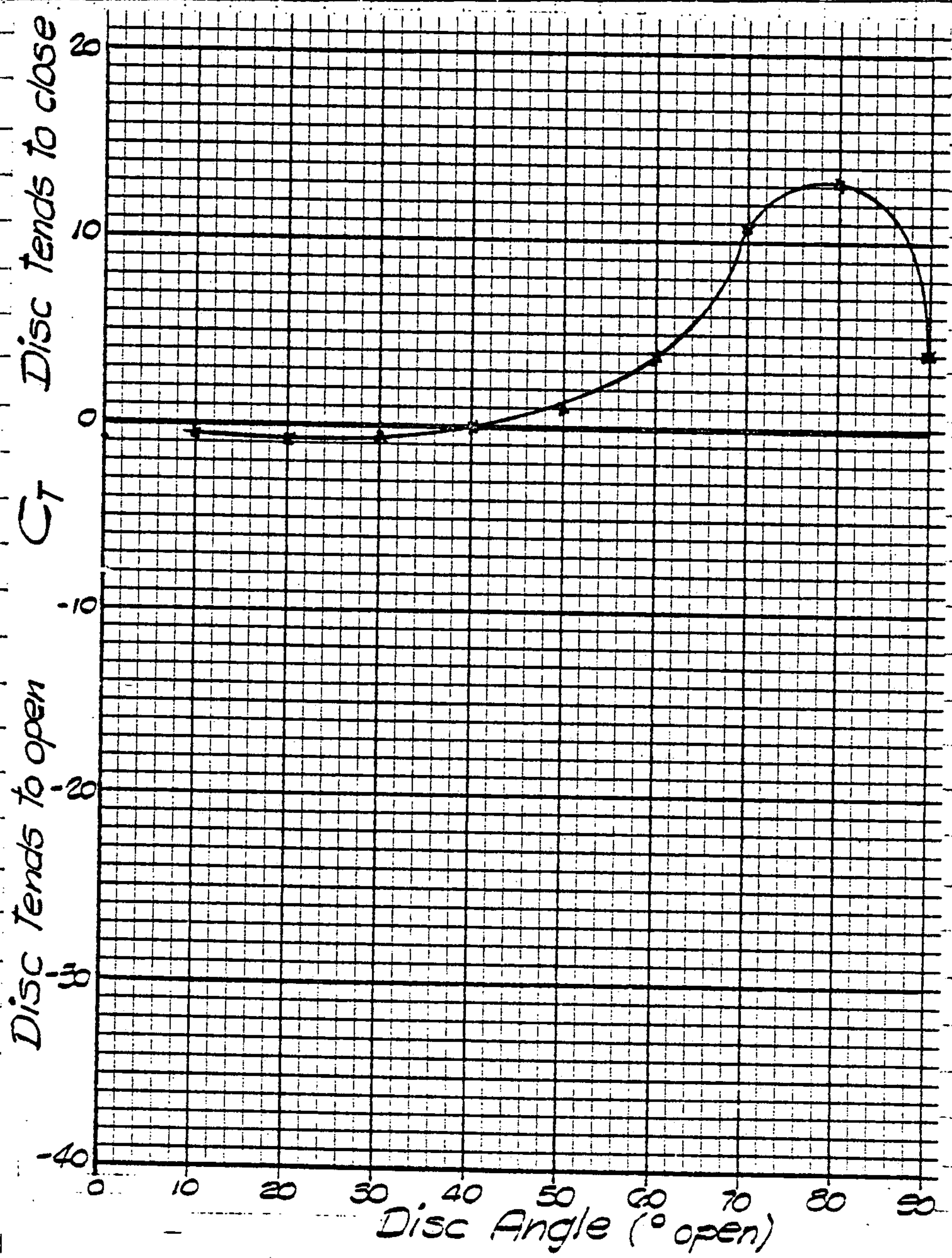
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 10 PSIG Valve orientation ref. Figure 10

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER	DATE	SHEET 2 OF 7
Air Flow Tests NASA/Langley Research Center	Nov. & Dec. 1979	

SUBJECT	PRELIM.	FINAL
Allis-Chalmers 6" Streamseal Butterfly Valve Model		

DRAWING NUMBER

LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY BHY.

Test No. 28

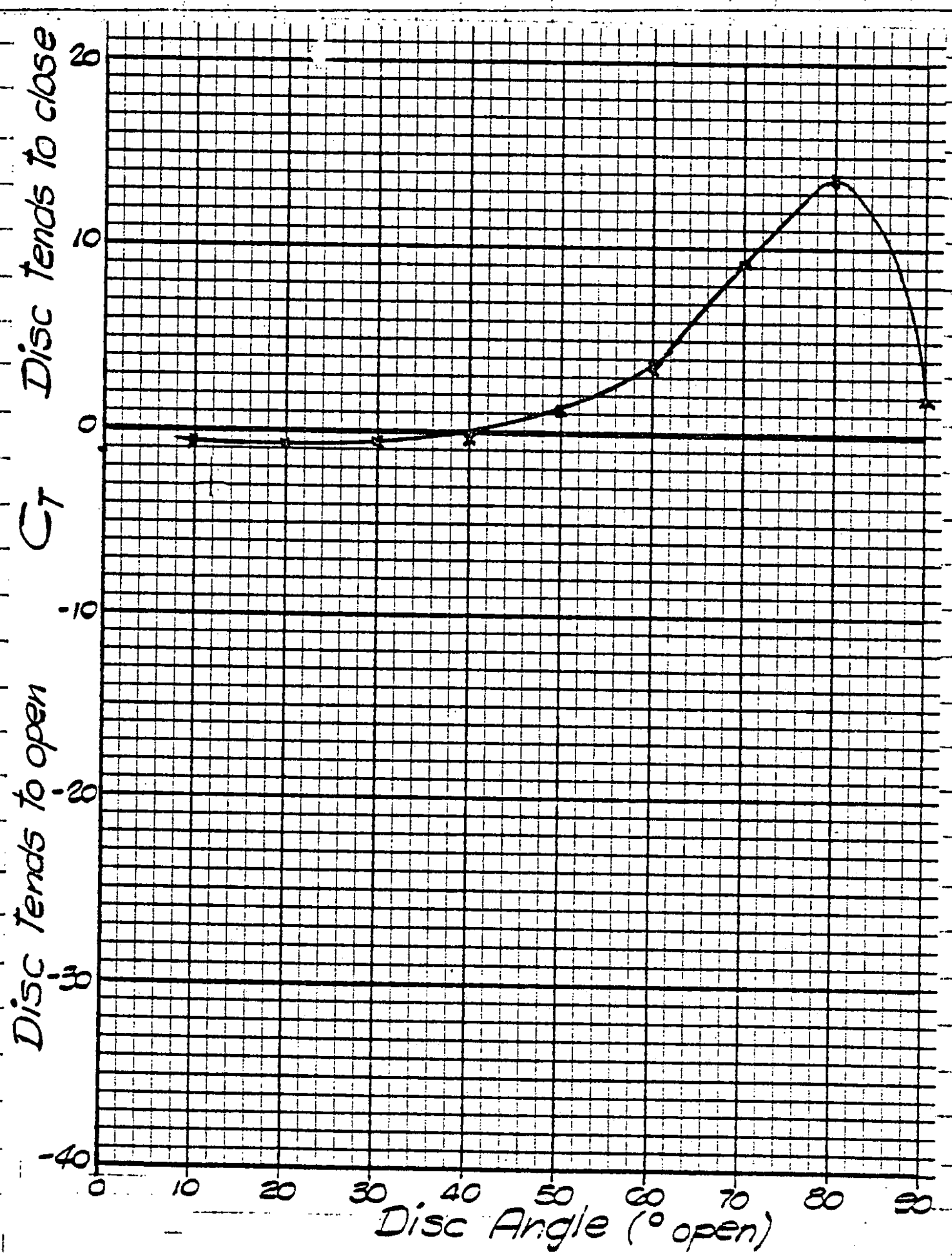
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 15 PSIG   Valve orientation ref. Figure 10

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 28 10 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	4.5	2.5	2.0	1.0	4.1	not recorded
80	4.5	2.0	2.5	4.1	13.2	
70	5.0	1.5	3.5	4.8	10.8	
60	7.5	1.0	6.5	3.1	3.8	
50	8.5	.5	8.0	1.0	1.0	
40	9.5	0	9.5	0	0	
30	9.5	0	9.5	-0.4	-.3	
20	9.5	0	9.5	-1.0	-.9	
10	9.5	0	9.5	-0.6	-.5	
0	9.5	0	9.5	-1.0	-.8	

Test 28 15 PSI

90	5.5	2.5	3.0	.7	1.9
80	5.0	2.0	3.0	5.2	13.8
70	6.5	2.0	4.5	5.2	9.2
60	9.5	1.0	8.5	3.7	3.5
50	10.5	1.0	9.5	1.4	1.2
40	11.0	1.0	10.0	-.4	-.3
30	11.5	1.0	10.5	-.6	-.5
20	12.5	.5	12.0	-1.2	-.8
10	12.5	.5	12.0	-.6	-.4
0	12.0	0	12.0	-1.7	-1.1

CUSTOMER: Air Flow Tests NASA/Langley Research Center | DATE: Nov. & Dec. 1979 | SHEET 3 OF 7

SUBJECT: Allis-Chalmers 6" Streamseal Butterfly Valve Model | PRELIM. | FINAL

DRAWING NUMBER | LITHO IN U.S.A.—A-C | CALCULATED BY [illegible]

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 28

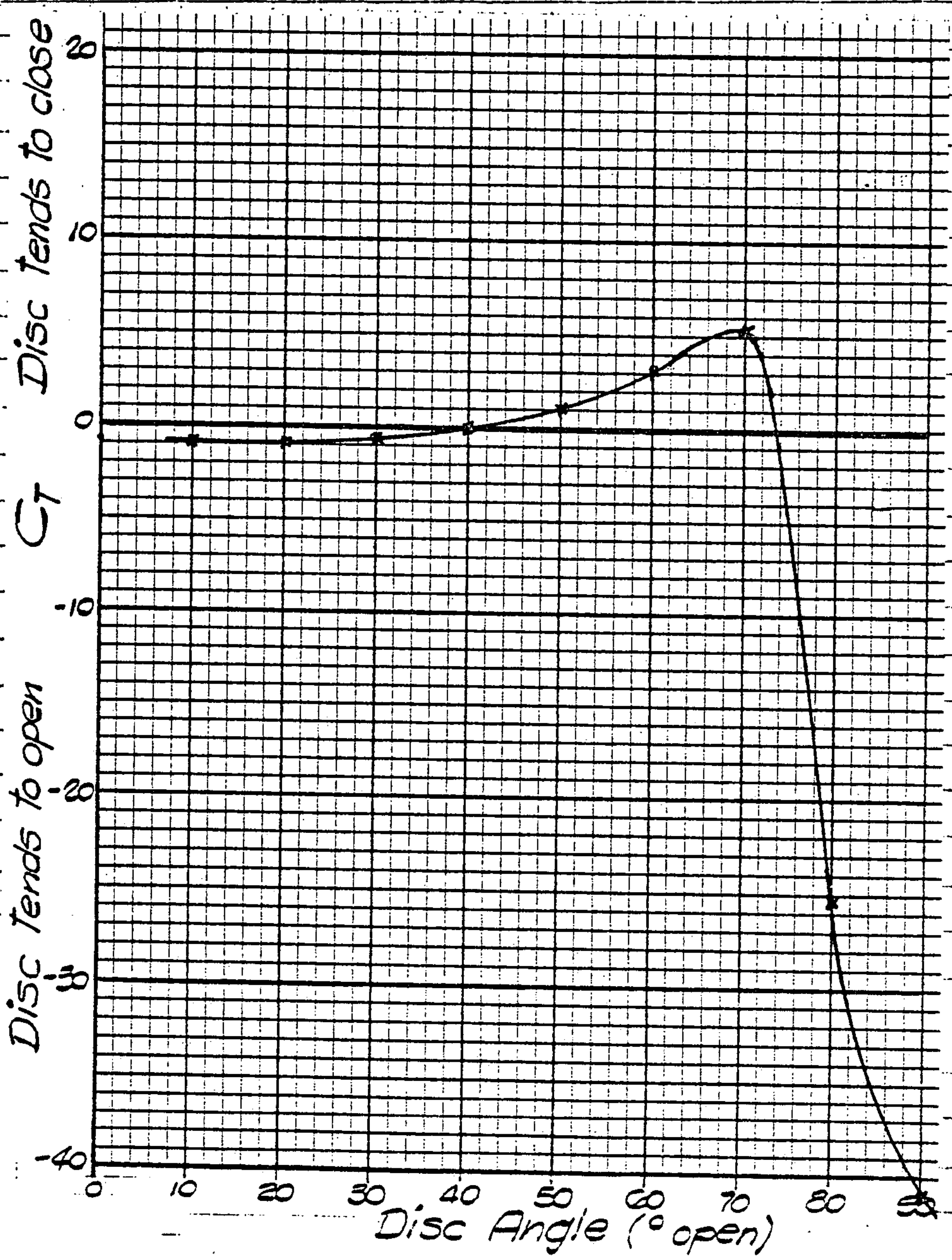
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 20 PSIG Valve orientation ref. Figure 10

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER	DATE	SHEET
Air Flow Tests NASA/Langley Research Center	Nov. & Dec. 1979	4 of 7

SUBJECT: Allis-Chalmers 6" Streamseal Butterfly Valve Model

PRELIM. | FINAL

DRAWING NUMBER

LITHO IN U.S.A.—A-C

CALCULATED BY: BHG.

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 28

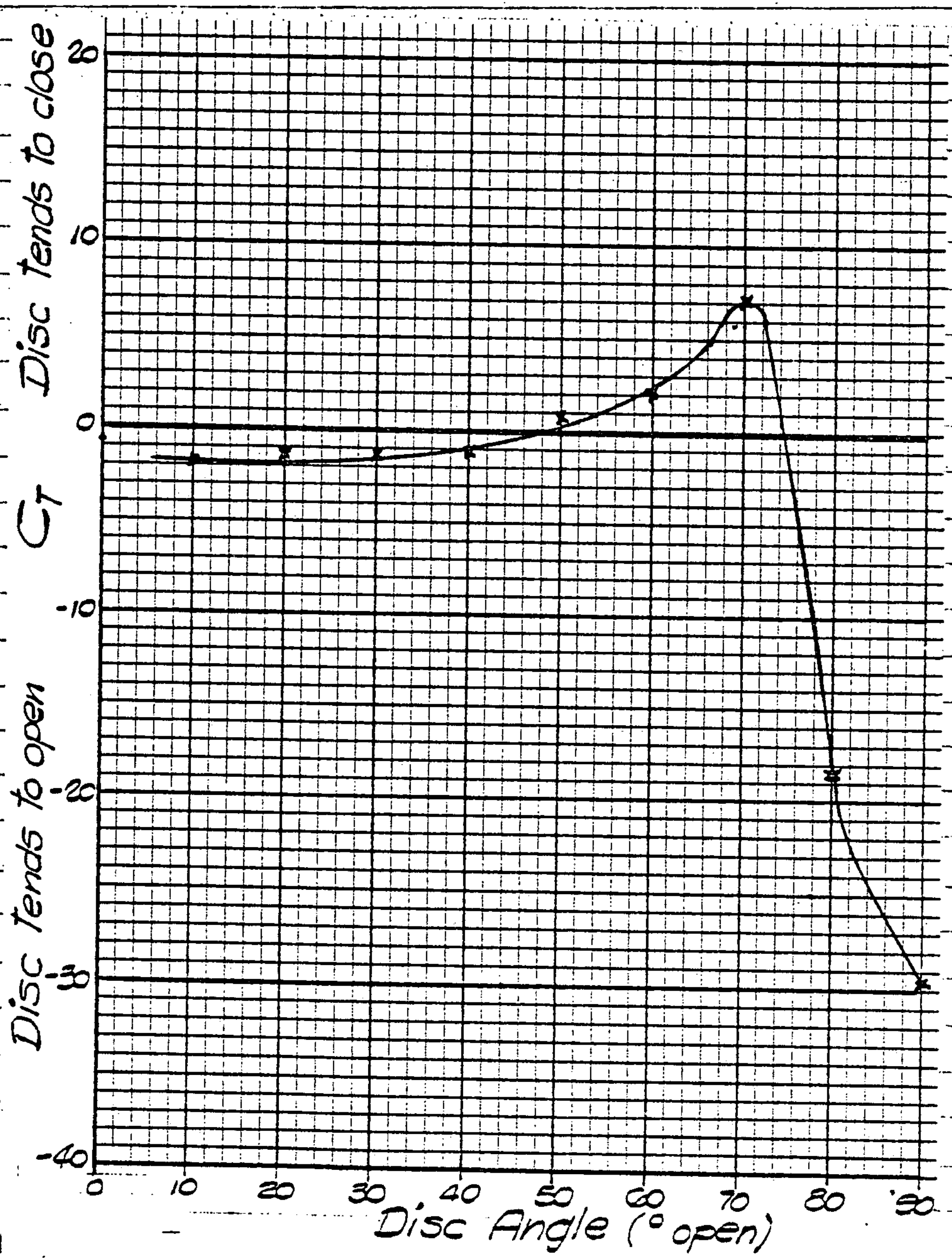
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 30 PSIG Valve orientation ref. Figure 10

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 28 20 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	7.2	5.0	2.2	-11.3	-41.3	not recorded
80	7.0	5.5	1.5	-4.7	-2.53	
70	12.5	2.5	10.0	6.6	5.3	
60	15.5	2.5	13.0	5.2	3.2	
50	17.5	1.0	16.5	2.1	1.0	
40	19.0	1.25	17.75	0	0	
30	19.5	1.0	18.5	-1.0	-.4	
20	19.5	1.0	18.5	-1.9	-.8	
10	19.5	1.0	18.5	-2.7	-.9	
0	19.5	1.0	18.5	-1.9	-.8	

Test 28 30 PSI

90	13	8.0	5.0	-18.6	-29.7
80	13	9.0	4.0	-9.3	-18.6
70	15	7.0	8.0	7.2	7.2
60	24	3.5	20.5	5.2	2.0
50	27	3.0	24.0	2.7	.9
40	28	1.5	26.5	-4.1	-1.2
30	28	1.5	26.5	-4.1	-1.2
20	28	1.0	27.0	-4.1	-1.2
10	28	.5	27.5	-6.2	-1.8
0	28	.5	27.5	-2.3	-.7

CUSTOMER	DATE	SHEET
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SUBJECT	PRELIM.	FINAL
Allis-Chalmers 6" Streamseal Butterfly Valve Model		

DRAWING NUMBER

LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY [illegible]

Test No. 28

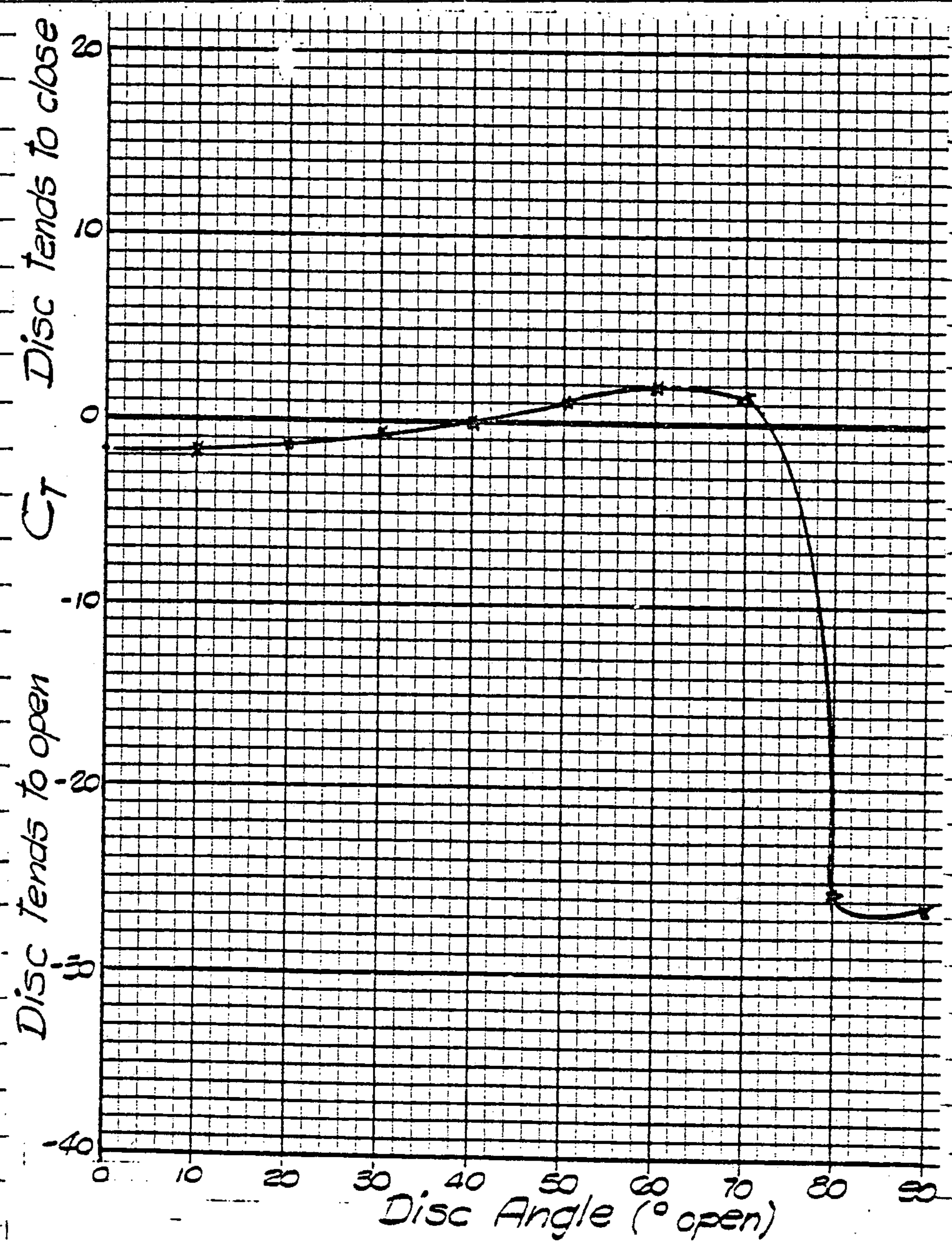
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 40 PSIG Valve orientation ref. Figure 10

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where Td is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER	DATE	SHEET
Air Flow Tests NASA/Langley Research Center	Nov. & Dec. 1979	6 of 7

SUBJECT	PRELIM.	FINAL
Allis-Chalmers 6" Streamseal Butterfly Valve Model		

DRAWING NUMBER

LITHO IN U.S.A.—A-C

CALCULATED BY BHG

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS — FORM 6715-1

Test No. 28

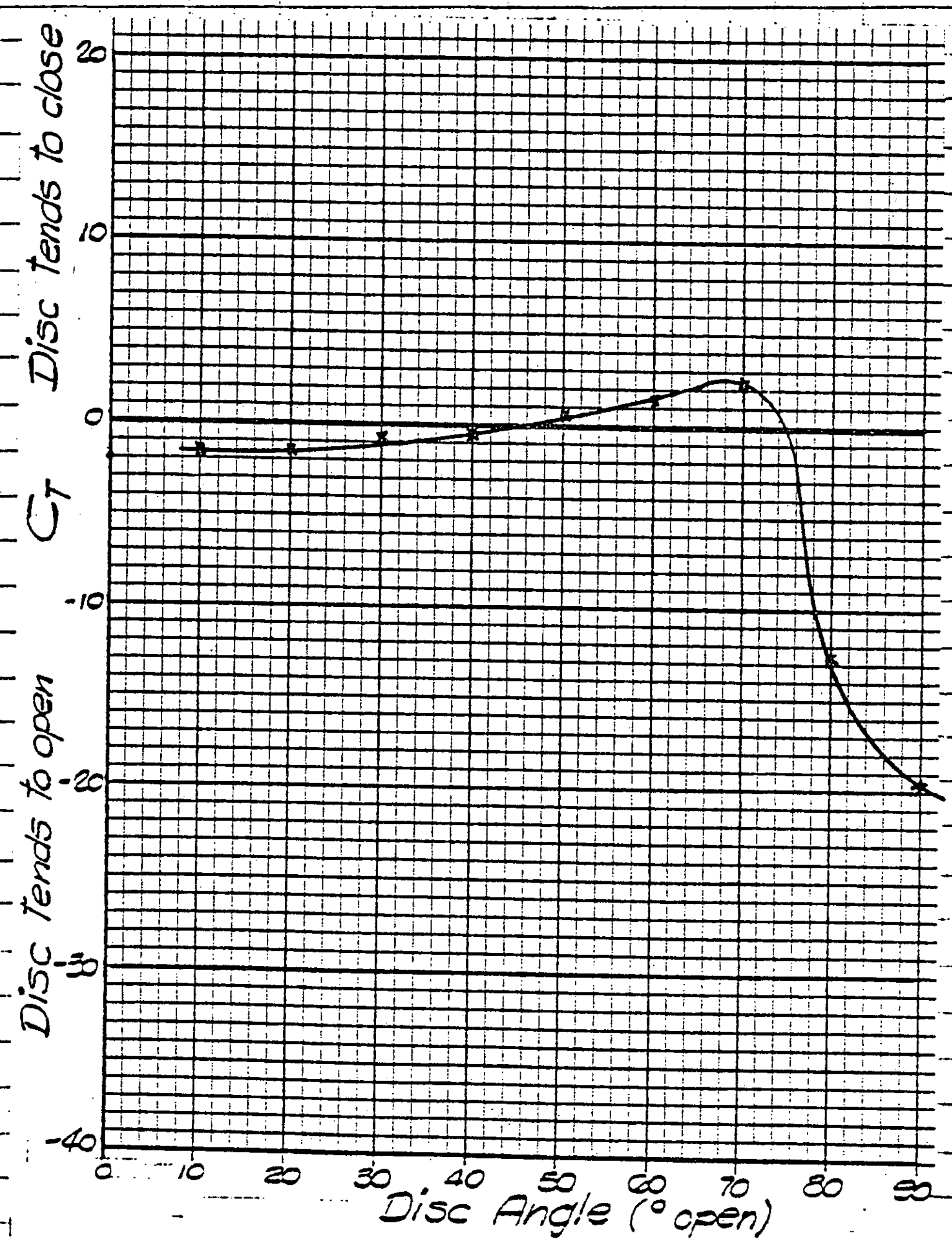
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 50 PSIG Valve orientation ref. Figure 10

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 28 40 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	18.0	11.0	7.0	-23.1	-26.4	not recorded
80	17.5	13.0	4.5	-14.4	-25.7	
70	20.0	10.0	10.0	1.7	1.3	
60	34.0	7.0	27.0	6.2	1.8	
50	35.5	4.0	31.5	4.1	1.0	
40	37.5	2.5	35.0	0	0	
30	38.0	1.0	37.0	-2.5	-0.5	
20	39.0	0	39.0	-6.4	-1.3	
10	39.0	0	39.0	-8.3	-1.7	
0	39.0	0	39.0	-8.3	-1.7	

Test 28 50 PSI

90	26	15	11	-26.8	-19.5
80	24	17.5	6.5	-10.3	-12.7
70	40	12.5	27.5	8.3	2.4
60	42	8	34	6.2	1.5
50	45	5	40	2.8	.6
40	46.5	2.5	44	-1.6	-.3
30	47.5	1.5	46.0	-4.1	-.7
20	47.5	1	46.5	-8.3	-1.4
10	47	1	46	-8.9	-1.5
0	47	1	46	-11.3	-2.0

CUSTOMER	DATE	SHEET
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SUBJECT	PRELIM.	FINAL
Allis-Chalmers 6" Streamseal Butterfly Valve Model		

DRAWING NUMBER

LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY BHL

Test No. 28

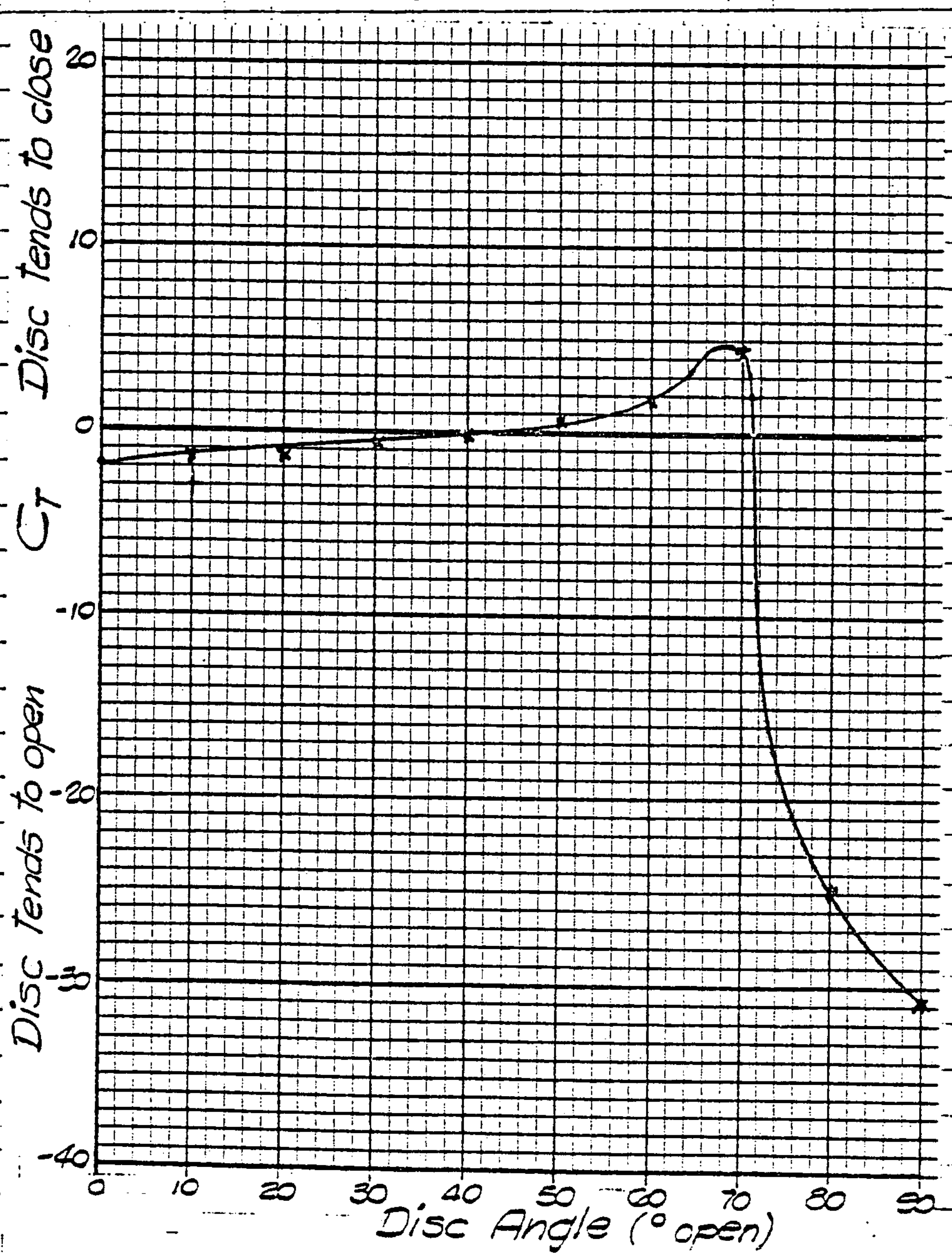
Valve disc thickness to diameter ratio: .12

Initial upstream pressure: 60 PSIG Valve orientation ref. Figure 10

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 28 60 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	25.0	17.5	7.5	-28.9	-30.8	not recorded
80	25.0	20.0	5.0	-15.5	-24.8	
70	35.0	15.0	20.0	11.3	4.5	
60	46.0	11.0	35.0	7.2	1.7	
50	50.0	6.0	44.0	3.7	0.7	
40	51.0	2.5	48.5	-0.6	-0.1	
30	52.0	1.0	51.0	-4.5	-0.7	
20	52.0	0	52.0	-9.1	-1.4	
10	52.0	0	52.0	-9.3	-1.4	
0	52.0	0	52.0	-12.4	-1.9	

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SUBJECT	PRELIM.	FINAL
Allis-Chalmers 6" Streamseal Butterfly Valve Model		

DRAWING NUMBER

LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY BHG.

Test No. 29 ✓

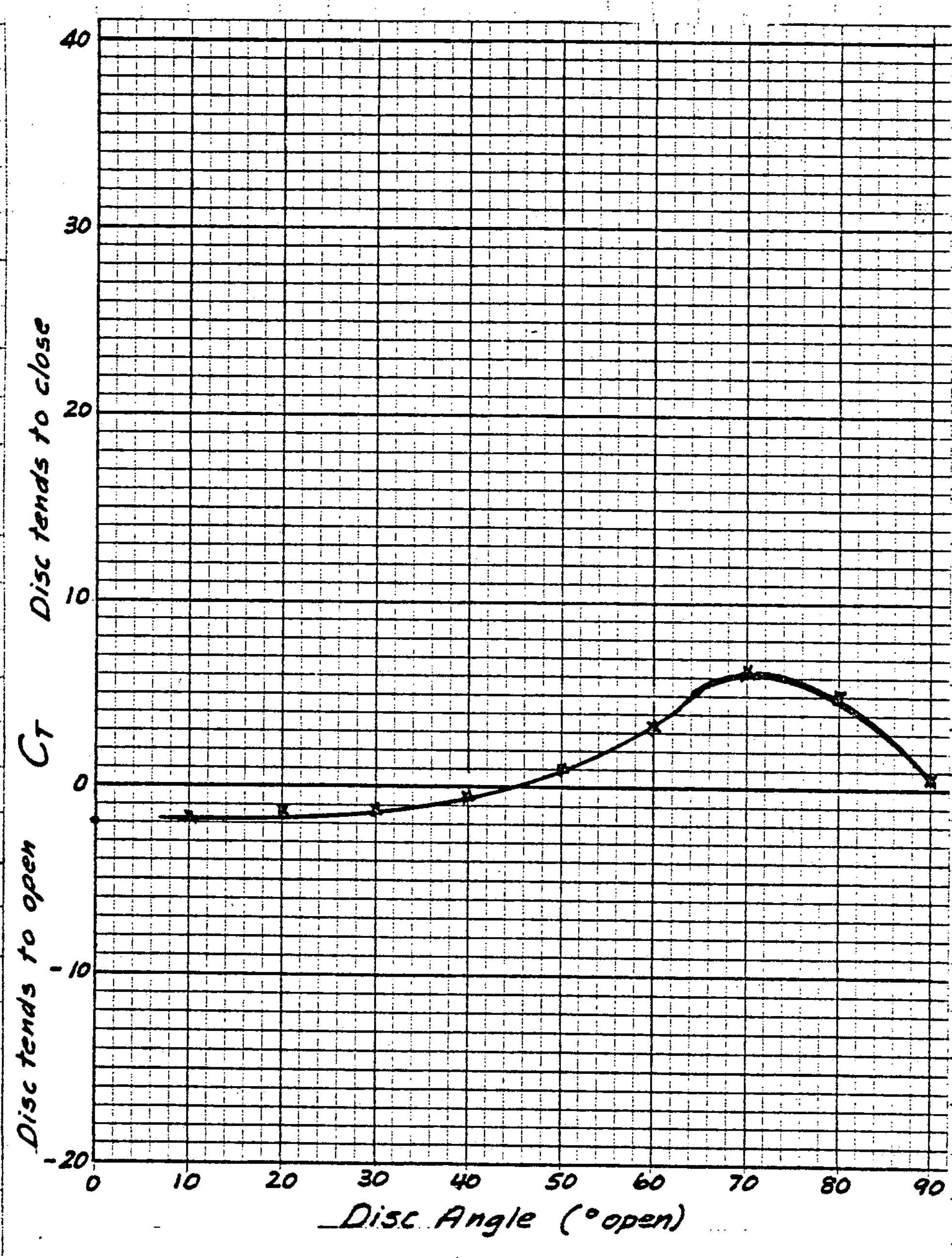
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 15PSIG Valve orientation ref. Figure 9

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER Air Flow Tests NASA/Langley Research Center | DATE Nov. & Dec. 1979 | SHEET 2 OF 6

SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model | PRELIM. | FINAL

DRAWING NUMBER | LITHO IN U.S.A.–A-C | CALCULATED BY DHG

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 29

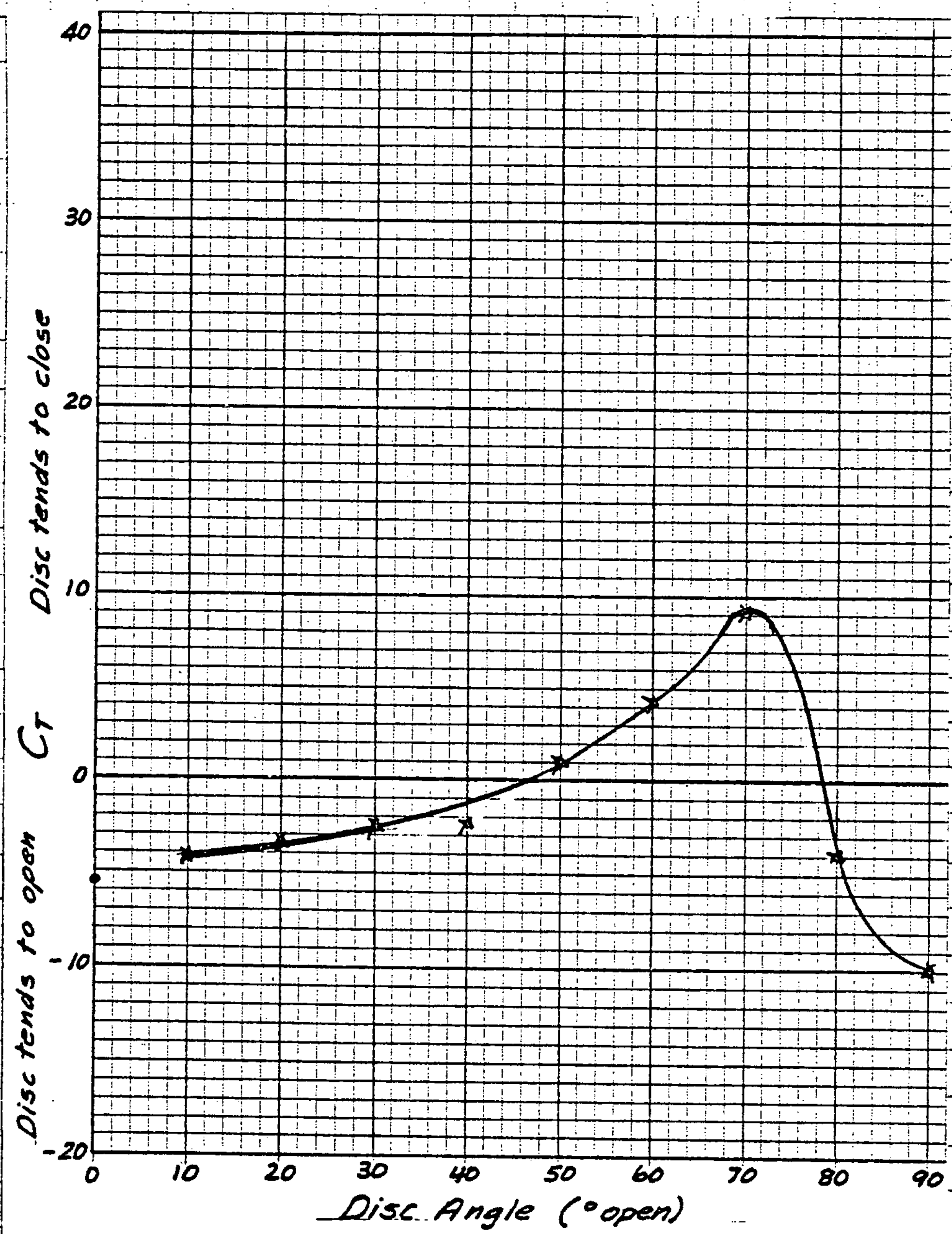
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 20 PSIG Valve orientation ref. Figure 9

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 29 P_T = 15 PSI

°Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	5.0	2.5	2.5	0.2	0.6	6.4
80	5.0	2.5	2.5	1.6	5.1	6.4
70	7.0	2.0	5.0	3.9	6.2	7.8
60	9.0	1.5	7.5	3.1	3.3	9.8
50	10.5	1.0	9.5	1.2	1.0	11.8
40	12.0	0.5	11.5	-0.8	-0.6	11.8
30	12.0	0	12.0	-1.6	-1.1	12.5
20	12.0	0	12.0	-2.0	-1.3	13.2
10	12.5	0	12.5	-2.8	-1.8	13.8
0	12.5	0	12.5	-3.1	-2.0	13.8

Test 29 20 PSI

90	7	3.0	4.0	-5.0	-10.0	2.4
80	9	3.0	6.0	-3.0	-4.0	3.7
70	10	3.0	7.0	8.0	9.2	5.1
60	14	2.5	11.5	6.0	4.2	8.4
50	17	2.0	15.0	2.0	1.1	11.1
40	18	1.0	17.0	-5.0	-2.4	11.8
30	18	0.5	17.5	-6.0	-2.7	13.2
20	19	0	19.0	-8.0	-3.4	13.8
10	19	0	19.0	-10.0	-4.2	15.2
0	19	0	19.0	-13.0	-5.5	15.2

CUSTOMER Air Flow Tests NASA/Langley Research Center | DATE Nov. & Dec. 1979 | SHEET 3 OF 6

SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model | PRELIM. | FINAL

DRAWING NUMBER | LITHO IN U.S.A.—A-C | CALCULATED BY BHH

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 29

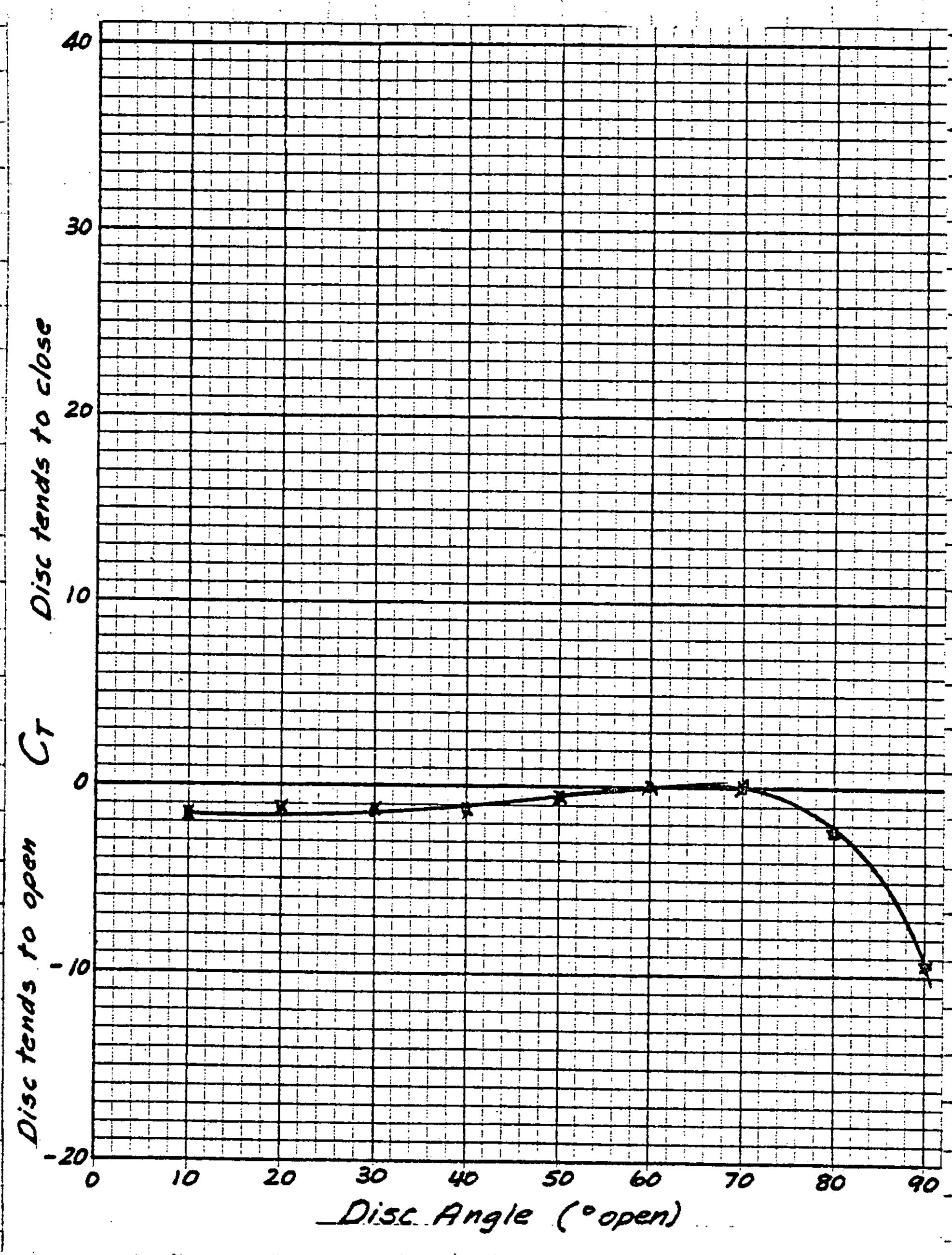
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 30 PSIG Valve orientation ref. Figure 9

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER	DATE	SHEET
Air Flow Tests NASA/Langley Research Center	Nov. & Dec. 1979	4 OF 6

SUBJECT: Allis-Chalmers 6" Streamseal Butterfly Valve Model

PRELIM. FINAL

DRAWING NUMBER

LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY [signature]

Test No. 29

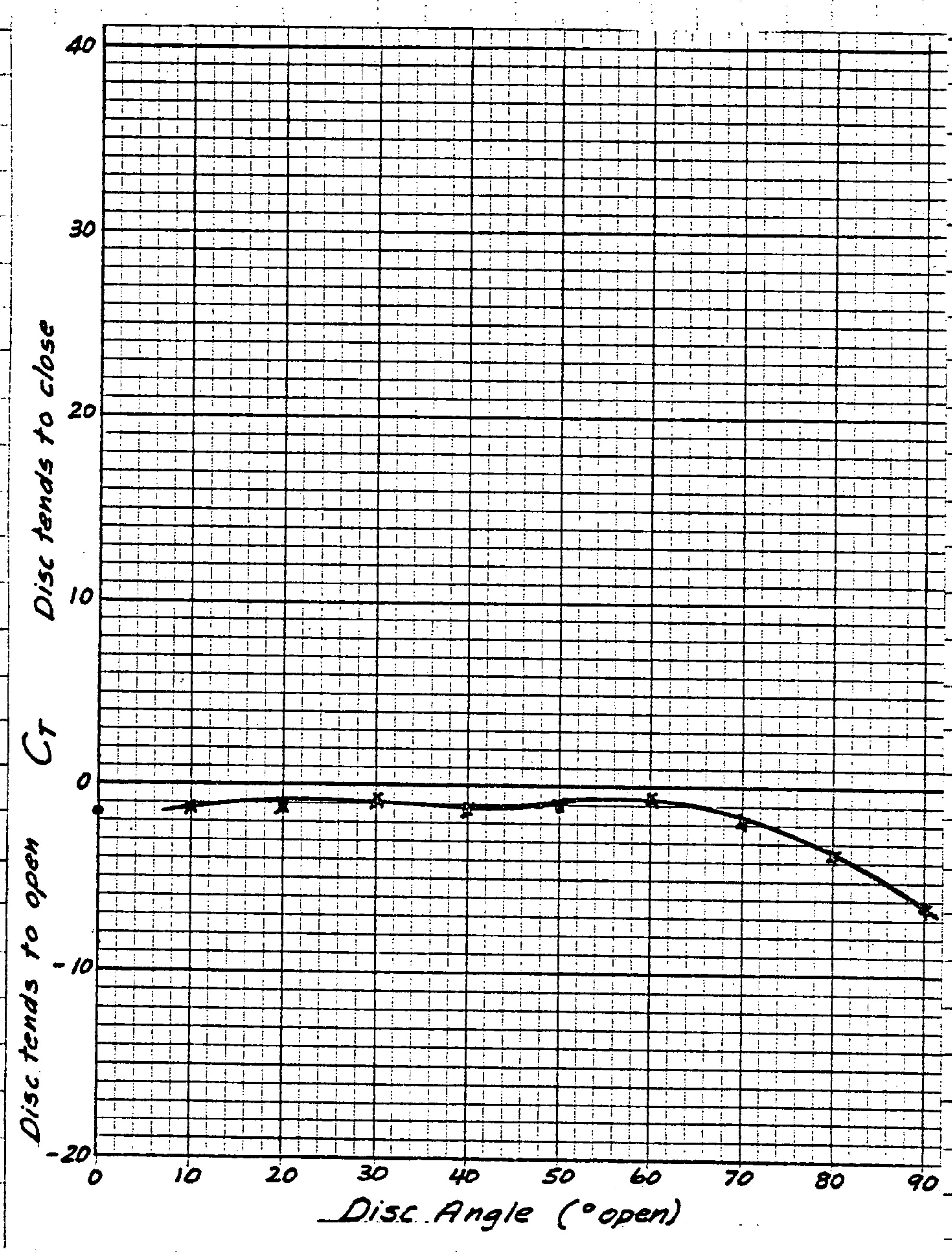
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 40 PSIG Valve orientation ref. Figure 9

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 29 30 PSIG

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	12	7	5	-5.9	-9.44	3.7
80	18	7	11	-3.15	-2.3	5.1
70	20	7	13	0	0	7.8
60	22.5	5	17.5	0	0	9.1
50	25	22.5	-1.57		-.558	11.8
40	27.5	1.5	26	-3.93	-1.2	13.8
30	28	0	28	-3.93	-1.12	16.5
20	29	0	29	-3.93	-1.08	18.5
10	30	0	30	-5.9	-1.57	18.5
0	30	0	30	-7.87	-1.57	18.5

Test 29 40 PSIG

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	20	10	10	-7.86	-6.29	9.8
80	20	10	10	-4.68	-3.74	10.5
70	25	10	15	-3.74	-1.99	11.8
60	30	7.5	22.5	-1.87	-.66	17.2
50	35	5	30	-3.92	-1.05	20.6
40	37.5	2.5	35	-5.97	-1.36	22.6
30	38	0	38	-4.68	-.985	23.9
20	39	0	39	-5.61	-1.15	24.6
10	39.5	0	39.5	-5.97	-1.21	25.3
0	40	0	40	-7.86	-1.56	25.3

CUSTOMER: Air Flow Tests NASA/Langley Research Center

DATE: Nov. & Dec. 1979

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SUBJECT: Allis-Chalmers 6" Streamseal Butterfly Valve Model

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LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY BHG.

Test No. 29

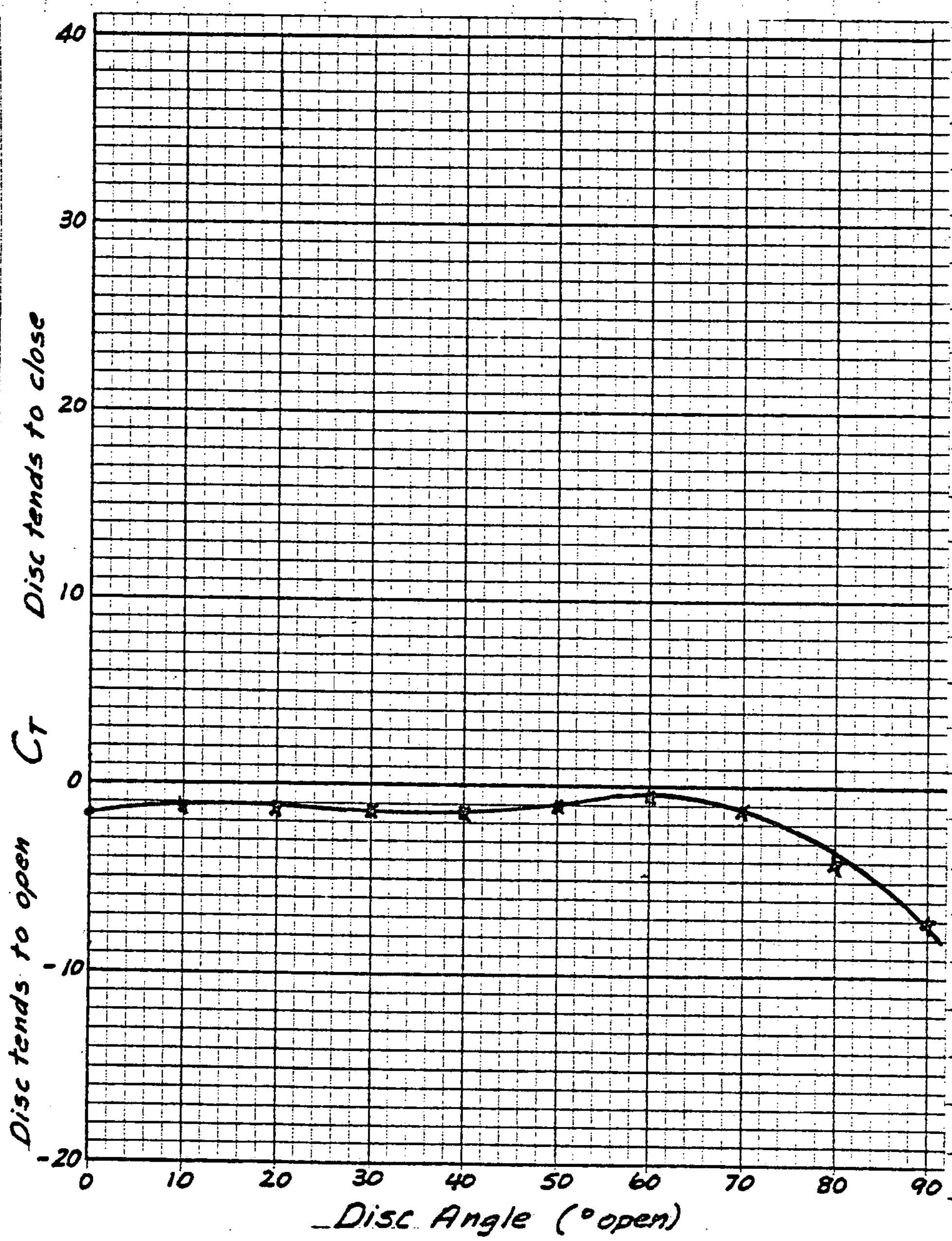
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 50 PSIG   Valve orientation ref. Figure 9

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER
Air Flow Tests NASA/Langley Research Center

DATE
Nov. & Dec. 1979

SUBJECT
Allis-Chalmers 6" Streamseal Butterfly Valve Model

PRELIM. FINAL

DRAWING NUMBER

LITHO IN U.S.A.—A-C

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ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 29

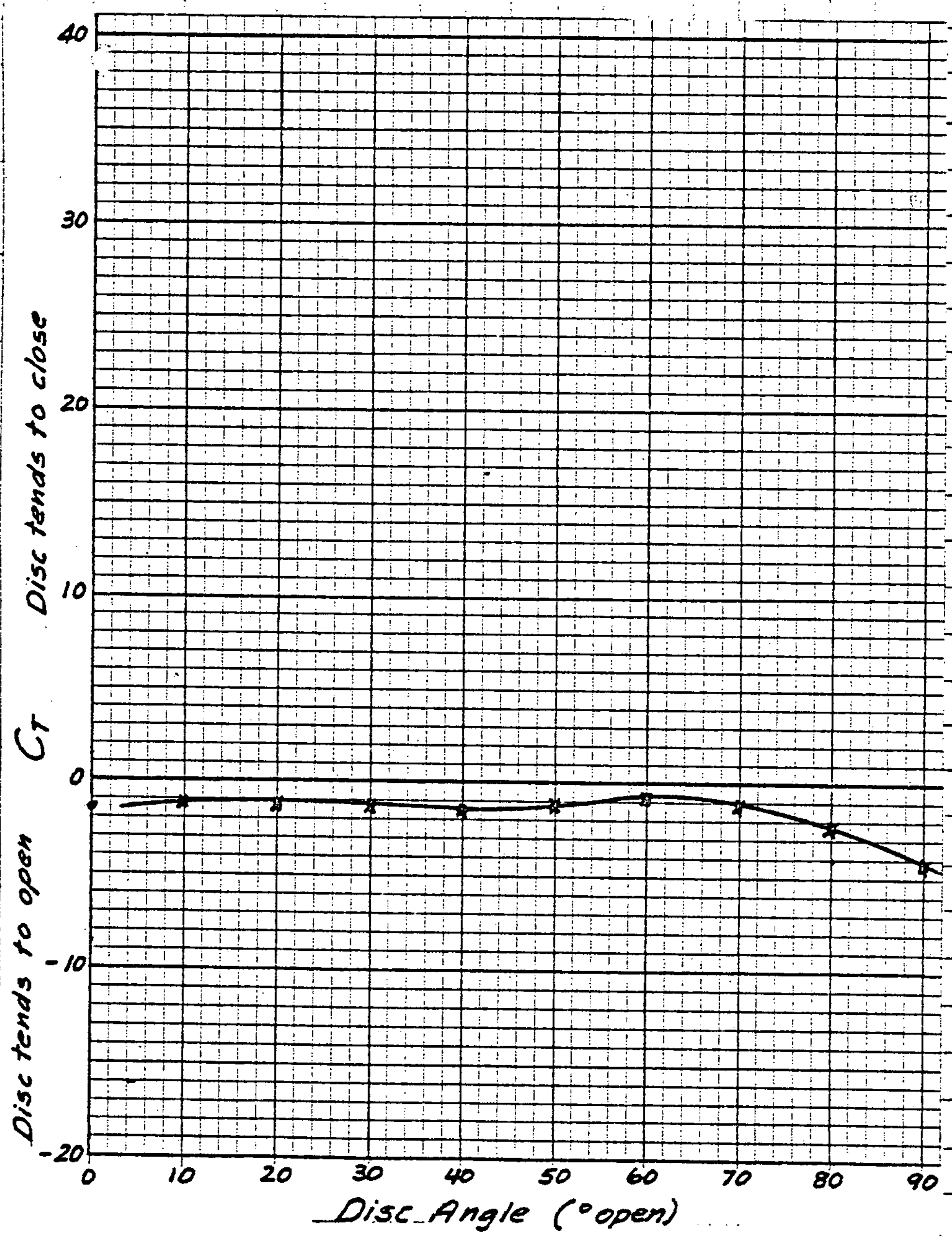
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 60 PSIG Valve orientation ref. Figure 9

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 29 50 PSIG

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	25	15	10	-8.88	-7.10	15.8
80	25	15	10	-5.14	-4.11	17.2
70	32.5	15	17.5	-2.81	-1.28	20.6
60	37.5	10	27.5	-2.25	-.65	25.3
50	42.5	7.5	35	-5.14	-1.17	28.6
40	45	2.5	42.5	-7.86	-1.48	30.7
30	46	2	44	-7.48	-1.36	32.8
20	47.5	1	46.5	-7.86	-1.35	33.3
10	48	1	47	-7.48	-1.27	34.0
0	49	0	49	-10.61	-1.73	34.7

Test 29 60 PSIG

90	30	15.5	14.5	7.87	-4.34	28.0
80	32.5	15.5	17	5.15	-2.42	28.6
70	40	15.5	24.5	3.93	-1.28	32.0
60	47.5	13.5	34	3.93	-.93	34.7
50	52	10	42	6.56	-1.25	40.1
40	55	5	50	9.82	-1.57	42.8
30	57	2.5	54.5	9.82	-1.44	44.1
20	58	2.5	55.5	9.82	-1.42	44.8
10	59	2	57	8.42	-1.18	45.5
0	60	0	60	11.79	-1.57	45.5

CUSTOMER: Air Flow Tests NASA/Langley Research Center
DATE: Nov. & Dec. 1979
SHEET 1 OF 6

SUBJECT: Allis-Chalmers 6" Streamseal Butterfly Valve Model

PRELIM. | FINAL

DRAWING NUMBER

LITHO IN U.S.A.-A-C

CALCULATED BY BHH

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS — FORM 6715-1

Test No. 30 ✓

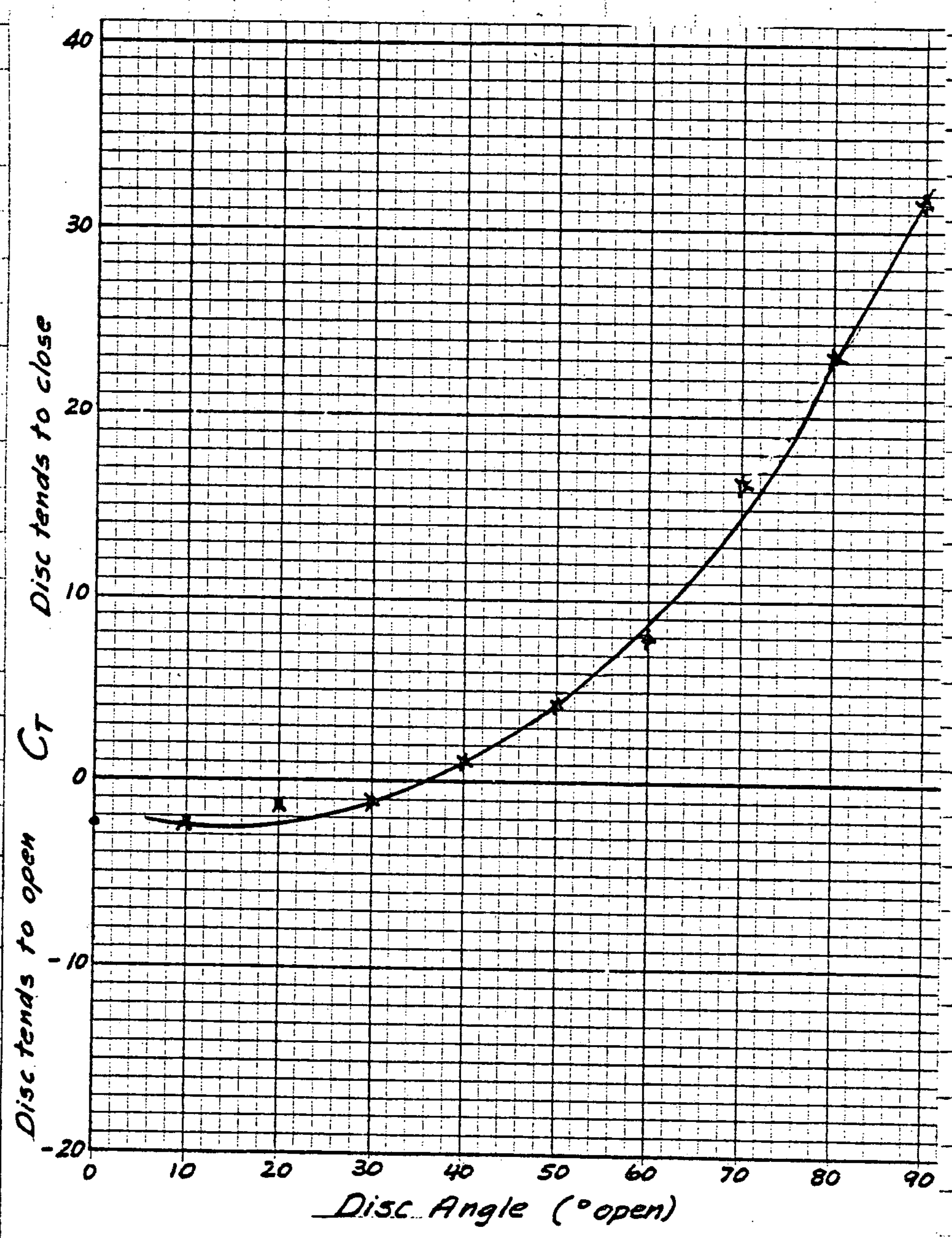
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 15 PSIG Valve orientation ref. Figure 11

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER Air Flow Tests NASA/Langley Research Center | DATE Nov. & Dec. 1979 | SHEET 2 OF 6

SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model | PRELIM. | FINAL

DRAWING NUMBER | LITHO IN U.S.A.-A-C | CALCULATED BY BHH

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 30

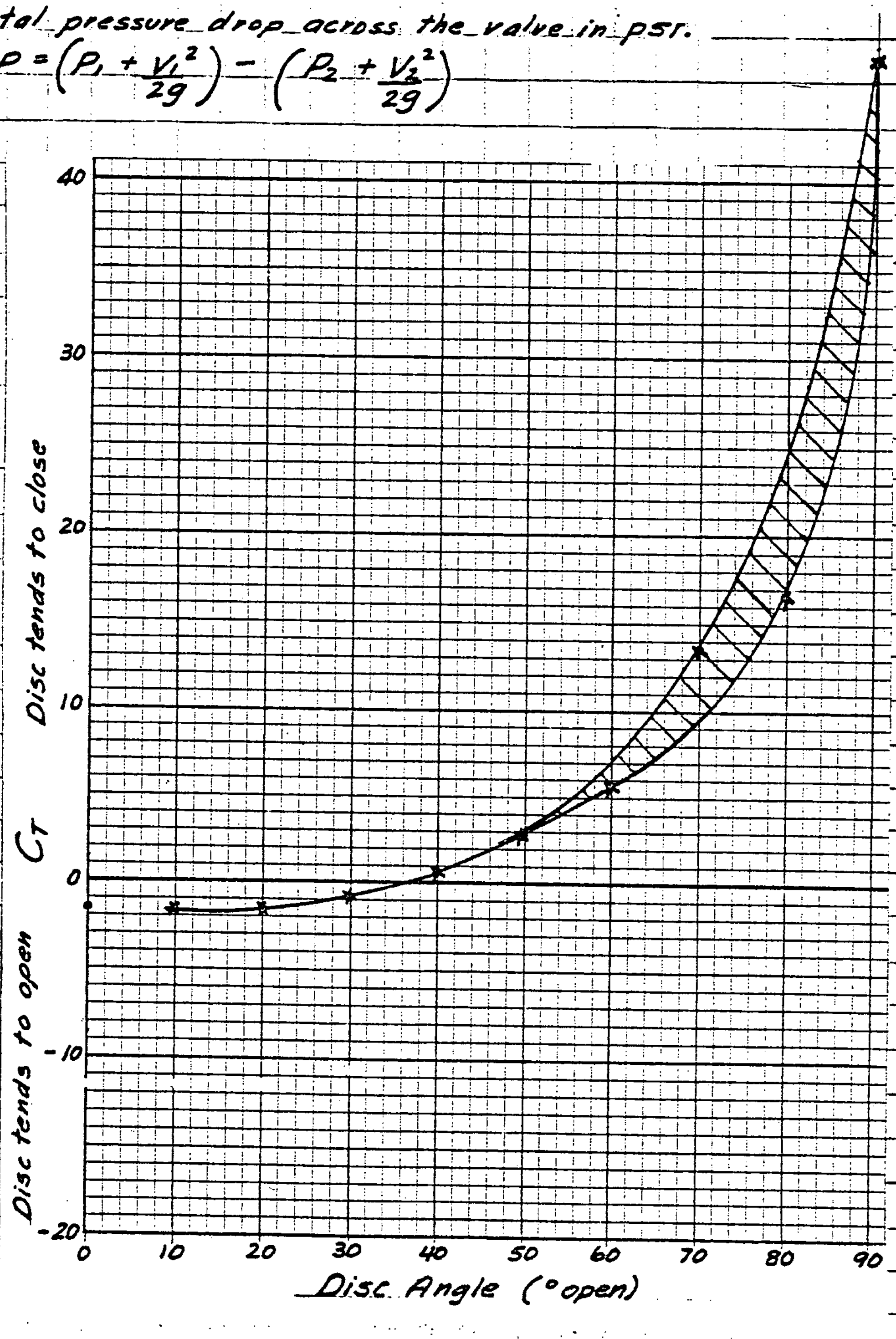
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 20PSIG   Valve orientation ref. Figure 11

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 30 ΔP_{T_1} = 15 PSI

°Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	4	2	2	7.9	31.6	5.1
80	5	2	3	8.7	23.2	5.1
70	6	1	5	10.2	16.3	6.4
60	9	1	8	7.9	7.9	8.4
50	10	1	9	4.7	4.2	10.5
40	11	0	11	1.6	1.2	11.8
30	12	0	12	-1.6	-1.1	12.5
20	12	0	12	-2.0	-1.3	13.2
10	12	0	12	-3.5	-2.3	13.8
0	12	0	12	-3.5	-2.3	13.8

Test 30 20 PSI

90	7	5	2	11.8	47.2	3.7
80	11	3	8	16.5	16.5	3.7
70	12	3	9	15.3	13.6	5.1
60	15	2	13	9.4	5.8	8.4
50	17	1	16	5.5	2.8	11.8
40	18	0	18	1.6	0.7	12.5
30	19	0	19	-2.0	-0.8	13.2
20	19	0	19	-3.5	-1.5	13.8
10	19	0	19	-3.9	-1.6	13.8
0	19	0	19	-3.9	-1.6	13.8

CUSTOMER	DATE	SHEET
Air Flow Tests NASA/Langley Research Center	Nov. & Dec. 1979	SHEET 3 OF 6

SUBJECT	PRELIM.	FINAL
Allis-Chalmers 6" Streamseal Butterfly Valve Model		

DRAWING NUMBER

LITHO IN U.S.A.—A-C

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ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 30

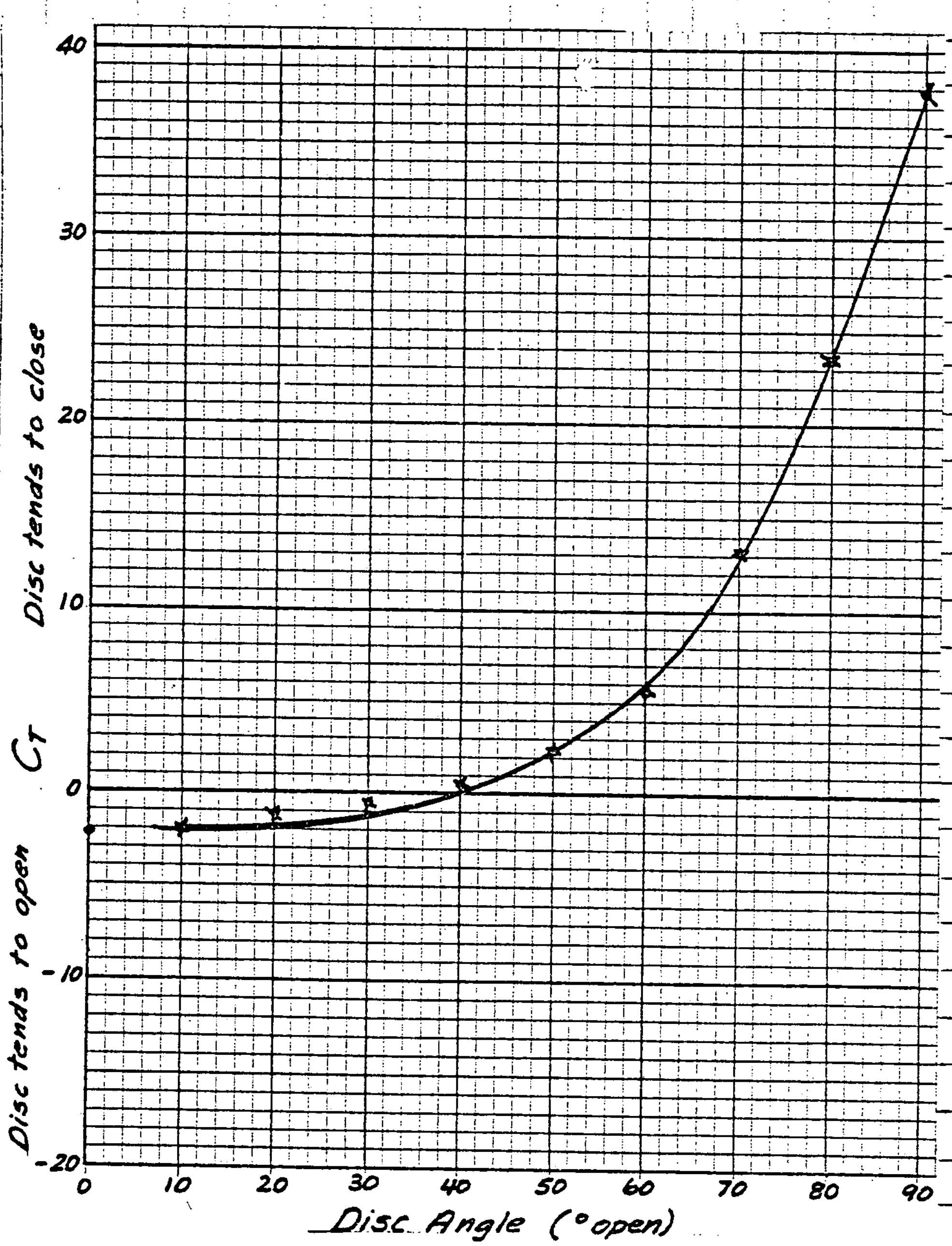
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 30 PSIG Valve orientation ref. Figure 11

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER	DATE	SHEET
Air Flow Tests NASA/Langley Research Center	Nov. & Dec. 1979	4 of 6

SUBJECT	PRELIM.	FINAL
Allis-Chalmers 6" Streamseal Butterfly Valve Model		

DRAWING NUMBER

LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY [illegible signature]

Test No. 30

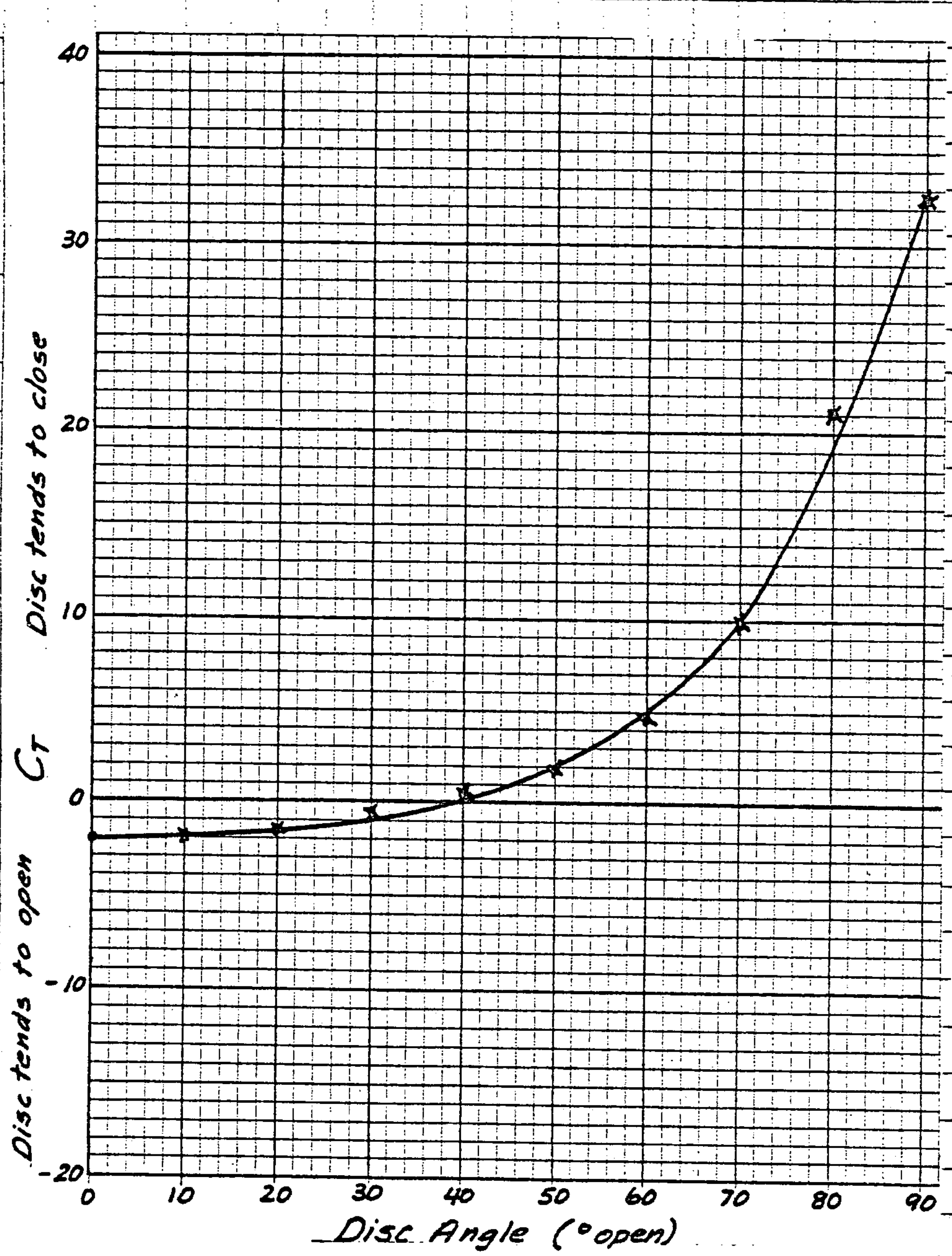
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 40 PSIG Valve orientation ref. Figure 11

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 30 30 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	12	8	4	18.9	37.8	5.1
80	14	6	8	23.6	23.6	7.1
70	18	6	12	19.7	13.1	9.8
60	22	5	17	11.8	5.6	13.2
50	25	3	22	6.3	2.3	16.5
40	27	2	25	1.6	0.5	18.4
30	28	0	28	-1.6	-0.5	19.2
20	29	0	29	-4.7	-1.3	19.9
10	29	0	29	-7.1	-2.0	20.6
0	29	0	29	-7.9	-2.2	20.6

Test 30 40 PSI

90	18	12	6	24.4	32.5	15.8
80	21	10	11	29.1	21.2	17.2
70	26	8	18	22.0	9.8	19.9
60	30	7	23	13.4	4.7	23.9
50	35	4	31	7.1	1.8	26.6
40	36	2	34	2.0	0.5	28.6
30	38	0	38	-2.4	-0.5	30.0
20	39	0	39	-7.1	-1.5	30.7
10	39	0	39	-9.4	-1.9	31.3
0	39	0	39	-9.8	-2.0	31.3

CUSTOMER	DATE	SHEET
Air Flow Tests NASA/Langley Research Center	Nov. & Dec. 1979	5 of 6

SUBJECT: Allis-Chalmers 6" Streamseal Butterfly Valve Model — PRELIM. — FINAL

DRAWING NUMBER — LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS — FORM 6715-1

CALCULATED BY: BHY

Test No. 30

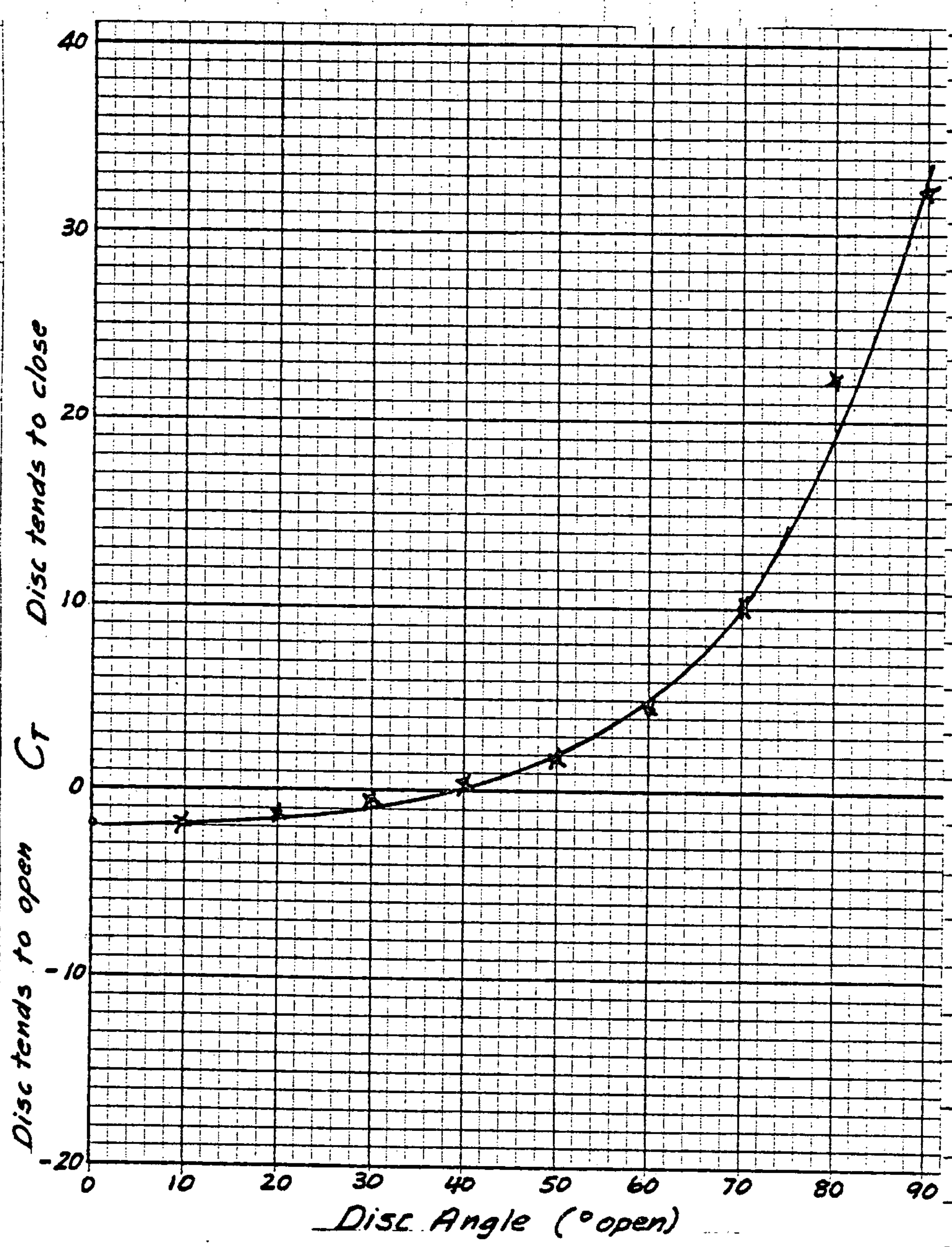
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 50 PSIG   Valve orientation ref. Figure 11

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER	DATE	SHEET
Air Flow Tests NASA/Langley Research Center	Nov. & Dec. 1979	6 of 6

SUBJECT	PRELIM.	FINAL
Allis-Chalmers 6" Streamseal Butterfly Valve Model		

DRAWING NUMBER

LITHO IN U.S.A.–A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY BHG

Test No. 30

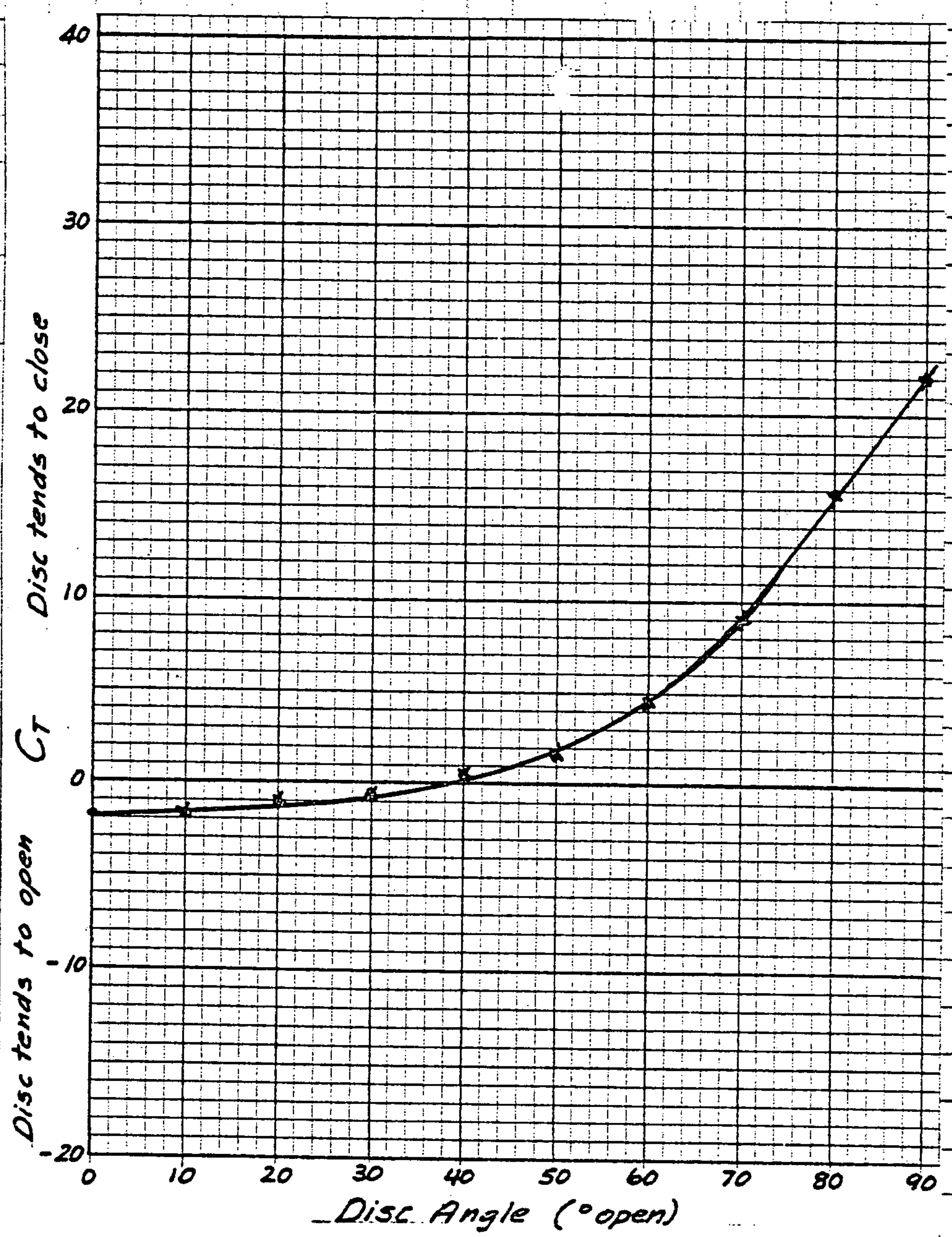
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 60PSIG Valve orientation ref. Figure 11

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 30 50 PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	24	17	7	28.3	32.3	25.3
80	26	14	12	33.4	22.3	25.3
70	34	13	21	26.8	10.2	31.3
60	39	11	28	15.7	4.5	35.4
50	43	7	36	7.9	1.8	38.7
40	45	3	42	2.4	0.5	40.1
30	46	1	45	-2.4	-0.4	41.4
20	47	0	47	-7.9	-1.3	42.1
10	47	0	47	-11.4	-1.9	42.1
0	47	0	47	-11.4	-1.9	42.8

Test 30 60 PSI

90	28	18	10	27.5	22.0	34.7
80	32	15	17	33.8	15.9	36.0
70	40	14	26	29.5	9.1	38.7
60	46	13	33	18.1	4.4	42.8
50	51	8	43	9.8	1.8	45.5
40	54	4	50	3.1	0.5	47.5
30	55	2	53	-3.1	-0.5	48.8
20	56	0	56	-7.9	-1.1	50.2
10	56	0	56	-11.8	-1.7	50.8
0	55	0	55	-11.8	-1.7	50.8

Test 31 P_{T_1} = 20 PSI

° Open	P_1	*P_2	ΔP	T_D	C_T	Temp °F
90	7	5	2	11.0	44.0	5.8
80	10	3	7	17.3	19.8	7.1
70	13	3	10	16.5	13.2	8.4
60	15	2	13	11.0	6.8	11.8
50	17	1	16	6.3	3.2	13.8
40	18	0	18	3.1	1.4	15.2
30	19	0	19	-1.6	-0.7	17.2
20	19	0	19	-3.9	-1.6	18.5
10	19	0	19	-4.7	-2.0	18.5
0	19	0	19	-5.9	-2.5	18.5

Test 31 ΔP_{T_1} = 15 PSI

90	5	2	3	7.9	21.1	9.1
80	5	2	3	9.4	25.1	8.4
70	7	1	6	11.8	15.7	9.8
60	9	1	8	8.7	8.7	11.1
50	10	1	9	5.5	4.9	11.8
40	11	0	11	2.4	1.7	13.2
30	12	0	12	-0.8	-0.5	13.8
20	12	0	12	-2.4	-1.6	14.5
10	12	0	12	-3.1	-2.1	15.2
0	12	0	12	-3.5	-2.3	15.8

CUSTOMER	DATE	SHEET
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SUBJECT	PRELIM.	FINAL
Allis-Chalmers 6" Streamseal Butterfly Valve Model		

DRAWING NUMBER

LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY [illegible]

Test No. 31 ✓

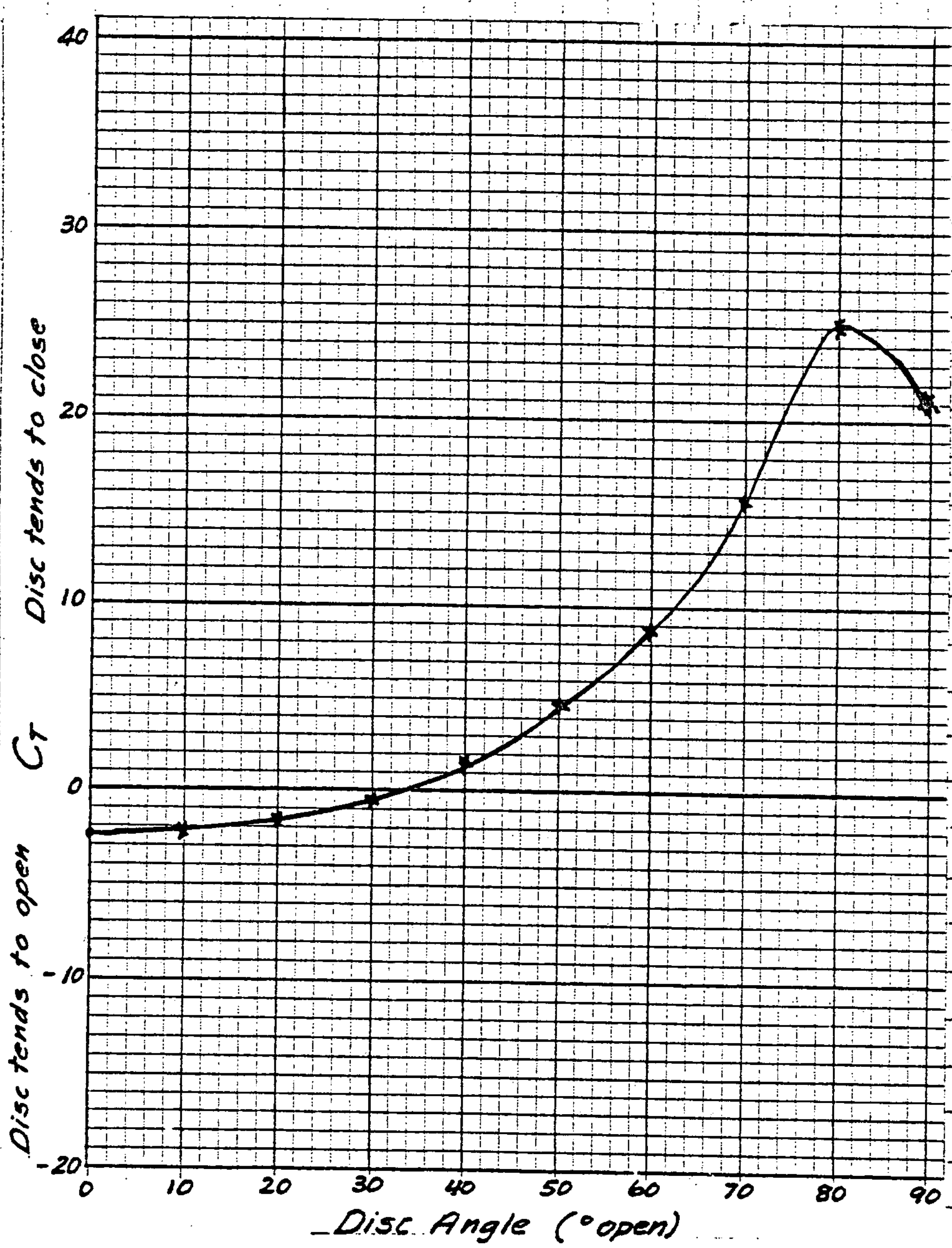
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 15 PSIG Valve orientation ref. Figure 12

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER
Air Flow Tests NASA/Langley Research Center

DATE
Nov. & Dec. 1979

SHEET 2 OF 6

SUBJECT
Allis-Chalmers 6" Streamseal Butterfly Valve Model

PRELIM. | FINAL

DRAWING NUMBER

LITHO IN U.S.A.—A-C

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ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 31

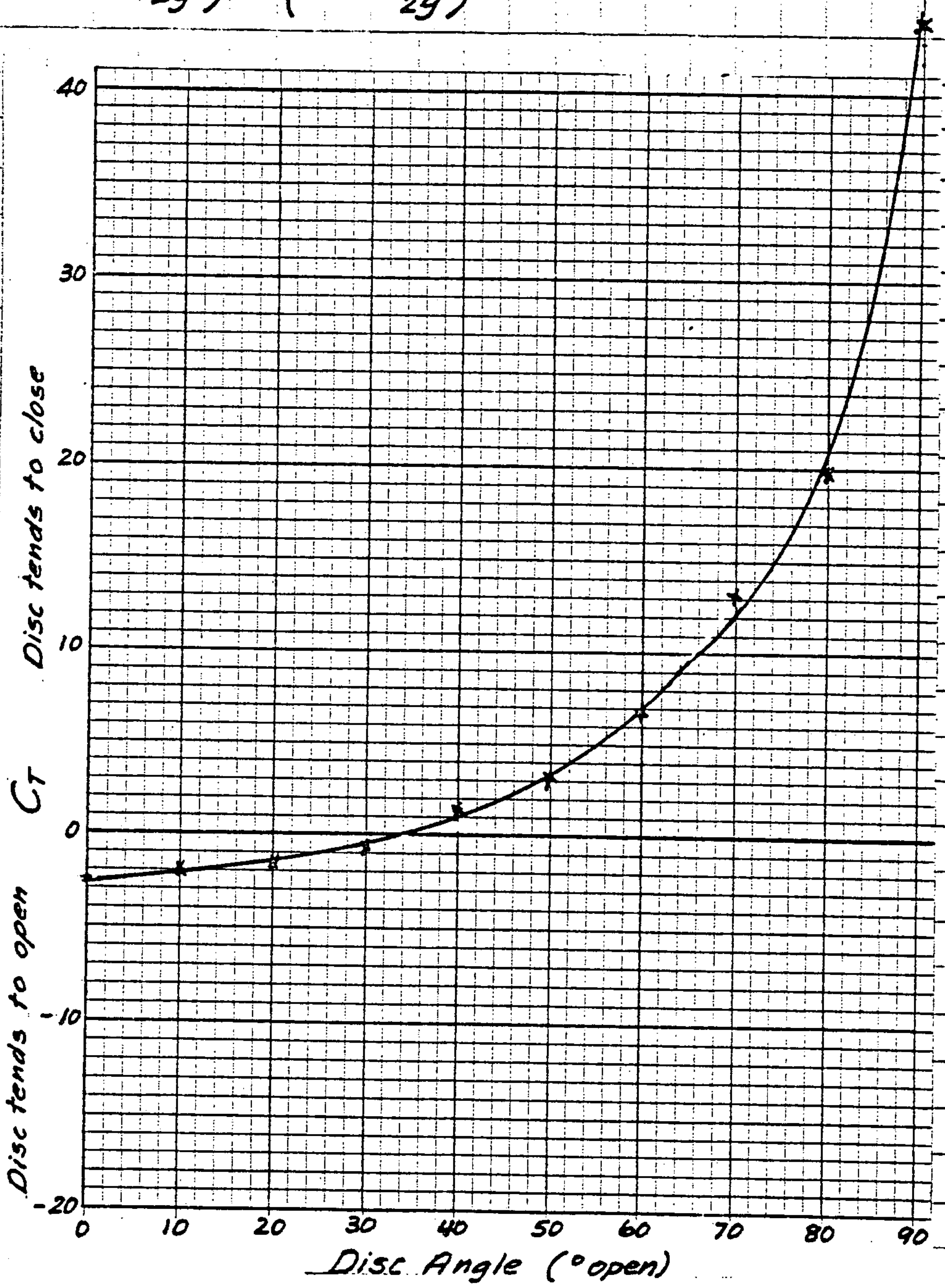
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 20PSIG Valve orientation ref. Figure 12

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER Air Flow Tests NASA/Langley Research Center | DATE Nov. & Dec. 1979 | SHEET 3 OF 6

SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model | PRELIM. | FINAL

DRAWING NUMBER | LITHO IN U.S.A.—A-C | CALCULATED BY [signature]

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 31

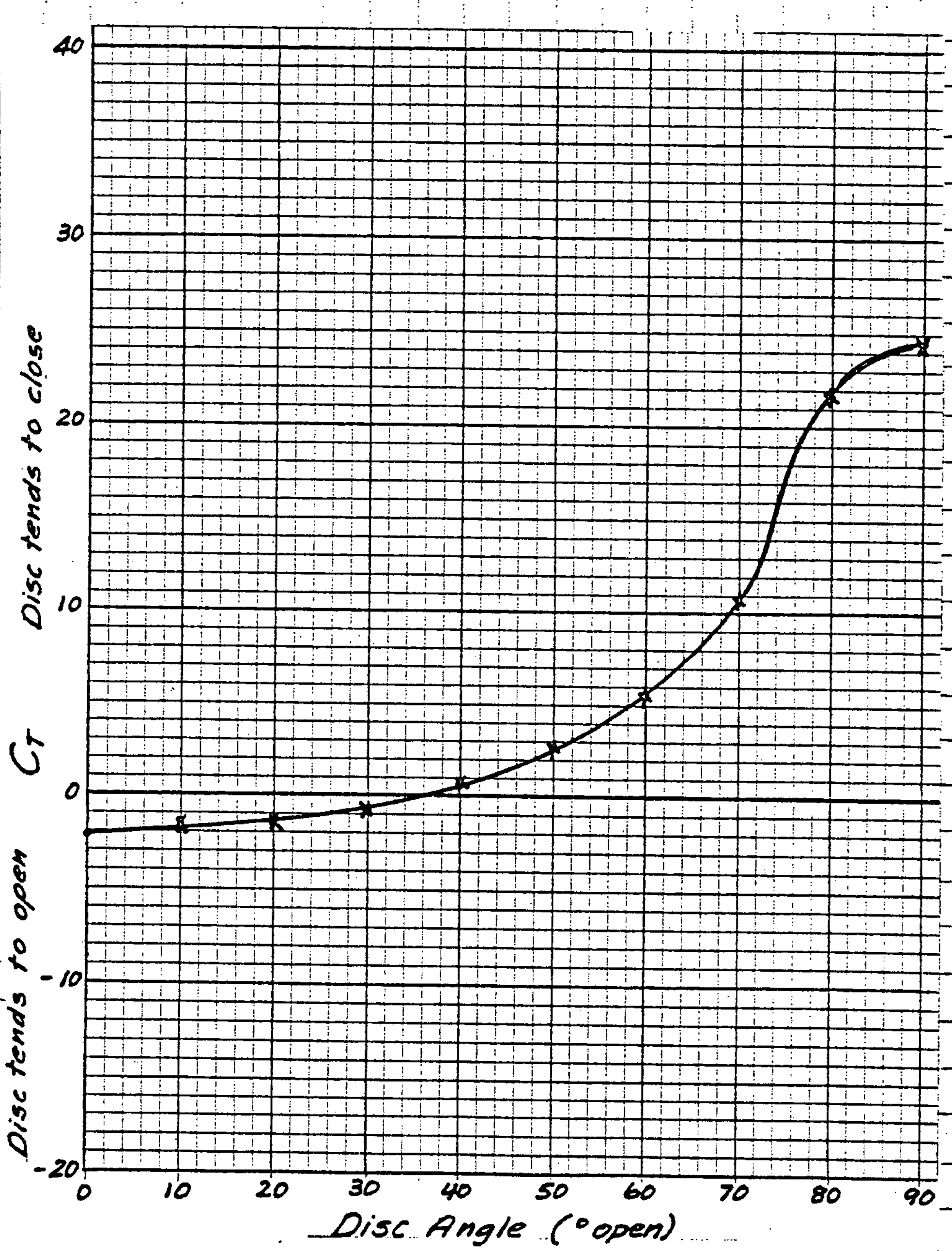
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 30 PSIG Valve orientation ref. Figure 12

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER Air Flow Tests NASA/Langley Research Center

DATE Nov. & Dec. 1979

SHEET 4 OF 6

SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model

PRELIM. FINAL

DRAWING NUMBER

LITHO IN U.S.A.—A-C

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ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 31

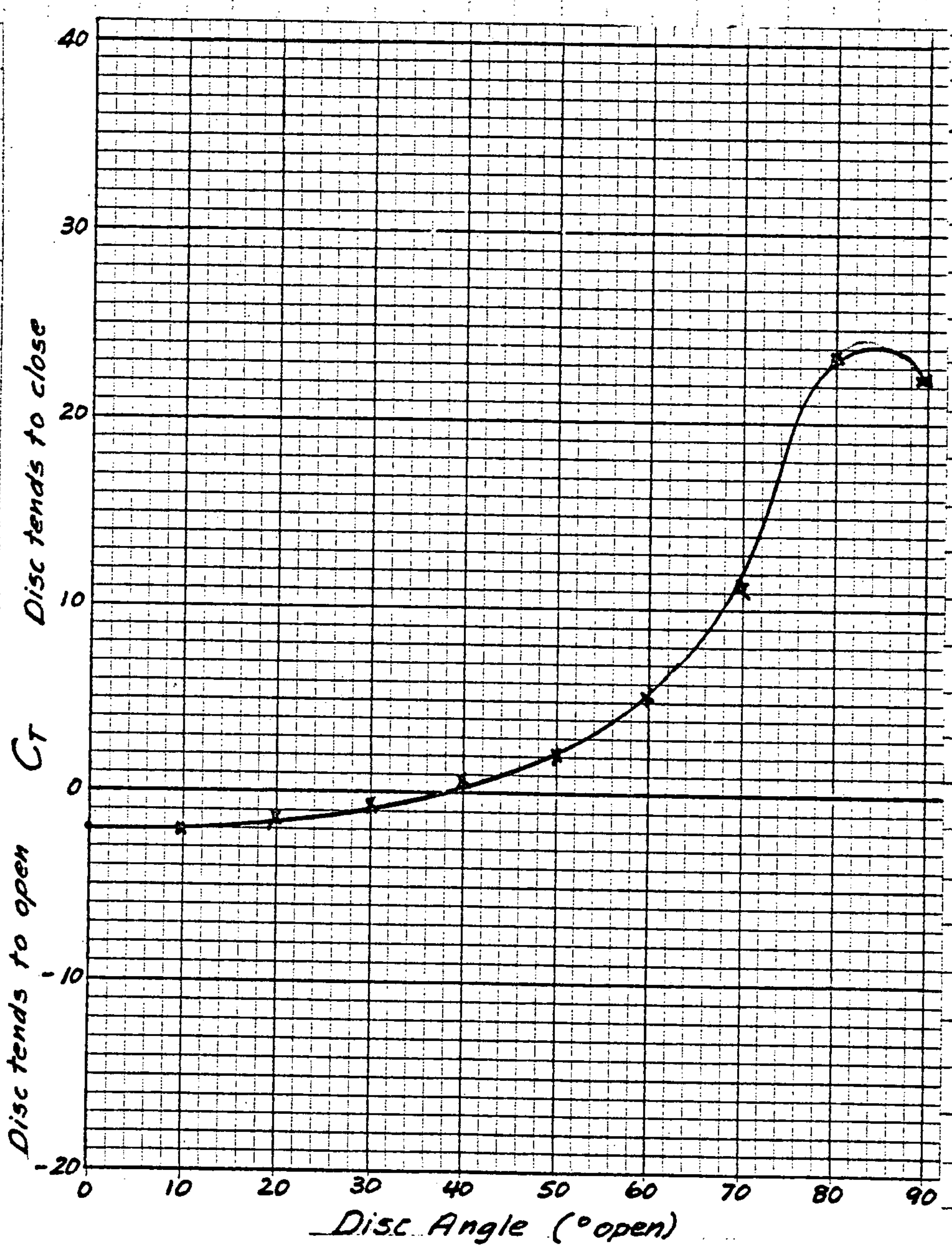
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 40 PSIG Valve orientation ref. Figure - 12

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 31 $\Delta P_{T_1} = 40$ PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	19	12	7	19.7	22.5	16.5
80	21	11	10	29.5	23.6	18.5
70	29	10	19	26.8	11.3	21.9
60	32	7	25	16.5	5.3	25.3
50	35	4	31	8.7	2.2	28.6
40	37	2	35	3.1	0.7	31.3
30	39	0	39	-2.4	-0.5	32.7
20	40	0	40	-6.3	-1.3	33.3
10	40	0	40	-9.8	-2.0	33.3
0	40	0	40	-9.8	-2.0	33.3

Test 31 $\Delta P_{T_1} = 30$ PSI

90	13	8	5	15.3	24.5	9.8
80	15	6	9	15.3	24.5	9.8
70	20	6	14	20.5	11.7	13.8
60	24	5	19	13.4	5.6	17.2
50	26	3	23	7.9	2.7	18.5
40	28	2	26	2.4	0.7	21.2
30	29	0	29	-3.1	-0.9	22.6
20	29	0	29	-5.5	-1.5	23.9
10	29	0	29	-5.9	-1.6	25.3
0	29	0	29	-7.9	-2.2	25.3

CUSTOMER Air Flow Tests NASA/Langley Research Center | DATE Nov. & Dec. 1979 | SHEET 5 OF 6

SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model | PRELIM. | FINAL

DRAWING NUMBER | LITHO IN U.S.A.—A-C | CALCULATED BY BHH

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 31

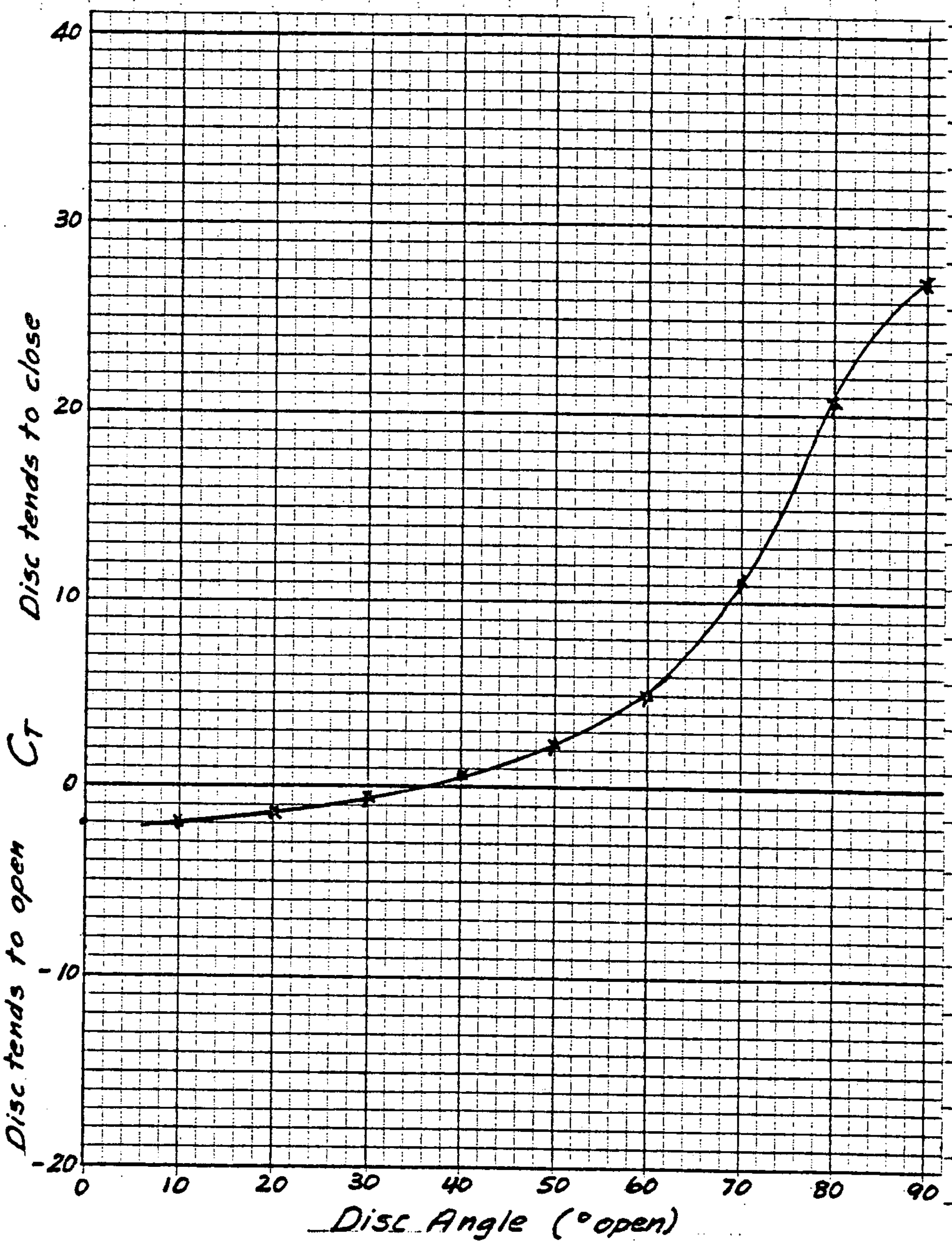
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 50 PSIG   Valve orientation ref. Figure 12

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER Air Flow Tests NASA/Langley Research Center | DATE Nov. & Dec. 1979 | SHEET 6 OF 6

SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model | PRELIM. | FINAL

DRAWING NUMBER | LITHO IN U.S.A.—A-C | CALCULATED BY BHH.

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS | FORM 6715-1

Test No. 31

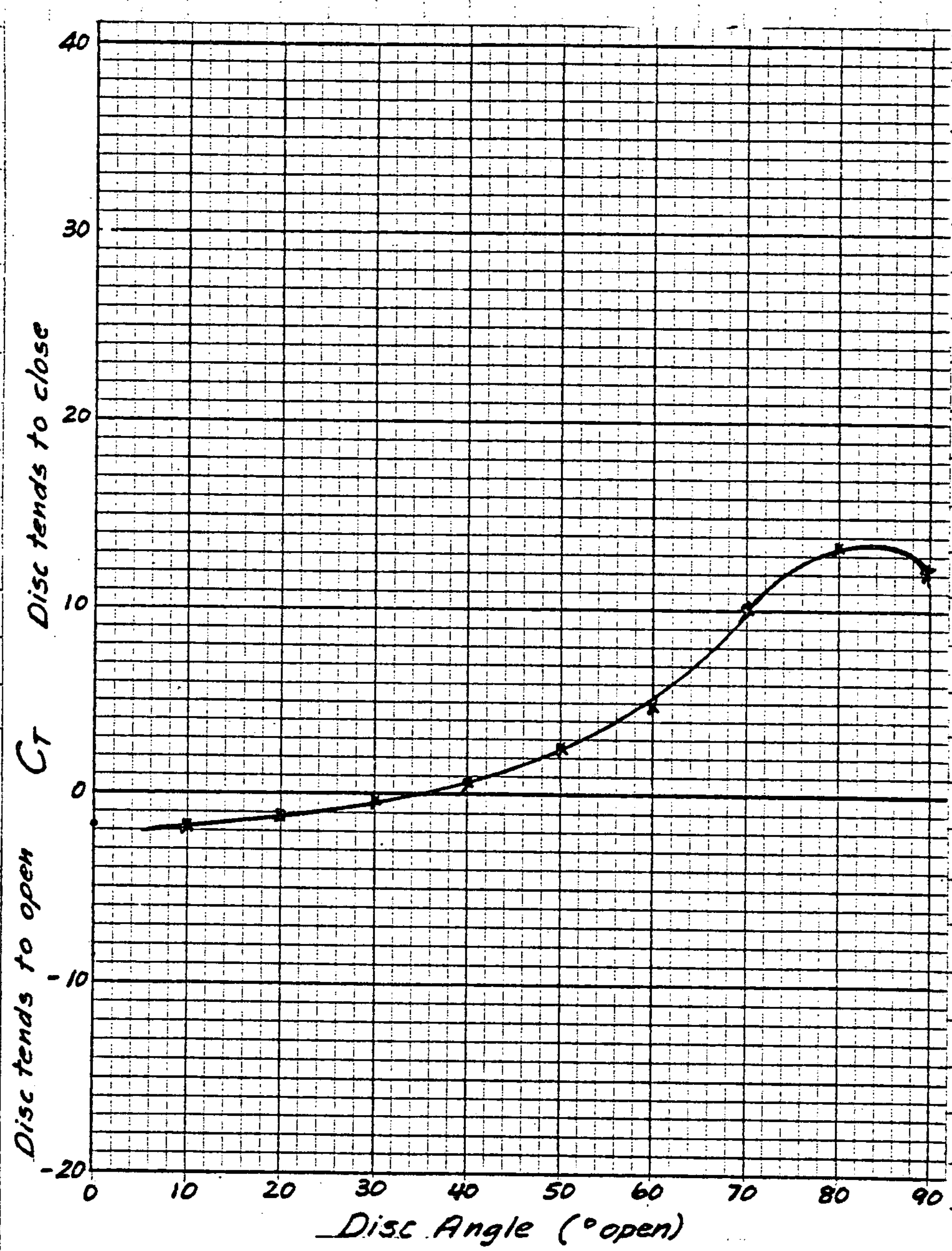
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 60 PSIG   Valve orientation ref. Figure 12

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 31 $\Delta P_{T_1} = 60$ PSI

° Open	P_1	P_2	ΔP	T_D	C_T	Temp °F
90	31	17	14	21.6	12.3	38.1
80	37	17	20	33.4	13.4	38.7
70	41	16	25	31.5	10.1	40.1
60	47	12	35	21.6	4.9	44.1
50	51	8	43	13.8	2.6	47.5
40	55	4	51	4.7	0.7	50.2
30	56	2	54	-2.0	-0.3	51.5
20	57	0	57	-7.9	-1.1	52.2
10	57	0	57	-11.8	-1.7	52.2
0	57	0	57	-11.8	-1.7	52.2

Test 31 $\Delta P_{T_1} = 50$ PSI

90	24	17	7	23.6	27.0	29.3
80	27	14	13	33.4	20.6	30.0
70	34	13	21	29.5	11.2	34.0
60	40	10	30	18.9	5.0	38.7
50	44	6	38	11.0	2.3	40.7
40	45	3	42	3.9	0.7	42.1
30	47	1	46	-2.4	-0.4	44.8
20	48	0	48	-7.9	-1.3	45.5
10	48	0	48	-11.8	-2.0	45.5
0	48	0	48	-11.8	-2.0	45.5

CUSTOMER Air Flow Tests NASA/Langley Research Center | DATE Nov. & Dec. 1979 | SHEET 1 OF 6

SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model | PRELIM. | FINAL

DRAWING NUMBER | LITHO IN U.S.A.—A-C | CALCULATED BY [illegible]

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS | FORM 6715-1

Test No. 32 ✓

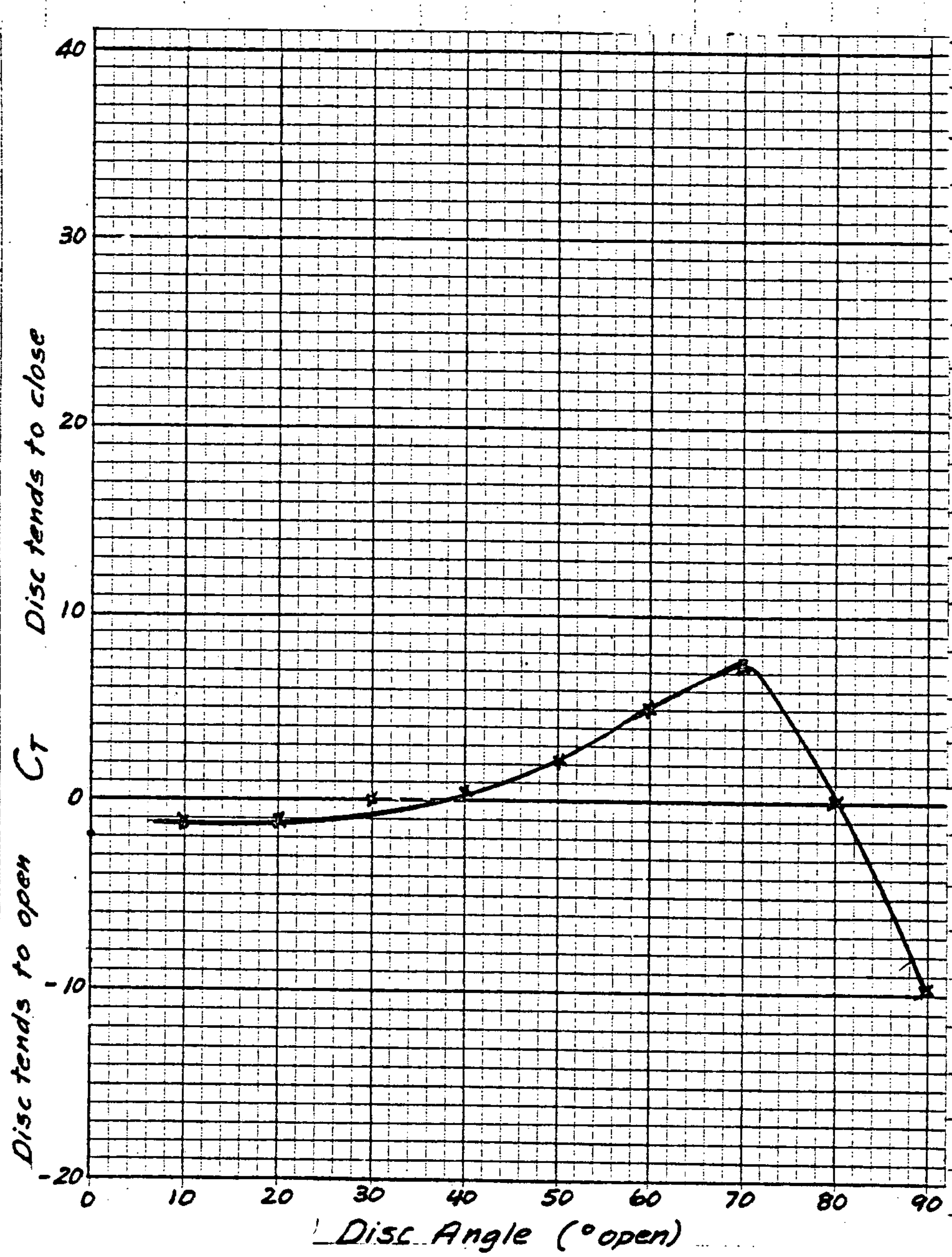
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 15PSIG Valve orientation ref. Figure 10

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER Air Flow Tests NASA/Langley Research Center | DATE Nov. & Dec. 1979 | SHEET 2 OF 6

SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model | PRELIM. | FINAL

DRAWING NUMBER | LITHO IN U.S.A.—A-C | CALCULATED BY GHH.

ENGINEERING CALCULATION SHEET

Test No. 32

ALLIS-CHALMERS FORM 6715-1

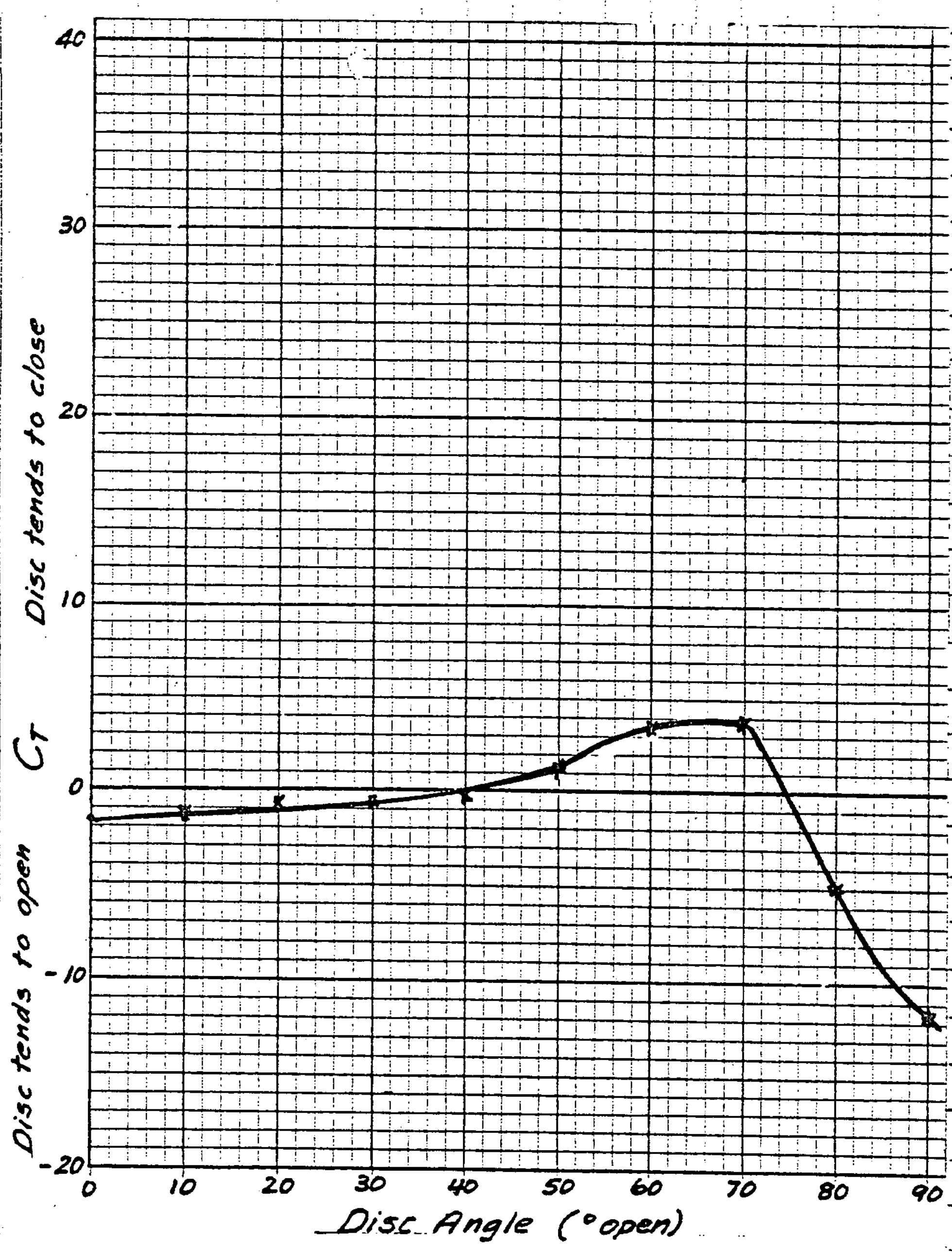
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 20 PSIG Valve orientation ref. Figure 10

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 32 $P_{T_1} = 20$ PSI

° Open	P_1	$*P_2$	ΔP	T_D	C_T	Temp °F
90	7	3	4	-5.9	-11.8	58.9
80	8	3	5	-3.1	-5.0	58.9
70	11	3	8	3.9	3.9	56.2
60	14	3	11	4.7	3.4	52.9
50	17	2	15	2.0	1.1	50.8
40	18	1	17	-0.8	-0.4	49.5
30	18	1	17	-1.2	-0.6	48.8
20	19	0	19	-1.6	-0.7	47.5
10	19	0	19	-3.1	-1.3	46.1
0	19	0	19	-3.9	-1.6	45.5

Test 32 $P_{T_1} = 15$ PSI

° Open	P_1	$*P_2$	ΔP	T_D	C_T	Temp °F
90	5	3	2	-2.4	-9.6	56.2
80	5	2	3	0	0	56.2
70	7	2	5	4.7	7.5	55.6
60	8	2	6	3.9	5.2	52.9
50	10	1	9	2.4	2.1	52.2
40	12	1	11	0.8	0.6	50.2
30	12	0	12	0	0	49.5
20	13	0	13	-1.6	-1.0	48.8
10	13	0	13	-2.0	-1.2	48.8
0	13	0	13	-3.1	-1.9	48.8

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CUSTOMER Air Flow Tests NASA/Langley Research Center | DATE Nov. & Dec. 1979 | SHEET 3 OF 6

SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model | PRELIM. | FINAL

DRAWING NUMBER | LITHO IN U.S.A.—A-C | CALCULATED BY BHH

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 32

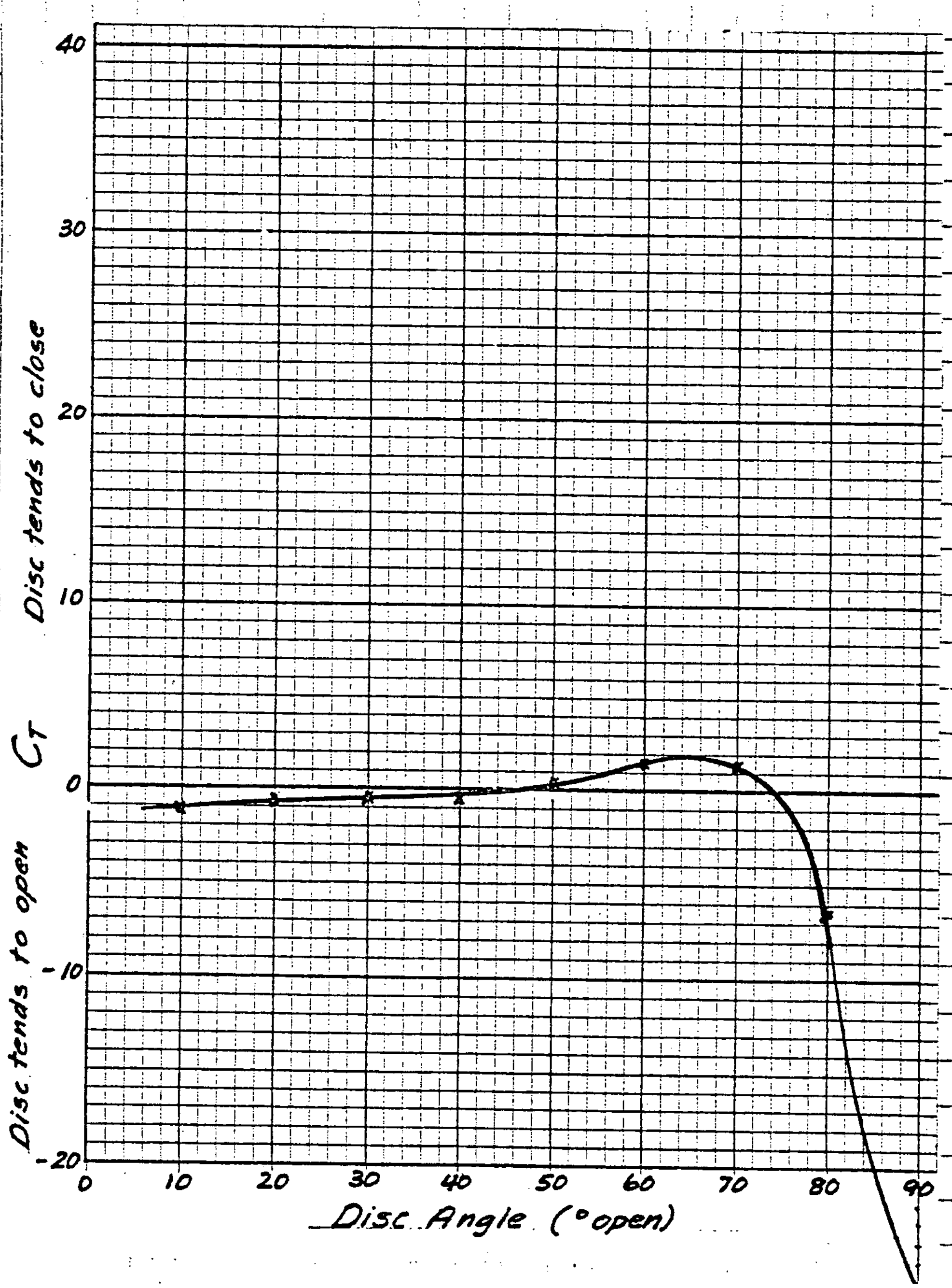
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 30 PSIG   Valve orientation ref. Figure 10.

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER Air Flow Tests NASA/Langley Research Center | DATE Nov. & Dec. 1979 | SHEET 4 OF 6

SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model | PRELIM. | FINAL

DRAWING NUMBER | LITHO IN U.S.A.—A-C | CALCULATED BY BHG

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 32

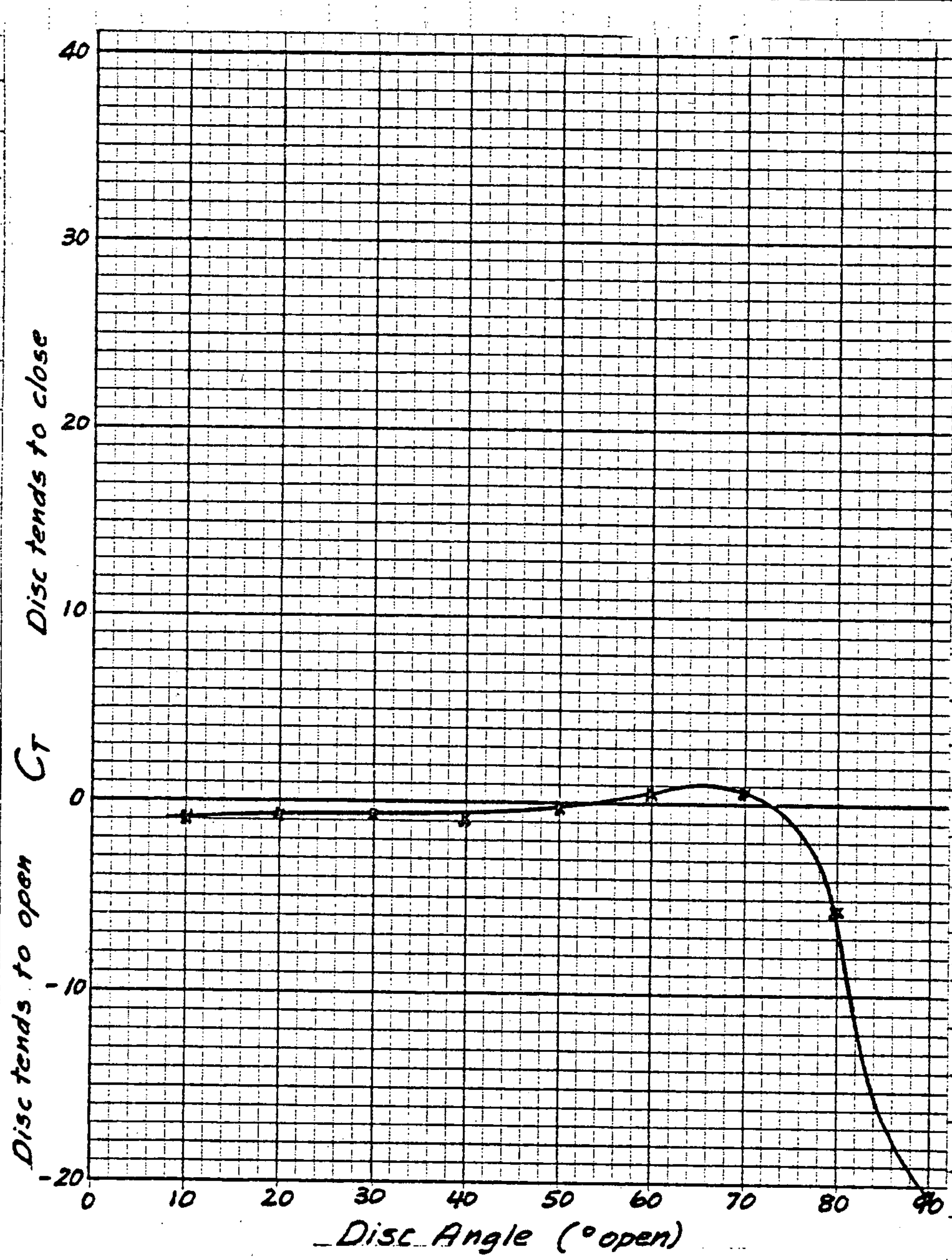
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 40PSIG Valve orientation ref. Figure 10

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 32 P_{T_1} = 40 PSIG

DA	P_{T_5}	P_{T_6}	ΔP	T_D	C_T	Temp °F
90	18	12	6	-15.7	-21	48.8
80	21	11	10	- 6.9	5.5	46.8
70	26	7	19	1.2	.51	45.5
60	33	5	28	2	.57	40.1
50	35	2	33	- .8	-.195	37.4
40	37	1	36	- 4.03	-.9	34.7
30	38	0	38	- 2.8	-.59	33.3
20	38	0	38	- 4.03	-.85	32.7
10	38.5	0	38.5	- 4.8	-1.0	0

Test 32 P_{T_1} = 30 PSIG

90	12	8.5	3.5	-11.7	-26.7	56.2
80	14	8	6	- 4.8	-6.4	25.6
70	18	7	11	2	1.5	52.2
60	22	5	17	3.2	1.5	48.8
50	26	2	24	.8	.27	46.1
40	27	1	26	-1.6	-.5	45.5
30	28	0	28	-1.2	-.34	43.4
20	28	0	28	-2.4	-.69	42.8
10	28.5	0	28.5	-4.03	-1.13	42.8

CUSTOMER Air Flow Tests NASA/Langley Research Center | DATE Nov. & Dec. 1979 | SHEET 5 OF 6

SUBJECT Allis-Chalmers 6" Streamseal Butterfly Valve Model | PRELIM. | FINAL

DRAWING NUMBER | LITHO IN U.S.A.—A-C | CALCULATED BY BHH

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

Test No. 32

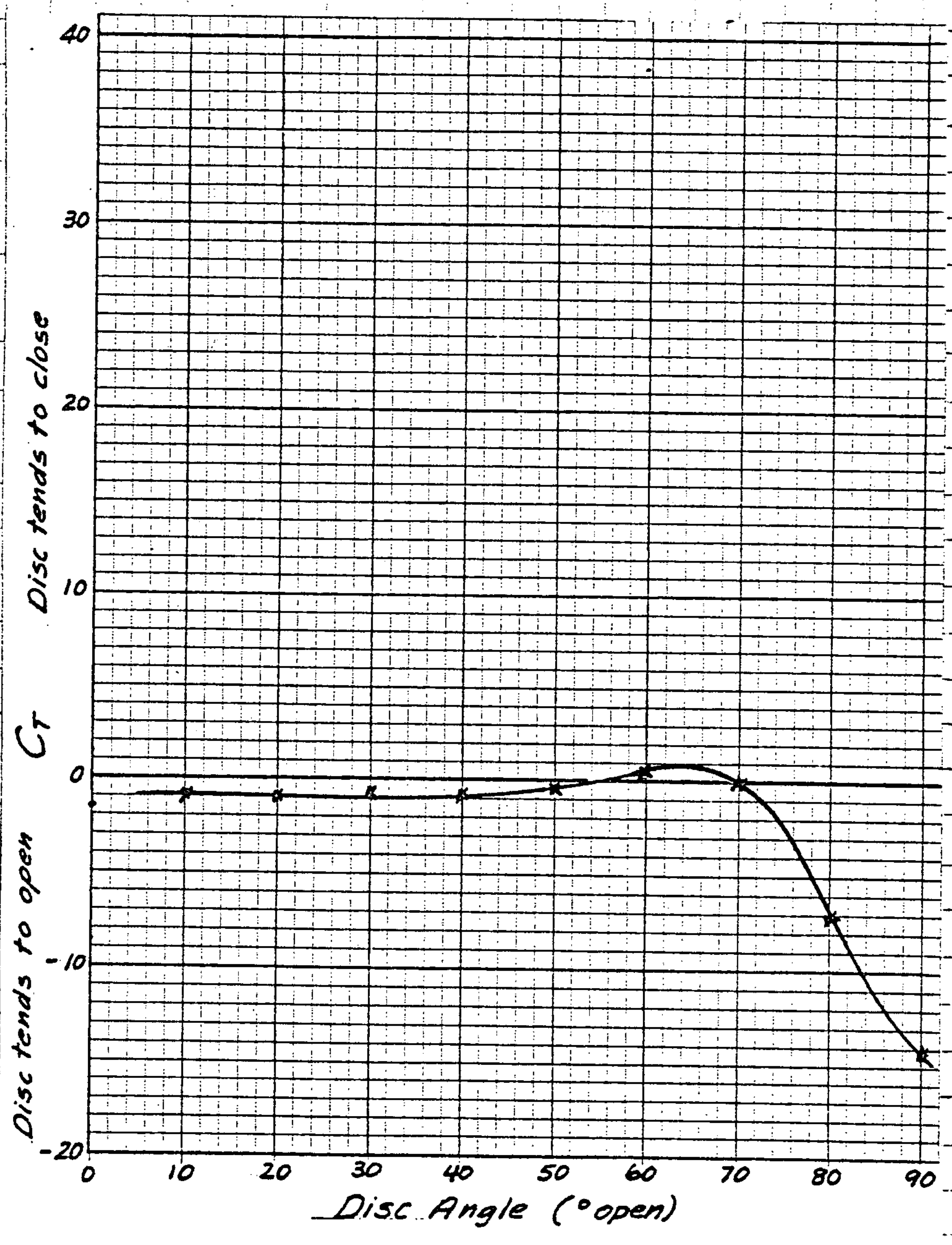
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 50 PSIG Valve orientation ref. Figure 10

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



CUSTOMER	DATE	SHEET
Air Flow Tests NASA/Langley Research Center	Nov. & Dec. 1979	6 OF 6

SUBJECT	PRELIM.	FINAL
Allis-Chalmers 6" Streamseal Butterfly Valve Model		

DRAWING NUMBER

LITHO IN U.S.A.—A-C

ENGINEERING CALCULATION SHEET

ALLIS-CHALMERS FORM 6715-1

CALCULATED BY [illegible]

Test No. 32

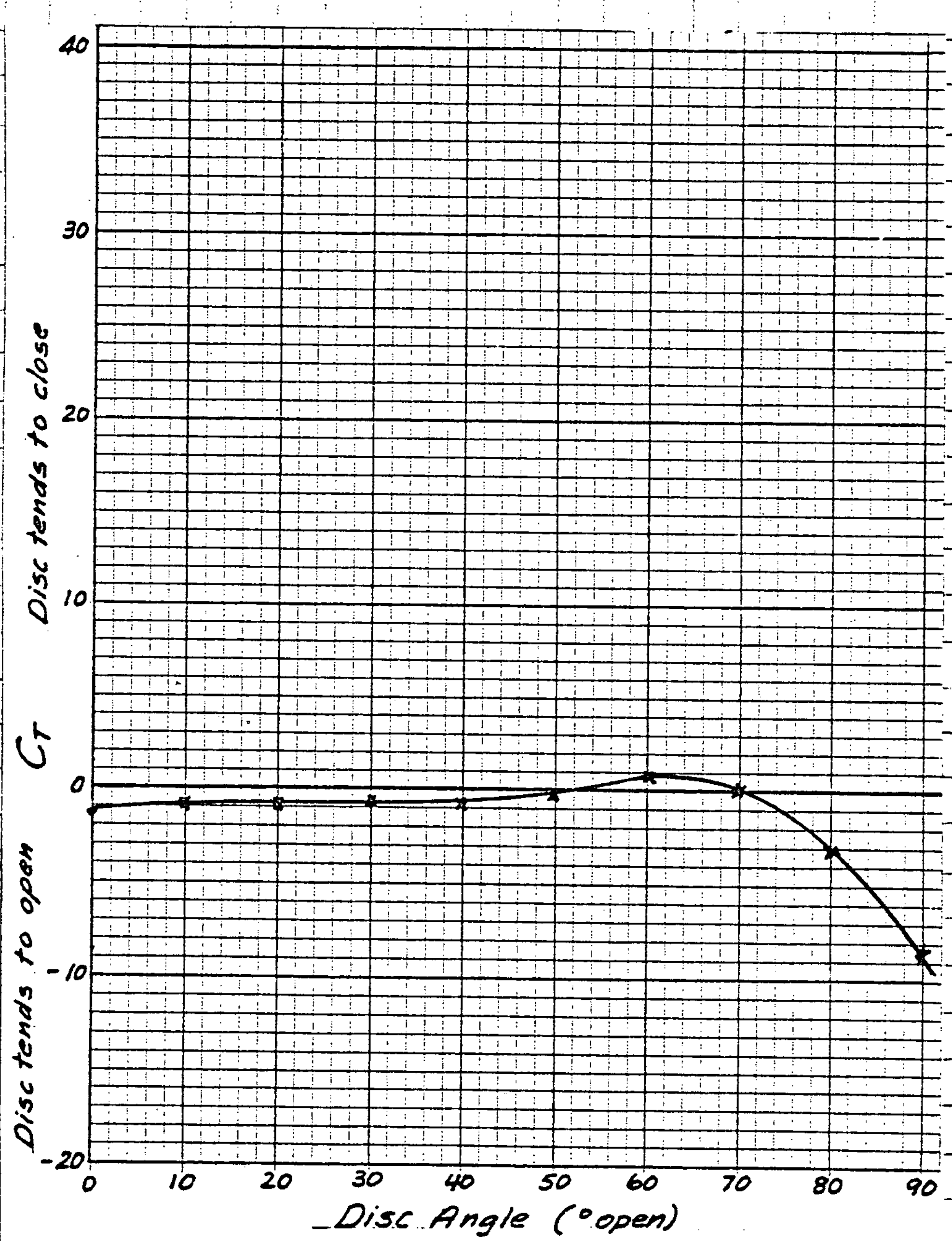
Valve disc thickness to diameter ratio: .17

Initial upstream pressure: 60 PSIG Valve orientation ref. Figure 10

Torque equation and coefficient: $T_d = C_T \times D^3 \times \Delta P$

where T_d is the dynamic torque in foot-pounds, C_T is the torque coefficient, D is the valve diameter in feet and ΔP is the total pressure drop across the valve in psi.

$$\Delta P = \left(P_1 + \frac{V_1^2}{2g}\right) - \left(P_2 + \frac{V_2^2}{2g}\right)$$



Test 32 P_{T_1} = 60 PSI

° Open	P_1	$*P_2$	ΔP	T_D	C_T	Temp °F
90	31	16	15	-15.7	-8.4	33.3
80	34	16	18	- 7.1	-3.2	34.7
70	40	17	23	0	0	36.7
60	45	13	32	3.1	0.8	38.7
50	51	8	43	-1.6	-0.3	44.8
40	54	5	49	-4.7	-0.8	45.5
30	55	3	52	-3.9	-0.6	45.5
20	55	2	53	-5.9	-0.9	46.1
10	56	1	55	-5.9	-0.9	47.5
0	56	0	56	-9.4	-1.3	48.2

Test 32 P_{T_1} = 50 PSI

° Open	P_1	$*P_2$	ΔP	T_D	C_T	Temp °F
90	24	14	10	-17.7	-14.1	25.3
80	25	14	11	-9.8	-7.1	26.6
70	35	13	22	0	0	33.3
60	39	11	28	2.0	0.6	35.4
50	43	7	36	-1.6	-0.4	38.7
40	45	3	42	-4.3	-0.8	40.1
30	46	2	44	-3.9	-0.7	41.4
20	46	2	44	-4.7	-0.9	42.1
10	47	1	46	-4.7	-0.8	42.1
0	47	0	47	-9.4	-1.6	42.8

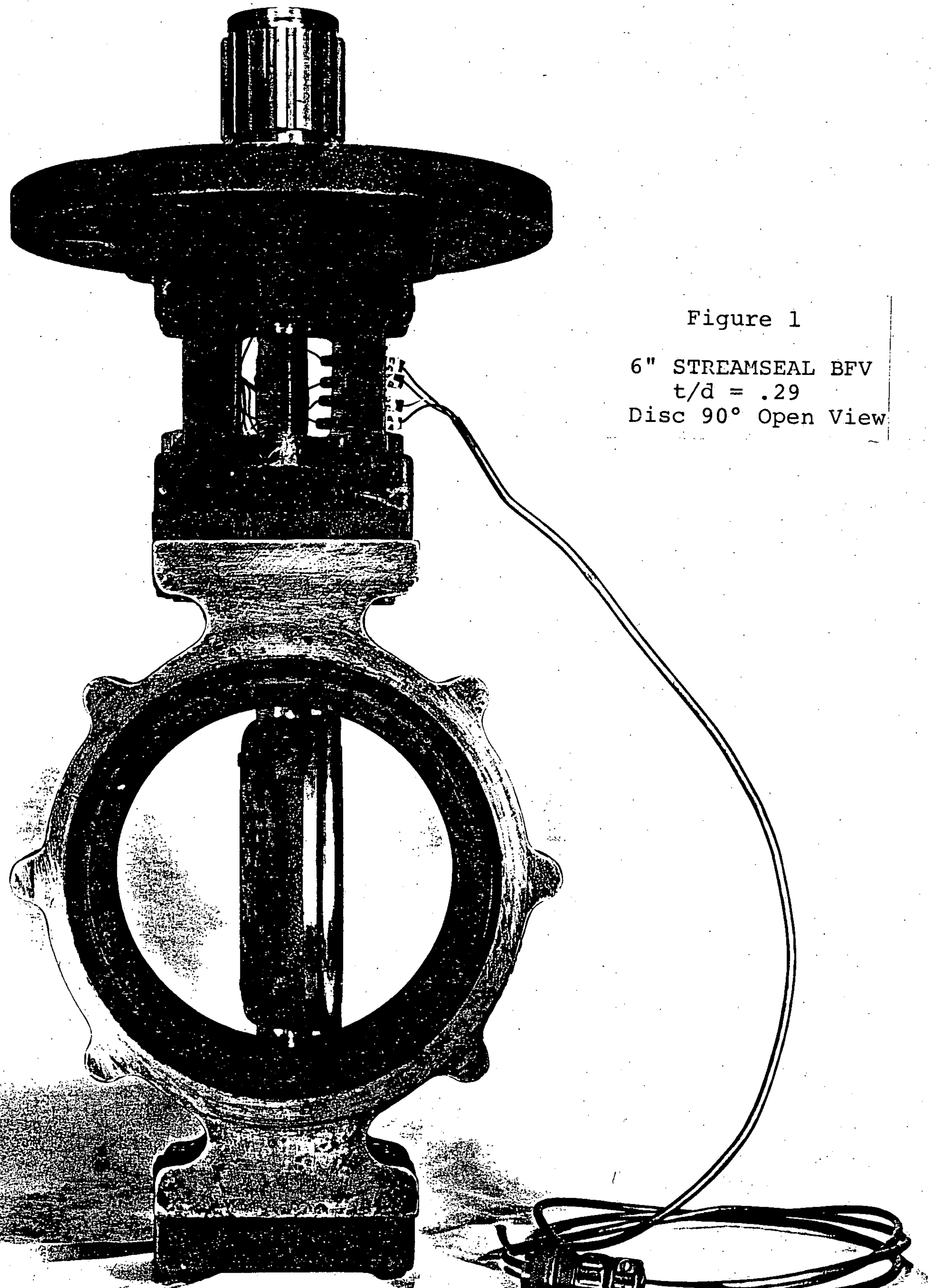


Figure 1

6" STREAMSEAL BFV
t/d = .29
Disc 90° Open View

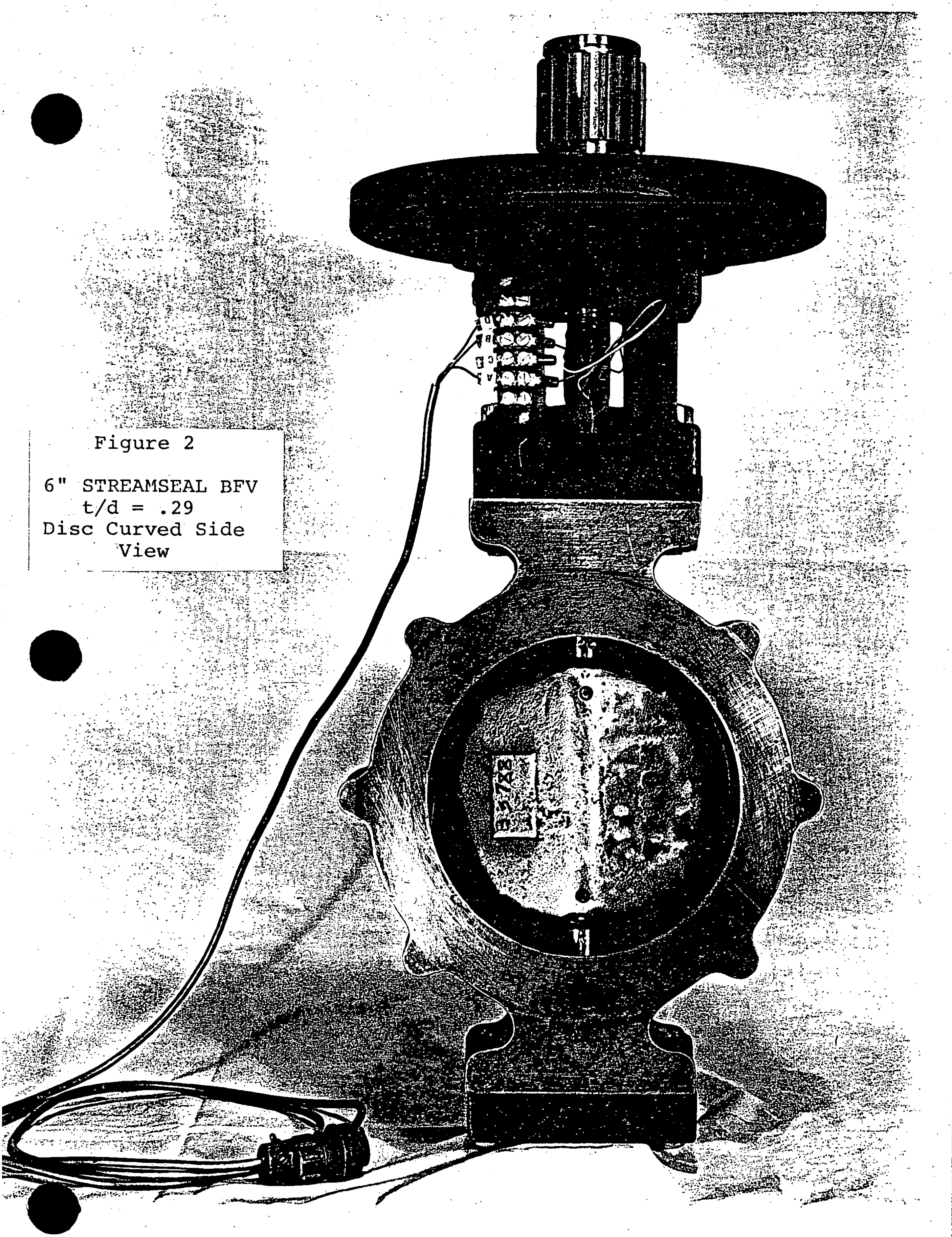


Figure 2

6" STREAMSEAL BFV
t/d = .29
Disc Curved Side
View

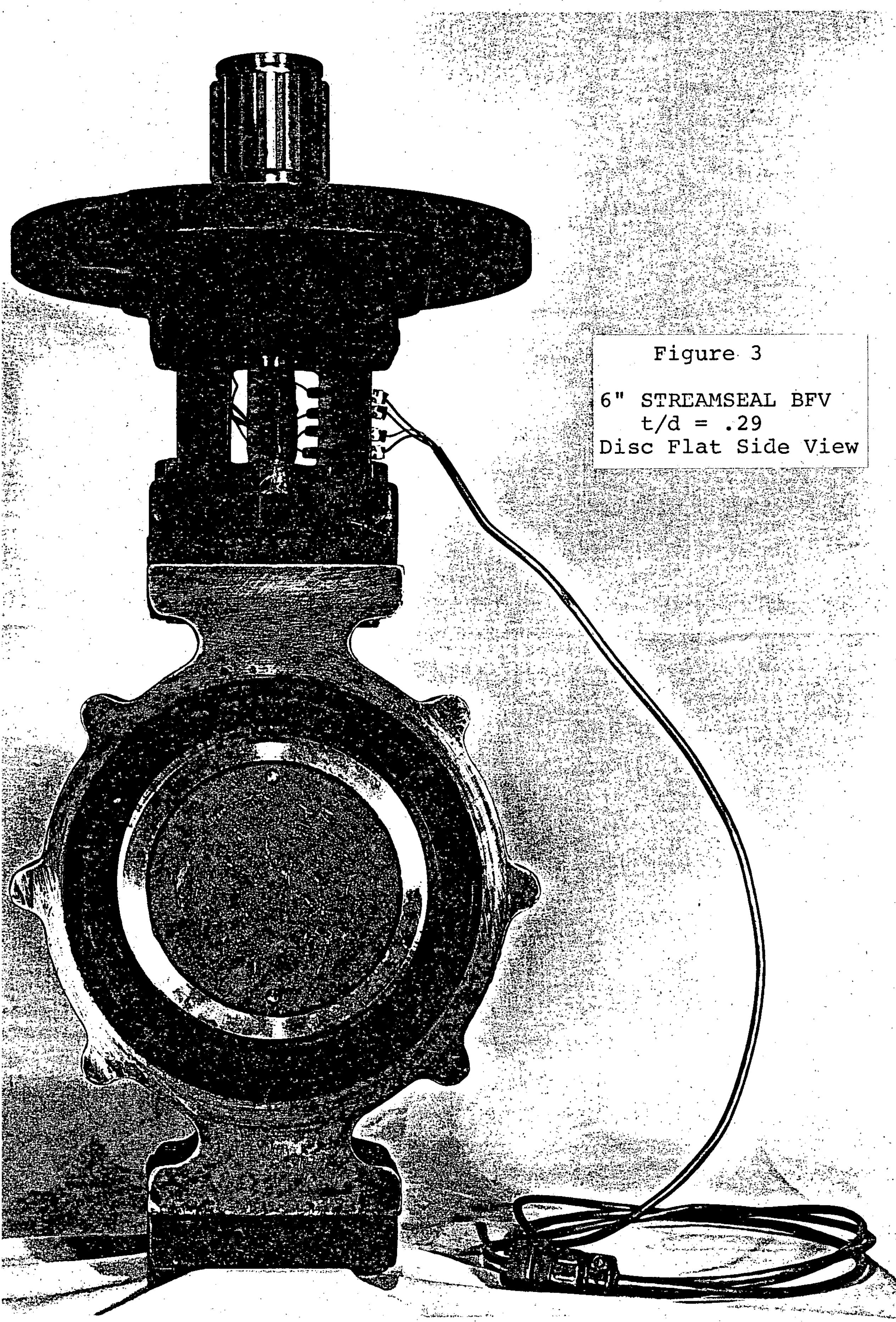


Figure 3

6" STREAMSEAL BFV
t/d = .29
Disc Flat Side View

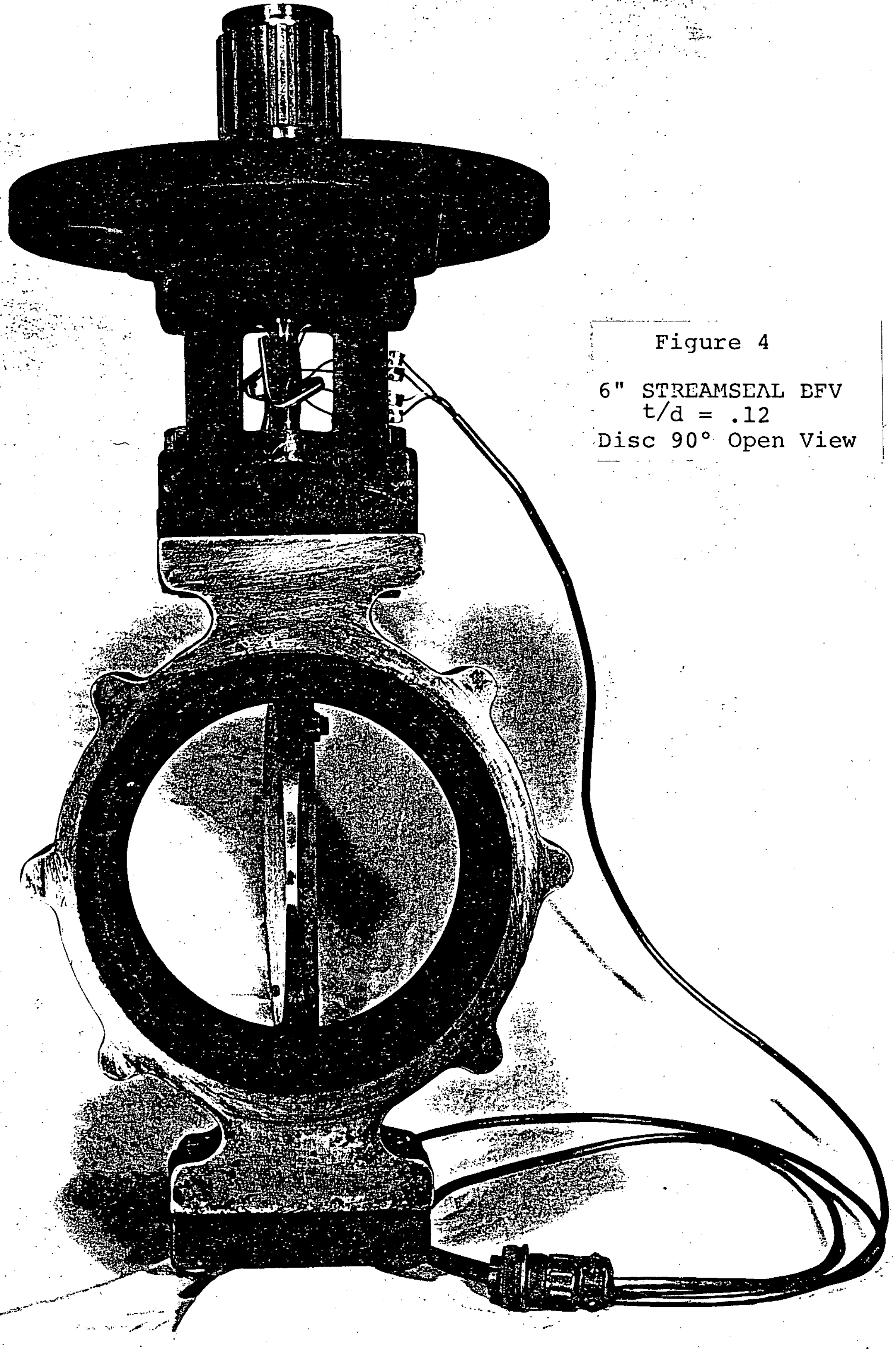


Figure 4

6" STREAMSEAL BFV
t/d = .12
Disc 90° Open View

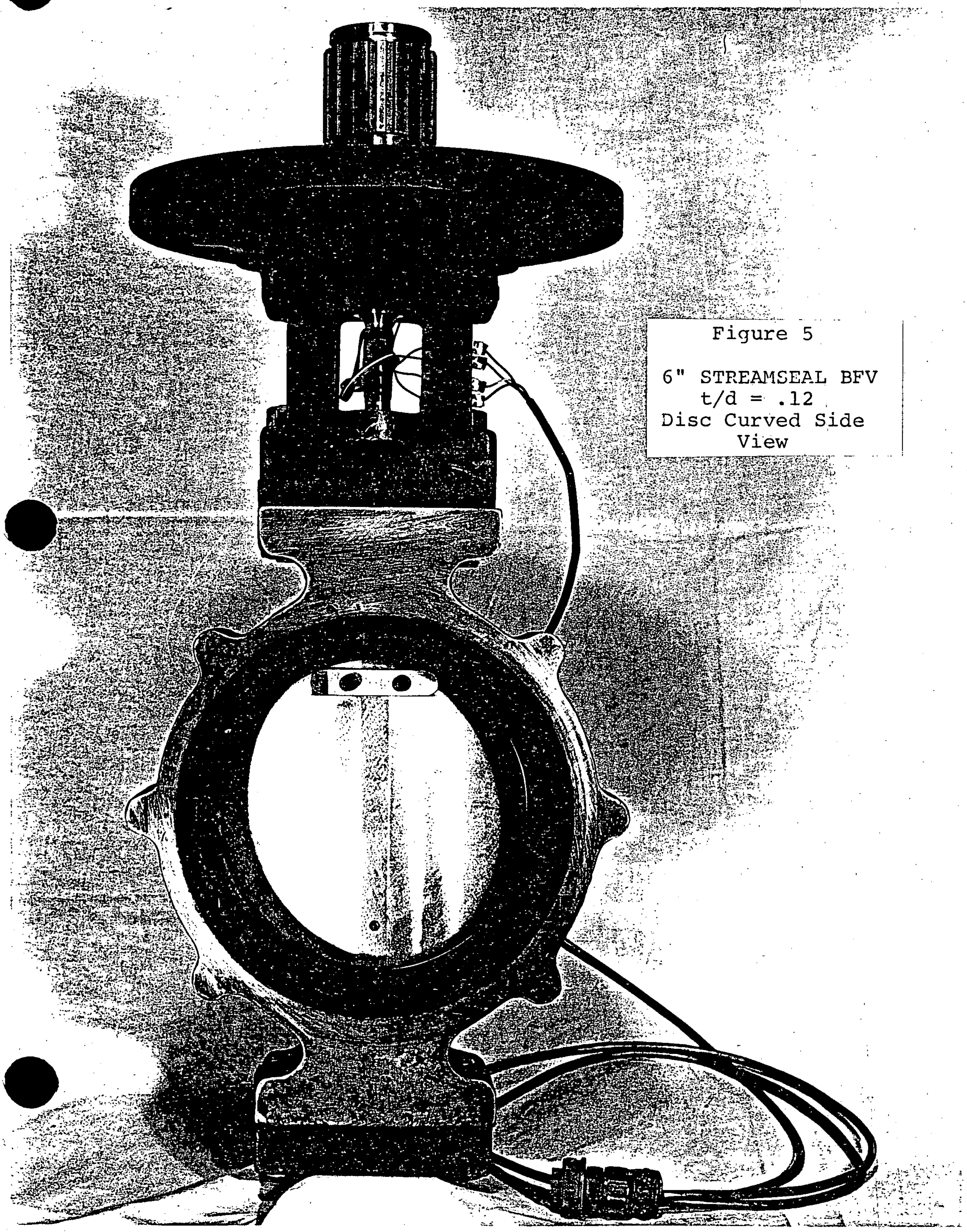


Figure 5

6" STREAMSEAL BFV
t/d = .12
Disc Curved Side
View

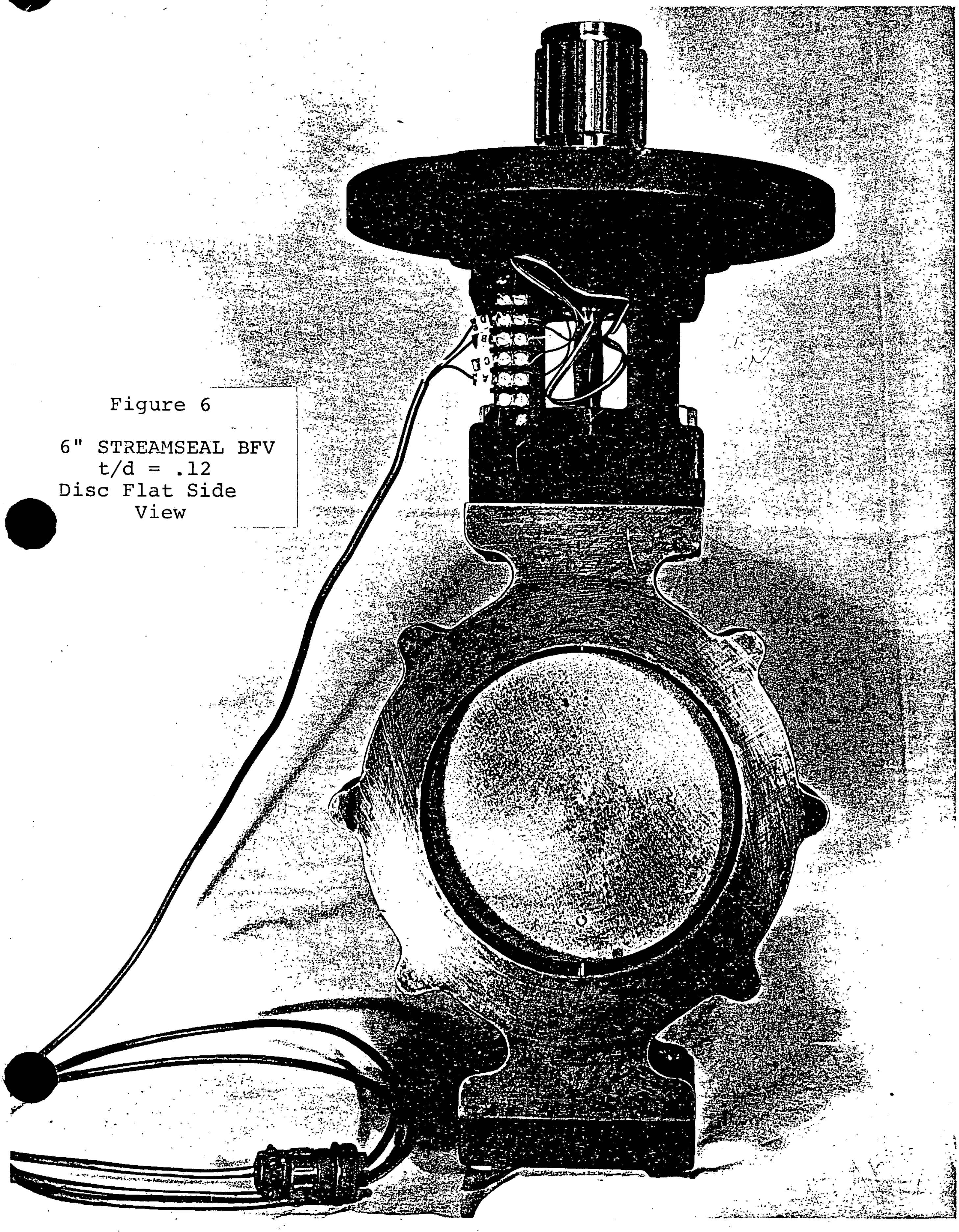


Figure 6

6" STREAMSEAL BFV
t/d = .12
Disc Flat Side
View

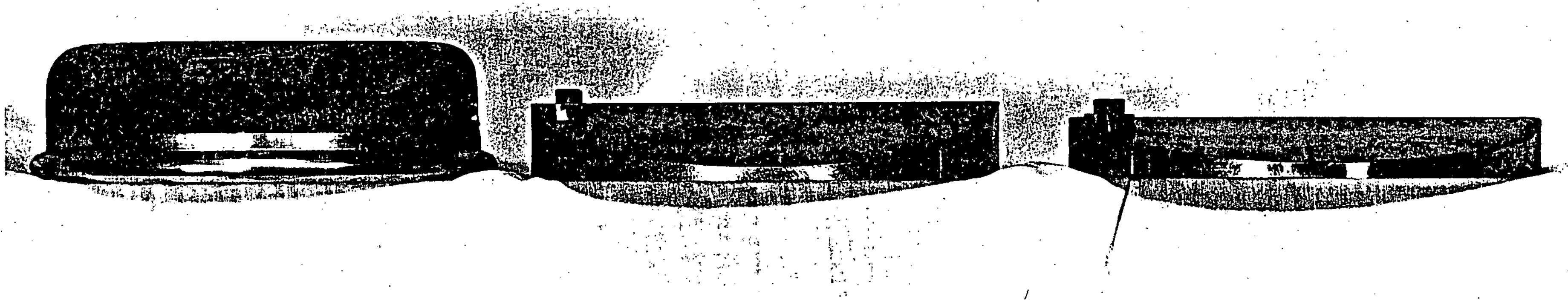


Figure 7

6" STREAMSEAL BFV
Left - t/d = .29
Center - t/d .17
Right - t/ .12

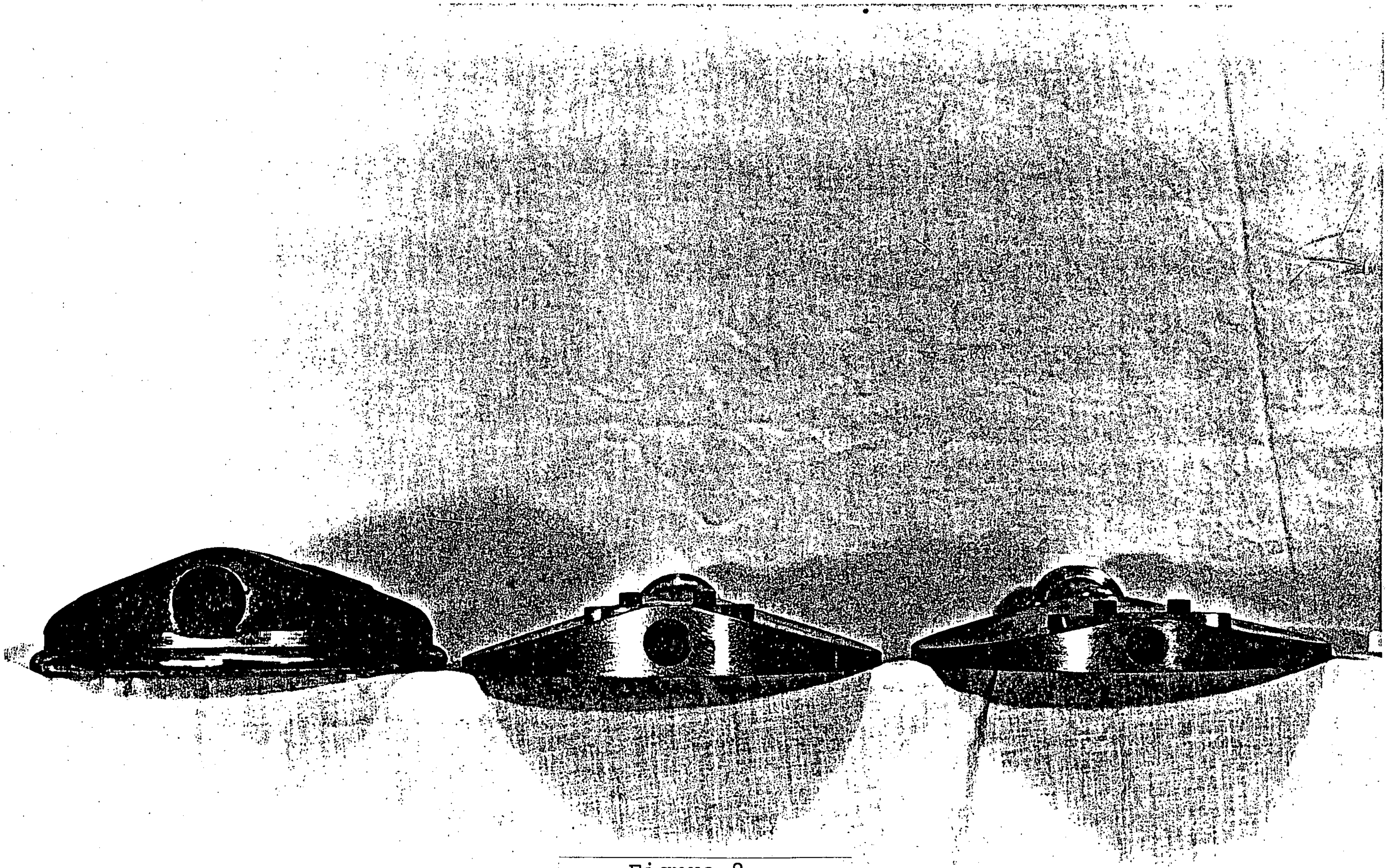


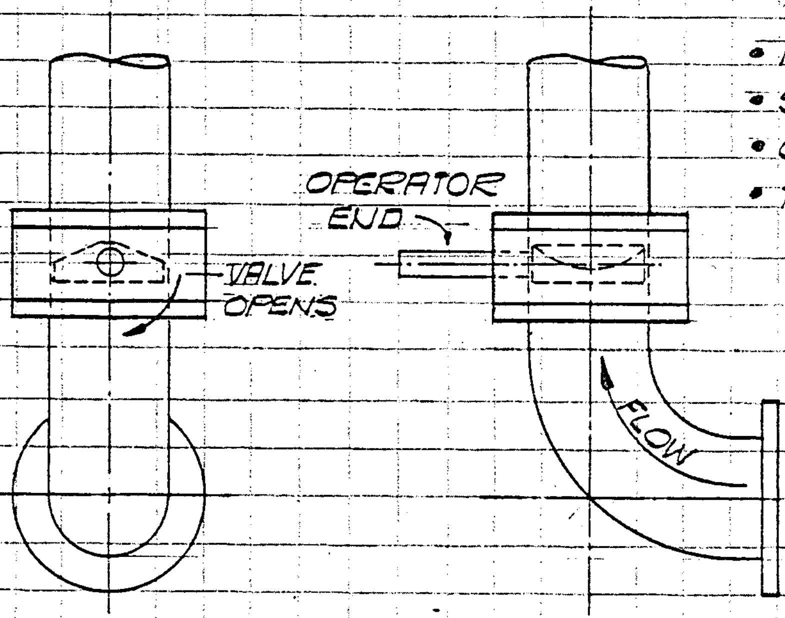
Figure 8

6" STREAMSEAL BFV
Left - t/d = .29
Center - t/d = .17
Right - t/d = .12

CUSTOMER	DATE	SHEET
NASA / LANGLEY	12-19-79	1 OF 2

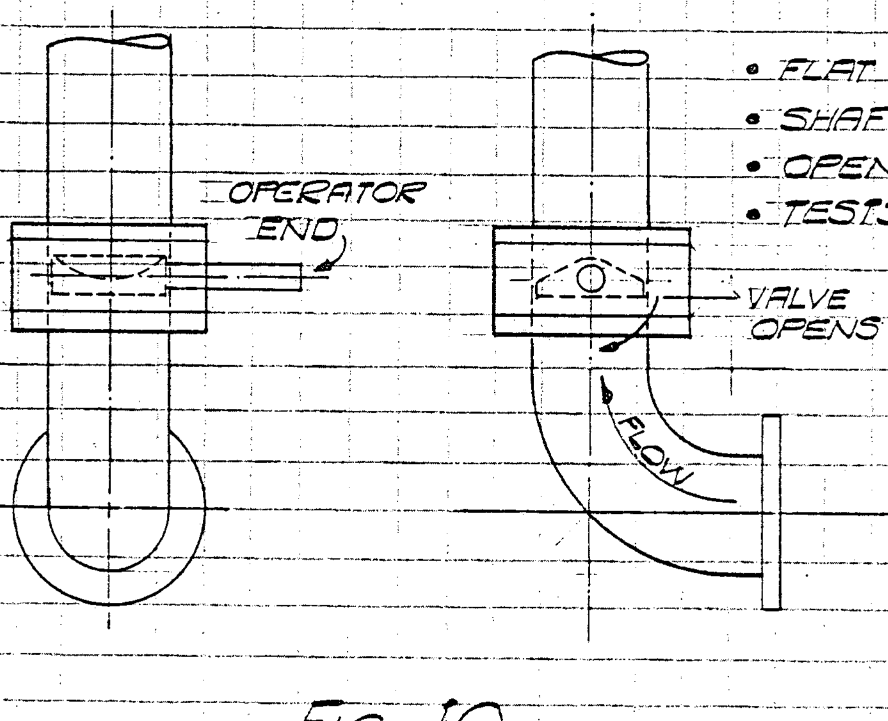
SUBJECT	PRELIM.	FINAL
TEST VALVE ORIENTATION		

DRAWING NUMBER		CALCULATED BY
	LITHO IN U.S.A.-A-C **ENGINEERING CALCULATION SHEET** ALLIS-CHALMERS FORM 6715-1	GILGORE



- FLAT FACE UPSTREAM
- SHAFT IN PLANE W/ELBOW
- OPEN RIGHT
- TESTS # 21, 25, & 29

FIG. 9



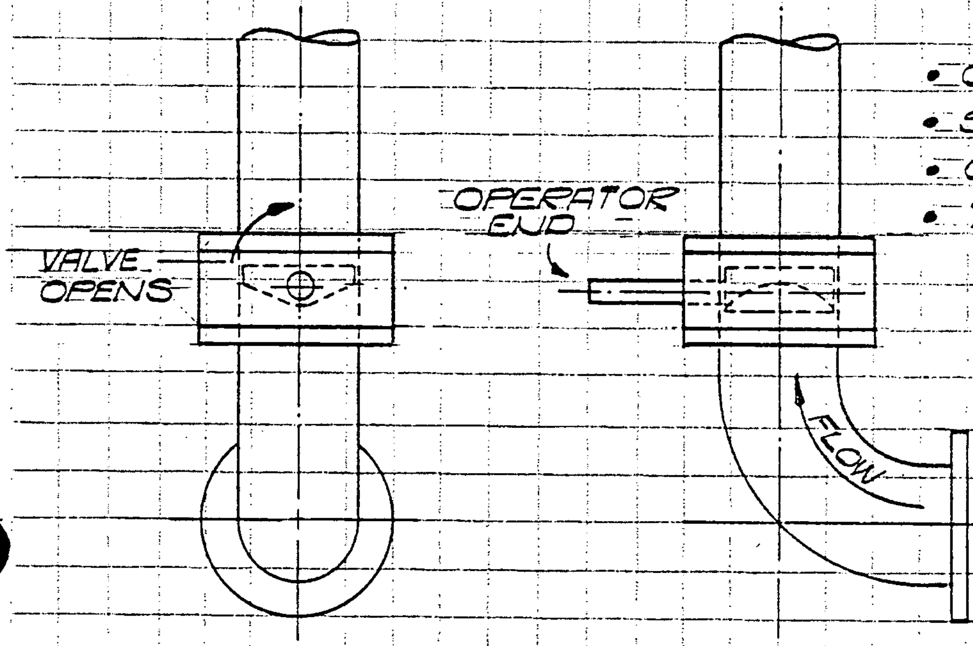
- FLAT FACE UPSTREAM
- SHAFT 90° TO RIGHT
- OPEN RIGHT
- TESTS # 24, 28, & 32

FIG. 10

CUSTOMER NASA / LANGLEY	DATE 12-19-79	SHEET 2 OF 2
SUBJECT TEST VALVE ORIENTATION	PRELIM.	FINAL
DRAWING NUMBER	ENGINEERING CALCULATION SHEET	CALCULATED BY GILGORE

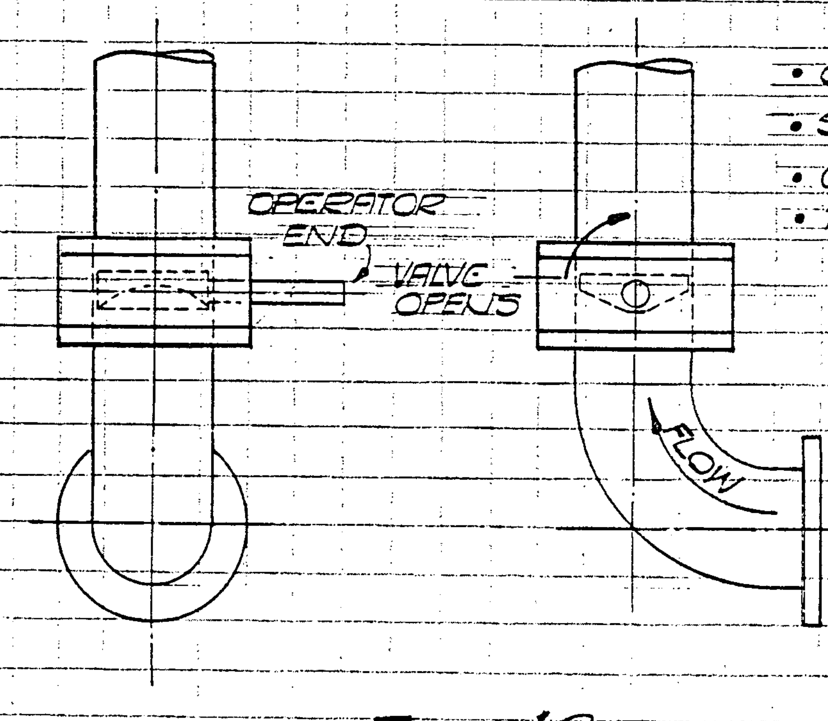
LITHO IN U.S.A.—A-C

ALLIS-CHALMERS FORM 6715-1



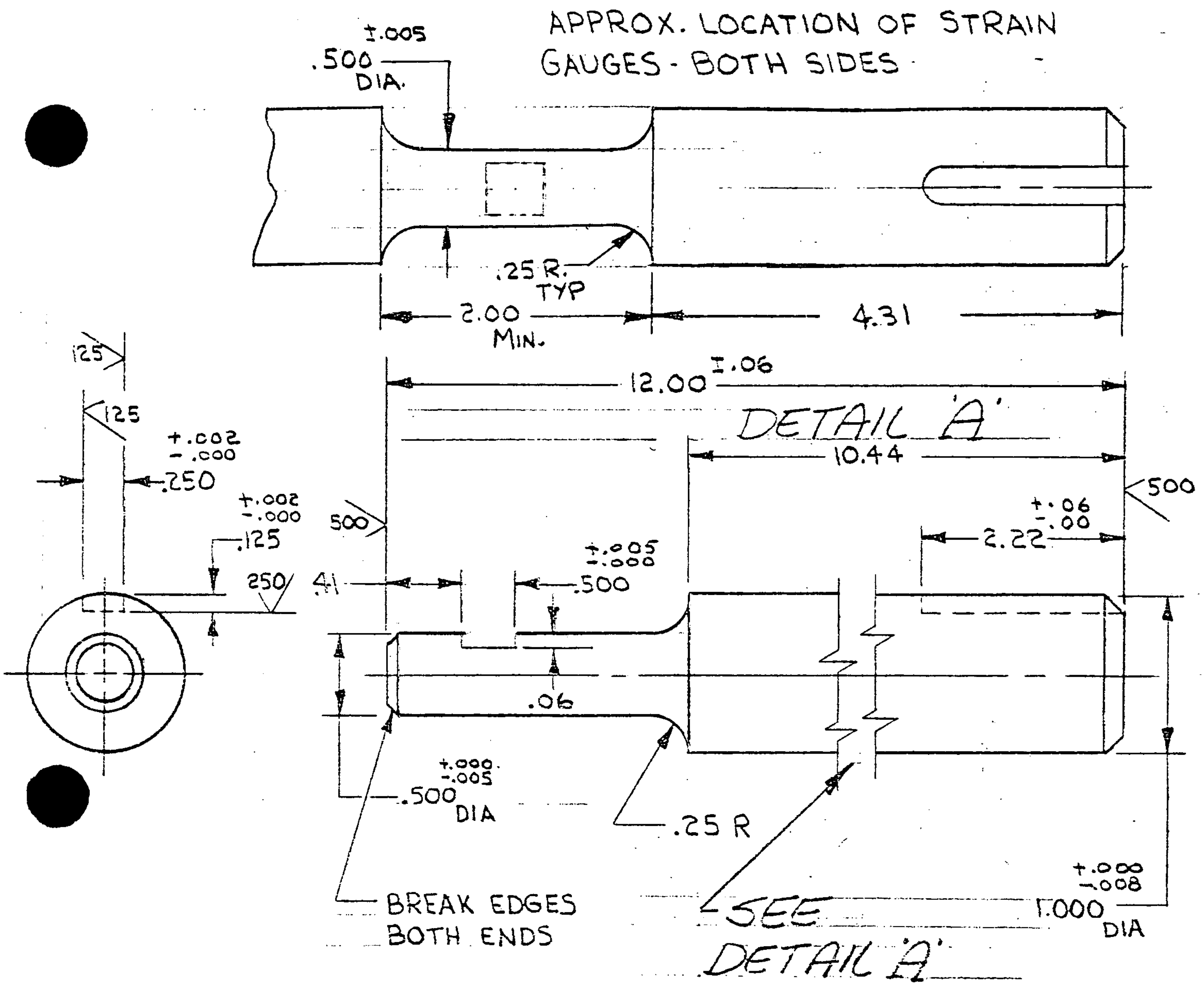
- CURVED FACE UPSTREAM
- SHAFT IN PLANE W/ELBOW
- OPEN RIGHT
- TESTS #22, 26, & 30

FIG. 11



- CURVED FACE UPSTREAM
- SHAFT 90° TO RIGHT
- OPEN RIGHT
- TESTS #23, 27, & 31

FIG. 12



Appendix IV

TOCK NO.-304805

ROUTING CODE

REVISIONS

UNLESS OTHERWISE NOTED DIMENSIONS ARE IN INCHES AND MACHINING TOL. ARE:
1 PLACE DEC ± .060
2 PLACE DEC ± .030
3 PLACE DEC ± .010
BREAK ALL CORNERS – .015

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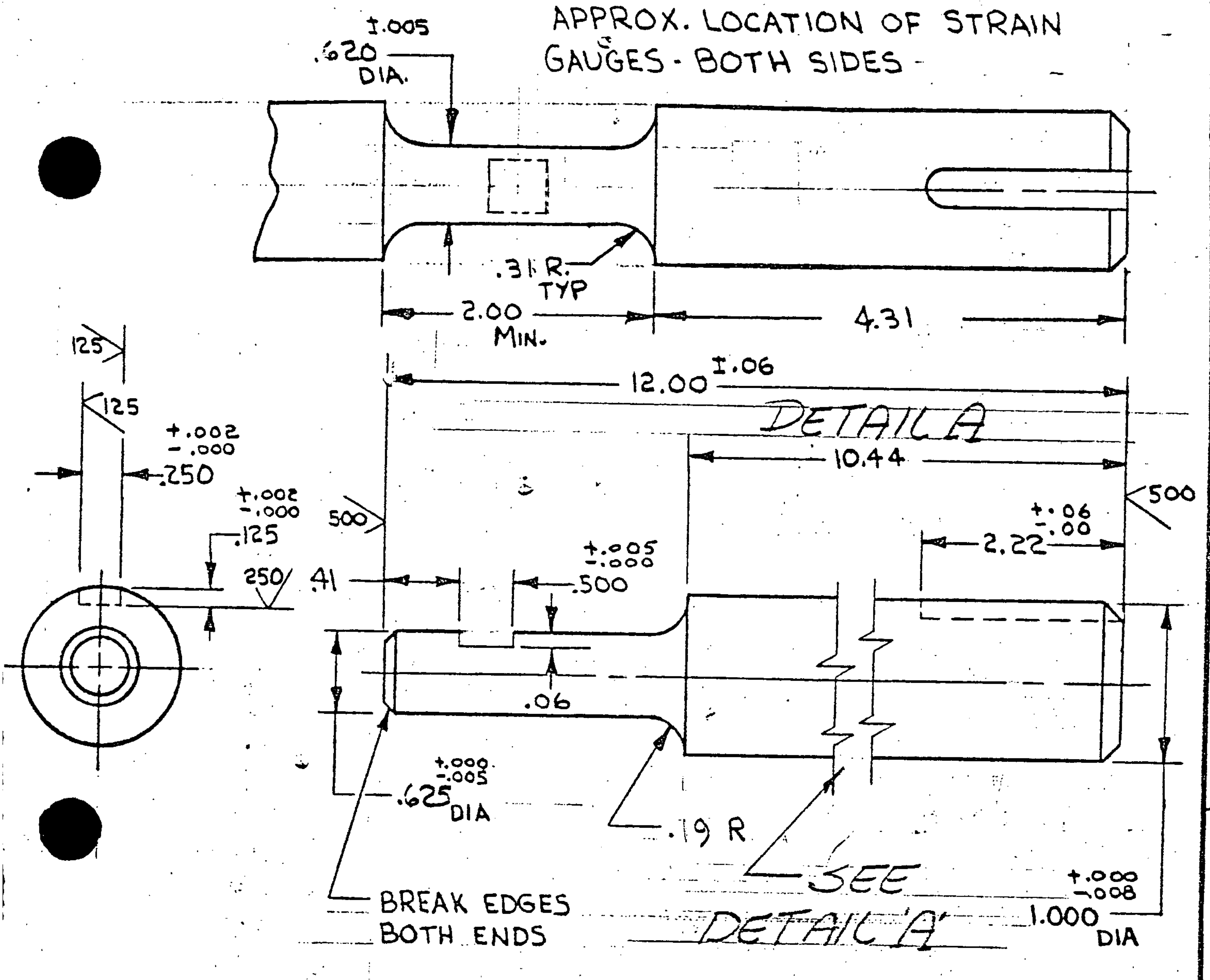
YORK PLANT VALVE DIVISION YORK, PA.

SHAFT 01.00-00.50 K

DSGN | DFTG APPD
DFTM: AFS | MECH ENG APPD
CHK | HYD ENG APPD
SCALE: ~~ | DATE: 9-28-79

WT R F | MATERIAL: SST
SIMILAR TO | MATERIAL SPEC: ASTM A479 TYPE 304

SK-092779 | 4 | REV NO 00



OCK NO.—304805

ROUTING CODE

REVISIONS

UNLESS OTHERWISE NOTED DIMENSIONS ARE IN INCHES AND MACHINING TOL. ARE:
1 PLACE DEC ± .060
2 PLACE DEC ± .030
3 PLACE DEC ± .010
BREAK ALL CORNERS — .015

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SHAFT 01.00-00.62 K

DSGN	DFTG APPD
DFTM AFS	MECH ENG APPD
CHK	HYD ENG APPD
SCALE	DATE 9-28-79

WT R F

MATERIAL SST

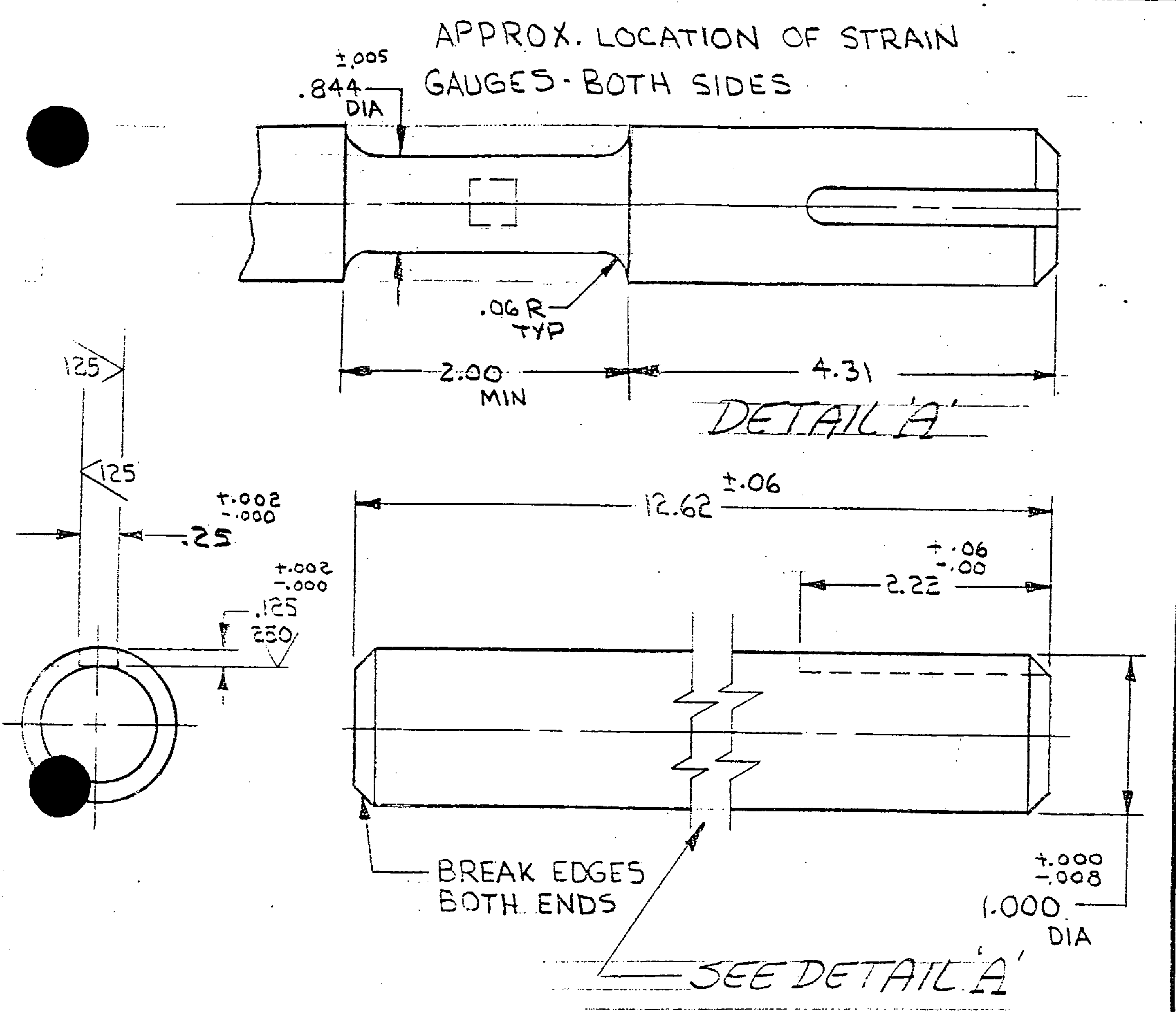
SIMILAR TO

MATERIAL SPEC ASTM A479 TYPE 304

SK-092780 | 4 | REV NO 00

A

4 3 2 1



DCK NO. 304805

ROUTING CODE

REVISIONS

UNLESS OTHERWISE NOTED DIMENSIONS ARE IN INCHES AND MACHINING TOL. ARE:
1 PLACE DEC ± .060
2 PLACE DEC ± .030
3 PLACE DEC ± .010
BREAK ALL CORNERS – .015

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SHAFT 01.00 K

DSGN	DFTG APPD		
DFTM AFS	MECH ENG APPD	WT R F	MATERIAL SST
CHK	HYD ENG APPD	SIMILAR TO	MATERIAL SPEC ASTM A479 TYPE 304
SCALE —	DATE 9-23-79	SK-092781	4 REV NO 00