AUG 07 1998

Station 4 (25)

ENGINEERING DATA TRANSMITTAL

Page 1 of 1

1. EDT 622246

2. To: (Receiving Organization)	3. From: (Originating Organization)	4. Related EDT No.:
Distribution	TWRS Projects/SST Retrieval	n/a
5. Proj./Prog./Dept./Div.: D2991 W-320 TWRS/TCPN # ~~D2MA1~~	6. Design Authority/ Design Agent/Cog. Engr.: JW Bailey, NHC	7. Purchase Order No.: n/a
8. Originator Remarks: For approval and release of a new supporting document. This document has been generated to ensure retrievability of the Project W-320 "Electrical Calculations, Vol. 2".		9. Equip./Component No.: n/a 10. System/Bldg./Facility: 241-C-106
11. Receiver Remarks: 11A. Design Baseline Document? [X] Yes [] No		12. Major Assm. Dwg. No.: n/a 13. Permit/Permit Application No.: n/a 14. Required Response Date:

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval Designator	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	HNF-2488	-	0	Project W-320, 241-C-106 Sluicing, Electrical Calculations, Vol. 2	NA			-

16. KEY

Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D or N/A (see WHC-CM-3-5, Sec.12.7)	1. Approval 4. Review 2. Release 5. Post-Review 3. Information 6. Dist. (Receipt Acknow. Required)	1. Approved 4. Reviewed no/comment 2. Approved w/comment 5. Reviewed w/comment 3. Disapproved w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION
(See Approval Designator for required signatures)

(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN
2	1	Design Authority	JW Bailey	RR Bevins 7/27/98	S2-48						
		Design Agent	MC Davenport	7/25/98							
2	1	Cog.Eng.	~~CE Graves~~		S2-48						
2	1	Cog. Mgr.	JW Bailey		S2-48						
		QA									
		Safety									
		Env.									

18. MC Davenport for ~~C.E. Graves~~ ~~7/24/98~~
MC Davenport 7/25/98
Signature of EDT Originator — Date

19. _____ _____
Authorized Representative for Receiving Organization — Date

20. J.W. Bailey ~~7/24/98~~
RR Bevins for JW 7/27/98
Design Authority/ Cognizant Manager — Date

21. DOE APPROVAL (if required) Ctrl. No.
[] Approved
[] Approved w/comments
[] Disapproved w/comments

BD-7400-172-2 (05/96) GEF097

Project W-320, 241-C-106 Sluicing Electrical Calculations, Vol. 2

John W. Bailey
Numatec Hanford Co., Richland, WA 99352
U.S. Department of Energy Contract DE-AC09-96RL13200

EDT/ECN: 622246 UC: 506
Org Code: 8C452 Charge Code: D2991/HANA0600
B&R Code: EW3130010 Total Pages: 14

Key Words: W-320, Sluicing, Tank 241-C-106, Tank 241-AY-102, WRSS, calculations, Electrical.

Abstract: This supporting document has been prepared to make the FDNW calculations for Project W-320, readily retrievable.

AUG 07 1998
DATE:
STA: 4
HANFORD RELEASE
ID: 25
Release Stamp

Release Approval 8/7/98 Date

Approved for Public Release

Cover Sheet page 1 of 2

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A-6000-237 (05/97) WEF220

HNF-2488 Coversheet
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Project W-320, 241-C-106 Sluicing Electrical Calculations, Vol. 2

TABLE OF CONTENTS

W320-31-014

C-Farm Electrical Heat Tracing

KAISER ENGINEERS HANFORD	CALCULATION IDENTIFICATION AND INDEX	Page i of 6 Date 09/19/95

This sheet shows the status and description of the attached Design Analysis sheets.

Discipline Electrical WO/Job No. ER4319 Calculation No. W320-31-014

Project No. & Name W-320 Tank 241-C-106 Sluicing

Calculation Item C-Farm Electrical Heat Tracing

These calculations apply to:

Dwg. No. H-2-818678, Sh. 3 Rev. No. 0

Dwg. No. H-2-818690 Rev. No. 0

Other (Study, CDR) Rev. No.

The status of these calculations is:

[] Preliminary Calculations

[X] Final Calculations

[] Check Calculations (On Calculation Dated)

[] Void Calculation (Reason Voided)

Incorporated in Final Drawings? [X] Yes [] No

This calculation verified by independent "check" calculations? [] Yes [X] No

Original and Revised Calculation Approvals:

	Rev. 0 Signature/Date	Rev. 1 Signature/Date	Rev. 2 Signature/Date
Originator	R.H. Graeber R.H. Graeber 9-29-95		
Checked by	S.A. Najjar Sarwat Najjar 9/29/95		
Approved by	J. Maenick 9/29/95		
Checked Against Approved Vendor Data	Rao Thanawala 1/23/98		

APPROVED VENDOR DATA NOT AVAILABLE. VERIFIED THAT HEAT-TRACE ITEMS WERE ACQUIRED IN FIELD PER MATERIAL LIST ON DWG. H-2-818569, SH. 1, 2 AND INDEX HEAT-TRACE WAS INSTALLED PER DESIGN ON DWG. H-2-818678, SH. 3

Design Analysis Page No.	Description
i	Calculation Identification and Index
ii	Calculation Cross Index
1	Objective; Design Inputs; Given Data; Assumptions
2	Method of Analysis; References
2-6	Calculations
6	Conclusions
A-1 To A-16	Appendix A: O'Brien Corp. "Tracepak" Catalog Application Guide
B-1 To B-17	Appendix B: Raychem Corp. "Chemelex" Heat Tracing Systems Design Guide
C-1 To C-8	Appendix C: Vendor Heat Tracing Design Information Package

CALCULATION CROSS INDEX (Typical)

Subject Calculation No. W320-31-014

Subject Calculation Revision No.	Superceded by Calculation No.	These interfacing calculation/documents provide input to the subject calculation, and if revised may require revision of the subject calculation.		Results and conclusions of the subject calculation are used in these interfacing calculations and/or documents.		Does the output interface calculation/ documents require revision?		Has the output interface calculation/ documents been revised?		Discipline manager's signature and date indicating evaluation complete.
		Calculation/Document No.	Revision No.	Calculation/Document No.	Revision No.	Yes	No	Yes	No	
0	N/A	H-2-818559 SH2	0	H-2-818678 SH3	0		✓		✓	
		↓ SH3	0	H-2-818690	0		✓		✓	
		H-2-818561 SH1	0							

DESIGN ANALYSIS

Client WHC
Subject C Farm Electrical Heat Tracing Systems
Location 200 E, C Farm

WO/Job No. W-320
Date 9/19/95
Checked 9/27/95
Revised

By R.H. Graeber
By S.A. Najjar S.N.
By

1.0 OBJECTIVE

1.1 To determine the power requirements needed to power electrical heat tracing segments contained within three manufactured insulated tubing assemblies. To verify thermal adequacy of tubing assembly selection by others.

1.2 To size the heat tracing feeder and branch circuit conductors & conduits. To size protective circuit breaker and fuses.

1.3 To accomplish thermal design for two electrical heat tracing segments: One @ C-106 tank riser 7 (CCTV) and one at the exhaust hatchway (condensate drain).

2.0 DESIGN INPUTS

2.1 Drawing H-2-818559, Shts. 2 & 3, P&ID Tank 241-C-106.

2.2 Drawing H-2-818561, Shts. 1, P&ID Tank 241-C-106 HVAC.

2.3 NFPA-70, National Electrical Code (1993 edition).

2.4 "In Tank" CCTV, WHC Purchase Requisition No. 422301.

3.0 GIVEN DATA

3.1 All electrical heat tracing provided by others as a part of tubing assemblies shall be powered by a 120 VAC, 1 phase source.

3.2 All electrical heat tracing shall be for freeze protection only. Need to maintain process piping at 40 Deg F minimum.

3.3 Minimum ambient temperature est. to be - 20 Deg. F., maximum ambient temperature estimated at 110 Deg. F.

3.4 Location to be outdoors and/or buried 12 inches below grade.

3.5 Field installed piping insulation to be 1/2 inch thick fiberglass (ASTM C547-77) with maximum "K" factor at 50 Deg. F. to be 0.2497 BTU-IN/HR-SQ FT-Deg.F.

4.0 ASSUMPTIONS

4.1 Estimated duration for this project is two years.

4.2 Electrical power is supplied from a panelboard source at 120 VAC (+ or - 10%).

DESIGN ANALYSIS

Client WHC
WO/Job No. W-320
By R.H. Graeber

Subject C Farm Electrical Heat Tracing Systems Design
Date 9/19/95
Checked 9/27/95
By S.A. Najjar S.N.

Location 200 E, C Farm
Revised
By

5.0 METHOD OF ANALYSIS

5.1 Hand calculations

6.0 REFERENCES

6.1 H-2-818569, Sht. 1, material list.

6.2 O'Brien Corporation "Tracepak" catalog application guide.

6.3 Raychem "Chemelex" heat tracing systems catalog design guide for insulated pipes and tubing.

6.4 NFPA-70, National Electrical Code (1993 edition).

7.0 CALCULATION

7.1 Description of tubing/piping systems to be protected and any heat tracing supplied by others.

Mech. System	Location	Dia.	Length	Insulation
7.1.1 I-752-I31	Underground & Outdoor	0.5"	25 ft.	O'Brien single tracepak (TPE1) with 5BTV1 Chemelex tracing.
7.1.2 IA(20#)-704-I31	Underground & Outdoor	0.5"	25 ft.	O'Brien single tracepak (TPE2) with 5BTV1 Chemelex tracing.
7.1.3 FW-626-I31 and IA(20#)-705-I31 (to CCTV @ R-7)	Underground & Outdoor	0.5" 0.5"	90 ft.	O'Brien dual tracepak with single 5 BTV1 Chemelex tracing.
7.1.4 Flex tubing & upper junction box @ CCTV (R-7)	Outdoors	(see 7.1.3)	Two 5 ft. long flex tubes.	0.5" thick fiber glass with PVC jacket. "K" = 0.2497
7.1.5 DR-305-M9	Outdoors	0.75"	10 ft.	0.5" thick fiber glass with PVC jacket. "K" = 0.2497

DESIGN ANALYSIS

Client WHC
WO/Job No. W-320
Subject C Farm Electrical Heat Tracing Systems Design
Date 9/19/95 By R.H. Graeber
Checked 9/27/95 By S.A. Najjar S.N.
Location 200 E, C Farm
Revised By

7.2 Analysis of electrical heat tracing supplied by others (see H-2-818569).

7.2.1 Mechanical systems identified in 7.1.1, 7.1.2 & 7.1.3 are protected by electrical heat tracing supplied by others. Notice that 7.1.1 & 7.1.2, although in different service, are identical.

a) On page 6 of reference 6.2, the TPE1 Chart confirms that the 5BTV1 type Chemelex heat tracing is adequate for the "single" tube freeze protection. The "5 watt/ft" tracer maintains the "TPE1" single, 0.5" process line at 60 Deg. F. given a -20 Deg. F. ambient temperature.

b) Again on page 6 of ref. 6.2, the TPE2 Chart confirms that the 5BTV1 type Chemelex heat tracing is adequate for the "dual" tube freeze protection. The "5 watt/ft" tracer maintains the "TPE2" double, 0.5" process lines at 55 (+ or -) Deg. F. given a -20 Deg. F. ambient temperature.

7.3 Determination of electrical tracer requirements installed on tubing & pipes in the field (by ICFKH).

7.3.1 Heat tracing requirements for mechanical systems identified in 7.1.4 and 7.1.5 are to be determined by this calculation section.

7.3.2 Calculation for 7.1.4 (from ref. 6.3).

a) Temperature differential = maintained temperature - lowest ambient temperature.

$\underline{T(Diff)} = 40 - (-20) = \underline{60 \text{ Deg. F.}}$

b) From Chart 1, pipe heat loss equals approximately 2.3 watts per foot for T(Diff) = 60, Insulation Thickness = 0.5" and Flexible Tubing Size = 0.5 ".

$$[\text{Interpolation: } 1.9 + \frac{(60-50)}{(100-50)} (3.9 - 1.9) = 2.3]$$

c) Also from the bottom of page 2 at Chart 1, the insulation factor for fiber glass insulation is 1.0.

d) The net pipe heat loss is 2.3 watts/ft X 1.0 = 2.3 $\underline{\text{watts/ft.}}$

e) Selection of tracer sizing is accomplished using Chart 3a. Chemelex 3BTV1 tracer would provide 3.4 watts per foot at 40 Deg F. To increase the degree of certainty and to assist in heating the upper junction box, upsize the tracer to a $\underline{\text{"5BTV1"}}$. This has the

additional advantage of matching the "TPE 2" tracer (being sliced onto). Two flexible tube assemblies each approximately 5 feet long are expected.

f) Chemlex "5BTV1" tracer will deliver 5.6 watts/foot @ 40 Deg F. Best guess is that the CCTV upper junction box will be fabricated by the vendor from a 12" long section of 12" dia. pipe (same as the 12" dia. pipe in Chart 1). From Chart 1 for T(Diff.)=60, pipe dia. = 12" and insulation thickness = 0.5", the pipe heat loss is:

$$25.2 + \frac{(60-50)}{(100-50)} (52.5 - 25.2) = 30.66 \text{ watts/foot}$$

30.66 watts/foot X 1.0 insulation factor X 1 foot length = 31 watts heat loss thru the junction box side walls.

Sidewall surface area = $\pi dh = (\pi)(1')1' = 3.14$ sq. ft.

Top & bottom surface area = $2[\pi r^2] = 2\pi(0.5)^2 = 1.57$ sq. ft.

Will add 50% for heat loss thru junction box top/bottom.

Total heat loss = (1.5) 30.66 = 46 watts.

At 5.6 watts/foot deliverable, we will need 46 watts/5.6 watts/foot = 8.2 feet (min.) of chemelex "5BTV1" tracer wrapped around the upper junction box. Will add 50% to this footage to ensure adequate coverage. Wrap 12 feet (+ or -) around the CCTV upper junction box. Approximately 4 wraps are involved.

7.3.3 Calculation for 7.1.5 (from ref. 6.3)

a) T(Diff.) is the same as 7.3.2a = 60 Deg. F.

b) From Chart 1 for T(Diff.) = 60, pipe dia. = 0.75" and insulation thickness = 0.5", the pipe heat loss

$$= 2.9 + \frac{(60-50)}{(100-50)} (6.1-2.9) = 3.54 \text{ watts/foot.}$$

c) 3.54 watts/foot X 1.0 insulation factor = 3.54 watts/foot.

d) Again, select Chemelex "5BTV1" tracer (5.6 watts/foot @ 40°F).

7.3.4 Appendix "C" is provided to confirm the Chemelex "5BTV1" tracer selected is more than adequate. These "unqualified" software calculations were provided by the Raychem vendor. These calculation summaries are only attached as a supplement to the official hand calculations.

7.4 Additionally, the Chemelex heat tracing cable option "CR" was selected for all field installed tracer so as to accomplish the following:

7.4.1 Provide improved mechanical protection and

7.4.2 Provide a ground path for electrical safety/protection.

7.5 Thermal Design Results:

MECH. SYSTEM NO.	CHEMELEX TRACER CAT. NO	APPROX. TRACER FOOTAGE	SOURCE
7.1.1	5BTV1	35'	By vendor (O'Brien)
7.1.2	5BTV1	35'	By vendor (O'Brien)
7.1.3	5BTV1	110'	By vendor (O'Brien)
7.1.4	5BTV1-CR	30'	By ICF/KH
7.1.5	5BTV1-CR	20'	By ICF/KH

TOTAL = 230'

All W-320 heat tracing cable is/will be RayChem Chemelex "5BTV1."

Maximum heat tracer length on one branch circuit is a combination of 7.1.3 plus 7.1.4 = 140' total. Three other branch circuits independently feed 7.1.1, 7.1.2 and 7.1.5.

7.6 Electrical Circuit Design

7.6.1 Heat tracing feeder is supplied power from the process building mini-power panel C106-PP1.

a) From the table in calculation section 7.5, total tracer footage is = 230 feet.

From Chart 6 on page 14 of reference 6.3, the maximum heating cable length for a 120 volt, 20amp circuit and start up temperature of 40 Deg. F. using "5BTV" is

$$185 + \frac{(40-0)}{(50-0)} (270-185) = \underline{253 \text{ feet}}$$

A 20 amp., single pole circuit breaker is adequate at C106-PP1 to feed all electrical heat tracing at C-106 tank.

b) Provide 2 #12 AWG,THWN and 1 #12 gnd. in 3/4" conduit to feed all electrical tracers. Voltage drop is not a concern. Distance from C106 - PP1 to the heat trace terminal box is approximately 15'. Distance from the heat trace terminal box to the farthest away "power connection kit" is approximately 25'.

c) 253 feet X 5.6 watts/foot = 1400 watts is the maximum "5BTV" tracer load a 20 amp., single pole circuit breaker can service.

7.6.2 Branch Circuits: The single heat trace feeder will feed four branch circuits. For segregation, each branch circuit will be fused.

a) From 7.5, the largest (longest) heat trace branch circuit will involve 140 feet of tracer.

140 feet X 5.6 watts/foot = 784 watts

784 watts at 120 VAC, 1-phase = 6.5 amp, indicates the fuse size should be no less than 7 amps - use a 10 amp fuse!

Use 10 amp. fuses for the other three branch circuits.

b) Provide 2 #12 AWG, THWN and 1 #12 gnd. in 3/4" conduit or flex conduit for each of the branch circuits.

8.0 Conclusions

8.1 All W-320 electrical heat tracing is located at the C-106 tank.

8.2 All W-320 electrical heat tracing cable is properly sized to provide freeze protection.

8.3 All electrical heat tracing related electrical circuits and protective devices are properly sized.

8.4 All related wire runs and conduits are properly sized.

APPENDIX A

16 PAGES

®

AN ENGINEERED, PREINSULATED TUBING BUNDLE SYSTEM FROM O'BRIEN CORPORATION

Solves the problems of: Freezing Dew point Component drop-out Viscosity Personnel protection

Freezing, dew point, component drop-out and viscosity control are major considerations in instrument and small diameter process lines. A properly designed and selected pretraced tubing bundle offers an effective solution to these problems.

The economical choice to field fabrication

Maintenance free TRACEPAK not only saves money and time during the installation process, but it ensures consistent, repeatable performance. Field fabrication requires a pipe fitter to lay out, measure, cut, dress, bend and install the tubing. Next the tracer (steam or electric) has to be installed and insulation put on the tubing. Finally, a weatherproof covering needs to be applied over the insulation. Clearly the economics of the TRACEPAK system versus field fabrication are significant.

Provides predictable and repeatable performance

O'Brien Corporation, long recognized as the leader in providing reliable instrumentation protection, has simplified installation while offering predictable operation. TRACEPAK tube bundles are prefabricated, pre-engineered and preinsulated assemblies.

Installation is simplified by the unique parallel configuration, in which process and tracer lines are always parallel inside the bundle. The bundle is much easier to bend during field routing and hookup because all tubes bend together and not against one another.

Connections are easy because tubing stays round and is not work hardened

TRACEPAK's configuration allows the tubing to stay round and malleable when used in conjunction with compression and flare fittings. The installation of process and instrument connections requires only a simple, one-plane offset bend to engage tubing and fittings.

Can be installed at temperatures as low as -40°F (-40°C)

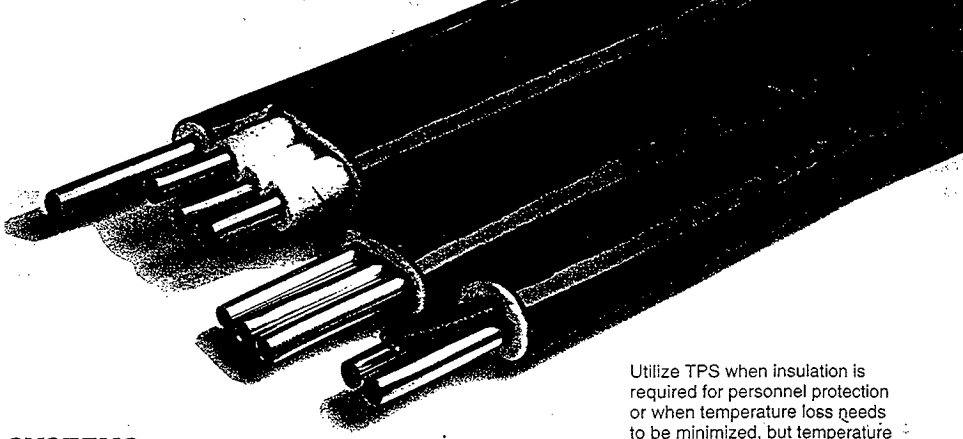
O'Brien Corporation utilizes the highest quality materials. The tough elastomeric jacket contains no halogens, eliminating the possibility of chlorides from the jacket causing stress corrosion in stainless steel tubing. This jacket has excellent abrasion and chemical resistance along with a wide, usable temperature range. TRACEPAK can be installed in temperatures as low as -40°F.

3 Types of traced lines

There are three common types of pretraced lines:

- Single preinsulated line, TPS, primarily for steam supply and condensate return.
- Steam traced lines, TPL & TPH, for freeze protection and temperature maintenance.
- Electric traced lines, TPE, for freeze protection and maintenance of temperature.


O'BRIEN



SYSTEMS APPROACH

With the advent of TRACEPAK, O'Brien Corporation has closed the loop in providing the entire instrument installation and protection needs for your plant. VIPAK®, HEATPAK® and HEATPAK®II are enclosure systems that provide protection and steam or electric heat for the instrument and manifold.

SADDLEPAK® is the perfect solution to the problems of mounting instrumentation. FLEXPAK® provides a custom, flexible cover for instrumentation.
The following pages will help you decide exactly which TRACEPAK product is right for your application.

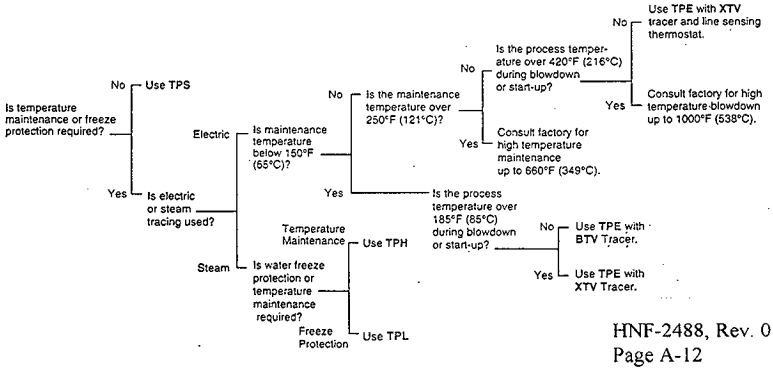
Utilize TPS when insulation is required for personnel protection or when temperature loss needs to be minimized, but temperature maintenance is not necessary. Typical applications are steam supply, condensate return, water purge lines where flow is sufficient to prevent freezing, chemical additives, etc.

Use TPE, TPL or TPH when the process must be maintained within a specific temperature range or above a specific temperature.

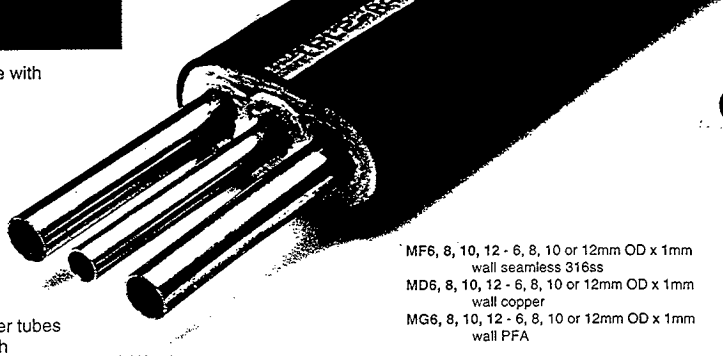
TYPICAL APPLICATIONS

Here are a few applications for the TRACEPAK System.

IMPULSE LINES	*SAMPLE LINES*	*PROCESS LINES*
flow transmitters	analyzers	steam supply
pressure transmitters	chromatographs	condensate return
level transmitters		water purge
pressure switches		chemical feed
controllers		air lines



TP



A preinsulated tubing bundle with light steam tracing

The process tubes and tracer tubes are individually wrapped with insulation to purposely reduce heat transfer.

TPL can maintain temperatures between 50°F (10°C) and 200°F (93°C). It provides a more constant tube temperature over a longer length than heavy traced designs.

It is suited for small diameter process lines such as those used for sampling and additives.

TPL is recommended for freeze protection of instrument impulse lines as well as the process lines for analyzers.

Model Number

Product Family
TPL1-Preinsulated Light Steam Traced Single Process Tube
TPL2-Preinsulated Light Steam Traced Dual Process Tubes

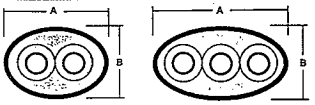
Process Tube
A2 1/4" x 0.035 wall welded 316ss
A3 3/8" x 0.035 wall welded 316ss
A4 1/2" x 0.035 wall welded 316ss
F1 1/8" x 0.035 wall seamless 316 ss
F2 1/4" x 0.035 wall seamless 316ss
F3 3/8" x 0.035 wall seamless 316ss
B4 1/2" x 0.049 wall seamless 316ss
J2 1/4" x 0.030 wall copper
C3 3/8" x 0.032 wall copper
D4 1/2" x 0.035 wall copper
G2 1/4" OD x 0.030 wall PFA Teflon®
G3 3/8" OD x 0.030 wall PFA Teflon
H4 1/2" OD x 0.062 wall PFA Teflon
MA6, 8, 10, 12 - 6, 8, 10 or 12mm OD x 1mm wall welded 316ss
MF6, 8, 10, 12 - 6, 8, 10 or 12mm OD x 1mm wall seamless 316ss
MD6, 8, 10, 12 - 6, 8, 10 or 12mm OD x 1mm wall copper
MG6, 8, 10, 12 - 6, 8, 10 or 12mm OD x 1mm wall PFA

Tracer
A2 1/4" x 0.035 wall welded 316ss
A3 3/8" x 0.035 wall welded 316ss
A4 1/2" x 0.035 wall welded 316ss
F2 1/4" x 0.035 wall seamless 316ss
F3 3/8" x 0.035 wall seamless 316ss
B4 1/2" x 0.049 wall seamless 316ss
J2 1/4" x 0.030 wall copper
C3 3/8" x 0.032 wall copper
D4 1/2" x 0.035 wall copper
MA6, 8, 10, 12 - 6, 8, 10 or 12mm OD x 1mm wall welded 316ss
MF6, 8, 10, 12 - 6, 8, 10, or 12mm OD x 1mm wall seamless 316ss
MD6, 8, 10, 12 - 6, 8, 10 or 12mm OD x 1mm wall copper

Example:
TPL2-A4-C3
Two 1/2" x 0.035 wall 316 SS welded process lines with a 3/8" x 0.032 wall copper tracer.

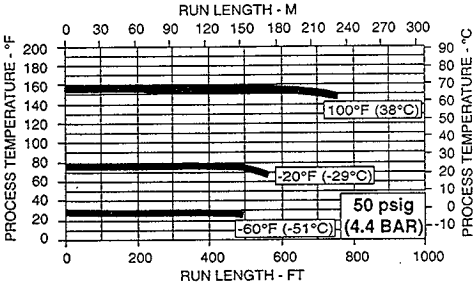
For specific information regarding each of these products, consult individual specification sheets.

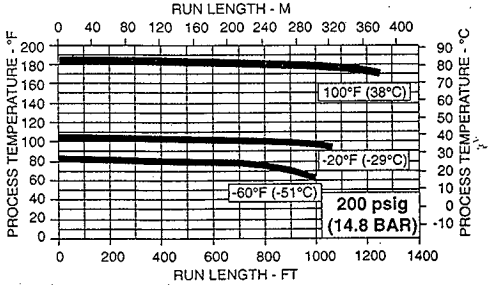
Dimensions	NOMINAL WT. LB/FT (KG/M)	NOMINAL DIMENSIONS - IN (CM) A	B
TPL1- One 3/8" Process with 3/8" Tracer	0.5 (0.74)	1.6 (4.1)	1.1 (2.8)
TPL1- One 1/2" Process with 3/8" Tracer	0.6 (0.89)	1.9 (4.8)	1.2 (3.0)
TPL1- One 1/2" Process with 1/2" Tracer	0.7 (1.04)	1.9 (4.8)	1.2 (3.0)
TPL2- Two 3/8" Process with 3/8" Tracer	0.6 (0.89)	2.3 (5.8)	1.2 (3.0)
TPL2- Two 1/2" Process with 3/8" Tracer	0.8 (1.19)	2.6 (6.6)	1.3 (3.3)
TPL2- Two 1/2" Process with 1/2" Tracer	0.9 (1.34)	2.6 (6.6)	1.3 (3.3)



TPL1 TPL2

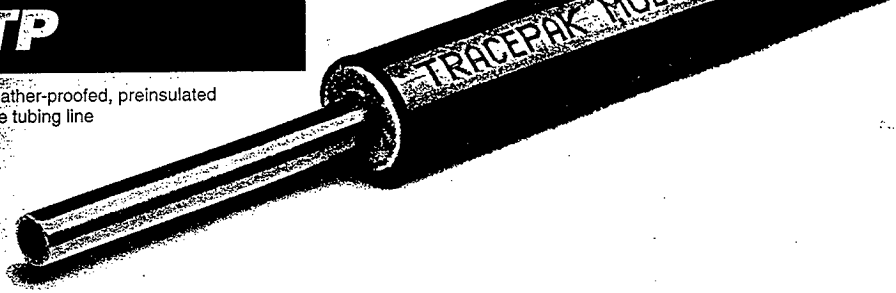
TWO 1/2" PROCESS LINES WITH 1/2" TRACER TYPICAL PERFORMANCE





TP

A weather-proofed, preinsulated single tubing line



TPS is designed specifically for liquid and gas transport lines where heat loss and personnel protection is important. TPS offers an inexpensive alternative to field insulation and weatherproofing of small lines.

Model Number

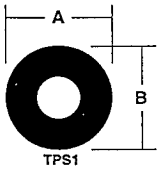
Product Family
TPS1-Preinsulated Single Process Tube

Process Tube
A2 1/4" x 0.035 wall welded 316ss
A3 3/8" x 0.035 wall welded 316ss
A4 1/2" x 0.035 wall welded 316ss
F2 1/4" x 0.035 wall seamless 316ss
F3 3/8" x 0.035 wall seamless 316ss
B4 1/2" x 0.049 wall seamless 316ss
J2 1/4" x 0.030 wall copper
C3 3/8" x 0.032 wall copper
D4 1/2" x 0.035 wall copper
MA6, 8, 10, 12 - 6, 8, 10 or 12mm OD x 1mm wall welded 316ss
MF6, 8, 10, 12 - 6, 8, 10 or 12mm OD x 1mm wall seamless 316ss
MD6, 8, 10, 12 - 6, 8, 10 or 12mm OD x 1mm wall copper

Example:
TPS1-C3
One preinsulated 3/8" x 0.032 wall copper process line.

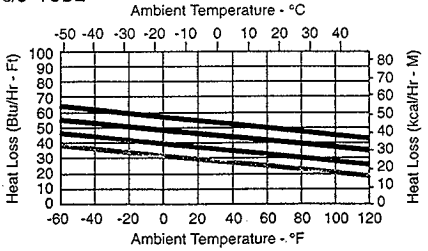
For specific information regarding each of these products, consult individual specification sheets.

Dimensions	NOMINAL WT. LB/FT (KG/M)	NOMINAL DIMENSIONS A - IN (CM)
TPS1- One 1/4" Process Line	0.2 (0.30)	1.0 (2.5)
TPS1- One 3/8" Process Line	0.3 (0.45)	1.1 (2.8)
TPS1- One 1/2" Process Line	0.4 (0.60)	1.2 (3.0)

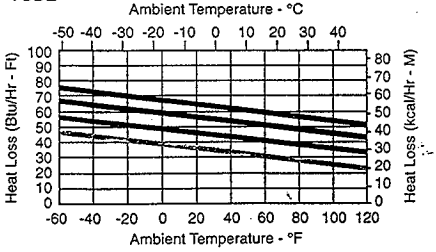


TPS1

3/8" TUBE

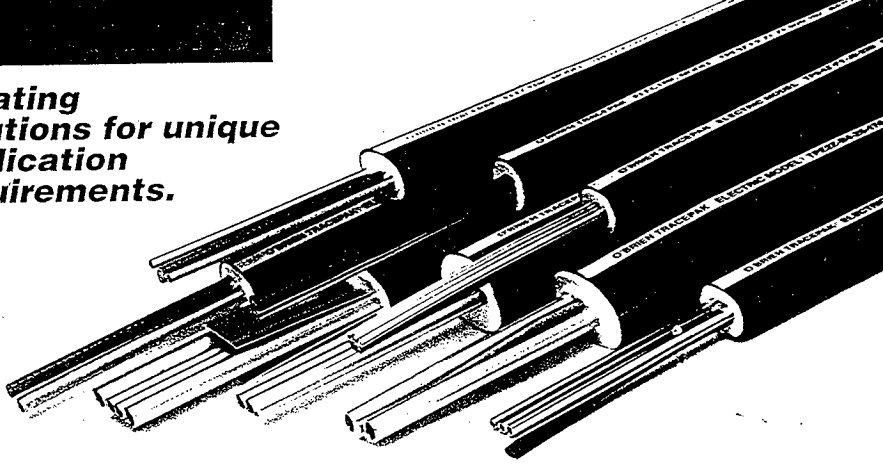


1/2" TUBE



200 psig (14.8 BAR) steam 388°F (198°C)
125 psig (9.6 BAR) steam 353°F (178°C)
50 psig (4.4 BAR) steam 299°F (148°C)
15 psig (2.0 BAR) steam 250°F (121°C)

Creating solutions for unique application requirements.



Continuous Emissions Monitoring Pharmaceutical & Semiconductor Cogeneration Process Analyzers

Standard TRACEPAK, pretraced and preinsulated tubing bundles are designed to solve your application problems. For other requirements, O'Brien will design and manufacture the appropriate tubing bundle. For example, some application requirements are best met by adding insulation rather than increasing the wattage or steam pressure.

Withstand High Intermittent Process Temperatures

By using insulation to buffer the standard self limiting tracer from the process tube, we can increase the maximum process exposure temperature limit and still provide freeze protection.

Communication Wires

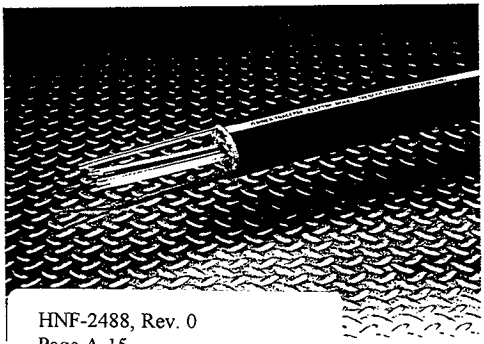
Communication, monitor and thermocouple wires may be added to the bundle as specified by the customer.

Maintain High Process Temperatures

Specialty tracers can be used to provide temperature maintenance up to and beyond 660°F (350°C). Depending on the specific tracer used, this product can also withstand process temperatures of 1000°F (538°C).

Meet Tubing Specifications

TRACEPAK can be manufactured with tubing that conforms to your requirements including exotic alloys, uncommon materials, odd sizes and coaxial tubing. For high purity applications, we can also supply tubing that has been cleaned for oxygen service and/or electro-polished.

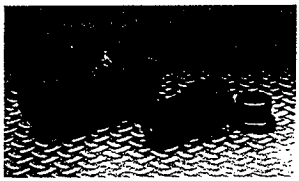


Sample Transport Bundles for Continuous Emissions Monitoring

Bundles with multiple process tubes, calibration gas supply tubes, tracers, communication wires and power wiring are designed to be in compliance with code. The sample transport bundle is developed to meet the needs of the application.

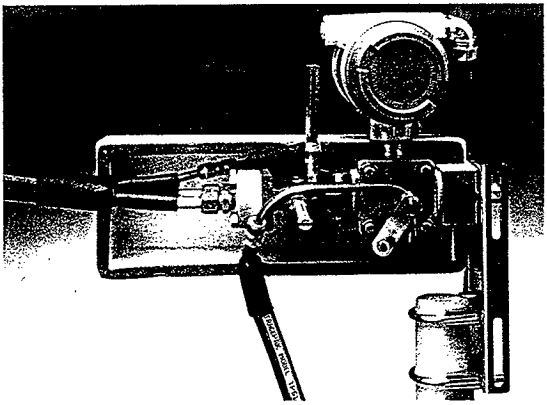
SEALING THE BUNDLE

Although TRACEPAK products use a non-hygroscopic, non-wicking insulation, all bundle ends must be sealed to prevent any possible moisture contamination.



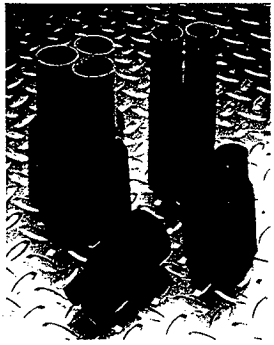
TPKES - Heat Shrink Entry Seal

The heat-shrinkable entry seal provides a waterproof fitting where TRACEPAK enters an enclosure. They can be added to parting line or surface mounted plates on VIPAK enclosures or any enclosure with up to a ½" (13mm) wall. The thermally stabilized, modified polyolefin entry seal consists of an O-ring assembly that seals at the enclosure and a heat-shrinkable nose that seals to the TRACEPAK bundle.



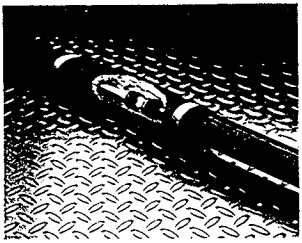
TPKHS - Heat Shrink Boots

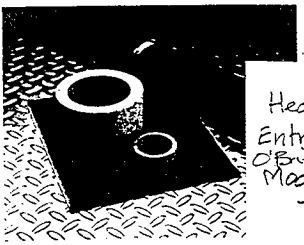
The heat-shrinkable boots provide a weatherproof end seal for TRACEPAK tubing bundles. They are made of thermally stabilized, modified polyolefin. Using a heat shrink end seal boot is recommended for all exposed ends. This installation will provide the best weather seal protection. The silicone end seal alone may be used to seal the end of the bundle inside of a VIPAK enclosure.



TPKJP - Jacket Patch

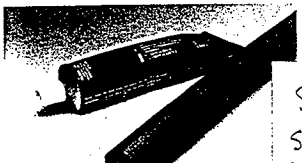
The jacket patch kits are used to seal a splice in a bundle or to extend the insulation and weatherproof jacket should the bundle be cut back too far during installation. They are used as a repair patch for any incidental field damage to bundles. The jacket patch kit is required with the optional line temperature sensing thermostat. Each kit contains thermal insulation, fiberglass tape and a self-sealing patch.





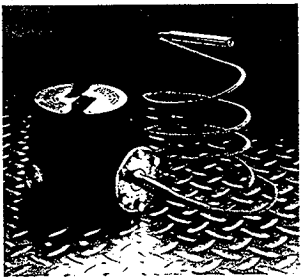
TPKSK - Silicone Sealant

This option is used to seal both ends of the tubing bundle from moisture. It is a black silicone RTV sealant. Cure time is approximately 24 hours at 77°F (25°C). Service temperature ranges from -50°F (-45°C) to 400°F (205°C). TPKSK offers excellent resistance to weather, oil and many chemicals.



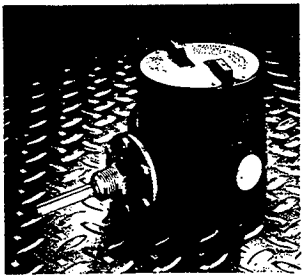
THERMOSTATS

When used with electrically traced tubing bundles, optional thermostats are used to control the temperature of the process tube or to turn on the heater at a specified ambient temperature.



Line Sensing

Line sensing thermostats directly control the temperature of the process tubes. They have an adjustable set point of 75°F (24°C) to 200°F (94°C). The capillary and bulb are stainless steel. The SPDT switch is rated for 15A at 120/240VAC. It is CSA certified and UL listed for Class I, Division 1 and 2, Groups B, C and D.



Ambient Sensing

This ambient sensing thermostat has an adjustable set point from 0°F (-18°C) to 100°F (38°C). The SPDT switch is rated for 15A at 120/240VAC. It is CSA certified and UL listed for Class I, Division 1 and 2, Groups B, C and D.

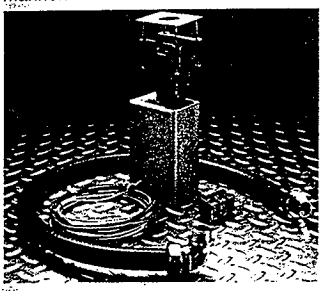
Note:
Models shown are typical of thermostats supplied. Units received may differ.

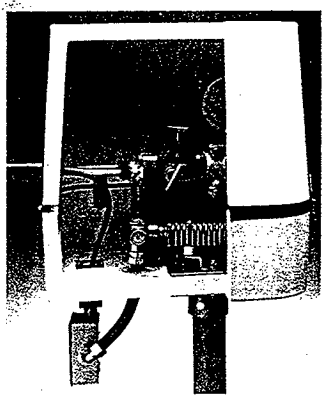
POWER CONNECTION AND TERMINATION KITS

These components are used to connect the electric tracer to the power source and terminate the non-powered ends in an approved manner.

PMKG-LE and PMKG-LE-CSA End Fitting

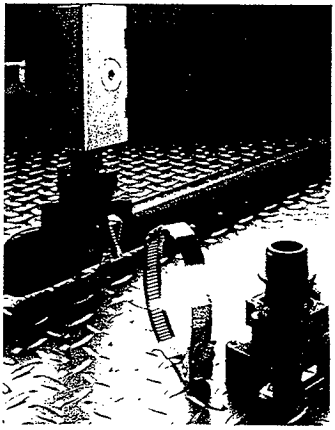
These end fittings are FM approved or CSA certified for XTV and BTV self-regulating tracer. They are NEMA 4X fittings and are used to terminate the non-powered end of the tracer. With a CENELEC accepted electric tracer the end fitting must be approved by the country of use.





LPD2 Combination Power Connection Kit

This power connection kit is used with E and LE series electric heaters. It incorporates FM approved and CSA certified components to provide a power connection assembly for the TPE tracer and the enclosure heater. When used with a VIPAK enclosure, the LPD2 provides the convenience of an external junction box with a 3/4" NPT connection.



PMKG-LP and PMKG-PC-CSA Power Connection Fittings

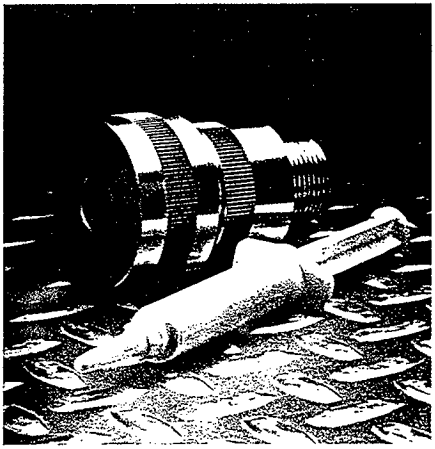
These fittings are used to power the tracer when the bundle is used by itself. They are also used when the bundle is powered from the end opposite the enclosure. They are FM approved or CSA certified for XTV or BTV self-regulating tracer. With a CENELEC accepted electric tracer the power fitting must be approved by the country of use.

TPC1 and PMKG-Y Combination Power Connection Kits

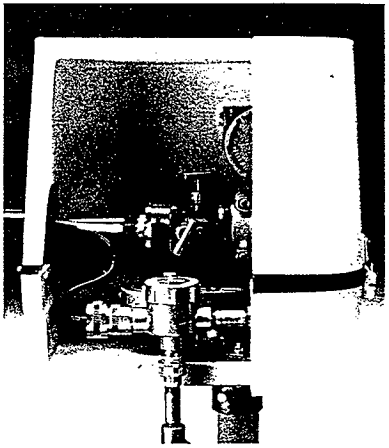
The TPC1 kit may be ordered alone or as part of a Div. 1, E or LE series heater. It is CSA certified for Division 1 applications.

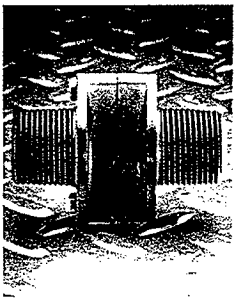
The PMKG-Y kit is ordered as part of a Div. 2, LE series heater. It is FM approved for Division 2 applications.

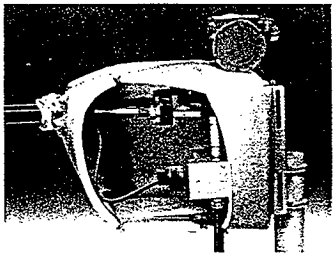
These kits are used with E and LE series heaters to power the tracer from the heater junction box in the instrument enclosure. If an outs junction box is not required, the provide the most economical an practical method of supplying po to the TRACEPAK tracer.



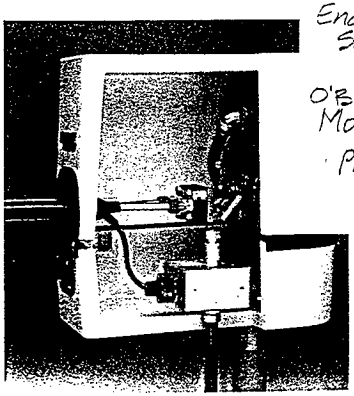
TPC1







PMKG-Y



TPE is designed to maintain freeze protection, close temperature tolerances or viscosity control. It provides an excellent means of maintaining very long, continuous lengths of impulse lines and piping at consistent temperatures end-to-end. TPE should be chosen when steam is not available or when the steam supply could be interrupted such as during shutdowns.

Use TPE if the allowable temperature ranges from 50°F (10°C) to 250°F (121°C). Because it is self regulating, this system will lower its heat output as the material gets warmer. When close temperature control is necessary, TPE can be utilized with an optional line sensing thermostat.

TPE offers a choice of two standard tracers. A high temperature tracer (XTV) is capable of maintaining temperatures of up to 250°F (121°C) and withstanding blowdown temperatures of 420°F (215°C). A low temperature tracer (BTV) will maintain temperatures up to 150°F (65°C) and withstand process temperatures of up to 185°F (85°C).

Other designs are available to maintain temperatures up to 660°F (350°C) and withstand 1000°F (538°C) blowdown conditions. Consult factory for specific design.

Electric tracer

Standard TPE-Self Regulating products utilize Chemelex® electric tracers. They are FM approved and CSA certified for use in hazardous areas when used with the recommended power connection kits.

CENELEC accepted approvals for Zone 1 and 2 heaters with T3 temperature limits are available.

The high temperature, Self Regulating XTV Tracer:

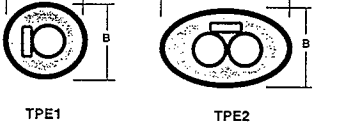
1. Withstands 420°F (215°C) intermittent blowdown temperatures.
2. Can maintain temperatures up to 250°F (121°C).

The low temperature Self Regulating BTV Tracer:

1. Withstands up to 185°F (85°C) blowdown temperatures.
2. Can maintain temperatures up to 150°F (65°C).

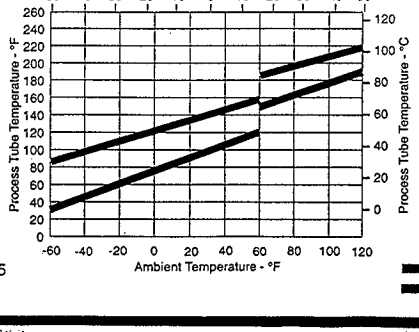
The choice between XTV and BTV must be made based on the desired performance and the conditions of the application. XTV and BTV are backed by a 10 year performance guarantee.

Dimensions	NOMINAL WT. LB/FT (KG/M)	NOMINAL DIMENSIONS - IN (CM) A	B
TPE1- One 1/4" Process Tubes	0.3 (0.45)	1.1 (2.8)	1.0 (2.5)
TPE1- One 3/8" Process Tubes	0.4 (0.60)	1.3 (3.3)	1.0 (2.5)
TPE1- One 1/2" Process Tubes	0.5 (0.74)	1.4 (3.6)	1.1 (2.8)
TPE2- Two 1/4" Process Tubes	0.4 (0.60)	1.3 (3.3)	1.1 (2.8)
TPE2- Two 3/8" Process Tubes	0.6 (0.89)	1.5 (3.8)	1.2 (3.0)
TPE2- Two 1/2" Process Tubes	0.8 (1.19)	1.7 (4.3)	1.4 (3.6)

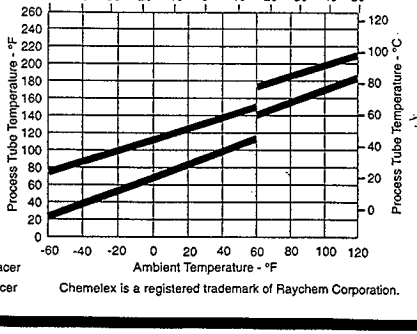


TPE1 TPE2

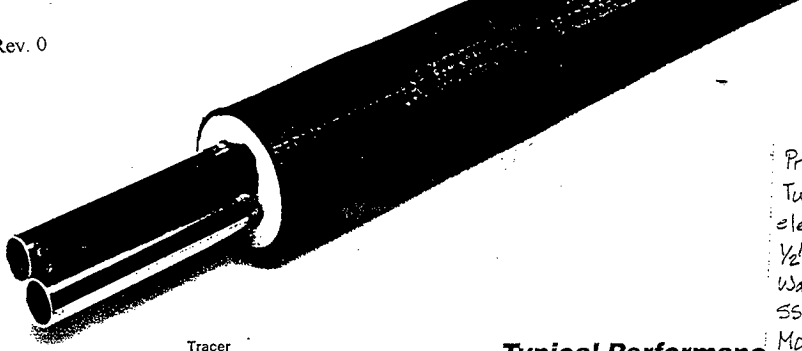
TPE1 - ONE 1/2" PROCESS LINE WITH XTV TRACER



TPE2 - TWO 1/2" PROCESS LINES WITH XTV TRACER



10 watt/ft Tracer
5 watt/ft Tracer



Prein
Tubi
electr
½" OD
wall,
SST
MODE
TPE

Model Number

Product Family

TPE1-Preinsulated Electrically Traced Single Process Tube

TPE2-Preinsulated Electrically Traced Dual Process Tubes

Process Tube

A2 1/4" x 0.035 wall welded 316ss
A3 3/8" x 0.035 wall welded 316ss
A4 1/2" x 0.035 wall welded 316ss
F1 1/8" x 0.035 wall seamless 316ss
F2 1/4" x 0.035 wall seamless 316ss
F3 3/8" x 0.035 wall seamless 316ss
B4 1/2" x 0.049 wall seamless 316ss
J2 1/4" x 0.030 wall copper
C3 3/8" x 0.032 wall copper
D4 1/2" x 0.035 wall copper
G2 1/4" OD x 0.030 wall PFA Teflon
G3 3/8" OD x 0.030 wall PFA Teflon
G2 1/4" OD x 0.030 wall PFA Teflon®
G3 3/8" OD x 0.030 wall PFA Teflon
H4 1/2" OD x 0.062 wall PFA Teflon
MA6, 8, 10, 12 - 6, 8, 10 or 12mm OD x 1mm wall welded 316ss
MF6, 8, 10, 12 - 6, 8, 10 or 12mm OD x 1mm wall seamless 316ss
MD6, 8, 10, 12 - 6, 8, 10 or 12mm OD x 1mm wall copper
MG6, 8, 10, 12 - 6, 8, 10 or 12mm OD x 1mm wall PFA

Tracer

XTV

B5 - 5 watt per foot self-regulating heater @50°F (10°C), 120 vac
B10 - 10 watt per foot self-regulating heater @50°F (10°C), 120 vac
N5 - 5 watt per foot self-regulating heater @50°F (10°C), 240 vac
N10 - 10 watt per foot self-regulating heater @50°F (10°C), 240 vac
MN4, 12 - 4 or 12 watt per foot @ 10°C, 220 vac

BTV

J5 - 5 watt per foot self-regulating heater @50°F (10°C), 120 vac
J8 - 8 watt per foot self-regulating heater @50°F (10°C), 120 vac
P5 - 5 watt per foot self-regulating heater @50°F (10°C), 240 vac
P8 - 8 watt per foot self-regulating heater @50°F (10°C), 240 vac
MP5, 8 - 5 or 8 watt per foot @ 10°C, 220vac

All tracers have a tinned copper shield and fluoropolymer outer jacket.
FM approved for Class I, II, III Div. 2 Gr. B, C, D, F, G.
CSA Certified for Class I, II Div. 1, 2 Gr. A, B, C, D, E, F, G.
CSA Certified for Class III Div. 2
MN and MP designated tracers are approved by CENELEC accepted agencies.

Typical Performanc

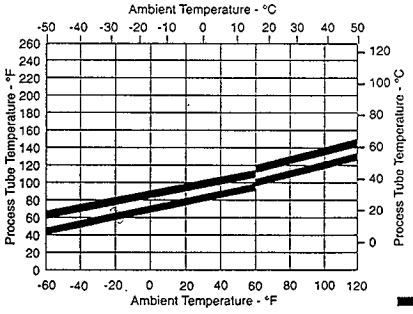
Each graph shows typical performance splitting summer/winter ambients. Each line is separated at 60°F (16°C) to designate the seasonal differences.

Winter ambients, below 60°F (16°C), assume a 25 mph (40 Km/H) wind and summer ambients, above 60°F (16°C), assume a 10 mph (16 Km/H) wind. For freeze protection, use 50°F (10°C) as the minimum allowable process tube temperature. This will provide a sufficient factor of safety.

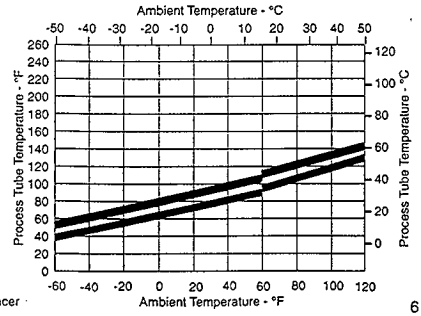
Example:
TPE2-A4-B5
Two 1/2" x 0.035 wall 316 SS welded process lines with a 5 watt/foot tracer.

For specific information regarding each of these products, consult individual specification sheets.

TPE1 - ONE 1/2" PROCESS LINE WITH **BTV** TRACER

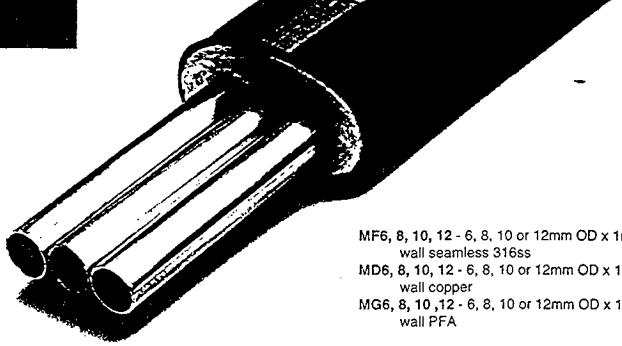


TPE2 - TWO 1/2" PROCESS LINES WITH **BTV** TRACER



8 watt/ft Tracer
5 watt/ft Tracer

A preinsulated tubing bundle with heavy steam tracing



TPH is recommended for use on impulse lines for instrumentation, process lines for analyzers, sampling, additives and other small process lines where higher temperature maintenance is necessary. It is especially important for viscosity control.

Heavy tracing keeps the process tubing in direct contact with the tracer and maintains higher process temperatures.

Model Number

Product Family
TPH1-Preinsulated Heavy Steam Traced Single Process Tube
TPH2-Preinsulated Heavy Steam Traced Dual Process Tubes

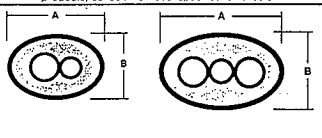
Process Tube
A2 1/4" x 0.035 wall welded 316ss
A3 3/8" x 0.035 wall welded 316ss
A4 1/2" x 0.035 wall welded 316ss
F1 1/8" x 0.035 wall seamless 316 ss
F2 1/4" x 0.035 wall seamless 316ss
F3 3/8" x 0.035 wall seamless 316ss
B4 1/2" x 0.049 wall seamless 316ss
J2 1/4" x 0.030 wall copper
C3 3/8" x 0.032 wall copper
D4 1/2" x 0.035 wall copper
G2 1/4" OD x 0.030 wall PFA Teflon
G3 3/8" OD x 0.030 wall PFA Teflon
H4 1/2" OD x 0.062 wall PFA Teflon
MA6, 8, 10, 12 - 6, 8, 10 or 12mm OD x 1mm wall welded 316ss
MF6, 8, 10, 12 - 6, 8, 10 or 12mm OD x 1mm wall seamless 316ss
MD6, 8, 10, 12 - 6, 8, 10 or 12mm OD x 1mm wall copper
MG6, 8, 10 ,12 - 6, 8, 10 or 12mm OD x 1mm wall PFA

Tracer
A2 1/4" x 0.035 wall welded 316ss
A3 3/8" x 0.035 wall welded 316ss
A4 1/2" x 0.035 wall welded 316ss
F2 1/4" x 0.035 wall seamless 316ss
F3 3/8" x 0.035 wall seamless 316ss
B4 1/2" x 0.049 wall seamless 316ss
J2 1/4" x 0.030 wall copper
C3 3/8" x 0.032 wall copper
D4 1/2" x 0.035 wall copper
MA6, 8, 10, 12 - 6, 8, 10 or 12mm OD x 1mm wall welded 316ss
MF6, 8, 10, 12 - 6, 8, 10 or 12mm OD x 1mm wall seamless 316ss
MD6, 8, 10, 12 - 6, 8, 10 or 12mm OD x 1mm wall copper

Example:
TPH2-A4-C3
Two 1/2" x 0.035 wall 316 SS welded process lines with a 3/8" x 0.032 wall copper tracer.

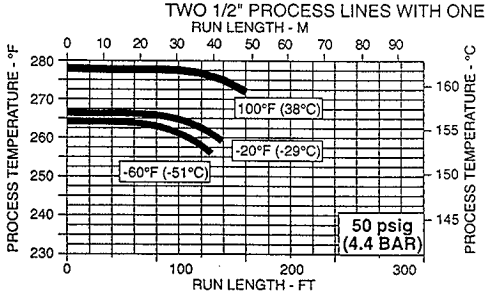
For specific information regarding each of these products, consult individual specification sheets.

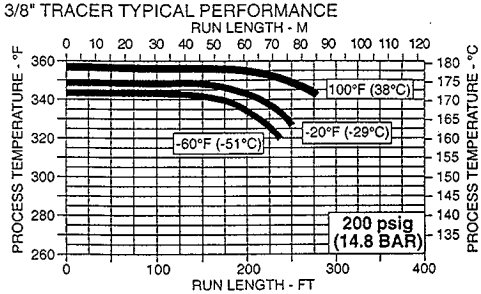
Dimensions	NOMINAL WT. LB/FT (KG/M)	NOMINAL DIMENSIONS - IN (CM) A	B
TPH1- One 3/8" Process with 3/8" Tracer	0.5 (0.74)	1.5 (3.8)	1.2 (3.0)
TPH1- One 1/2" Process with 3/8" Tracer	0.6 (0.89)	1.6 (4.1)	1.2 (3.0)
TPH1- One 1/2" Process with 1/2" Tracer	0.7 (1.04)	1.7 (4.3)	1.2 (3.0)
TPH2- Two 3/8" Process with 3/8" Tracer	0.6 (0.89)	2.0 (5.1)	1.2 (3.0)
TPH2- Two 1/2" Process with 3/8" Tracer	0.7 (1.04)	2.1 (5.4)	1.2 (3.0)
TPH2- Two 1/2" Process with 1/2" Tracer	0.8 (1.19)	2.2 (5.6)	1.2 (3.0)



TPH1 TPH2

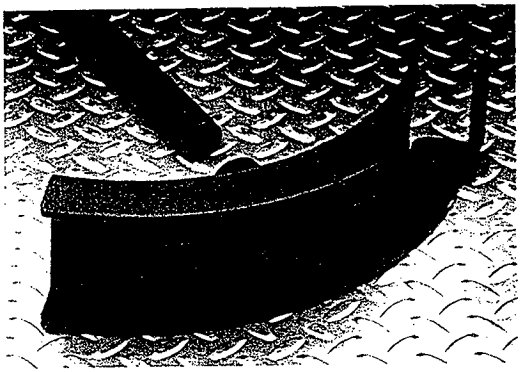
TWO 1/2" PROCESS LINES WITH ONE 3/8" TRACER TYPICAL PERFORMANCE





INSTALLATION TOOLS

TRACEPAK is designed to be installed using standard bending tools. We have designed two special tools that make installation of TRACEPAK tube bundles easier and more compact.

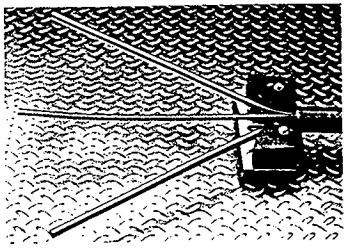


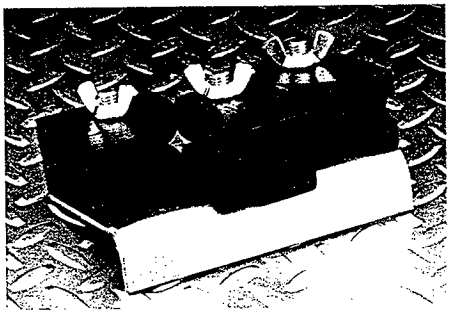
Bundle Bending Tool

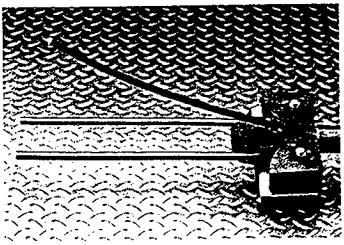
Similar to a common electrical conduit bender, this tool is compact and easy to use. It eliminates the need for larger and heavier benders that have the required 8" minimum bending radius.

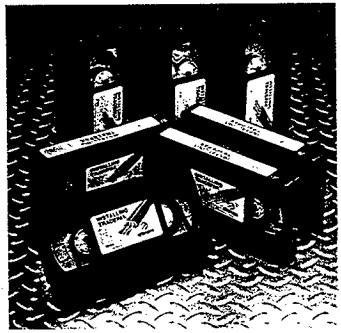
2⅛" Centerline Tool

A replacement for the standard tube bender, it brings the process tubes to the correct centerline for connecting to typical transmitters. This tool makes back-to-back bends easier accomplishing the bends in a much shorter distance than possible with a standard tube bender.









Installation Video

Informative, current information on the installation of TRACEPAK tubing bundles. The video deals with general installation procedures and gives a good overview of the products and accessories available to complement and complete the total 'PAK'age.

MATERIAL SPECIFICATIONS

The following specifications apply to all members of the TRACEPAK family.

JACKET

Thermoplastic Polyether Urethane Elastomer

Hydrolytically Stabilized

Halogen Free

Abrasion Resistance

UV Resistant

Low Temperature Flexibility

INSULATION

Fibrous Glass

Water Soluble Chlorides less than 100 ppm.

Non-hygroscopic

TUBING

OD	WALL	CONSTRUCTION AND MATERIAL	ASTM
1/4"	0.035	welded 316ss	A-269
3/8"	0.035	welded 316ss	A-269
1/2"	0.035	welded 316ss	A-269
1/4"	0.035	seamless 316ss	A-269
3/8"	0.035	seamless 316ss	A-269
1/2"	0.049	seamless 316ss	A-269
1/4"	0.030	copper	B-68, B-75
3/8"	0.032	copper	B-68, B-75
1/2"	0.035	copper	B-68, B-75
1/4"	0.030	1/4" OD PFA	
3/8"	0.030	3/8" OD PFA	
1/2"	0.062	1/2" OD PFA	
6mm	1mm	welded 316ss	A-269
8mm	1mm	welded 316ss	A-269
10mm	1mm	welded 316ss	A-269
12mm	1mm	welded 316ss	A-269
6mm	1mm	seamless 316ss	A-269
8mm	1mm	seamless 316ss	A-269
10mm	1mm	seamless 316ss	A-269
12mm	1mm	seamless 316ss	A-269
6mm	1mm	copper	B-68, B-75
8mm	1mm	copper	B-68, B-75
10mm	1mm	copper	B-68, B-75
12mm	1mm	copper	B-68, B-75
6mm	1mm	1/4" OD PFA	
8mm	1mm	3/8" OD PFA	
10mm	1mm	1/2" OD PFA	
12mm	1mm	1/2" OD PFA	

Tubing meeting NACE MR-01-75-90 and ASTM A-213-EAW specifications are also stocked. Consult factory for the availability of these as well as other materials and specifications.

TEMPERATURE LIMITS

Minimum installation temperature
-40°F (-40°C)

Maximum jacket surface temperature
140°F (60°C) at ambient temperature of 80°F (27°C) with maximum process or tracer tube temperature.

Maximum process tube temperature
TPH, TPL and TPS
400°F (204°C)*
TPE
Continuous exposure power on.
XTV 250°F (121°C)*
BTV 150°F (65°C)*

Intermittent exposure power on or off.
XTV 420°F (215°C)*
BTV 185°F (85°C)*

Maximum TPE tracer temperature
XTV T-rating T2C, 446°F (230°C)
BTV T-rating T6, 185°F (85°C)

*Consult Factory for Higher Temperature Limits.

Customer Service

Customer service takes on a whole new meaning at O'Brien Corporation. Our reputation as a customer-oriented problem solver has been long recognized.

O'Brien's customer-oriented approach offers these benefits:

- responsive, knowledgeable personnel
- unparalleled delivery service
- dependable, tested results of all product lines
- in-house stock of hard -to-find materials

ISO9000 & CANZ299 Unparalleled Quality

Certified to current ISO 9000 and CAN Z299 standards. Our adherence to recognized international quality standards provides one of the strongest assurances of product and service quality available.

Total solution

From Instrument to Process Line: Working together, we can develop installation details. Our total engineering package will reduce field installation costs and provide a dependable solution for your needs.

O'Brien Corporation now provides a product for any installation.

SADDLEPAK HEATPAK VIPAK FLEXPAK TRACEPAK

O'BRIEN

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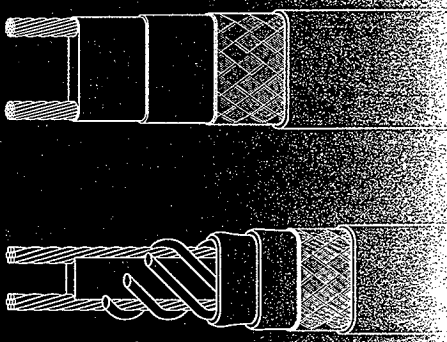
APPENDIX B

17 PAGES

Design Guide for Insulated Pipes and Tubing

Auto-Trace® Heat-Tracing Systems for Ordinary and Division 2 Areas



CHEMELEX®

How to Select and Design the Heat-Tracing System:

This guide outlines a simple procedure for designing and selecting a complete heat-tracing system using Auto-Trace BTV, QTVR, or XTV heating cables.

By following the design steps in the seven sections, a bill of materials can be easily produced which includes the heating cable type, length, components, and accessories needed to install the Auto-Trace heat-tracing system correctly. Use the Design Worksheet and Bill of Materials Summary at the end of this guide to record the design and bill of materials.

Computer-aided Design Speeds Selection

To speed the design and selection of a Chemelex Auto-Trace heat-tracing system, the Chemelex TraceCalc® computer program is also available. TraceCalc runs on IBM-PC or compatible computers and calculates heat loss, circuit loading, breaker sizing, and other required design information. The program produces a complete bill of materials, design summary, and line list in minutes.

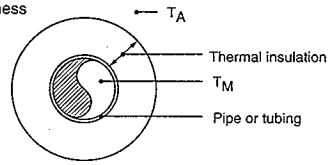
For a TraceCalc demonstration, contact the nearest Chemelex representative or Raychem field sales office (see back cover).

1.0 Thermal Design

To calculate the heat loss that must be replaced by the heating cable, determine:

- T_M: Maintenance temperature (°F)
- T_A: Minimum expected ambient temperature (°F)
- T_E: Maximum intermittent exposure temperature (°F)
- Pipe or tubing size
- Thermal insulation type and thickness

Example:
T_M: 40°F (water freeze protection)
T_A: -40°F
T_E: 366°F (150 psig steam cleaning)
Pipe size: 6" steel
Insulation: 2 1/2" calcium silicate



Step 1. Calculate temperature differential.

$\Delta T = T_M - T_A$
Calculate ΔT $= T_M - T_A$
$= 40°F - (-40°F)$
$\Delta T = 80°F$

Step 2. Determine pipe heat loss.

Note: Heat loss calculations are based on IEEE Std. 515-1989, Equation 1, page 19.

Note: Heat losses for valves and pipe supports are addressed in Section 3.0, Step 1.

From Chart 1, match the pipe size and insulation thickness with the temperature differential ΔT to find the base heat loss of the pipe (Q_B).

From Chart 1, for 6" pipe, with 2 1/2" insulation and $\Delta T = 80°F$, Q_B must be calculated through interpolation. For this example 80 is 30/50 of the way between 50° and 100°:

$Q_B = 3.6$ W/ft + 30/50 x (7.4 - 3.6)
$= 3.6 + 2.3$
$Q_B = 5.9$ W/ft @ $T_M = 40°F$

Step 3. Compensate for insulation type.

Multiply the base heat loss of the pipe (Q_B) from Step 2 by the insulation compensation factor (f) from the bottom of Chart 1 to get the actual heat loss per foot of pipe (Q_T).

$Q_T = Q_B \times f$

From Chart 1, f = 1.50 for calcium silicate:

$Q_T = Q_B \times f$
$= 5.9$ W/ft x 1.50
$Q_T = 8.9$ W/ft @ 40°F

Chart 1 Pipe Heat Loss (watts per foot)

Insulation Thickness	ΔT (°F)	Pipe Diameter (IPS) in inches: 1/4	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2
		Tubing Size (inches):	3/4	1	1 1/4	1 1/2	2		
0.5"	50	1.9	2.5	2.9	3.5	4.1	4.6	5.5	6.5
	100	3.9	5.2	6.1	7.2	8.6	9.6	11.5	13.5
	150	6.1	8.1	9.5	11.2	13.4	14.9	17.9	21.1
	200	8.5	11.3	13.2	15.6	18.6	20.7	24.9	29.2
1.0"	50	1.3	1.6	1.9	2.2	2.5	2.8	3.2	3.8
	100	2.7	3.4	3.9	4.5	5.2	5.8	6.8	7.8
	150	4.2	5.3	6.1	7.0	8.2	9.0	10.6	12.2
	200	5.8	7.4	8.4	9.7	11.3	12.4	14.6	16.9
	250	7.6	9.7	11.0	12.7	14.8	16.3	19.1	22.1
1.5"	50	1.1	1.3	1.5	1.7	1.9	2.1	2.4	2.8
	100	2.2	2.8	3.1	3.5	4.0	4.4	5.1	5.8
	150	3.5	4.3	4.8	5.5	6.3	6.9	8.0	9.1
	200	4.8	5.9	6.7	7.6	8.7	9.5	11.0	12.6
	250	6.3	7.8	8.7	9.9	11.4	12.4	14.4	16.5
	300	7.9	9.7	11.0	12.4	14.3	15.6	18.1	20.6
	350	9.6	11.9	13.3	15.1	17.4	19.0	22.0	25.1
2.0"	50	0.9	1.1	1.3	1.4	1.6	1.8	2.0	2.3
	100	2.0	2.4	2.7	3.0	3.4	3.7	4.2	4.8
	150	3.1	3.7	4.2	4.7	5.3	5.8	6.6	7.5
	200	4.3	5.2	5.8	6.5	7.4	8.0	9.2	10.4
	250	5.6	6.8	7.5	8.5	9.6	10.4	12.0	13.5
	300	7.0	8.5	9.4	10.6	12.1	13.1	15.0	17.0
	350	8.5	10.3	11.5	12.9	14.7	15.9	18.2	20.6
2.5"	50	0.9	1.0	1.2	1.3	1.4	1.6	1.8	2.0
	100	1.8	2.2	2.4	2.7	3.0	3.3	3.7	4.2
	150	2.8	3.4	3.7	4.2	4.7	5.1	5.8	6.5
	200	3.9	4.7	5.2	5.8	6.5	7.0	8.0	9.0
	250	5.1	6.1	6.8	7.6	8.5	9.2	10.5	11.7
	300	6.4	7.7	8.5	9.5	10.7	11.5	13.1	14.7
	350	7.8	9.3	10.3	11.5	13.0	14.0	15.9	17.9
3.0"	50	0.8	1.0	1.1	1.2	1.3	1.4	1.6	1.8
	100	1.7	2.0	2.2	2.4	2.7	2.9	3.3	3.7
	150	2.6	3.1	3.4	3.8	4.3	4.6	5.2	5.8
	200	3.6	4.3	4.8	5.3	5.9	6.4	7.2	8.0
	250	4.8	5.7	6.2	6.9	7.8	8.3	9.4	10.5
	300	6.0	7.1	7.8	8.7	9.7	10.4	11.8	13.2
	350	7.3	8.6	9.5	10.5	11.8	12.7	14.3	16.0
4.0"	50	0.7	0.9	0.9	1.0	1.1	1.2	1.4	1.5
	100	1.5	1.8	2.0	2.1	2.4	2.5	2.9	3.2
	150	2.4	2.8	3.0	3.4	3.7	4.0	4.4	4.9
	200	3.3	3.9	4.2	4.6	5.2	5.5	6.2	6.8
	250	4.3	5.1	5.5	6.1	6.7	7.2	8.1	8.9
	300	5.4	6.3	6.9	7.6	8.5	9.0	10.1	11.2
	350	6.6	7.7	8.4	9.3	10.3	11.0	12.3	13.6

Insulation Factors

Preformed Pipe Insulation	Insulation Factor (f)	K factor @ 50°F (BTU/hr-°F-ft²/ in)
Glass Fiber (ASTM C547)	1.00	.25
Calcium Silicate (ASTM C533)	1.50	.375
Cellular Glass (ASTM C552)	1.60	.40
Rigid Cellular Urethane (ASTM C591)	0.66	.165
Foamed Elastomer (ASTM C534)	1.16	.29
Mineral Fiber Blanket (ASTM C553)	1.20	.30
Expanded Perlite (ASTM C610)	1.50	.375

3	3 1/2	4	6	8	10	12	14	16	18	20	24
7.7	8.6	9.6	13.6	17.4	21.4	25.2	27.5	31.3	35.0	38.8	46.2
16.0	18.0	20.0	28.4	36.3	44.6	52.5	57.4	65.2	73.0	80.8	96.3
25.0	28.1	31.2	44.3	56.6	69.6	81.9	89.5	101.7	113.8	126.0	150.2
34.6	39.0	43.3	61.5	78.6	96.6	113.6	124.2	141.1	158.0	174.8	208.5
4.4	4.9	5.4	7.5	9.4	11.5	13.5	14.7	16.6	18.6	20.5	24.4
9.1	10.2	11.2	15.6	19.7	24.0	28.1	30.6	34.7	38.7	42.8	50.9
14.2	15.9	17.5	24.3	30.7	37.4	43.8	47.8	54.1	60.4	66.7	79.4
19.7	22.0	24.2	33.7	42.5	51.9	60.7	66.2	75.0	83.8	92.5	110.0
25.8	28.7	31.7	44.0	55.6	67.9	79.4	86.6	98.1	109.6	121.0	143.9
3.2	3.6	3.9	5.3	6.7	8.1	9.4	10.2	11.5	12.9	14.2	16.8
6.7	7.4	8.1	11.1	13.9	16.8	19.6	21.3	24.0	26.8	29.5	35.0
10.5	11.6	12.7	17.3	21.6	26.2	30.5	33.2	37.5	41.8	46.1	54.6
14.5	16.1	17.6	24.0	30.0	36.3	42.3	46.0	52.0	57.9	63.8	75.7
19.0	21.0	23.0	31.4	39.2	47.5	55.3	60.2	68.0	75.7	83.5	99.0
23.8	26.3	28.8	39.3	49.2	59.6	69.3	75.4	85.1	94.9	104.6	124.0
28.9	32.0	35.0	47.8	59.8	72.4	84.3	91.7	103.5	115.4	127.2	150.8
2.6	2.9	3.1	4.2	5.2	6.3	7.3	7.9	8.9	9.9	10.9	12.9
5.5	6.0	6.6	8.8	10.9	13.1	15.2	16.5	18.6	20.7	22.8	26.9
8.5	9.4	10.2	13.8	17.0	20.5	23.8	25.8	29.0	32.3	35.5	42.0
11.8	13.0	14.2	19.1	23.6	28.4	32.9	35.7	40.2	44.7	49.2	58.2
15.5	17.0	18.5	24.9	30.9	37.2	43.1	46.7	52.6	58.5	64.3	76.1
19.4	21.3	23.2	31.2	38.7	46.6	54.0	58.6	65.9	73.3	80.6	95.3
23.6	25.9	28.3	38.0	47.1	56.6	65.6	71.2	80.2	89.1	98.1	115.9
2.3	2.5	2.7	3.6	4.4	5.2	6.1	6.6	7.4	8.2	9.0	10.6
4.7	5.2	5.6	7.4	9.1	10.9	12.6	13.7	15.3	17.0	18.7	22.0
7.4	8.1	8.7	11.6	14.2	17.0	19.7	21.3	23.9	26.5	29.1	34.3
10.2	11.2	12.1	16.1	19.7	23.6	27.2	29.5	33.1	36.7	40.3	47.5
13.3	14.6	15.8	21.0	25.8	30.9	35.6	38.6	43.3	48.0	52.8	62.2
16.7	18.3	19.8	26.3	32.3	38.7	44.6	48.4	54.3	60.2	66.1	77.9
20.3	22.2	24.1	32.0	39.3	47.1	54.3	58.8	66.0	73.2	80.4	94.7
2.0	2.2	2.4	3.1	3.8	4.5	5.2	5.6	6.3	7.0	7.6	9.0
4.2	4.6	4.9	6.5	7.9	9.4	10.8	11.7	13.1	14.5	15.9	18.7
6.6	7.1	7.7	10.1	12.4	14.7	16.9	18.3	20.5	22.6	24.8	29.2
9.1	9.9	10.7	14.0	17.1	20.4	23.4	25.3	28.3	31.4	34.4	40.4
11.9	12.9	14.0	18.3	22.4	26.6	30.6	33.1	37.1	41.0	45.0	52.8
14.9	16.2	17.5	23.0	28.1	33.4	38.4	41.5	46.5	51.4	56.3	66.2
18.1	19.7	21.3	28.0	34.1	40.6	46.7	50.5	56.5	62.5	68.5	80.5
1.7	1.8	2.0	2.5	3.1	3.6	4.1	4.4	5.0	5.5	6.0	7.0
3.5	3.8	4.1	5.3	6.4	7.5	8.6	9.3	10.3	11.4	12.4	14.5
5.5	6.0	6.4	8.3	10.0	11.8	13.4	14.5	16.1	17.8	19.4	22.7
7.6	8.3	8.9	11.4	13.8	16.3	18.6	20.0	22.3	24.6	26.9	31.4
10.0	10.8	11.6	15.0	18.1	21.3	24.3	26.2	29.2	32.2	35.2	41.1
12.5	13.5	14.6	18.8	22.6	26.7	30.5	32.8	36.6	40.3	44.1	51.5
15.2	16.5	17.7	22.8	27.5	32.4	37.1	39.9	44.5	49.0	53.6	62.6

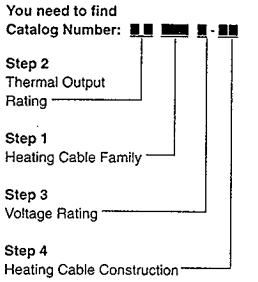
Pipe heat loss (Q_p) is shown in watts per foot. Heat loss calculations are based on IEEE Std. 515-1989, Equation 1, Page 19, with the following provisions:

- pipes insulated with glass fiber in accordance with ASTM C547
- pipes located outdoors in a 20 mph wind
- no insulating air-space assumed between pipe and insulation
- no insulating air-space assumed between the insulation and outer cladding
- a 10% safety factor has been included

2.0 Heating Cable Selection

To select the heating cable catalog number, determine:

- T_M: Maintenance temperature (°F)
- T_E: Maximum intermittent exposure temperature (°F)
- Q_T: Actual heat loss per foot of pipe at T_M
- Service voltage
- Electrical area classification
- Chemical environment



Example (continued from page1):
T_M = 40°F (water freeze protection)
T_E = 366°F (150 psig steam cleaning)
Q_T = 8.9 W/ft @ 40°F
Service voltage: 120 volts
Electrical area classification: Hazardous (classified), CID2
Chemical environment: Corrosive

Step 1. Select the heating cable family.

Considering the maximum intermittent exposure temperature (T_E) and the maintenance temperature (T_M), select the appropriate Auto-Trace heating cable family.

Note: The heating cable selection section is for BTV, QTVR, and XTV heating cables in, base, -CR and -CT versions for Ordinary and Division 2 hazardous areas only. For other products or applications consult the factory or the Chemelex representative.

	BTV	QTVR	XTV
Maximum maintenance (T_M) or continuous exposure-power on			
	150°F (65°C)	225°F (110°C)	250°F*(121°C)
Maximum continuous exposure-power off			
	150°F (65°C)	225°F (110°C)	370°F (187°C)
Maximum intermittent exposure (T_E) up to 1000 cumulative hours -power on			
	185°F (85°C)	225°F (110°C)	420°F (215°C)
T-rating (Table 500-3 (b) of National Electrical Code, 1990)			
	T6,185°F (65°C)	T4, 275°F (135°C)	T2C, 446°F (230°C) [T3 (392°F, 200°C) product available on request]

** If during normal operation the pipe temperature is expected to exceed 250° F (121°C), thermostatic control is required. To estimate pipe temperature, use Chemelex TraceCalc or call the Chemelex representative.*

Heating cable family selection: For intermittent exposure to 366°F (185°C), select XTV.

Heating cable family: XTV

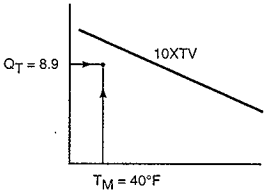
Catalog number: ■■ XTV ■ - ■■

Step 2. Select the thermal output rating.

From Chart 3a or 3b, match the actual heat loss per foot of pipe (Q_T) with the maintenance temperature (T_M), and select the thermal output ratings for which the rating at T_M equals or exceeds Q_T.

From Chart 3b, 10XTV exceeds 8.9 W/ft at 40°F. Select 10XTV.

Thermal output rating: 10
Catalog number: 10XTV■ - ■■



If the heat loss Q_T is in between the two heating cable thermal output curves, select the higher rated heating cable. If the heat loss Q_T is greater than the thermal output of the highest rated heating cable you can:

a) use thicker insulation
b) use insulation material with a lower K factor
c) use two or more heating cables run in parallel
d) spiral the heating cable

Note: If plastic pipe is used, see Chart 4 for BTV thermal output adjustment factors. Auto-Trace QTVR and XTV are not recommended for plastic pipe applications as they may exceed the temperature rating of the pipe material.

Spiraling: If spiraling is elected, determine the spiral factor according to the following formula:

$$\text{Spiral factor (length of heating cable/foot of pipe)} = \frac{Q_T}{\text{Heater thermal output at } T_M}$$

When the spiral factor exceeds 1.6 or the pipe size is less than 3 IPS, consider using two or more heating cables run in parallel.

Step 3. Select the voltage rating.

Service voltage options:
1 ≡ 120 volts (100-130 Vac)
2 ≡ 240 volts (200-277 Vac)

Available service voltage: 120 volts.
Select 120-volt version of 10XTV.

Voltage rating: 1
Catalog number: 10XTV1-■■

Note: If the service voltage is 208 or 277 volts, multiply the thermal output rating of the 240 volt heating cable by the appropriate power output factor in Chart 7. This will give the adjusted power output at the service voltage.

Step 4 Select the heating cable options.

Select the appropriate heating cable options from Chart 2 considering the electrical area classification and chemical environment.

Whenever a heating cable with braid (ground path) and outer jacket is selected, -CT (or -CR for BTV heating cables) is added to the catalog number.

Note: This example is continued on page 12 for metal pipes. For plastic pipes, use the example on page 10.

From Chart 2, -CT is indicated for hazardous (classified) CID2 areas and for exposure to corrosive chemicals. Select the -CT options of 10XTV1.

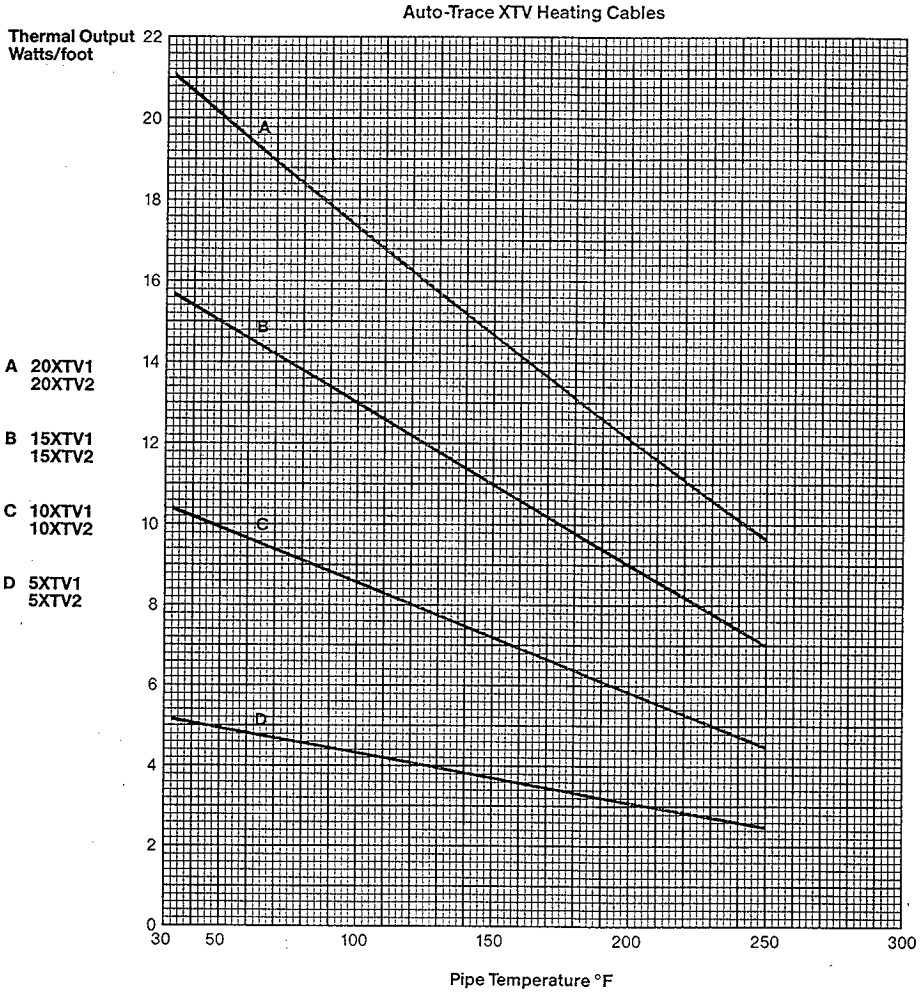
Heating cable option: -CT
Catalog number: 10XTV1-CT

Chart 2 Chemelex Auto-Trace Heating Cable Options

Heating Cable Options	Base	-CR	-CT
Area Classification:			
Hazardous [1]		•	•
Ordinary	•	•	•
Heat-traced Surface Type:			
Carbon Steel	•	•	•
Stainless Steel	•	•	•
Plastic		•	•
Painted		•	•
Chemical Resistance:[2]			
Organics and Corrosives			•
Mild Inorganic Solutions	•	•	•
Improved Mechanical Protection		•	•
Ground Path for Electrical Protection [3]		•	•

1 For FM approvals and CSA certifications see Section 5.0, Approvals for area classification.
2 Heating cables are not recommended for continuous exposure. For strong corrosives and organics consult Chemelex.
3 NEC Section 427-22, 1990 requires a Ground Fault Equipment Protection Device for supplying electric heating equipment not having a metal covering.

Chart 3b Thermal Output Ratings on Insulated Metal Pipes



Note: Watts/foot x 3.28 = Watts/meter
(°F−32) x 5/9 = °C

BTV Heating Cable Selection for Insulated Plastic Pipes

BTV heating cable with braid and outer jacket is ideal for heat-tracing plastic pipes.

However, increased resistance to heat transfer from the heating cable to the plastic pipe necessitates compensation of its thermal output. Aluminum tape may be used to increase the thermal output of BTV heating cables on plastic pipes. For tape specifications, see Chart 9.

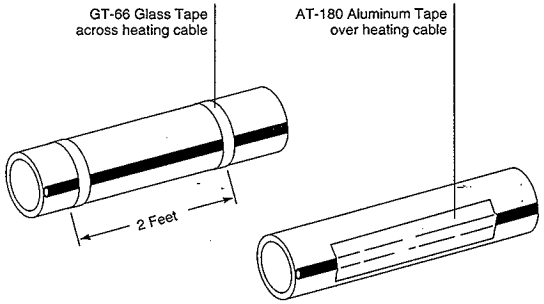
The thermal output adjustment factors for typical applications are shown below.

Chart 4 Thermal Output Adjustment Factors

Pipe Wall Thickness 0.250" or Less*

-CT or -CR Heating Cable	Glass Tape Across Heating Cable	Aluminum Tape Over Heating Cable
3BTV1	0.55	0.80
3BTV2	0.60	0.75
5BTV1	0.55	0.75
5BTV2	0.50	0.75
8BTV1	0.50	0.70
8BTV2	0.45	0.65
10BTV1	0.40	0.60
10BTV2	0.45	0.70

**Equivalent to a 3 1/2" schedule 40 PVC pipe. For greater pipe wall thickness consult the factory or the Chemelex representative.*



BTV Heating Cable Selection for Insulated Plastic Pipes

To select the catalog number for BTV on plastic pipe, follow the next five steps.

Plastic pipe example:
Pipe size: 2 1/2" schedule 40
Pipe material: PVC
Insulation: 1" glass fiber
T_M: 40°F
T_A: -10°F
T_E: 140°F
Service voltage: 120 volts
Electrical area classification: Ordinary
Chemical exposure: None

Step 1. Calculate temperature differential.

$\Delta T = T_M - T_A$
Calculate $\Delta T = T_M - T_A$
$= 40°F - (-10°F)$
$\Delta T = 50°F$

Step 2. Determine pipe heat loss.

From Chart 1, match the pipe size and insulation thickness with the temperature differential (ΔT) to find the base heat loss of the pipe (Q_B).

From Chart 1, for 2 1/2" pipe, with 1" insulation and $\Delta T = 50°F$, the heat loss is 3.8 W/ft

$Q_B = 3.8$ W/ft @ $T_M = 40°F$

Step 3. Compensate for insulation type.

Multiply the base heat loss of the pipe (Q_B) from Step 2 by the insulation factor (f) from Chart 1 to get the actual heat loss (Q_T).

$Q_T = Q_B \times f$

From Chart 1, f = 1.00 for glass fiber:

$Q_T = Q_B \times f$
$= 3.8$ W/ft x 1.00
$Q_T = 3.8$ W/ft @ 40°F

Step 4. Select the heating cable family, voltage rating, and options.

For a plastic pipe application with a service voltage of 120 volts, select BTV1.

From Chart 2, a ground path is required for plastic pipe. Select -CR option for BTV since there is no chemical exposure.

Heating cable = BTV1-CR

Step 5. Select the thermal output rating.

Determine the adjusted thermal output of BTV at the maintenance temperature (T_M) when on plastic pipe. Then select the BTV heating cable for which the adjusted thermal output at T_M equals or exceeds the actual heat loss (Q_T).

From Chart 3a, the thermal output of 5BTV1 at 40°F equals 5.7 W/ft; and from Chart 4, the thermal output adjustment factors are 0.55 (using glass tape) and 0.75 (using aluminum tape). If aluminum tape is used, the adjusted thermal output exceeds Q_T:

5.7 W/ft x 0.75 = 4.3 W/ft
(this exceeds Q_T, which is 3.8 W/ft)

Thermal output rating: 5
Catalog number: 5BTV1-CR .

3.0 Electrical Design

To select the circuit breaker sizing, determine:

- T_M: Maintenance temperature (°F)
- Q_T: Actual heat loss per foot of pipe at T_M
- Pipe or tubing size
- Pipe length
- Type and number of valves and pipe supports
- Heating cable catalog number
- Minimum startup temperature (°F)

Example (continued from page 6):
T_M: 40°F
Q_T: 8.9 W/ft @ 40°F
Pipe size: 6" steel
Pipe length: 100 ft
Valves: Gate, 3 each
Pipe supports: Support shoes, 5 each, 1-foot length
Heating cable catalog number: 10XTV1-CT
Minimum startup temperature: 0°F
Power connection kit: 1
End seal: 1

Step 1. Calculate the total length of heating cable required by combining lengths from each component of the piping system.

For the pipe: Determine the amount of heating cable required for the pipeline length.

Piping: 100 ft of pipe = 100 ft

For each valve: Add a heating cable length determined by multiplying Q_T by the valve heat loss factor from Chart 5 and dividing by the heating cable thermal output at T_M.

$$\text{Valves: 3 valves} \times \frac{(8.9\ \text{W/ft} \times 4.3\ \text{ft})}{10.2\ \text{W/ft}} = 11.2\ \text{ft}$$

For each pipe support shoe calculate the additional heat required as follows:

$Q_{SUPPORT} = 0.7L \times (T_M - T_A)$, where L = support length (ft)

This formula is based on a 0.25" steel welded shoe partially shielded from winds.

Heat loss from supports: 5 x [1 x 0.7 x 80] = 280 W

Calculate the additional heating cable required by dividing the total support heat loss by the heating cable power output per foot at T_M from Chart 3a or 3b.

$$\text{Heating cable required for supports} = \frac{280\ \text{W}}{10.2\ \text{W/ft}} = 27.5\ \text{ft}$$

Total heating cable: (A) + (B) + (C) = 100 + 11.2 + 27.5 = 138.7 ft

Components: Allow an additional 3 ft for each component.

Total heating cable to be used: 138.7 + 3 + 3 = 144.7 ft

Chart 5 Valve Heat Loss Factors

Valve Type	Heat Loss Factor
Gate	4.3
Butterfly	2.3
Ball	2.6
Globe	3.9

Example: Heat loss for a 2" gate valve is 4.3 times the heat loss for one foot of pipe of the same size and insulation.

Step 2. Determine the circuit breaker trip rating.

Note: All thermal and electrical design information provided here is based upon a "standard" installation, i.e., with heating cable fastened with glass tape to an insulated metal pipe.

For any other method of installation, consult the Chemelex representative for design assistance.

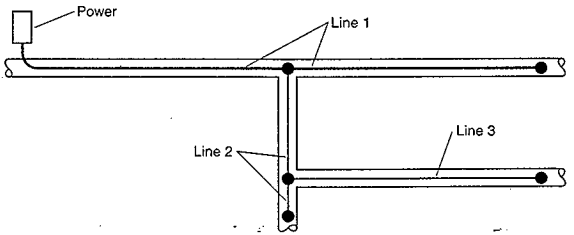
Using Chart 6, match the heating cable catalog number at the expected minimum startup temperature with the total heating cable length and select a circuit breaker trip rating. Circuit breaker trip rating should not exceed the maximum trip rating shown for heating cables of that product family. For example, the trip rating of a circuit breaker protecting several XTV circuits should not exceed 50 amps. To maximize fault current protection use the lowest allowable circuit breaker sizing.

From Step 1, the total heating cable circuit length is 144.7 feet. From Chart 6, the maximum heating cable length allowed for 10XTV powered at 120 volts with a 0°F startup temperature on a 20 amp circuit breaker is 130 feet, and on a 30 amp breaker is 195 feet. Select the 30 amp circuit breaker.

Circuit breaker trip rating: 30 amps

⚠

WARNING: Fire and shock hazard. To minimize the danger of fire if the heating cable is damaged or improperly installed, use a Ground Fault Equipment Protection Device (GFEPD). Electrical fault currents may be insufficient to trip a conventional circuit breaker.



Line 1 + Line 2 + Line 3 ≤ Maximum Circuit length

Step 3. Select the circuit breaker

Ground Fault Protection
The IEEE standard (515-1989) for heating cables recommends the use of GFEPDs with a nominal 30 milliampere trip level "for piping systems in classified areas requiring a high degree of maintenance, or which may be exposed to physical abuse or corrosive atmospheres."

Article 427-22 of the 1990 National Electrical Code requires the use of GFEPD with non braided (base) electric heating cables.

Device selection
Using the information below, select the appropriate device for the system.

Note: Because magnetic circuit breakers could nuisance trip at low temperatures, thermal circuit breakers are recommended.

Ground Fault Equipment Protection Devices
- Square D
  Type QOB-EPD
- Westinghouse
  Types GFEP, GFEPD

Conventional Devices
- General Electric
  Type TEB
- Square D
  Types EH, QO
- Westinghouse
  Types BA, GH

Chart 6 Circuit Breaker Selection

Circuit breaker trip ratings are based on Article 427-4 of the 1990 National Electrical Code, which says in part "....the rating or setting of overcurrent devices supplying fixed electric heating equipment for pipelines and vessels shall not be less than 125 percent of the total load of the heating cable."

Heating Cable	Startup Temp.	Maximum Heating Cable Length (feet) vs. Circuit Breaker Trip Rating (amps) 120 volts 15A	20A	30A	40A	50A	240 volts 15A	20A	30A	40A	50A
3BTV	50°F	330	330	330	330	-	660	660	660	660	-
	0°F	195	265	330	330	-	395	530	660	660	-
	-20°F	170	225	330	330	-	340	455	660	660	-
	-40°F	145	195	295	330	-	295	395	595	660	-
5BTV	50°F	230	270	270	270	-	460	540	540	540	-
	0°F	140	185	270	270	-	280	375	540	540	-
	-20°F	120	160	245	270	-	245	325	490	540	-
	-40°F	105	145	215	270	-	215	290	435	540	-
8BTV	50°F	150	200	210	210	-	300	400	420	420	-
	0°F	100	130	200	210	-	200	265	400	420	-
	-20°F	85	115	175	210	-	175	235	350	420	-
	-40°F	75	105	155	210	-	155	210	315	420	-
10BTV	50°F	120	160	180	180	-	240	320	360	360	-
	0°F	75	105	155	180	-	155	210	315	360	-
	-20°F	65	90	135	180	-	135	185	275	360	-
	-40°F	60	80	120	165	-	120	165	245	330	-
10QTVR	50°F	100	130	195	195	-	200	265	390	390	-
	0°F	80	105	160	195	-	160	210	320	390	-
	-20°F	70	95	145	195	-	145	195	295	390	-
	-40°F	65	90	135	180	-	135	180	275	365	-
15QTVR	50°F	75	100	150	200	220	160	210	320	340	-
	0°F	60	80	120	160	200	125	170	255	340	-
	-20°F	55	70	110	145	185	115	155	235	315	-
	-40°F	50	65	100	135	170	110	145	220	290	-
20QTVR	50°F	60	80	120	160	195	120	160	240	320	390
	0°F	45	60	95	125	160	95	125	190	255	320
	-20°F	40	55	85	115	145	85	115	175	235	295
	-40°F	40	55	80	110	135	80	110	165	220	275
5XTV	50°F	180	240	360	380	380	360	480	720	765	765
	0°F	160	215	325	380	380	320	425	640	765	765
	-20°F	155	210	315	380	380	305	410	615	765	765
	-40°F	150	200	305	380	380	295	390	590	765	765
10XTV	50°F	110	145	220	270	270	220	295	440	540	540
	0°F	95	130	195	265	270	195	260	390	520	540
	-20°F	95	125	190	255	270	185	245	370	495	540
	-40°F	90	120	180	245	270	175	235	355	475	540
15XTV	50°F	75	100	150	200	220	150	200	300	400	440
	0°F	65	90	135	180	220	130	175	265	355	440
	-20°F	65	85	130	170	215	125	170	255	340	425
	-40°F	60	80	125	165	205	120	160	240	325	405
20XTV	50°F	60	80	120	160	190	115	150	230	305	380
	0°F	50	70	105	140	175	100	135	200	270	335
	-20°F	50	65	100	135	170	95	125	190	255	320
	-40°F	45	65	95	130	165	90	120	185	245	310

When using 240 volt Auto-Trace heating cables at operating voltages of either 208 or 277 volts, use the circuit length adjustment factors in Chart 7.

Chart 7 Alternate Voltage Adjustment Factors

Chemelex Auto-Trace heating cables can be used with nominal variations in operating voltages without causing significant changes in power output.

Chart 7 shows the effect of alternate voltages on 240-volt Chemelex Auto-Trace heating cables relative to the nominal thermal output rating.

Note: When using circuit length adjustment factors, do not exceed the maximum circuit lengths shown in Chart 7.

Heating Cable	Thermal Output Adjustment Factor	Circuit Length Adjustment Factor	Maximum Heating Cable Circuit Length
Operating voltage: 208 Volts			
3BTV2	0.82	0.99	630 feet
5BTV2	0.85	0.99	500 feet
8BTV2	0.89	0.93	385 feet
10BTV2	0.89	0.93	330 feet
10QTVR2	0.85	0.98	365 feet
15QTVR2	0.91	0.91	305 feet
20QTVR2	0.90	0.92	350 feet
5XTV2	0.84	1.00	720 feet
10XTV2	0.83	0.98	510 feet
15XTV2	0.85	0.97	415 feet
20XTV2	0.88	0.97	350 feet
Operating voltage: 277 Volts			
3BTV2	1.13	1.03	710 feet
5BTV2	1.12	1.07	585 feet
8BTV2	1.08	1.08	465 feet
10BTV2	1.08	1.05	395 feet
10QTVR2	1.18	0.96	410 feet
15QTVR2	1.09	1.06	370 feet
20QTVR2	1.07	1.06	430 feet
5XTV2	1.18	1.03	750 feet
10XTV2	1.17	1.06	575 feet
15XTV2	1.13	1.08	475 feet
20XTV2	1.10	1.11	440 feet

Example 1:
Adjust the thermal output of 8BTV2 powered at 208 volts:

The thermal output of 8BTV2 at 50°F is 8 W/ft. From Chart 7, the thermal output of 8BTV2 if powered at 208 volts is 0.89.

Adjusted thermal output:
8 W/ft x 0.89 = 7.1 W/ft @ 208 volts

Example 2:
To find the maximum heating cable circuit length for 8BTV2 if started at 50°F and powered at 208 volts:

From Chart 6, the maximum circuit length for 8BTV2 is 300 feet when started at 50°F on a 15 amp circuit breaker.

From Chart 7, the circuit length adjustment factor for 8BTV2 is 0.93 powered at 208 volts.

Adjusted maximum circuit length:
300 ft x 0.93 = 279 ft @ 208 volts
Maximum Heating Cable Circuit Length: 279 ft

APPENDIX C

8 PAGES

FIELD INSTRUMENTS & CONTROLS, INC.

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Fax: (206) 896-9905

5302 North Millview Drive
Spokane, WA 99212
(509) 926-3284
Fax: (509) 926-3529

2928 - 162nd Street S.E.
Mill Creek, WA 98012
(206) 402-0427
Fax: (206) 402-0625

December 30, 1994

ICF KAISER HANFORD
P.O. Box 888
Richland, WA 99352

Attention: Mr. Dick Graber

Subject: Raychem Heat Trace Requirement

Dear Dick:

Thank you for the opportunity to work with you on the referenced application. We are pleased to offer the following for your consideration:

FOAMED ELASTOMER - 1/2" THICKNESS:

QTY		DESCRIPTION	UNIT PRICE	EXT. PRICE
32	FT	5BTV1-CT *Heater Cable; 5 Watt, 120V*	$ 5.05	$161.60
1	EA	PMKG-JLP *Power Connection Kit*	$ 64.95	$ 64.95
1	EA	PMKG-LE *End Termination Kit*	$ 8.45	$ 8.45
1	EA	AMC-1A *Ambient Sensing Thermostat*	$157.60	$157.60
3	EA	ETL *"Electric Traced" Label*	$ 0.85	$ 2.55
1	EA	GT66 *Glass Tape*	$ 3.70	$ 3.70
1	EA	PMK-B *Pipe Strap Adaptor Kit*	$ 16.60	$ 16.60
		BILL OF MATERIALS TOTAL:		$415.45

1/2" FIBERGLASS OR 1" FOAMED ELASTOMER:

QTY		DESCRIPTION	UNIT PRICE	EXT. PRICE
32	FT	3BTV1-CT *Heater Cable; 3 Watt, 120V*	$ 4.55	$145.60
1	EA	PMKG-JLP *Power Connection Kit*	$ 64.95	$ 64.95
1	EA	PMKG-LE *End Termination Kit*	$ 8.45	$ 8.45
1	EA	AMC-1A *Ambient Sensing Thermostat*	$157.60	$157.60
3	EA	ETL *"Electric Traced" Label*	$ 0.85	$ 2.55
1	EA	GT66 *Glass Tape*	$ 3.70	$ 3.70
1	EA	PMK-B *Pipe Strap Adaptor Kit*	$ 16.60	$ 16.60
		BILL OF MATERIALS TOTAL:		$399.45

Prices quoted remain valid for thirty days from date of quote. The FOB point is Vancouver, WA and payment terms are net 30 days from date of invoice. The standard lead time for these items is 1 week after receipt of order, or sooner (items shown are normally stocked in Vancouver).

Please give us a call if you need any more detail regarding this application. Thanks again for the chance to quote.

Sincerely,

FIELD INSTRUMENTS & CONTROLS

Russ Sutter
Inside Sales/Vancouver

rls

Enclosures

cc: Jamie Sullivan/Spokane

FOAMED ELASTOMER INSULATION (1/2")

LineList

Project Name: FLEX
Done For: DICK GRABER
Done By: RUSS SUTTER
Design Name: FLEX

Project ID: ICFKAI
Design ID: ICFKAI
Lines ID: ICFKAI

Temperatures
Maintain: 40 F
Min Ambient: -20 F
Max Ambient: 110 F
Mean: 10 F
Process Oper: 40 F
Max Htr Exp: 150 F
System Limit: 150 F
Startup: -20 F

Insulation: FOAMED ELASTOMER
(ASTM C534-70)
K Factor at 50 F: 0.2933 BTU-in/hr-ft2-F
Area Classification Code: Ordinary
Chemical Exposure Code: Severe
Heat Loss Safety Factor: 10 %
Pipe Length per Support: 20 ft
Allow Spiralling: No
Allow Uncontrolled: Yes

Voltage: 120
Location: Outdoors
Maximum CB Load: 32 A
Pipe Category: IPS/Steel
Support HL Factor: 0.00 ft
Valve HL Factor: 0.00 ft

Ref #	Line No	Pipe Size (in)	Insul Thick (in)	Pipe Length (ft)	# Valve	# Support	Heater Type	Trace Ratio	HL Rate (W/ft)	Output Rate (W/ft)	Heater Length (ft)	# Comp Sets	Start Load (Amp)	Oper Load (kVA)	Comment
1	FLEX	0.50	0.5	30.0	0	1	5BTV1-CT	1.0	3.5	5.6	30.0	1	3	0.2	

Notes:

Data used in this design assumes that pipe supports are thermally insulated from the pipes; therefore, no heating cable is included for tracing supports. Raychem recommends that you verify the correctness of this assumption as pipe supports often cause substantial heat losses which should be compensated by heat tracing.

To aid electrical design, TraceCalc provides electrical circuit load estimates based on the total heating cable length. However, an engineer must independently perform the actual circuit design. TraceCalc estimates "Start Load" based on current drawn at start-up temperature. TraceCalc estimates the operating load ("Oper Load") based on power output at maintain temperature. For detailed sizing information, consult the Raychem Electrical Protection Bulletin or contact your Raychem representative.

In accordance with IEEE Heat-Tracing Design Recommended Practice, Raychem recommends the use of Ground Fault Circuit Breakers for piping systems in classified areas requiring a high degree of maintenance, or which may be exposed to physical abuse or corrosive atmospheres.

FOAMED ELASTOMER INSULATION (1/2")

Design Summary

Project Name: FLEX
Done For: DICK GRAGER
Done By: RUSS SUTTER
Design Name: FLEX
Project ID: ICFKAI
Design ID: ICFKAI
Lines ID: ICFKAI

Temperatures
Maintain: 40 F
Min Ambient: -20 F
Max Ambient: 110 F
Mean: 10 F
Process Oper: 40 F
Max Htr Exp: 150 F
System Limit: 150 F
Startup: -20 F

Insulation: FOAMED ELASTOMER
(ASTM C534-70)
K Factor at 50 F: 0.2933 BTU-in/hr-ft2-F
Area Classification Code: Ordinary
Chemical Exposure Code: Severe
Heat Loss Safety Factor: 10 %
Pipe Length per Support: 20 ft
Allow Spiralling: No
Allow Uncontrolled: Yes

Voltage: 120
Location: Outdoors
Maximum CB Load: 32 A
Pipe Category: IPS/Steel
Support HL Factor: 0.00 ft
Valve HL Factor: 0.00 ft

DS Ref #	Pipe Size (in)	Insul Thick (in)	HL Rate (W/ft)	Heater Type	Output Rate (W/ft)	Feet of Heater /ft Pipe	per Valve	per Supp	Pitch (in)	Min T Maintained	Max T	K Factor @ Mean T	Start Load (A/ft)	Oper Load (KW/ft)	Total Pipe (ft)	Total Heater (ft)	Total Comp Sets
1	0.50	0.5	3.5	SBTV1-CT	5.6	1.0	0.0	0.0	0	57	126	0.2830	0.097	0.0063	30	30	1

Notes:

Data used in this design assumes that pipe supports are thermally insulated from the pipes; therefore, no heating cable is included for tracing supports. Raychem recommends that you verify the correctness of this assumption as pipe supports often cause substantial heat losses which should be compensated by heat tracing.

The columns labeled "Min T Maintained" and "Max T Maintained" are indicative of the most likely temperature range. The actual range will vary depending on insulation thermal conductivity, pipe location, wind speed, and other details of the specific installation. For temperature-sensitive applications, use the temperature range indicated to determine if thermostatic control is advisable.

To aid electrical design, TraceCalc provides electrical circuit load estimates based on the total heating cable length. However, an engineer must independently perform the actual circuit design. TraceCalc estimates "Start Load" based on current drawn at start-up temperature. TraceCalc estimates the operating load ("Oper Load") based on power output at maintain temperature. For detailed sizing information, consult the Raychem Electrical Protection Bulletin or contact your Raychem representative.

In accordance with IEEE Heat-Tracing Design Recommended Practice, Raychem recommends the use of Ground Fault Circuit Breakers for piping systems in classified areas requiring a high degree of maintenance, or which may be exposed to physical abuse or corrosive atmospheres.

FIBERGLASS INSULATION (12)

LineList

Project Name: FLEX
Done For: DICK GRABER
Done By: RUSS SUTTER
Design Name: FLEX

Project ID: ICFKAI
Design ID: ICFKAI
Lines ID: ICFKAI

Temperatures:
Maintain: 40 F
Min Ambient: -20 F
Max Ambient: 110 F
Mean: 10 F
Process Oper: 40 F
Max Htr Exp: 150 F
System Limit: 150 F
Startup: -20 F

Insulation: GLASS FIBER
(ASTM C547-77)
K Factor at 50 F: 0.2497 BTU-in/hr ft2 F
Area Classification Code: Ordinary
Chemical Exposure Code: Severe
Heat Loss Safety Factor: 10 %
Pipe Length per Support: 20 ft
Allow Spiralling: No
Allow Uncontrolled: Yes

Voltage: 120
Location: Outdoors
Maximum CB Load: 32 A
Pipe Category: IPS/Steel
Support HL Factor: 0.00 ft
Valve HL Factor: 0.00 ft

Ref #	Line No	Pipe Size (in)	Insul Thick (in)	Pipe Length (ft)	# Valve	# Support	Heater Type	Trace Ratio	HL Rate (W/ft)	Output Rate (W/ft)	Heater Length (ft)	# Comp Sets	Start Load (Amp)	Oper Load (kVA)	Comment
1	FLEX	0.50	0.5	30.0	0	1	3BTV1-CT	1.0	2.9	3.4	30.0	1	2	0.1	

Notes:

Data used in this design assumes that pipe supports are thermally insulated from the pipes; therefore, no heating cable is included for tracing supports. Raychem recommends that you verify the correctness of this assumption as pipe supports often cause substantial heat losses which should be compensated by heat tracing.

To aid electrical design, TraceCalc provides electrical circuit load estimates based on the total heating cable length. However, an engineer must independently perform the actual circuit design. TraceCalc estimates "Start Load" based on current drawn at start-up temperature. TraceCalc estimates the operating load ("Oper Load") based on power output at maintain temperature. For detailed sizing information, consult the Raychem Electrical Protection Bulletin or contact your Raychem representative.

In accordance with IEEE Heat-Tracing Design Recommended Practice, Raychem recommends the use of Ground Fault Circuit Breakers for piping systems in classified areas requiring a high degree of maintenance, or which may be exposed to physical abuse or corrosive atmospheres.

Design Summary

Project Name: FLEX
Done For: DICK GRABER
Done By: RUSS SUTTER
Design Name: FLEX

Project ID: ICFKAI
Design ID: ICFKAI
Lines ID: ICFKAI

Temperatures
Maintain: 40 F
Min Ambient: -20 F
Max Ambient: 110 F
Mean: 10 F
Process Oper: 40 F
Max Htr Exp: 150 F
System Limit: 150 F
Startup: -20 F

Insulation: GLASS FIBER
(ASTM C547-77)
K factor at 50 F: 0.2497 BTU-in/hr-ft2-F
Area Classification Code: Ordinary
Chemical Exposure Code: Severe
Heat Loss Safety Factor: 10 %
Pipe Length per Support: 20 ft
Allow Spiralling: No
Allow Uncontrolled: Yes

Voltage: 120
Location: Outdoors
Maximum CB Load: 32 A
Pipe Category: IPS/Steel
Support HL Factor: 0.00 ft
Valve HL Factor: 0.00 ft

DS Ref #	Pipe Size (in)	Insul Thick (in)	HL Rate (W/ft)	Heater Type	Output Rate (W/ft)	Feet of Heater /ft Pipe	per Valve	per Supp	Pitch (in)	Min T Maintained	Max T @ Mean T	K factor	Start Load (A/ft)	Oper Load (KW/ft)	Total Pipe (ft)	Total Heater (ft)	Total Comp Sets
1	0.50	0.5	2.9	3BTV1-CT	3.4	1.0	0.0	0.0	0	45	122	0.2345	0.070	0.0041	30	30	1

Notes:

Data used in this design assumes that pipe supports are thermally insulated from the pipes; therefore, no heating cable is included for tracing supports. Raychem recommends that you verify the correctness of this assumption as pipe supports often cause substantial heat losses which should be compensated by heat tracing.

The columns labeled "Min T Maintained" and "Max T Maintained" are indicative of the most likely temperature range. The actual range will vary depending on insulation thermal conductivity, pipe location, wind speed, and other details of the specific installation. For temperature-sensitive applications, use the temperature range indicated to determine if thermostatic control is advisable.

To aid electrical design, TraceCalc provides electrical circuit load estimates based on the total heating cable length. However, an engineer must independently perform the actual circuit design. TraceCalc estimates "Start Load" based on current drawn at start-up temperature. TraceCalc estimates the operating load ("Oper Load") based on power output at maintain temperature. For detailed sizing information, consult the Raychem Electrical Protection Bulletin or contact your Raychem representative.

In accordance with IEEE Heat-Tracing Design Recommended Practice, Raychem recommends the use of Ground Fault Circuit Breakers for piping systems in classified areas requiring a high degree of maintenance, or which may be exposed to physical abuse or corrosive atmospheres.

RAYCHEM
Chemelex Division

TraceCalc [V3.0/10#1A-A15-SN1667]

30-Dec-94 14:39:56

LineList

Project Name: N
Done For: DICK GRABER
Done By: RUSS SUTTER
Design Name: FLEX

Project ID: ICFKAI
Design ID: ICFKAI
Lines ID: ICFKAI

Temperatures
Maintain: 40 F
Min Ambient: -20 F
Max Ambient: 110 F
Mean: 10 F
Process Oper: 40 F
Max Htr Exp: 150 F
System Limit: 150 F
Startup: -20 F

Insulation: FOAMED ELASTOMER (ASTM C534-70)
K Factor at 50 F: 0.2933 BTU-in/hr-ft2-F
Area Classification Code: Ordinary
Chemical Exposure Code: Severe
Heat Loss Safety Factor: 10 %
Pipe Length per Support: 20 ft
Allow Spiralling: No
Allow Uncontrolled: Yes

Voltage: 120
Location: Outdoors
Maximum CB Load: 32 A
Pipe Category: IPS/Steel
Support HL Factor: 0.00 ft
Valve HL Factor: 0.00 ft

Ref #	Line No	Pipe Size (in)	Insul Thick (in)	Pipe Length (ft)	# Valve	# Support	Heater Type	Trace Ratio	HL Rate (W/ft)	Output Rate (W/ft)	Heater Length (ft)	# Comp Sets	Start Load (Amp)	Oper Load (kVA)	Comment
1	FLEX	0.50	1.0	30.0	0	1	3BTV1-CT	1.0	2.3	3.4	30.0	1	2	0.1	

Notes:

Data used in this design assumes that pipe supports are thermally insulated from the pipes; therefore, no heating cable is included for tracing supports. Raychem recommends that you verify the correctness of this assumption as pipe supports often cause substantial heat losses which should be compensated by heat tracing.

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FOAMED ELASTOMER INSULATION (1)

TraceCalc [V3.0/10#1A-A15-SN1667]

30-Dec-94 14:40:03

A Y C H E M
hemelex Division

Design Summary

Project Name: N
Done For: DICK GRABER
Done By: RUSS SUTTER
Design Name: FLEX

Project ID: ICFKAI
Design ID: ICFKAI
Lines ID: ICFKAI

Temperatures
Maintain: 40 F
Min Ambient: -20 F
Max Ambient: 110 F
Mean: 10 F
Process Oper: 40 F
Max Mtr Exp: 150 F
System Limit: 150 F
Startup: -20 F

Insulation: FOAMED ELASTOMER
(ASTM C534-70)
K Factor at 50 F: 0.2933 BTU-in/hr-ft2-F
Area Classification Code: Ordinary
Chemical Exposure Code: Severe
Heat Loss Safety Factor: 10 %
Pipe Length per Support: 20 ft
Allow Spiralling: No
Allow Uncontrolled: Yes

Voltage: 120
Location: Outdoors
Maximum CB Load: 32 A
Pipe Category: IPS/Steel
Support HL Factor: 0.00 ft
Valve HL factor: 0.00 ft

DS Ref #	Pipe Size (in)	Insul Thick (in)	HL Rate (W/ft)	Heater Type	Output Rate /ft (W/ft)	Feet of Heater per Pipe	per Valve	per Supp	Pitch (in)	Min T Maintained	Max T Maintained	K Factor @ Mean T	Start Load (A/ft)	Oper Load (KW/ft)	Total Pipe (ft)	Total Heater (ft)	Total Comp Sets
1	0.50	1.0	2.3	3BTV1-CT	3.4	1.0	0.0	0.0	0	34	124	0.2628	0.070	0.0041	30	30	1

Notes:

Data used in this design assumes that pipe supports are thermally insulated from the pipes; therefore, no heating cable is included for tracing supports. Raychem recommends that you verify the correctness of this assumption as pipe supports often cause substantial heat losses which should be compensated by heat tracing.

The columns labeled "Min T Maintained" and "Max T Maintained" are indicative of the most likely temperature range. The actual range will vary depending on insulation thermal conductivity, pipe location, wind speed, and other details of the specific installation. For temperature-sensitive applications, use the temperature range indicated to determine if thermostatic control is advisable.

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W320-31-015

Cable Ampacity, Lighting, Conduit Fill, & Voltage Drop

KAISER ENGINEERS HANFORD	CALCULATION IDENTIFICATION AND INDEX	Page i of 9 Date 8/01/94

This sheet shows the status and description of the attached Design Analysis sheets.

Discipline Electrical WO/Job No. ER4319 Calculation No. W320-31-015

Project No. & Name W-320 TANK 241-C-106 WASTE RETRIEVAL

Calculation Item Cable Ampacity, Lighting, ~~Conductor~~ Conduit Fill, & Voltage Drop

These calculations apply to:

Dwg. No. H-2-818677 Elect Service Building Details Rev. No. 0

Dwg. No. H-2-818430 241-C-106 Raw Water System Plan Rev. No. 0

Other (Study, CDR) KGS-94-009 Project 93L-EW-320, Tank 241-C-106 Sluicing, Letter of Instruction, Definitive Design, Revision 6 dated April 1, 1994 Rev. No. NA

Functional Design Criteria for Tank 241-C-106 Waste Retrieval, Project W-320, Revision 2

The status of these calculations is:

[] Preliminary Calculations

[X] Final Calculations

[] Check Calculations (On Calculation Dated)

[] Void Calculation (Reason Voided)

Incorporated in Final Drawings? [X] Yes [] No

Calculation verified by independent "check" calculations? [] Yes [X] No

Original and Revised Calculation Approvals:

	Rev. 0 Signature/Date	Rev. 1 Signature/Date	Rev. 2 Signature/Date
Originator	D. E. Larson Don Larson 8/01/94	Don Larson 9/22/94	K.F. Thanawala 1/25/98
Checked by	Juanito Del Rosario 8/01/94 Juanito C. del Rosario	9/23/94 Juanito C del Rosario	7/25/98
Approved by	J.F. Kosmick 8/23/94	J.F. Kosmick 9/23/94	J.F. Kosmick 7/25/98
Checked Against Approved Vendor Data			K.F. Thanawala 7/25/98

INDEX

Design Analysis Page No.	Description
i	Calculation Identification and Index
ii	Calculation Cross Index
1	Objective; Design Inputs; Criteria and Source; Assumptions
2	Methods to be Used
2	References
4 - 8	Calculation
8	Findings and Conclusions

Discipline Electrical | WO/Job No. ER4319 | Calculation No. W-320-31-015

	Rev. 0 Signature/Date	Rev. 1 Signature/Date	Rev. 2 Signature/Date
Originator	D. E. Larson 8/01/94	Dan Larson 9/22/94	[illegible] 1/25/98
Checked by	Juanito Del Rosario 8/01/94	Juanito C. del Rosario 9/23/94	[illegible] 7/25/98

INDEX

Design Analysis Page No.	Description	
A-1 to A-3	Attachment A: Catalog Cut Square D Mini Power-Zone	(2)
B-1	Attachment B: Catalog Cut Chromalox Room Thermostats	
C-1 to C-3	Attachment C: Catalog Cut Crouse-Hinds NFW Fluorescent Fixtures	(2)
D-1	Attachment D: Illumination Levels from IESNA Lighting Handbook	
E-1 to E-3	Attachment E: Simplified Procedure for Calculating Footcandles from MEANS Electrical Cost Data 1991	
F-1	Attachment F: Technical Data for Dry-Type Transformers from Westinghouse Catalog 55-000, 10th Edition, 1991 - 1992 (page 116)	
G-1 to G-2	Attachment G: ~~Catalog cut sheets for Anaconda Type MC (XHHW)~~ cable.	(2)
H-1	Attachment H: cc:mail from Shana L. Sovern to Dan Larson dated 5/17/94.	
I-1	Attachment I: Voigt Wall-Most catalog cut sheets for outdoor luminaires	
J-1 to J-4	Attachment J: "Chromalox" Wall mounted Convection Heater	
K-1 to K-4	Attachment K: "ACME" Centrimaster Wall Exhausters	(2)
L-1 to L-2	Attachment L: "VANAIR" Heatless Regenerative Dryer	
M-1 to M-4	Attachment M: "INGERSOLL RAND" Air Compressors	

(1) Added changes to reflect load changes & editorial changes; page affected are pages 3, 4, 5, 8, 9. "Southwire" information for THHN (2)

(2) General Revision as shown.

DESIGN ANALYSIS

Client WHC
Subject Service Building Installation
Location Tank Farm C

WO/Job No. ER4319
Date 8/01/94
Checked 8/01/94
Revised ~~NA~~ 7/25/98

By D.E. Larson D.E.L.
By J. Del Rosario
By ~~NA~~ K P Thanawala

1.0 OBJECTIVE

The objective of this calculation is:

a. To size and select a Mini-Power Zone.

b. To size and select the main feeder cables that supply the service building loads. (including the ~~5~~ 7½ HP air compressor) (2)

c. To size and select branch and feeder cables.

d. To size conduits for fill.

e. To verify lighting fixtures for proper illumination levels

f. To calculate voltage drops, including during air compressor motor starting.

2.0 DESIGN INPUTS

a. KGS-94-009 Project 93L-EW-320, Tank 241-C-106 Sluicing, Letter of Instruction, Definitive Design, Revision 6 dated April 1, 1994

b. NFPA-70, National Electrical Code, 1993. (2)

3.0 CRITERIA AND SOURCE

Functional Design Criteria for Tank 241-C-106 Waste Retrieval, Project W-320, Revision 2

4.0 ASSUMPTIONS

~~a. Power is supplied initially from the Power Distribution Panel (C-PDP-1) and later from an MCC, N1.~~ (2)

b. All conductors are stranded copper rated for 90°C (194°F), 600V insulated

c. Ambient temperature inside building is considered to be 46°C (115°F) for worst case condition. Temperature outside of the building is considered to be 46°C (115°F) the same for worst case condition.

d. All conductors are assumed to be routed in rigid steel conduit or EMT.

e. Electrical loads are listed later in this calculation. In the absence of manufacturer's information, values from the 1993 NEC are used.

f. Assume reflectances of 80 % for the ceiling and 50 % for the walls.

JSP1 (7/24/98)

g. Short circuit calculation need not be considered. The basis for this is that preliminary calculations have shown low fault values.

h. Emergency lighting is not necessary. The building is small and largely unoccupied.

i. Illumination levels within the Service Building are needed for performance of visual tasks of high contrast or large size. Assume .9 maintenance factor (MF).

j. Power Factor is assumed to be .85.

k. Air compressor KVA/HP is class G

l. Motors may be assumed to be 1 kVA/HP.

5.0 METHODS TO BE USED

5.1 CABLE, PANELBOARD AND CIRCUIT BREAKER SIZING

a. Determine maximum rated load of each component (receptacles, lights, and misc. equipment).

b. Determine maximum load on Mini-Power Zone.

c. Select cables and circuit breakers.

d. Derate cable ampacities for ambient temperature.

5.2 LIGHTING REQUIREMENTS AND FIXTURE SELECTION

a. Lighting requirements are from the Illumination Engineering Society of North America, IESNA. Simplified method of calculation from Means Cost Data is used to calculate light intensities.

5.3 CONDUIT FILL AND VOLTAGE DROP

a. Application of NEC tables and application of ohm's law

6.0 REFERENCES

a. National Electric al Code (1993)
b. Lighting Handbook 8th Edition - Illumination Engineering Society of North America (IESNA)
c. NEMA MG 1- 1993 Motors and Generators
d. Westinghouse Lighting Handbook

DESIGN ANALYSIS

Client WHC
Subject Service Building Installation
Location Tank Farm C

WO/Job No. ER4319
Date 8/01/94 By D.E. Larson D.E.L.
Checked ~~8/1/94~~ By J. Del Rosario ~~JDR~~
Revised ~~NA~~ 7/25/98 By ~~NA~~ KP Thanawala.

7.0 CALCULATION

7.1 LOADING WITHIN THE SERVICE BUILDING

7.1.1.1 Total Load

Two duplex receptacles	2 X 180 = 360 VA
Electric Heater	2,000 ~~1000~~ VA
Exhaust Fan ~~(1/6 HP)~~ ~~8~~ (1/6 HP)	~~139~~ ~~528 VA~~ 528 VA
Two fluorescent fixtures	200 VA
Outdoor fixture	60 VA
SUBTOTAL	3148 ~~2759~~ ~~2140~~ VA
Air Dryer ~~(future load)~~ (200 mA)	24 ~~30~~ VA
~~CO_2 Solenoid Valve (future load)~~	~~30 VA~~
SUBTOTAL	3172 ~~2789~~ ~~2208~~ VA

Select a Mini-Power Zone of size 5000 VA. This will provide acceptable margin of ~~56%~~ 36.5 % for unanticipated future loads. Additional margin is available because the exhaust fan should not be operating at the same time as the heater. The total load must include the load of the air compressor. This ~~3~~ 1½ HP motor may be assumed as drawing ~~7.6~~ 11.0 amps as shown in NEC table 430-150.

VA = V X A X 1.732 = 480 X ~~7.6~~ 11.0 X 1.732 = ~~6318 VA~~ 9145 VA

This brings the total load to:

TOTAL	12317 ~~9107~~ ~~8526~~ VA

7.2 Mini-Power Zone Over-Current Protection

Mini-Power Zone rated 5 kVA with 2 pole primary main circuit breaker with rating of 20 Amps @ 480 volts AC and secondary 2 pole main circuit breaker of 30 Amps at 240 volts AC (see Attachment A) will supply ~~2208~~ ~~2789~~ 3172 VA (~~44~~ ~~55~~ 63.5 %) plus ~~56~~ ~~44~~ 36.5 % capacity for future expansion.

DEL. 9/22/94 KPT (7/24/98)

DESIGN ANALYSIS

Client WHC
Subject Service Building Installation
Location Tank Farm C

WO/Job No. ER4319
Date 8/01/94
Checked 8/01/94
Revised ~~NA~~ 7/25/98

By D.E. Larson D.E.L.
By J. Del Rosario ~~JDR~~
By ~~NA~~ KP Thanawala.

Secondary full load current = 5000 ~~K~~VA / 240 V = 20.83 A

1.25 X Sec. full load current = 26 Amps [NEC ART. 450-3]

Manufacturer's standard breaker of 30 amps is next higher rating.

The maximum primary current through the Mini-Power Zone is:

I = VA / V = 5000 / 480 = 10.42 amps

The manufacturer's standard for the Primary breaker rating is 20 A. This will coordinate with the secondary breaker and handle the full load rating of the Mini-Power Zone.

The largest load is the electric heater. This will draw the most current:

I = W / V = ~~1000~~ 2000 watts / 120 volts = ~~8.3~~ 16.7 amps. × 1.25 = 20.875 A [NEC 424-3(b)]
all

Industry standard circuit breakers of 20 A shall be used for branch circuits, except {They will be satisfactory for any of the proposed loads.
the electric heater branch circuit which shall require a 25 amp breaker per NEC 384-16(c).

7.3 Feeder and Cable Selection

7.3.1 Supply Cable ~~Selection~~: A ~~minimum~~ size of ~~#12~~ 10 AWG provided feeder cable is ~~selected~~ to supply the Service Building from the Power Distribution Panel to satisfy Air Compressor and MPZ ~~the 20 A~~ panel rating. Full load current at the primary of the Mini-Power Zone and the air compressor is:

Mini Power Center: I = VA/V = 5,000/480 = 10.4 amperes

Air Compressor: I = ~~7.6~~ 11.0 amperes (from NEC table 430-150)

The total current is then the sum or ~~18~~ 21.4 amperes.
For cable sizing: I = 1.25 × 11.0 + 10.4 = 24.15 amps. ~~40~~ 30
The ampacity of ~~#12~~ AWG cable from NEC table 310-16 is ~~30~~ A (90°C rating). This ampacity is derated for the ambient condition
I = .82 * ~~30~~ = ~~24.6~~ amps
40 32.8

It is not known what the rating of the terminations are at the Power Distribution Panel supplying the Service building. It must be assumed that they are

DEL 9/22/94 KPT (7/25/98)

DESIGN ANALYSIS

Client WHC
Subject Service Building Installation
Location Tank Farm C

WO/Job No. ER4319
Date 8/01/94
Checked 8/1/94
Revised ~~NA~~ 7/25/98

By D.E. Larson D.E.L.
By J. Del Rosario ~~JDR~~
By ~~NA~~ KP Thanawala.

only rated for 60° C rise. Per NEC article 110-14(c) Exception No. 1:

Conductors with higher temperature ratings shall be used, provided the ampacity of such conductors is determined based on the 60°C (140°F) ampacity of the conductor size provided.

Per conversations with Hanford Code experts, Attachment H, the derating for terminations need not be considered along with derating for high ambient conditions. They are to be treated separately. The 60°C rating of ~~#12~~ 10 AWG wire is ~~20~~ 30 amperes, this will carry the full load of the Mini-Power Zone so this satisfies the termination derating.

7.3.2 Branch Cable Selection: The ~~1~~ 2 largest anticipated load to be supplied from the Mini-Power Zone is a ~~1~~ 2 kW heater. This is the worst case for normal branch circuit ampacity. This will draw:

$$I = VA/V = \overset{2}{\cancel{1}}000/120 = \overset{16.7}{\cancel{8.33}} \text{ amps} \times 1.25 = 20.875 \text{ amps}$$

Select #12 AWG for branch circuits. Branch circuits will be protected by 20 A circuit breakers, with exception of heater branch circuit which requires a 25A circuit breaker, and #10 AWG cable, per NEC table 310-16. The ampacity of #12 AWG cable from NEC table 310-16 is 30 A (90°C rating). This ampacity is derated for the 120° F ambient temperature condition:

I = .82 * 30 = 24.6 amps

It is ~~not known what the rating of~~ assumed that the terminations ~~are~~ at each device ~~As above, it must be assumed that they~~ are only rated for 60° C rise. The 60°C rating of the #12 AWG cable is 25 amperes. This is adequate ampacity for the branch circuits.

7.4 MOTOR CONTROL

There are two motors to be considered. The first is a ~~1/6~~ 1/8 HP exhaust fan motor. Per NEC table 430-148, the full load motor current is 4.4 amps. It is intended that the Mini-Power-Zone circuit breaker supplying the motor serves as means of disconnect and that the thermostat serve as the controller. This will be within line of sight satisfying NEC 430-102. Per NEC 430-109, it is acceptable to use a circuit breaker as a disconnect for a 1/6 HP motor provided ~~its~~ the circuit brkr rating is not less than twice the full load rating of the motor.

$I_B = 2 \times I_M = 2 \times 4.4 = 8.8$ amps

~~At 8 Mini-Zone Motor Ckt~~

DEL 9/22/94 KPT (7/25/98)

DESIGN ANALYSIS

Client WHC
Subject Service Building Installation
Location Tank Farm C

WO/Job No. ER4319
Date 8/01/94
Checked 8/4/94
Revised ~~NA~~ 7/25/98

By D.E. Larson D.E.L.
By J. Del Rosario ~~JDR~~
By ~~NA~~ KP Thanawala

The circuit breaker is rated at 20 amps. 20 > 8.8 It is acceptable to use a circuit breaker as a disconnect.

Per NEC 430-110, the ampere rating of motor interrupting means (thermostat) shall have 115% the full load rating of the motor. 1.15 X 4.4 = 5.06 amps The selected thermostat has a rating of 25 amps. (See Attachment B) 25 > 5.06. It is acceptable to use the thermostat as a motor interrupting means.

The second motor is the ~~future, 5~~ 1 1/2 HP air compressor packaged unit. Control for this motor will be supplied by the compressor vendor.

7.5 ~~Conductor~~ conduit Fill

Branch Circuits: Per NEC Chapter 9 Table ~~3A~~ 3B we can have up to ~~7~~ 10 # 12 or 6 # 10 THHN ~~XHHW~~ conductors in a 1/2" conduit. Inspection of the drawings shows that we have no more than 4 conductors in any of our EMT conduits.

Supply Circuit: Per NEC Chapter 9 Table ~~3A~~ 3B, we can have ~~17 #8~~ 11 #10 in 3/4" conduit AWG and 18 ~~36~~ # 10 AWG in an ~~1"5"~~ conduit. ~~There is a possibility that our~~ The supply will be a ~~4~~ 3 conductors ~~#8~~ AWG type ~~MC~~ THHN cable. This will have a cross-sectional area of ~~.082~~ 0.091 square inches. (See Attachment G) ~~Inherent with this cable is an inherent #10 AWG ground conductor.~~ The total area taken up by the cable is ~~.62~~ 0.21 square inches. Per NEC table 4 one not lead covered cable can be up to ~~1.08~~ 0.21 square inches and still not exceed the ~~53~~ 40 % fill requirement. in 3/4" conduit and 0.34 sq. in. in 1" conduit,

0.21 or ~~1.08~~ > 0.091 ~~.637~~ square inches
0.34 or 3/4"

A 1"~~.5"~~ conduit is adequate for type ~~MC 3 / C #8~~ THHN 3 #10 with ground.

7.6 LIGHTING

Inside Lighting: Per IES (Attachment D), average of 30 footcandles is adequate. The Zonal-Cavity Method will be used to determine the number of fixtures.

Room Cavity Ratio (RCR) = [5 X h X (L + W)] / (L X W)

h = height of light
L = room length
W = room width

RCR = [5 X 8 X (10 + 8.5)] / (10 X 8.5) = 8.7

KPT (7/24/98)

DESIGN ANALYSIS

Client WHC
Subject Service Building Installation
Location Tank Farm C

WO/Job No. ER4319
Date 8/01/94
Checked 8/01/94
Revised ~~NA~~ 9/25/98

By D.E. Larson D.E.L.
By J. Del Rosario
By ~~NA~~ KP Thanawala.

Using the Crouse-Hinds photometric data (Attachment C), with an assumed ceiling reflectance of 80 % and an assumed wall reflectance of 50 %, the coefficient of utilization is ~~.25~~ .28 (2)

# of fixtures = (FC X FT^2) / (# of lamps X lumens/lamp X CU X MF)

# of fixtures = (30 X 10 X 8.5) / (2 X 3200 X ~~.25~~ .28 X .9) = ~~1.77~~ 1.58 (3)

Use two fixtures.

Entrance lighting needs 3 footcandles. Total area that needs to be lit is approximately 6' X 3' = 18 ft^2

The fixture selected for outdoor use is the Voigt SOX-35 Wall-Most. The manufacturer's data in Attachment I may be used to determine whether this fixture is adequate for our needs. The Footcandle Isolux diagram shows the footcandles available from a Voigt SOX-55 at a height of 15 ft. This must be adjusted to obtain values for the SOX-35 at 10 feet.

To adjust for the lower lamp output, the footcandles will be multiplied by .6. This is obtained from the ratio of the lumen output of the lamps. The Westinghouse lighting handbook provides guidance for adjusting for the height difference. The following is quoted from page 2-14 of the 1969 Westinghouse lighting handbook, "Footcandles for other mounting heights than the one shown are obtained by multiplying the values given on the curves by the ratio of the square of the present mounting height to the square of the new mounting height."

This adjustment factor will be (15^2 / 10^2) = 2.25

We will consider an area 3 ft out from the wall. The chart shows this as approximately 7 footcandles.

KP (9/24/98)

DESIGN ANALYSIS

Client WHC
Subject Service Building Installation
Location Tank Farm C

WO/Job No. ER4319
Date 8/01/94 By D.E. Larson D.E.L.
Checked 8/01/94 By J. Del Rosario ~~KBR~~
Revised ~~NA~~ 7/25/98 By ~~NA~~ KP Thanawala

Using our adjustment factors this becomes:

7 footcandles X 2.25 X .6 = 9.5 footcandles

Outdoor fixtures will give adequate light.

7 ~~2~~

7.~~2~~ Voltage Drop

From the Power Distribution Panel (PDP) to the Service building is approximately 55 ft. The voltage drop to the load is divided into ~~four~~ three parts. These are the voltage drop from the PDP supply to the main disconnect, ~~the voltage drop across the transformer~~, the voltage drop across branch circuit wiring to the load and the starting voltage drop when the compressor starts.

Supply cables are ~~minimum~~ 10 #~~12~~ AWG 55 ft long. Using conductor information from NEC Chapt. 9 Table 9:

(55 ft/~~1000ft~~) X 1.1 ~~1.7~~ ohms/1000 ft = .0605 .0935 ohms

Full load amps are ~~18~~ 21.4 ~~16.41~~ amps for air compressor and the mini power zone. (Refer to Section 7.3.1)

Volts dropped = .0605 .0935 ohms X ~~18~~ 21.4 ~~16.41~~ amps = ~~+68~~ 1.295 ~~1.53~~ volts

% Voltage drop = (~~68~~ 295 ~~1.53~~ V / 480 V) X 100 = ~~.35~~ .27 ~~.318~~ % for 10 #~~12~~ wire

~~Transformer Z may be assumed to be 2.64 %. (see Attachment F) By definition, this is the voltage drop across our transformer.~~

Branch circuit conductors can be no longer than (10 ft length + 8 ft length) with a 20 percent margin. This is a total length of 21.6 ft. Per Chapter 9 table 9 the impedance of a # 12 AWG conductor is 1.7 ohms / 1000 ft.

V = I * Z = 20 amps X 21.6 ft X 1.7 ohms / 1000 ft = .7344 volts

% Voltage Drop = .734 V / 120 V X 100 = .6 % [must be < 3%]

Total Voltage Drop = .27 ~~.318%~~ ~~+ 2.64%~~ + .6% = ~~3.6 %~~ ~~3.51%~~ 0.87%

Total voltage drop must be less than 5 %. 3.57 ~~3.6~~ % < 5 %
0.87

Voltage drop is satisfactory.

DEL 9/22/94 (7/25/98)

KEH 0037.00 (06/92) KEF055

DESIGN ANALYSIS

Client WHC
Subject Service Building Installation
Location Tank Farm C

WO/Job No. ER4319
Date 8/01/94 By D.E. Larson D.E.L.
Checked 8/01/94 By J. Del Rosario
Revised ~~NA~~ 1/25/98 By ~~NA~~ K P Thanawala.

Upon starting our compressor will draw about ~~45.6~~ 63.5 LRA amps per NEC Table 430-151. In order to start our compressor motor our supply voltage should not dip below 80 % of the motor's voltage rating. This current is in conjunction with the current to our mini-power zone. The total worst case current will then be: (Ref. Sec. 7.3.1)

10.4 + ~~45.6~~ 63.5 ≃ ~~56~~ 74 amps

Voltage drop to compressor is the drop across our 55 foot # ~~12~~ 10 supply and an additional 20 ft. to the compressor motor.

~~.0935~~ .0605 X ~~56~~ 74 = ~~5.236~~ 4.477 volts to the disconnect. (of #12)

~~45.6~~ 63.5 amps X 20 ft/~~1000 ft~~ X 1.7 ohms/1000 ft = ~~1.55~~ 2.159 volts

% drop is (~~5.236~~ 4.477 + ~~1.55~~ 2.159)V / 480 V * 100 = ~~1.4~~ 1.38 % voltage drop

The total ~~1.4~~ 1.38 % voltage drop is within the allowable limits given for NEMA motors. (NEMA MG-1 12.44.2)

8.0 FINDINGS AND CONCLUSIONS

8.1 Supply cable to the Service Building is adequately sized.

8.2 Branch circuit conductors are adequately sized.

8.3 ~~Conductor~~ Conduit fill is satisfactory.

8.4 Lighting system designed meets or exceeds the minimum required illumination for the W-320 Service Building.

8.5 Total voltage drop on air compressor feeder and branch circuit is within tolerance for NEMA motors.

DEL 9/22/94 KPT (9/25/98)

The Square D Mini Power-Zone™ power supply provides the answer to requirements for a portable, compact, package power supply for small loads. It is suitable for both indoor and outdoor use with its weather-resistant enclosure and sand-epoxy encapsulated transformer, operating at a maximum full load temperature rise of 115°C.

All sizes are furnished from warehouse stock with Square D primary and secondary main circuit breakers only, sized in accordance with National Electrical Code requirements.

Feeder circuit breakers are standard Square D, QO plug-on type which may be ordered, as required, from your local Square D distributor's stock. (No tandem breakers permitted.)

Since the Mini Power-Zone is furnished as a complete package, considerable savings in installation time and costs can be realized.

If ground fault protection is required, QWIK-GARD circuit breakers may be used in all sizes except the 5 KVA, single phase.

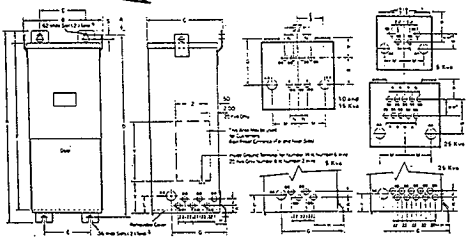
Refer to Bulletin D-1F for more details.

SINGLE PHASE, 480 VOLTS PRIMARY 240/120 VOLTS SECONDARY, 2-5.0% TAPS FCBN

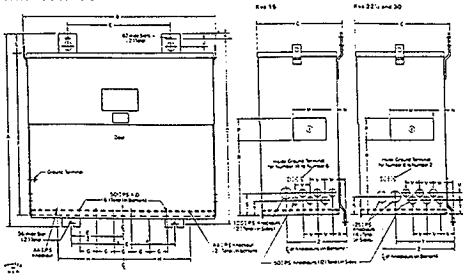
KVA	Catalog Number	Weight Lbs.	DIMENSIONS ① A	B	C	D	E	F	G	H	J	K	L	M	N	Primary ② Main Circuit Breaker	Secondary Main Circuit Breaker	Feeder Breakers Maximum Number 1 Pole or 2 Pole	Maximum Amps
5	MPZ 5S40F	95	25.5	9.62	8.82	24.18	6.00	22.3	5.6	1.22	.94	1.32	1.62	3.32	2.00	FAL24020 20 Amps.	QO225 25 Amps.	4 or 2	20
10	MPZ 10S40F	167	34.0	12.34	11.85	32.62	8.00	29.7	8.1	1.50	.94	1.32	1.68	4.44	1.50	FAL24040 40 Amps.	QO250 50 Amps.	8 or 4	40
15	MPZ 15S40F	202	34.0	12.34	11.86	32.62	8.00	29.7	8.1	1.50	.94	1.32	1.68	4.44	1.50	FAL24060 60 Amps.	Q1280 80 Amps.	12 or 6	60
25	MPZ 25S40F	358	41.5	15.60	14.62	40.12	9.00	37.3	10.6	2.38	1.76	1.56	2.38	4.62	2.00	FAL24100 100 Amps.	Q2L-2125 125 Amps.	20 or 10	100
THREE PHASE, 480 VOLTS ▲PRIMARY, 208Y/120 VOLTS SECONDARY, 2-5.0% TAPS FCBN																		Maximum Number 1 Pole or 3 Pole	
15	MPZ 15T2F	310	31.06	25.7	9.38	29.8	14.0	26.8	2.5	9.00	1.12	.76	2.62	4.00	1.38	FAL34040 40 Amps.	Q1-360 60 Amps.	12 or 4	40
22.5	MPZ 22T2F	555	35.8	29.8	13.6	34.5	16.0	31.6	3.0	10.5	1.12	.76	2.62	7.00	1.62	FAL34070 70 Amps.	Q1-380 80 Amps.	18 or 6	60
30	MPZ 30T2F	625	36.80	29.8	13.6	35.5	16.0	32.6	3.0	10.5	1.12	.76	2.62	7.00	1.62	FAL34090 90 Amps.	FAL34100 100 Amps.	24 or 8	80

	P	R	S	T	U	V	W	X	Y	Z	Knockouts AA
MPZ 1ST2F	3.00	12.3	2.70	1.44	—	1.38	2.38	1.70	—	6.08	1.00
MPZ 22T2F	3.00	14.1	2.00	1.44	1.26	1.38	2.60	2.20	7.20	9.70	1.25
MPZ 30T2F	3.00	16.1	2.00	1.44	1.26	1.38	2.60	2.20	7.20	9.70	1.25

SINGLE PHASE



THREE PHASE



① DO NOT USE FOR CONSTRUCTION; CONTACT SORGEL PLANT FOR CERTIFIED PRINTS.

② Shunt trip can be provided on primary main circuit breaker when required for fire department use. No change in dimensions. Contact factory or your local Square D distributor for price and availability.

CALC. W320-31-015
ATTACHMENT: A
SH. 1 OF 3

COMPANY

208

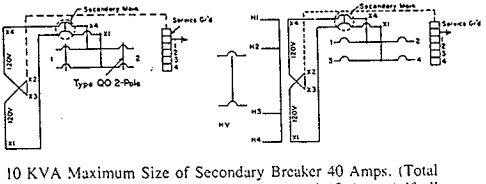
SINGLE PHASE

Suitable for use as Service Equipment

HV	
Volts	Line
480	H1-H4
456	H2-H4
432	H2-H3

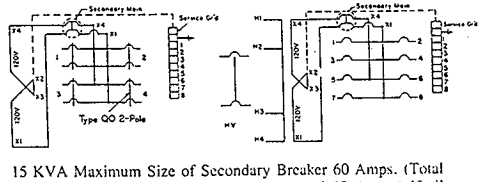
5 KVA Maximum Size of Secondary Breaker 20 Amps. (Total current per secondary main bus not to exceed 20 Amps.) If all breaker spaces are utilized, maximum current that can be drawn through each is 10 Amps.

240 VOLT LINE TO LINE CIRCUIT 120 VOLT CIRCUIT



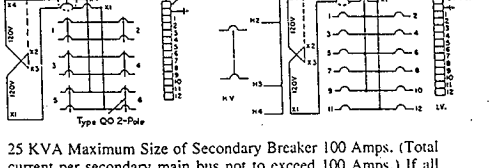
10 KVA Maximum Size of Secondary Breaker 40 Amps. (Total current per secondary main bus not to exceed 40 Amps.) If all breaker spaces are utilized, maximum current that can be drawn through each is 10 Amps.

240 VOLT LINE TO LINE CIRCUIT 120 VOLT CIRCUIT



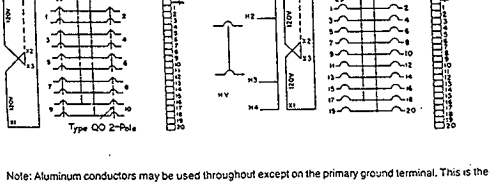
15 KVA Maximum Size of Secondary Breaker 60 Amps. (Total current per secondary main bus not to exceed 60 Amps.) If all breaker spaces are utilized, maximum current that can be drawn through each is 10 Amps.

240 VOLT LINE TO LINE CIRCUIT 120 VOLT CIRCUIT



25 KVA Maximum Size of Secondary Breaker 100 Amps. (Total current per secondary main bus not to exceed 100 Amps.) If all breaker spaces are utilized, maximum current that can be drawn through each is 10 Amps.

240 VOLT LINE TO LINE CIRCUIT 120 VOLT CIRCUIT



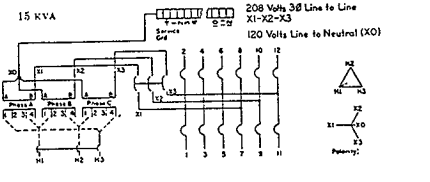
THREE PHASE

Suitable for use as Service Equipment

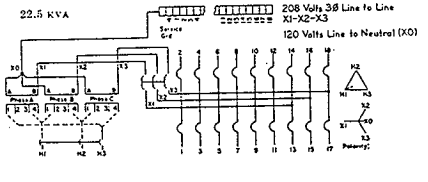
HV		
Volts	Conn.	Line
480	1 & 4	H1-H2-H3
456	2 & 4	H1-H2-H3
432	2 & 3	H1-H2-H3

LV 208Y/120 X1-X2-X3

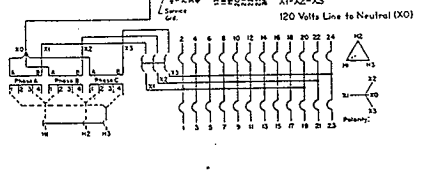
15 KVA



22.5 KVA



30 KVA



CALC. W320-31-015
ATTACHMENT: A
SH. 2 OF 3

Note: Aluminum conductors may be used throughout except on the primary ground terminal. This is the copper terminal attached to the case. A copper conductor must be used with this terminal.

TYPICAL SPECIFICATIONS

Furnish and install, as indicated on the electrical plans, Sorgel Mini Power-Zone Dry-Type Package Power Supplies, or approved equal.

Single phase transformers shall be 480 volt primary and 240/120 volt secondary. Three phase transformers shall be 480 volt primary and 208Y/120 volt secondary.

All transformers shall have a minimum of 2-5% full capacity primary taps below normal and shall be rated 115°C temperature rise above 40°C maximum ambient. All insulating materials are to be in accordance with current NEMA ST20 standards for a 185°C UL component recognized insulation system.

Transformers are to be encapsulated using a sand-epoxy resin mixture to provide maximum protection against moisture, dust and corrosive environments.

Package power supplies shall include integrally mounted and wired primary and secondary circuit breakers in accordance with the National Electrical Code requirements.

Branch circuit breakers shall be Square D Type QO or approved equal. All breakers shall be plug-on type. Trip indication shall be clearly shown by the breaker handle taking a position between ON and OFF when the breaker is tripped and by VISI-TRIP® indication consisting of a highly visible red tripped circuit indication.

Package power supplies shall be capable of being mounted horizontally or vertically. A hinged access door shall be provided which maintains itself in the open position when desired, and which has padlock provisions to prevent unauthorized entry. All live parts are to be fully enclosed for personnel protection when installation is completed.

All sizes shall be UL Listed for use as service equipment.

LIST PRICES

Single Phase		Three Phase	
Catalog Number	Price	Catalog Number	Price
MPZ 5S40F	$ 925.	MPZ 15T2F	$2400.
MPZ 10S40F	1175.	MPZ 22T2F	2975.
MPZ 15S40F	1525.	MPZ 30T2F	3650.
MPZ 25S40F	2275.		

All units stocked at Central Warehouse
Prices subject to change without notice.

CALC-W320-31-015
ATTACHMENT: A
SH. 3 OF 3

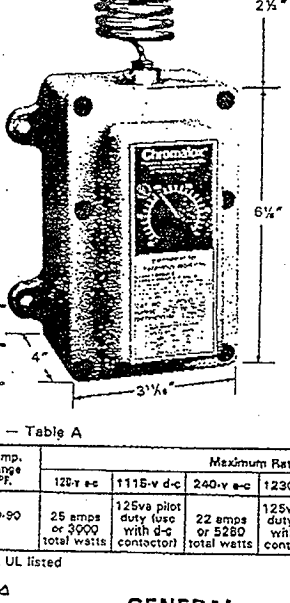
Chromalox #45

Installation and Operating Instructions

SERVICE REFERENCE		
DIV. 4	SEC. WR	NUMBER 3013C
SALES REFERENCE	(Supersedes PK435-2)	PK435-3
		181-048630-001
DATE	MAY, 1986	

Chromalox Explosion Proof Room Thermostat Type WR-80EP

CALC. W320-31-015
ATTACHMENT: B
SH. 1 OF 1



WR-80EP
40 to 90°F.
UL Listed

GEORGE A. GRANT, INC.
P.O. BOX 789 • RICHLAND, WASH.
CONTRACT NO. K-5420 (W320)
TRANSMITTAL NO. 45

VI. 2266F SUP. 18
SHT. 192-195
Bldg. M021

Specifications — Table A

Catalog No.	Temp. Range °F.	Maximum Rating					
		120-v a-c	1115-v d-c	240-v a-c	1230-v d-c	277-v a-c	480-v a-c
WR-80EP	40-90	25 amps or 3000 total watts	125va pilot duty (use with d-c contactor)	22 amps or 5280 total watts	125va pilot duty (use with d-c contactor)	18 amps or 5000 total watts	125va pilot duty (use with a-c contactor)

†d-c ratings not UL listed

wt = 7 lbs

GENERAL

Positive accuracy, long and reliable service, 3° differential. Heavy-duty, single stage, SPST line voltage snap-acting switch. Patented hydraulic element. WR-80EP has external, coiled sensing element and a low position which drops control point to keep heater off.

Uses — Automatically controls room temperature by turning electric air heaters on and off. Can be used to control the air heaters directly, within thermostat rating. For higher ratings use thermostat with magnetic contactor. Place thermostat on inside wall, away from undue heating or cooling influences, about 4 feet above the floor. The explosion proof WR-80EP is suitable for Class I, Group D and Class II, Groups E, F, and G locations.

NOTICE: Type WR thermostats are designed for temperature control service only. Because they do not fail safe, they should not be used for temperature limiting duty.

CAUTION: *Users should install adequate back-up controls and safety devices with their electric heating equipment. Where the consequences of failure may be severe, back-up controls are essential. Although the safety of the installation is the responsibility of the user, Chromalox will be glad to make equipment recommendations.*

Principle of Operation — Control action of these thermostats is provided through the principle of liquid volume change. With a variation in temperature, the liquid in the sensing element expands or contracts, causing a bellows to actuate the switching mechanism.

Housing — The control housing and cover assembly is of heavy-duty cast aluminum.

19
3062/255 F1

CROUSE-HINDS

NFW Fluorescent Industrial Lighting Fixtures

VI. 22668 SUP. 28
SHT. 244-249
Bldg. M02.11

CALC. W320-31-015
ATTACHMENT: C
SH. 1 OF 3

Application:

NFW fixtures are used:
- in non-hazardous locations where protection is required from wet, dirty and corrosive atmospheres
- where cleanliness and sanitation are prime factors, such as dairies, canneries, food processing plants, bottling plants, laboratories
- in dock areas for protection against salt spray

Features:

- One-piece high impact fiberglass housing provides durability and corrosion resistance
- Energy efficient ballast is standard
- One-piece prismatic acrylic lens for resistance to accidental damage
- Plastic latches apply positive, uniform pressure on gasketing to seal against dust and moisture. Six latches per four foot unit.
- Mounting lugs for ballast and channel are molded into housing

Standard Materials:

- Reflector housing and latches – reinforced fiberglass
- Prismatic lens – acrylic plastic
- Gasket – closed cell neoprene

Standard Finishes:

- Fiberglass – pearl gray
- Acrylic plastic – clear

Size Ranges:

- 4 and 8 foot lengths
- 2 and 4 lamp

Electrical Rating Ranges:

- 120 and 277 volt
- 60 hertz
- 40 watt

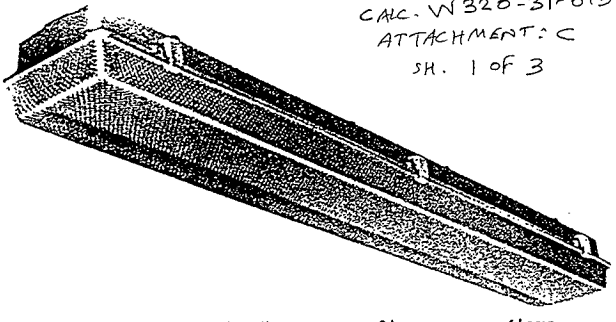
Certifications and Compliances:

- UL Standard: 1570

Options:

The following special options are available from the factory by adding suffix to Cat. No.:

Description	Suffix to be Added to Fixture Cat. #
• Chain mounting assembly§	CMA
• Chain sets	CS
• Low temperature ballast – rated 0°F (40 watt)	BY
• Fuse and holder (one per fixture)	FB
• Suitable for 220V 50Hz.	Consult Crouse-Hinds
• Electronic ballast	S801

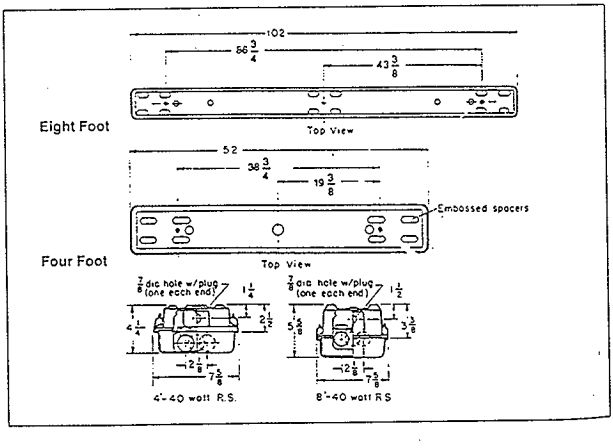


Line Voltage (60 hertz)	Watts	Length (Nominal-In Feet)	2 Lamp Cat. #	4 Lamp Cat. #
120	40	4	NFW4240	
		8		NFW8440*
277	40	4	NFW4240/277	
		8		NFW8440/277*

Lamps and Ballasts

Watts	Lamp	Ballast Type†
40	F40 (T12 Med. Bi-Pin)	430 ma

Dimensions



* Two pairs of 4' lamps in tandem.

† 40 watt ballasts are rapid start.

§ Chain sets not included. Order chain sets by adding CS to Cat. No.

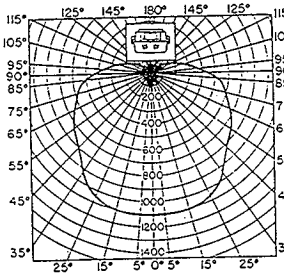
GEORGE A. GRANT, INC.
P.O. BOX 769 • RICHLAND, WASH.
CONTRACT NO. 5-5928
TRANSMITTAL NO. 52
REVIEWED BY

CALC. W320-31-015
ATTACHMENT C
SH. 2 of 3

CROUSE-HINDS

Fixture: NFW4240

Lamp: 2-40/T-12
Zonal Degrees: 0-30 0-40 0-60 0-90 0-180
Zonal Lumens: 857 1394 2478 3678 4211
Total Bare Lamp Lumens: 3200 x 2 = 6400
To determine number and placement of fixtures, see Lighting Selector Guide, pages L-7 to L-12.



Angle	Candelas Along	Candelas Across
0	1166	1166
10	1141	1170
20	1100	1192
30	1013	1190
40	841	1104
50	631	957
60	429	781
70	249	616
80	107	497
90	18	350
100	14	220
110	12	161
120	8	79
130	5	30
140	3	15
150	2	7
160	1	3
170	1	1
180	0	0

Coefficient of Utilization

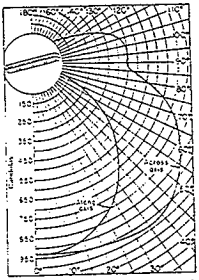
Effective Floor Cavity Reflectance 20%

% Reflectance Eff. Ceil.	Wall	Room Cavity Ratio 1	2	3	4	5
80	50	.71	.61	.54	.47	.42
	30	.68	.56	.47	.40	.35
	10	.64	.51	.42	.35	.30
70	50	.69	.60	.52	.46	.41
	30	.66	.55	.46	.40	.34
	10	.63	.50	.41	.35	.30
50	50	.65	.56	.49	.43	.39
	30	.62	.52	.44	.38	.33
	10	.60	.48	.40	.34	.29
30	50	.61	.53	.46	.41	.37
	30	.59	.40	.42	.36	.32
	10	.57	.46	.38	.33	.28
10	50	.58	.50	.44	.39	.35
	30	.56	.47	.40	.35	.30
	10	.54	.44	.37	.31	.27
0	0	.52	.42	.35	.30	.25

% Reflectance Eff. Ceil.	Wall	Room Cavity Ratio 6	7	8	9	10
80	50	.38	.34	.31	.28	.26
	30	.31	.27	.25	.22	.20
	10	.26	.23	.20	.18	.16
70	50	.37	.33	.30	.28	.25
	30	.30	.27	.24	.22	.20
	10	.26	.23	.20	.18	.16
50	50	.35	.31	.29	.26	.24
	30	.29	.26	.23	.21	.19
	10	.25	.22	.20	.18	.16
30	50	.33	.30	.27	.25	.23
	30	.28	.25	.23	.21	.19
	10	.24	.21	.19	.17	.16
10	50	.31	.28	.26	.24	.22
	30	.27	.24	.22	.20	.18
	10	.24	.21	.19	.17	.15
0	0	.22	.19	.17	.15	.14

Fixture: FMR4240

Lamp: 2-40/T-12
Zonal Degrees: 0-30 0-40 0-60 0-90 0-180
Zonal Lumens: 761 1300 2508 3826 4601
Total Bare Lamp Lumens: 3200 x 2 = 6400
To determine number and placement of fixtures, see Lighting Selector Guide, pages L-7 to L-12.



Angle	Candelas Along	Candelas Across
0	933	933
10	912	936
20	860	954
30	774	975
40	649	969
50	486	912
60	314	827
70	169	719
80	68	574
90	14	443
100	12	432
110	11	367
120	9	261
130	7	144
140	3	55
150	1	15
160	0	3
170	0	0
180	0	0

Coefficient of Utilization

Effective Floor Cavity Reflectance 20%

% Reflectance Eff. Ceil.	Wall	Room Cavity Ratio 1	2	3	4	5
80	50	.69	.59	.51	.45	.40
	30	.65	.53	.44	.38	.33
	10	.62	.48	.39	.33	.28
70	50	.66	.56	.49	.43	.38
	30	.63	.51	.43	.37	.32
	10	.59	.47	.38	.32	.27
50	50	.61	.52	.45	.39	.35
	30	.58	.48	.40	.34	.30
	10	.55	.44	.36	.30	.25
30	50	.56	.48	.41	.36	.32
	30	.54	.44	.37	.32	.28
	10	.51	.41	.34	.28	.24
10	50	.51	.44	.38	.33	.30
	30	.50	.41	.35	.30	.26
	10	.48	.38	.32	.27	.23
0	0	.45	.36	.29	.25	.21

% Reflectance Eff. Ceil.	Wall	Room Cavity Ratio 6	7	8	9	10
80	50	.35	.32	.29	.26	.24
	30	.29	.25	.23	.20	.18
	10	.24	.21	.18	.16	.15
70	50	.34	.31	.28	.25	.23
	30	.28	.25	.22	.20	.18
	10	.23	.20	.18	.16	.14
50	50	.31	.28	.26	.24	.22
	30	.26	.23	.21	.19	.17
	10	.22	.19	.17	.15	.14
30	50	.29	.26	.24	.22	.20
	30	.24	.22	.19	.18	.16
	10	.21	.18	.16	.14	.13
10	50	.27	.24	.22	.21	.19
	30	.23	.20	.18	.17	.15
	10	.20	.17	.15	.14	.12
0	0	.18	.16	.14	.12	.11

U-Shaped Lamps

Straight Lamps

SOUND RATED A

T12 RAPID START NORMAL LIGHT OUTPUT SERIES

Lamp Data			Min Start Temp °F	Input Volts	Model Number	Line Amps	Input Watts	Ballast Factor	THD %	Power Factor	Wiring Diagram
Number	Length	Watts									
F30T12											
1	3'	25	60	120	REL-1S40-RH-TP	0.24	27	0.95	<20	>0.96	1
		30	50			0.27	31				
		25	60	277	VEL-1S40-RH-TP	0.10	27				
		30	50			0.12	31				
2	3'	25	60	120	REL-2S40-RH-TP	0.41	48	0.95	<20	>0.98	2
		30	50			0.51	60				
		25	60	277	VEL-2S40-RH-TP	0.18	48				
		30	50			0.22	60				
3	3'	25	60	120	REL-3S40-RH-TP	0.69	80	0.95	<20	>0.97	3
		30	50			0.78	90				
		25	60	277	VEL-3S40-RH-TP	0.30	80				
		30	50			0.34	90				
F40T12 & F40T12/U											
1	4'	34	60	120	REL-1S40-RH-TP	0.27	31	0.90	<20	>0.98	1
		40	50			0.33	38				
		34	60	277	VEL-1S40-RH-TP	0.12	31				
		40	50			0.14	38				
2	4'	34	60	120	REL-2S40-RH-TP	0.51	60	0.87	<20	>0.98	2
		40	50			0.61	72				
		34	60	277	VEL-2S40-RH-TP	0.22	60				
		40	50			0.27	72				
		34	60	347	GEL-2S40-RH-TP	0.18	60				
		40	50			0.21	72				
3	4'	34	60	120	REL-3S40-RH-TP	0.77	91	0.87	<20	>0.98	3
		40	50			0.91	107				
		34	60	277	VEL-3S40-RH-TP	0.33	91				
		40	50			0.39	107				

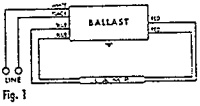


Fig. 1

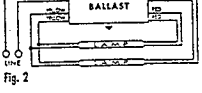


Fig. 2

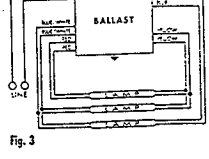
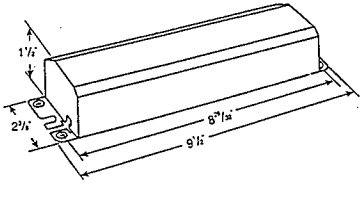


Fig. 3



CALC. W320-31-015
ATTACHMENT C
SH. 3 OF 3

Refer to pages 144 to 145 for lead lengths and shipping data

Fig. 11-1. Currently Recommended Illuminance Categories and Illuminance Values for Lighting Design—Targeted Maintained Levels

The following table is a consolidated listing of the IESNA's current illuminance recommendations. This listing is intended to guide the designer in selecting an appropriate illuminance.

Guidance is provided in two forms: (1), in Parts I, II and III as an *Illuminance Category*, representing a range of illuminances; and (2), in Parts IV, V and VI as an *Illuminance Value*. Illuminance categories are represented by letter designations A through I. Illuminance Values are given in *lux* with equivalents in *footcandles* and as such are intended as *target* values with deviations expected. These target values also represent *maintained* values.

This table has been divided into six parts for ease of use. Part I lists both Illuminance Categories and Illuminance Values for generic types of interior activities and normally is to be used when Illuminance Categories for a specific Area/Activity cannot be found in Parts II and III. Parts IV, V and VI provide target maintained Illuminance Values for outdoor facilities, sports and recreational areas, and transportation vehicles where special considerations apply as discussed.

In all cases the recommendations in this table are based on the assumption that the lighting will be properly designed to take into account the visual characteristics of the task.

I. Illuminance Categories and Illuminance Values for Generic Types of Activities in Interiors

Type of Activity	Illuminance Category	Ranges of Illuminances		Reference Work-Plane
		Lux	Footcandles	
Public spaces with dark surroundings	A	20-30-50	2-3-5	
Simple orientation for short temporary visits	B	50-75-100	5-7.5-10	General lighting throughout spaces
Working spaces where visual tasks are only occasionally performed	C	100-150-200	10-15-20	
Performance of visual tasks of high contrast or large size	D	200-300-500	20-30-50	
Performance of visual tasks of medium contrast or small size	E	500-750-1000	50-75-100	Illuminance on task
Performance of visual tasks of low contrast or very small size	F	1000-1500-2000	100-150-200	
Performance of visual tasks of low contrast and very small size over a prolonged period	G	2000-3000-5000	200-300-500	
Performance of very prolonged and exacting visual task	H	5000-7500-10000	500-750-1000	Illuminance on task, obtained by a combination of general and local (supplementary lighting)
Performance of very special visual tasks of extremely low contrast and small size	I	10000-15000-20000	1000-1500-2000	

II. Commercial, Institutional, Residential and Public Assembly Interiors

Area/Activity	Illuminance Category
Accounting (see Reading)	
Air terminals (see Transportation terminals)	
Armories	C[1]
Art galleries (see Museums)	
Auditoriums	
Assembly	C[1]
Social activity	B
Banks (also see Reading)	
Lobby	
General	C
Writing area	D
Tellers' stations	E[3]
Barber shops and beauty parlors	E
Churches and synagogues .. (see chapter 17)[4]	
Club and lodge rooms	
Lounge and reading	D
Conference rooms	
Conferring	D
Critical seeing (refer to individual task)	
Court rooms	
Seating area	C
Court activity area	E[3]
Dance halls and discotheques	B
Depots, terminals and stations (see Transportation terminals)	

For footnotes, see end of table.

Calculation W320-31-015
Attachment D
Sheet 1 of 1

Table 9.2-204 Procedure for Calculating Footcandles and Watts Per Square Foot

1. Initial footcandles = No. of fixtures x lamps per fixture x lumens per lamp x coefficient of utilization ÷ square feet
2. Maintained footcandles = initial footcandles x maintenance factor
3. Watts per square foot = No. of fixtures x lamps x (lamp watts + ballast watts) ÷ square feet

Example — To find footcandles and watts per S.F. for an office 20' x 20' with 11 fluorescent fixtures each having 4-40 watt C.W. lamps.

Based on good reflectance and clean conditions:
Lumens per lamp = 40 watt cool white at 3150 lumens per lamp (Table C9.2-251)
Coefficient of utilization = .42 (varies from .62 for light colored areas to .27 for dark)
Maintenance factor = .75 (varies from .80 for clean areas with good maintenance to .50 for poor)
Ballast loss = 8 watts per lamp. (Varies with manufacturer. See manufacturers' catalog.)

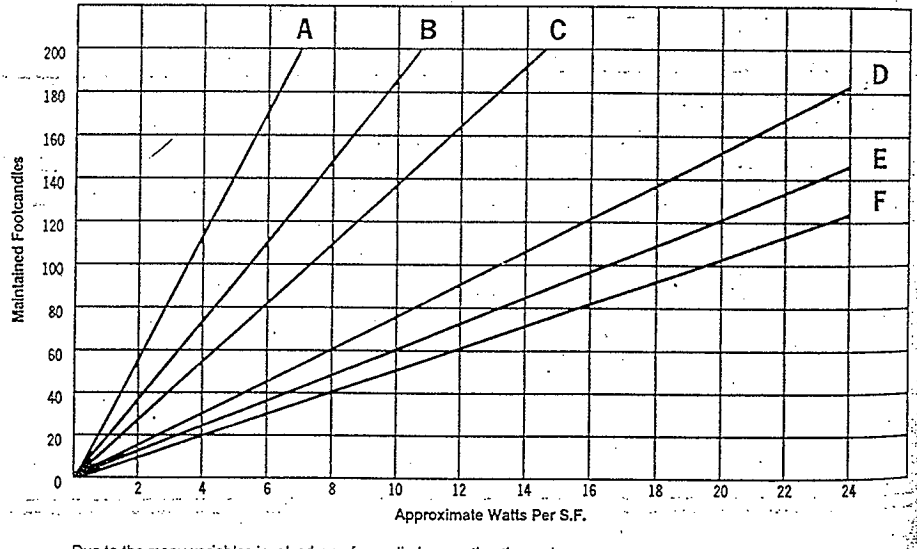
1. Initial footcandles:

$$\frac{11 \times 4 \times 3150 \times .42}{400} = \frac{58212}{400} = 145 \text{ footcandles}$$

2. Maintained footcandles:
   145 x .75 = 109 footcandles
3. Watts per S.F.

$$\frac{11 \times 4 \times (40 + 8)}{400} = \frac{2112}{400} = 5.3 \text{ watts per S.F.}$$

Table 9.2-205 Approximate Watts Per Square Foot for Popular Fixture Types



Due to the many variables involved, use for preliminary estimating only:

A. Fluorescent — industrial System B9.2-212
B. Fluorescent — lens unit System B9.2-212 Fixture types B & C
C. Fluorescent — louvered unit
D. Incandescent — open reflector System B9.2-222, Type D
E. Incandescent — lens unit System B9.2-222, Type A
F. Incandescent — down light System B9.2-222, Type B

From: Means Electrical Cost Data 1991
Calculation: W320-31-015 Attachment E
Sheet 1 of 3

A. Strip Fixture

B. Surface Mounted

C. Recessed

D. Pendent Mounted

Design Assumptions:

1. A 100 footcandle average maintained level of illumination.
2. Ceiling heights range from 9' to 11'.
3. Average reflectance values are assumed for ceilings, walls and floors.
4. Cool white (CW) fluorescent lamps with 3150 lumens for 40 watt lamps and 6300 lumens for 8' slimline lamps.
5. Four 40 watt lamps per 4' fixture and two 8' lamps per 8' fixture.
6. Average fixture efficiency values and spacing to mounting height ratios.
7. Installation labor is average U.S. rate as of January 1.

System Components	QUANTITY	UNIT	COST PER S.F. MAT.	INST.	TOTAL
SYSTEM 09.2-212-0520					
FLUORESCENT FIXTURES MOUNTED 9'-11" ABOVE FLOOR, 100 FC					
TYPE A, 8 FIXTURES PER 400 S.F.					
Steel intermediate conduit, (IMC) ½" diam	.404	L.F.	.39	1.20	1.59
Wire, 600V, type THWN-THHN, copper, solid, #12	.008	C.L.F.	.05	.21	.26
Fluorescent strip fixture 8' long, surface mounted, two 75W SL	.020	Ea.	1.03	.97	2
Steel outlet box 4" concrete.	.020	Ea.	.10	.30	.40
Steel outlet box plate with stud, 4" concrete	.020	Ea.	.04	.07	.11
TOTAL			1.61	2.75	4.36

9.2-212	Fluorescent Fixtures (by Type)	COST PER S.F. MAT.	INST.	TOTAL
0520	Fluorescent fixtures, type A, 8 fixtures per 400 S.F.	1.61	2.75	4.36
0560	11 fixtures per 600 S.F.	1.51	2.67	4.18
0600	17 fixtures per 1000 S.F.	1.47	2.62	4.09
0640	23 fixtures per 1600 S.F.	1.30	2.49	3.79
0680	28 fixtures per 2000 S.F.	1.30	2.49	3.79
0720	41 fixtures per 3000 S.F.	1.27	2.48	3.75
0800	53 fixtures per 4000 S.F.	1.25	2.42	3.67
0840	64 fixtures per 5000 S.F.	1.25	2.42	3.67
0880	Type B, 11 fixtures per 400 S.F.	3.37	3.93	7.30
0920	15 fixtures per 600 S.F.	3.09	3.78	6.87
0960	24 fixtures per 1000 S.F.	3	3.77	6.77
1000	35 fixtures per 1600 S.F.	2.80	3.59	6.39
1040	42 fixtures per 2000 S.F.	2.73	3.62	6.35
1080	61 fixtures per 3000 S.F.	2.76	3.47	6.23
1160	80 fixtures per 4000 S.F.	2.63	3.57	6.20
1200	98 fixtures per 5000 S.F.	2.62	3.54	6.16
1240	Type C, 11 fixtures per 400 S.F.	2.75	4.29	7.04
1280	14 fixtures per 600 S.F.	2.40	4.01	6.41
1320	23 fixtures per 1000 S.F.	2.39	3.98	6.37
1360	34 fixtures per 1600 S.F.	2.29	3.93	6.22
1400	43 fixtures per 2000 S.F.	2.32	3.89	6.21
1440	63 fixtures per 3000 S.F.	2.26	3.84	6.10
1520	81 fixtures per 4000 S.F.	2.18	3.78	5.96
1560	101 fixtures per 5000 S.F.	2.18	3.78	5.96
1600	Type D, 8 fixtures per 400 S.F.	2.68	3.28	5.96
1640	12 fixtures per 600 S.F.	2.67	3.27	5.94
1680	19 fixtures per 1000 S.F.	2.56	3.19	5.75
1720	27 fixtures per 1600 S.F.	2.38	3.10	5.48
1760	34 fixtures per 2000 S.F.	2.37	3.07	5.44
1800	48 fixtures per 3000 S.F.	2.26	2.99	5.25
1880	64 fixtures per 4000 S.F.	2.26	2.99	5.25
1920	79 fixtures per 5000 S.F.	2.26	2.99	5.25

Calculation W320-31-015
Attachment E
Sheet 2 of 3

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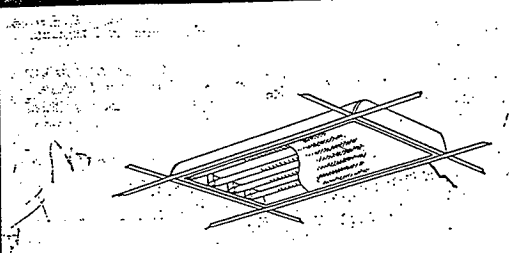


Type C. Recessed, mounted on grid ceiling supsension system, 2' x 4', four 40 watt lamps, acrylic prismatic diffusers.

5.3 watts per S.F. in 100 footcandles.
3 watts per S.F. for 57 footcandles.

System Components	QUANTITY	UNIT	COST PER S.F. MAT.	INST.	TOTAL
SYSTEM 09.2-213-0200					
FLUORESCENT FIXTURES RECESS MOUNTED IN CEILING					
1 WATT PER S.F., 20 FC, 5 FIXTURES PER 1000 S.F.					
Steel intermediate conduit, (IMC) ½" diam	.128	L.F.	.12	.38	.50
Wire, 600 volt, type THW, copper, solid, #12	.003	C.L.F.	.02	.08	.10
Fluorescent fixture, recessed, 2'x4', four 40W, w/lens, for grid ceiling	.005	Ea.	.35	.33	.68
Steel outlet box 4" square	.005	Ea.	.03	.07	.10
Fixture whip, Greenfield w/#12 THHN wire	.005	Ea.	.01	.02	.03
TOTAL			.53	.88	1.41

9.2-213	Fluorescent Fixtures (by Wattage)	COST PER S.F. MAT.	INST.	TOTAL
0190	Fluorescent fixtures recess mounted in ceiling			
0200	1 watt per S.F., 20 FC, 5 fixtures per 1000 S.F.	.53	.88	1.41
0240	2 watts per S.F., 40 FC, 10 fixtures per 1000 S.F.	1.05	1.74	2.79
0280	3 watts per S.F., 60 FC, 15 fixtures per 1000 S.F	1.58	2.62	4.20
0320	4 watts per S.F., 80 FC, 20 fixtures per 1000 S.F.	2.09	3.47	5.56
0400	5 watts per S.F., 100 FC, 25 fixtures per 1000 S.F.	2.61	4.35	6.96

Calculation W320-31-015
Attachment E
Sheet 3 of 3

Dry-Type Distribution Transformers

Technical Data

Calculation W-320-31-015
Attachment F
Sheet 1 of 1

Typical Data for 600 Volt Class Dry-Type Transformer

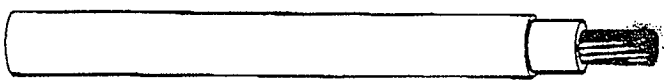
kVA	Type	Deg. C Rise	Dimensions, (In.)					Losses in Watts		Efficiency				% Regulation		
			Height	Width	Depth	Weight (Alum) Lbs.	Weight (Cu.) Lbs.	N.L.	Total	¼ Load	½ Load	¾ Load	Full Load	100% P.F.	80% P.F.	% Imp.
0.25	EP	80	7 1/16	4⅛	4⅛		12	13	36	80.0	82.0	85.0	87.5	9.2	8.0	9.24
0.5		80	7 1/16	4⅛	4⅛		13	20	45	85.2	90.5	91.6	91.8	5.07	4.54	5.12
0.75		80	8⅜	6	5½		20	21	54	89.1	92.8	93.5	93.3	4.14	3.33	4.44
1		80	8⅜	6	5½		30	29	71	95.2	96.0	96.0	95.1	4.09	3.62	4.18
1.5		80	10½	6⅜	6⅛		40	37	92	94.5	95.5	95.1	94.3	3.83	3.60	3.70
2		80	10½	6⅜	6⅛		40	37	97	95.4	96.5	96.4	96.0	3.18	3.30	3.42
3		115	14¼	7 11/16	8	65	69	74	144	95.0	96.3	96.3	95.9	3.25	3.50	3.53
5		115	16	10⅜	9⅛	113	120	104	201	96.6	97.35	97.2	96.85	2.58	2.50	2.64
7.5		115	16	10⅜	9⅞	123	133	149	271	97.0	97.65	97.5	97.15	2.31	2.50	2.54
10		115	19	13⅜	10½	193	208	160	317	96.1	97.3	97.4	97.25	1.95	2.10	2.18
15		115	19	13⅜	10½	216	235	230	454	97.6	98.15	98.1	97.8	1.71	1.80	1.85
25		115	22 5/16	16⅜	14⅛	385	414	284	550	97.3	98.0	98.0	97.8	1.18	1.63	1.65
3	EPT	115	13⅜	15 15/16	8 5/16	116	123	121	189	94.2	94.75	94.0	92.9	6.73	7.9	7.93
6		115	15⅞	16½	9⅞	143	153	140	288	93.6	95.3	95.2	94.8	3.35	3.6	3.7
9		115	15⅞	16½	9⅞	166	178	199	412	95.0	96.8	96.7	96.2	3.07	3.4	2.96
15		115	17⅜	19 1/16	10 7/16	275	300	216	534	96.9	97.5	97.4	97.0	2.38	2.91	2.8
30		115	26⅜	25⅛	12¾	422	504	229	681	96.7	97.8	97.9	97.8	1.51	2.12	2.14
25	DS-3	150	37⅞	22½	20	310	360	200	1050	96.1	96.8	96.6	96.0	3.5	4.0	4.0
37.5		150	43¾	22½	20	375	450	250	1550	96.1	96.8	96.5	96.0	3.5	5.1	5.2
50		150	43¾	22½	20	425	500	300	1950	95.8	97.2	96.8	96.2	3.5	5.9	6.6
75		150	52⅛	26	24¾	635	725	350	2750	97.7	98.2	98.1	97.8	2.1	5.5	7.6
100		150	52⅛	26	24¾	725	825	450	2850	97.7	97.9	97.6	97.5	2.7	5.7	7.3
167		150	62⅛	30	34	1200	1350	750	3250	97.8	98.3	98.3	98.0	1.7	5.1	6.8
15	DT-3	150	25	20⅛	14⅛	152	172	150	875	95.0	95.5	95.3	94.5	4.8	5.0	5.2
30		150	30⅛	20⅛	14⅛	230	300	200	1600	96.3	96.5	95.9	95.0	4.7	5.6	5.6
45		150	30⅛	20⅛	14⅛	310	370	300	1900	96.5	96.9	96.5	96.1	3.7	4.5	4.5
75		150	37⅛	26⅛	19⅛	480	550	400	3000	97.0	97.2	96.8	96.1	3.6	4.9	4.9
112.5		150	37⅞	26⅛	19⅛	600	675	500	4900	97.3	97.2	96.6	95.8	3.9	5.8	5.9
150		150	46½	26	20 5/16	760	850	600	6700	97.4	97.2	96.5	95.7	3.8	5.7	6.2
225		150	56	31¼	24¼	1100	1200	700	8600	97.9	97.7	97.0	96.3	3.7	6.0	6.4
300		150	56	31¼	24¼	1300	1750	800	10200	98.2	97.9	97.4	97.6	3.4	6.3	7.1
500		150	75	44½	36	2400	3100	1700	9000	98.4	98.7	98.6	98.4	1.5	4.2	5.5
750		150	75	44½	36	2900	3600	2200	11700	98.4	98.7	98.7	98.5	1.5	4.7	6.3
1000		150	75	47	41	4000	—	2800	13600	98.6	98.9	98.8	98.6	1.2	4.7	6.5
15		115	25	20⅛	14⅛	152	172	150	700	95.3	96.3	96.1	95.6	3.8	5.1	5.2
30		115	30⅛	20⅛	14⅛	230	300	200	1500	96.4	96.6	96.1	95.3	4.3	4.5	5.3
45		115	30⅛	20⅛	14⅛	310	370	300	1700	96.7	97.2	96.9	96.4	3.1	3.7	3.7
75		115	37⅛	26⅛	19⅛	480	550	400	2300	97.3	97.7	97.5	97.0	2.6	4.0	4.6
112.5		115	37⅞	26⅛	19⅛	600	675	500	3100	97.7	98.0	97.7	97.3	2.5	5.5	6.5
150		115	46½	26	20 5/16	760	850	600	5900	97.8	97.9	97.5	97.1	3.8	5.9	6.2
225		115	56	31¼	24¼	1100	1200	700	6000	98.2	98.2	97.9	97.4	2.5	5.7	7.2
300		115	56	31¼	24¼	1300	1750	800	6600	98.4	98.5	98.2	97.9	2.1	5.0	6.3
500		115	75	44½	36	2400	3100	1700	6800	98.4	98.8	98.8	98.7	1.2	4.1	5.5
15		80	30⅛	20⅛	14⅛	230	300	200	500	94.5	96.4	96.8	96.8	2.0	2.2	2.3
30		80	30⅛	20⅛	14⅛	310	370	300	975	95.5	96.8	97.0	96.8	2.3	2.9	2.9
45		80	37⅛	26⅛	19⅛	480	550	300	1100	97.0	97.8	97.8	97.6	1.8	2.8	2.9
75		80	37⅞	26⅛	19⅛	600	675	400	1950	97.5	97.9	97.8	97.4	2.2	3.5	3.7
112.5		80	46½	26	20 5/16	750	850	600	3400	97.3	97.7	97.4	97.0	2.6	4.1	4.3
150		80	56	31¼	24¼	1100	1200	700	3250	97.8	98.2	98.1	97.9	1.8	3.6	4.1
225		80	56	31¼	24¼	1300	1750	800	4000	98.2	98.6	98.5	98.2	1.6	4.2	5.3
300		80	75	44½	36	2400	3100	1700	4300	97.6	98.4	98.6	98.6	1.1	2.7	4.1
500		80	75	44½	36	2900	3600	2000	5500	98.9	98.9	98.8	98.2	1.2	4.0	4.5

ATTACHMENT: G
SH. 1 OF 2

THHN

600 Volt. Copper Conductor. Thermoplastic Insulation/Nylon Sheath. Heat, Moisture, Oil & Gasoline Resistant[1], All Sizes Rated THWN-2. All Stranded Sizes Rated MTW. AWG Sizes 14 Through 8 AWG Rated AWM (105°C). AWG Sizes 14 Through 1 Rated VW-1 and Larger Sizes Rated for CT Use.

VI. 22668 SUP 029
SHT. 250-251
Bldg. M021



APPLICATIONS

Southwire Type THHN or THWN-2 conductors are primarily used in conduit and cable trays for services, feeders, and branch circuits in commercial or industrial applications as specified in the National Electrical Code[2]. When used as Type THHN, conductor is suitable for use in dry locations at temperatures not to exceed 90°C. When used as Type THWN-2, conductor is suitable for use in wet or dry locations at temperatures not to exceed 90°C or not to exceed 75°C when exposed to oil or coolant. When used as Type MTW, conductor is suitable for use in wet locations or when exposed to oil or coolant at temperatures not to exceed 60°C or dry locations at temperatures not to exceed 90°C (with ampacity limited to that for 75°C conductor temperature per NFPA 79). Conductor temperatures not to exceed 105°C in dry locations when rated AWM and used as appliance wiring material. Voltage for all applications is 600 volts.

SPECIFICATIONS

Southwire Type THHN or THWN-2 or MTW (also AWM) meets or exceeds all applicable ASTM specifications, UL standard 83, UL standard 1063 (MTW), Federal Specification J-C-30B, and requirements of the National Electrical Code.

CONSTRUCTION

Southwire Type THHN or THWN-2 or MTW copper conductors are annealed (soft) copper, insulated with a tough, heat and moisture resistant polyvinyl chloride (PVC), over which a nylon (polyamide) or UL-listed equal jacket is applied. Available in black, white, red, blue, green, yellow, brown, orange, or grey. Some colors standard, some subject to economic order quantity. Sizes 1-19 through 1,000 kcmil available in black only.

[1] Oil and gasoline resistance II as defined by Underwriters Laboratories.
[2] 1996 Edition.

THHN

Conductor Size (AWG or kcmil)	Conductor No. Strands	Insulation Thickness (mils)	Jacket Thickness (mils)	Nominal O.D. (mils) Sol.	Nominal O.D. (mils) Str.	Approx. Net Weight Per 1000' (lbs.) Sol.	Approx. Net Weight Per 1000' (lbs.) Str.	Allowable Ampacities+ 60°C	Allowable Ampacities+ 75°C	Allowable Ampacities+ 90°C	Standard Package
**14	19*	15	4	102	109	15	16	15	15	15	DNF*
**12	19*	15	4	119	128	23	24	20	20	20	DNF*
**10	19*	20	4	150	161	37	38	30	30	30	DQF^
**8	19	30	5		212		63	40	50	55	F
**6	19	30	5		250		95	55	65	75	E
4	19	40	6		319		153	70	85	95	C
3	19	40	6		346		189	85	100	110	BC
2	19	40	6		378		234	95	115	130	C
1	19	50	7		435		300	110	130	150	B
1/0	19	50	7		474		372	125	150	170	B
2/0	19	50	7		518		463	145	175	195	B
3/0	19	50	7		568		576	165	200	225	B
4/0	19	50	7		624		719	195	230	260	B
250	37	60	8		694		849	215	255	290	B
300	37	60	8		747		1010	240	285	320	B
350	37	60	8		797		1172	260	310	350	B
400	37	60	8		842		1332	280	335	380	B
500	37	60	8		925		1652	320	380	430	B
600	61	70	9		1024		1990	355	420	475	C
750	61	70	9		1126		2468	400	475	535	C
1000	61	70	9		1275		3263	455	545	615	C

* Solid construction available in sizes 14, 12, & 10 as Types THHN or THWN-2 or AWM only.
** Also suitable for 105°C appliance wiring material (AWM).
# Four 500' spools per carton.
^ Two 500' spools per carton.
+ Allowable Ampacities:
Allowable ampacities shown are for general use as specified by the National Electrical Code, 1996 Edition, section 310-15.
60°C - When terminated to equipment for circuits rated 100 amperes or less or marked for #14 through #1 conductors. MTW wet locations or when exposed to oil or coolant.
75°C - When terminated to equipment for circuits rated over 100 amperes or marked for conductors larger than #1. THWN-2 when exposed to oil or coolant. MTW dry locations.
90°C - THHN dry locations; THWN-2 wet or dry locations.
All AWG sizes 14 through 1 rated VW-1. Larger sizes rated for CT Use.

STANDARD PACKAGE CODE:
B = 1000' Reel
C = 500' Reel
D = 2500' Spool
E = 1000' Spool
F = 500' Spool
N = 2000' Carton
Q = 250' Carton

RECOMMENDED SAMPLE SPECIFICATIONS:

(MTW OR THHN OR THWN-2)

Conductors shall be UL-listed Type MTW or THHN or THWN-2 gasoline and oil resistant II, suitable for operations at 600 volts as specified in the National Electrical Code. AWG sizes 14 through 1 shall be rated VW-1, larger sizes shall be rated for CT use. Conductors shall be annealed copper, insulated with high-heat and moisture resistant PVC, jacketed with abrasion, moisture, gasoline, and oil resistant nylon or UL-listed equivalent, as manufactured by Southwire Company or approved equal.

(AWM)

Conductors shall be UL-listed Type THHN or THWN-2 or MTW or AWM, suitable for operation at 600 volts at conductor temperatures not to exceed 105°C.

P.O. Box 1000
Carrollton, GA USA 30119-0001
770/832-4242

42] From: Shana L Sovern at ~WHC160 5/17/94 2:55PM (1774 bytes: 33 ln)
o: Daniel E Larson at ~KEH13, Timothy J Kasnick at ~WHC61
ubject: CODE QUESTION
---------- Message Contents ----------

Dan,
NEC Art.310, table 310-16, the heading for the ampacity of conductors is for not more than three conductors in a raceway and is based on 86 degrees F. If the ambient temperature is subject to vary appropriate multipliers are given on the correction factor table below table 310-16. This applies only to the ampacity of that conductor in that wireway.
NEC Art.110-14(c) applies to where the termination of the conductor is made. If the circuit breaker is rated for 60 degree at the termination, the allowable ampacity of that wire is then taken from the 60 degree column of table 310-16.
Hope this answers your question.
Thanks, Shana Sovern

Several weeks ago I asked you a question having to do with the connection between two sections of the code; NEC 110-14 (c) Temperature Limitations and ampacity Table 310-16.

You did a good job of explaining that the two areas are like "apples and oranges." The table is meant for cables in raceway or earth and is not meant for the temperature limitation criteria of 110-14 (c). They are to be looked at separately.

I was hoping to have a CC:mail verifying what we discussed. Would you please send me one? I've had this discussion with several people and a cc:mail would put it to rest.

Thanks; Dan Larson

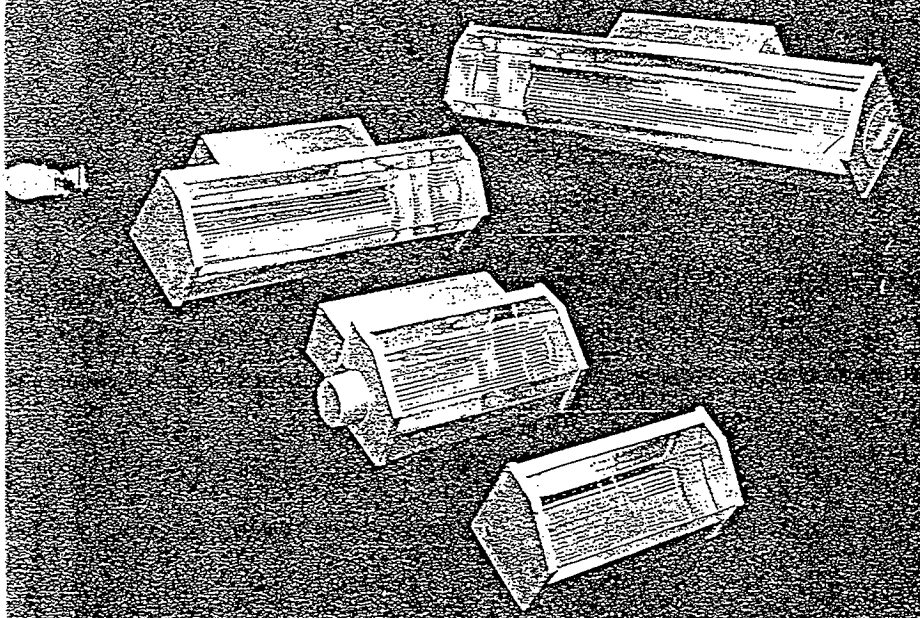
Calculation W320-31-015
Attachment H
Sheet 1 of 1

Voigt

Calculation W320-37-018
Attachment I
Sheet 1 of 4

Wall-Most™

FAMILY OF OUTDOOR LUMINAIRES



Aesthetically styled in pure architectural form for all low pressure sodium lamps (35 watt, 55 watt, 90 watt, 135 watt, 180 watt).

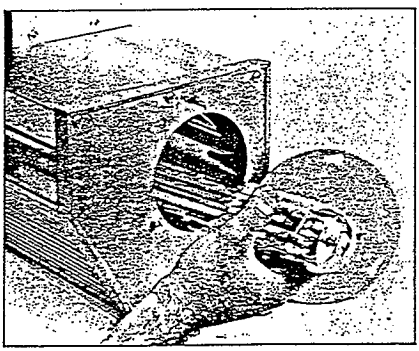
Voigt Lighting Industries, Inc.

Outdoor Energy-Dollar Saver Check-Chart

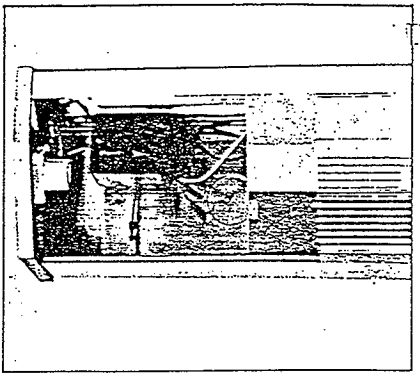
If You Now Use or Plan to Use	Use Voigt Wall-Most for Equivalent Lighting Results—Instead	Watts Saved for Each Unit Used	Annual Dollar Saving for Nightly Use (6¢/Kwhr)
1-300 Watt Incandescent Fish Bowl Unit	No. 0-36 (35 watt)	240	58
3-150 Watt Inc. Reflector Lamp Cluster	No. 0-36 (55 watt)	370	89
1-500 Watt Inc. Quartz Floodlight	No. 0-36 (55 watt)	420	101
1-1000 Watt Inc. Quartz Light	No. 0-39 (180 watt)	780	187
1-175 Watt Mercury Vapor Wall-Unit	No. 0-36 (55 watt)	125	30
1-400 Watt Mercury Vapor Wall-Unit	No. 0-38 (135 watt)	275	66
1-400 Watt Metal Halide Wall-Unit	No. 0-39 (180 watt)	245	59
1-250 Watt H.P.S. Wall-Unit	No. 0-38 (135 watt)	132	32

Whether you seek to
Protect visitors in a parking lot
Secure a fence against intruders
Highlight a building entrance
Provide visibility for your watchman
Pour light into a loading 18-wheeler
Or
Assure proper T.V. surveillance lighting

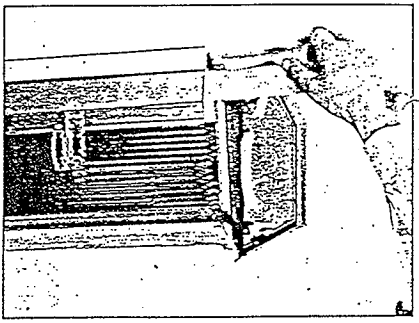
The Wall-Most family does it exceptionally well and attractively using fewer watts and often for a much smaller dollar outlay.



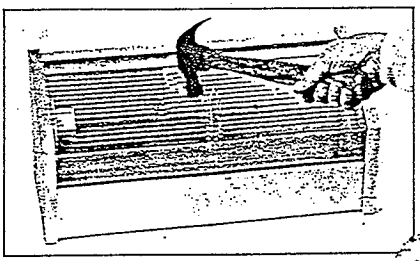
Relamping is accomplished through fully-gasketed door in end—keeping optical chamber sealed against bug and dirt entry.



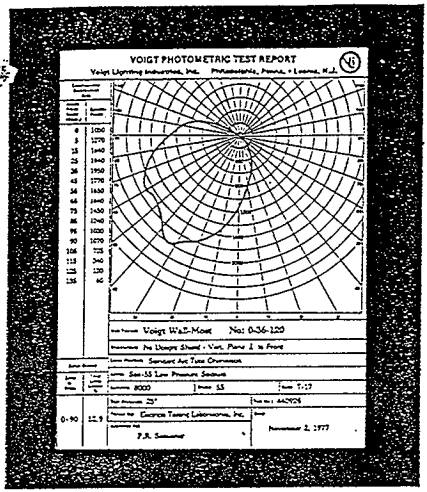
Installation, even under adverse outdoor conditions, is remarkably easy; with all mounting bolts and wire splices fully accessible as lens & reflector slide out of the way.



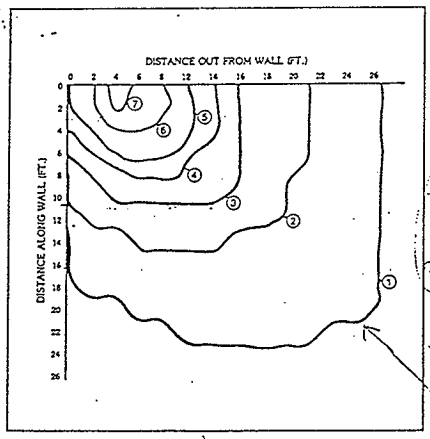
Internally mounted uplight shield can be field installed or removed at any time (SD-1 shown with 0-36).



Polycarbonate lens resists breakage. Absence of ultraviolet in L.P.S. source eliminates lens embrittlement and yellowing over time.



Wide beam spread of Wall-Most achieves coverage of large areas adjacent to buildings and mounting walls.



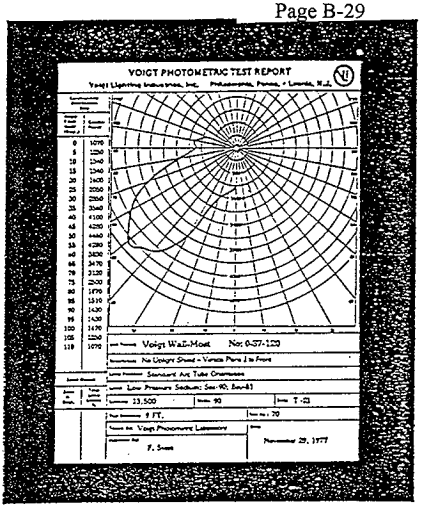
Footcandle Isolux

Top View of Footcandles on Ground From Single Unit.

Mounting Height - 15'-0"

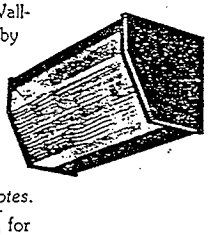
From: Voigt Wall-Most™ No. 0-36-120 with 55 watt Low Pressure Sodium Lamp.

(Data: Electrical Testing Laboratories Test No. 440926).



Larger (90 through 180 watts) Wall-Most have a more sharply defined distribution of light—to cover even larger areas. For 135 watts prorate data by multiplying factor of 1.67. For 180 watts multiply by 2.44.

Aesthetic elegance of Wall-Most can be enhanced by versions in black — or other architectural color finishes as desired. Simply specify color.



Additional Wall-Most notes.

Long luminous arc size, for all lamps, spreads the light over the entire Wall-Most lens face—reducing the viewing brightness—so that unit is comfortable to look at—even when viewed directly.

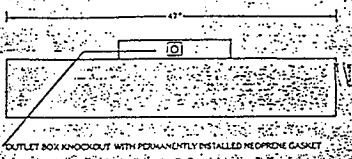
The yellow monochromatic light of Wall-Most does not attract bugs to your building. The light, however, does penetrate smoke, haze, fog & smog more forcefully than other sources of illumination.

Unique prismatic lens structure precisely designed for twin Arc L.P.S. source, significantly aids in control of light into efficient beam pattern; and optically disperses source for greater comfort.

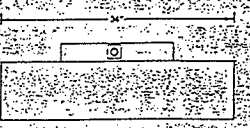
Lamp Specifications and Ordering Information

LOW PRESSURE SODIUM LAMPS ONLY (Order Separately)				
CATALOG NUMBER	Watts	Rated Life (Hours)	Initial & Maintained Lumen Output	Max. O.A. Length in Inches
SOX-18	18	10,000	1,800	8-1/2
SOX-35	35	18,000	4,800	12-3/16
SOX-55	55	18,000	8,000	16-3/4
SOX-90	90	18,000	13,500	20-3/4
SOX-135	135	18,000	22,500	30-1/2
SOX-180	180	18,000	33,000	44-1/8

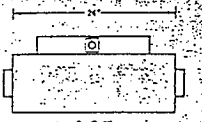
Back View Mounting Details



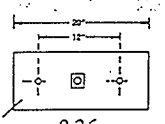
0-39



0-38



0-37



0-36

Table of Electrical Characteristics for Wall-Most

Low Pressure Sodium Lamping	180 WATTS					135 WATTS					90 WATTS					55 WATTS					35 WATTS				
Nominal Primary Voltage (Volts)	120	208	240	277	480	120	208	240	277	480	120	208	240	277	480	120	208	240	277	480	120	208	240	277	480
Starting Line Current (Amps)	2.0	1.15	1.0	0.85	0.5	1.5	1.04	0.9	0.8	0.45	1.2	0.7	0.6	0.5	0.4	0.95	0.53	0.48	0.41	0.3	0.8	0.46	0.4	0.35	0.2
Operating Line Current (Amps)	1.9	1.18	0.95	0.82	0.5	1.44	0.95	0.82	0.71	0.4	1.16	.67	.58	.50	.29	0.68	0.43	0.37	0.32	0.19	0.54	0.32	0.27	0.24	0.14
Primary Ground-2 Voltage (Volts)	90	156	180	208	360	66	114	132	152	264	66	114	132	152	240	66	114	132	152	250	48	83	96	111	185
Ballast Power Input (Watts)	40	40	40	40	40	43	43	43	43	43	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Total Power Input (Watts)	220	220	220	220	220	178	178	178	178	178	125	125	125	125	125	80	80	80	80	80	60	60	60	60	60
Power Factor	Over 90%					Over 90%					Over 90%					Over 90%					Over 90%				
Lamp Current Regulation	±5% at ±10% Voltage Regulation																								
Maximum Ambient Start Temp.	-20°F (Lower Temperatures on Source Order)																								

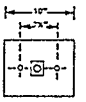
Basic Wall-Most Specification and Ordering Information

CATALOG NUMBER	L.P.S. Nominal Lampwatts	Front View Silhouette	Dimensions in Inches A	B	C	D	Max. Out From Wall	Approx. Weight Lbs.
0-34-000*	18		10	8	–	–	8	15
0-36-000*	55 OR 35		20	8	–	–	8	21
0-37-000*	90		24	8	13½	17½	8	31
0-38-000*	135		34	8	13½	17½	8	39
0-39-000*	180		47	8	13½	17½	8	44

*Specify voltage required: 120, 208, 240, 277 or 480 i.e., No. 0-36-120.
Listed by Underwriters Laboratories, Inc.
Units carry IBEW label.

For additional technical or application data or actual demonstration of the Voigt Wall-Most contact Voigt Lighting Industries, Inc. Headquarters, or:

Wall-Most with exposed portions wholly made of extruded and cast aluminum and transparant polycarbonate lens is the standard for strength and durability in outdoor wall mounted luminaires.



0-34

Optional Accessories

CATALOG NUMBER SUFFIX	Description
PR	Twist-Lock Photocell Receptacle
PI	Internally Mounted Photocell (120 volts only)
MULTI	Multi-Tap Ballas (120, 208, 244 & 277 volts)
NB	Unit without ballast to allow remote mounting
ES	Emergency Lighting Socket for 15 watt Bayone Base, T-7 Inc. Lamp
F	Single Fuse
FF	Double Fuse
BLACK	Black Painted outside finish
COLOR	Painted Finish—specify color
TP	Vandal Resistant, Tamper-Proof Screws
SD-1	Internal Shield for 0-36
SD-2	Internal Shield for 0-37
SD-3	Internal Shield for 0-38
SD-4	Internal Shield for 0-39

For additional accessories information contact Voigt Engineering Department. Cost for optional accessories available on request.

Voigt Lighting Industries, Inc.
Headquarters Location
135 Fort Lee Rd.
Leonia, N.J. 07605
201-461-2493
Manufacturing Location
1636 No. Carlisle St.
Philadelphia, Penna. 19121

12.08.95 04:40 PM

#41 - Revised

F/24 Comfort heaters Vl. 22668 SUP. 21 **Chromalox®**

SHT. 201-205 CALC. W320-31-015

Bldg. M0241 ATTACHMENT: J

SH. 1 OF 4

Wall mounted convection heater

- 0.5 to 5.0 kW
- 120 to 600V
- 1 & 3 phase
- 24, 36 & 48 In. width
- U.L. Listed
- Type HCH

Applications

☐ A rugged, reliable industrial convection heater designed for easy installation in hard-use areas such as entranceways, stairwells, guard shacks or other isolated buildings.

☐ Ideal for cold spots in offices or plants.

Features

Built-in thermostat (55°F to 105°F) with overtemperature cutout and choice of either automatic reset (standard) or manual reset (optional).

Easy electrical hookup — terminal blocks are standard.

Built in contactor supplied with all 208V and 240V 3 phase heaters.

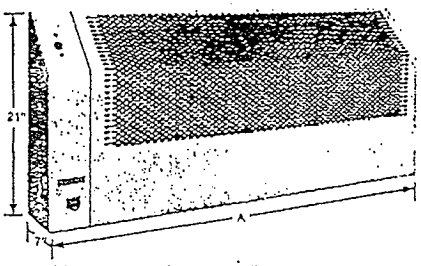
Transformer, transformer fusing and built-in contactor supplied on all heaters rated 480V and above.

Heavy gauge (#18) steel case with zinc chromate primer and neutral gray baked on finish.

Rugged shock proof steel fintube elements with furnace brazed fins.

Additional ratings available. Please contact your nearest Chromalox factory representative.

Specify: Quantity, catalog no., PCN, volts, watts, phase, process air heaters.



CAUTION: Not intended for use where flammable vapors, gases, hours or other combustible atmospheres are present. For these applications, see Bulletin PF114 (CUH-EP).
For other sizes and ratings see Bulletin PF-116

				Without manual reset			With manual reset			
kW	Volts	Ph	Width A (in.)	Catalog No.	Status	PCN	Catalog No.	Status	PCN	Wt. lbs.
0.5	120	1	24	HCH-051	NS	330376	HCH-051M	NS	331459	41
0.5	208	1	24	HCH-051	NS	330384	HCH-051M	NS	331467	41
0.5	240	1	24	HCH-051	NS	330392	HCH-051M	NS	331475	41
0.5	277	1	24	HCH-051	NS	330405	HCH-051M	NS	331483	41
0.75	120	1	24	HCH-071	NS	330413	HCH-071M	NS	331491	41
0.75	208	1	24	HCH-071	NS	330421	HCH-071M	NS	331504	41
0.75	240	1	24	HCH-071	NS	330430	HCH-071M	NS	331512	41
0.75	277	1	24	HCH-071	NS	330448	HCH-071M	NS	331520	41
1.0	120	1	24	HCH-101	NS	330455	HCH-101M	NS	331539	41
1.0	208	1	24	HCH-101	NS	330464	HCH-101M	NS	331547	41
1.0	208	3	24	HCH-101	NS	330501	HCH-101M	NS	331580	41
1.0	240	1	24	HCH-101	NS	330472	HCH-101M	NS	331555	41
1.0	240	3	24	HCH-101	NS	330510	HCH-101M	NS	331598	41
1.0	277	1	24	HCH-101	NS	330480	HCH-101M	NS	331563	41
1.0	450	1	24	HCH-101	NS	330499	HCH-101M	NS	331571	41
1.0	480	3	24	HCH-101	NS	330528	HCH-101M	NS	331600	41
1.0	480	3	24	HCH-101 (4W)	NS	330536	HCH-101M (4W)	NS	331619	41
1.5	120	1	24	HCH-151	NS	330544	HCH-151M	NS	331627	41
1.5	208	1	24	HCH-151	NS	330552	HCH-151M	NS	331635	41
1.5	208	3	24	HCH-151	NS	330595	HCH-151M	NS	331678	41
1.5	240	1	24	HCH-151	NS	330560	HCH-151M	NS	331643	41
1.5	240	3	24	HCH-151	NS	330608	HCH-151M	NS	331686	41
1.5	277	1	24	HCH-151	NS	330579	HCH-151M	NS	331651	41
1.5	480	1	24	HCH-151	NS	330587	HCH-151M	NS	331661	41
1.5	480	3	24	HCH-151	NS	330616	HCH-151M	NS	331694	41
1.5	480	3	24	HCH-151 (4W)	NS	330659	HCH-151M (4W)	NS	331731	41
1.5	550	3	24	HCH-151	NS	330624	HCH-151M	NS	331707	41
1.5	575	3	24	HCH-151	NS	330632	HCH-151M	NS	331715	41
1.5	600	3	24	HCH-151	NS	330640	HCH-151M	NS	331723	41
2.0	120	1	24	HCH-201	NS	330667	HCH-201M	NS	331740	41
2.0	208	1	24	HCH-201	NS	330675	HCH-201M	NS	331758	41
2.0	208	3	24	HCH-201	NS	330712	HCH-201M	NS	331790	41
2.0	240	1	24	HCH-201	S	330683	HCH-201M	NS	331766	41
2.0	240	3	24	HCH-201	NS	330720	HCH-201M	NS	331803	41
2.0	277	1	24	HCH-201	NS	330691	HCH-201M	NS	331774	41
2.0	480	1	24	HCH-201	S	330704	HCH-201M	NS	331782	41
2.0	480	3	24	HCH-201	NS	330739	HCH-201M	NS	331811	41
2.0	480	3	24	HCH-201 (4W)	NS	330771	HCH-201M (4W)	NS	331854	41
2.0	550	3	24	HCH-201	NS	330747	HCH-201M	NS	331820	41
2.0	575	3	24	HCH-201	NS	330755	HCH-201M	NS	331838	41
2.0	600	3	24	HCH-201	NS	330763	HCH-201M	NS	331846	41

(4W) — 4 wire

HC-1363

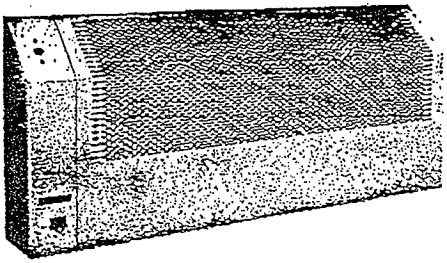
GEORGE A. GRANT, INC.
P.O. BOX 769 • RICHLAND, WASH.
CONTRACT NO. KHL-5420(W320)
TRANSMITTAL NO. 4.A

3062/234 F9

Chromalox®

Installation, Operation and RENEWAL PARTS IDENTIFICATION

SERVICE REFERENCE			
DIV. 4	SEC. HCH	NUMBER	3001B
SALES REFERENCE	(Supersedes PF422-1)		PF422-2
			161-027008-001
DATE	NOVEMBER, 1988		



Type HCH Convection Heater

NOTICE: *Carefully remove heater from carton and check for shipping damage. Any damage claims should be entered immediately with the carrier.*

CAUTION: *This heater is not intended for use in hazardous atmospheres where flammable vapors, gases, liquids, or other combustible atmospheres are present as defined in the National Electric Code. Failure to comply can result in explosion or fire.*

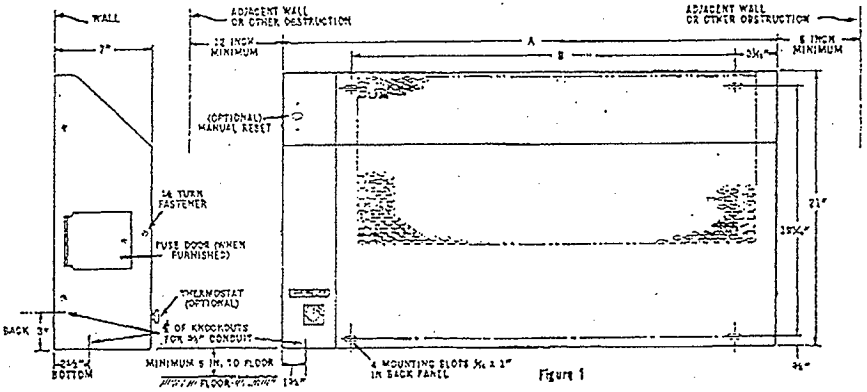


Figure 1

Specifications — Table A

Catalog* Number	Voltage (60 Hertz — AC)	Wattage	Phase	Dimensions — Inches A	Dimensions — Inches B
HCH-051	120, 208, 240 or 277	500	1	24	15⅞
HCH-071	120, 208, 240 or 277	750	1		
HCH-101	120 or 277	1000	1		
	208, 240 or 480		1 or 3		
HCH-151	120 or 277	1500	1		
	208, 240 or 480		1 or 3		
	550, 575 or 600		3		
HCH-201	120 or 277	2000	1		
	208, 240 or 480		1 or 3		
	550, 575 or 600		3		
HCH-251	120 or 277	2500	1	36	27½
	208, 240 or 480		1 or 3		
	550, 575 or 600		3		

Catalog* Number	Voltage (60 Hertz — AC)	Wattage	Phase	Dimensions — Inches A	Dimensions — Inches B
HCH-301	277	3000	1	36	27½
	208, 240 or 480		1 or 3		
	550, 575 or 600		3		
HCH-351	277	3500	1		
	208, 240 or 480		1 or 3		
	550, 575 or 600		3		
HCH-401	277	4000	1	48	39½
	208, 240 or 480		1 or 3		
	550, 575 or 600		3		
HCH-451	277	4500	1		
	208, 240 or 480		1 or 3		
	550, 575 or 600		3		
HCH-501	277	5000	1		
	208, 240 or 480		1 or 3		
	550, 575 or 600		3		

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MOUNTING

CAUTION: *Hazard of electric shock. Disconnect all power before installing heater.*

1. Locate on vertical wall with length of heater positioned horizontally.
2. When selecting a mounting location, the following minimum distances must be observed:
   a. Six (6") inches from bottom of heater to floor to allow for adequate air flow through the heater.
   b. Six (6") inches from wall or other obstruction to right side of heater to allow for access to ¼ turn fasteners.
   c. Twelve (12") inches from wall or other obstruction to left side of heater to allow for access to controls and wire entry.
3. Avoid mounting heater in a recess since such mounting interferes with free air circulation, increases heater temperatures, and prevents proper thermostat operation.
4. Remove front cover by giving two fasteners on right end of heater ¼ turn then sliding cover approximately 1" to right, then lifting.
5. At the correct height for the top of the heater, draw a pencil line on the wall, parallel to the floor.
6. Using dimensions shown in Figure 1, mark the mounting slot location on the wall.
7. Mount heater to the wall by using fasteners (not furnished) to suit the wall construction. Four (4) ⅜" × 1" mounting slots are provided in heater back panel. NOTE: If wall surface is not flat, resulting in gap between rear case and wall in excess of ¼" at location of fasteners, use metal washers to fill in gap. Tighten left hand fasteners securely. The right hand fasteners should be pulled up snug to allow for movement during operation to avoid expansion noise.
8. Replace cover and tighten ¼ turn fasteners.

WIRING

CAUTION: *Hazard of electric shock. Any installation involving electric heaters must be grounded to earth to eliminate shock hazard.*

NOTE: Electrical wiring is to be in accordance with National Electrical Code and local codes using at least 75°C (167°F) type RH, THW or equivalent insulated conductors.

1. Electrical wiring can be brought into heater through ⅞" knockout located either in back panel or bottom of left hand end of heater (wiring compartment).
2. Grounding conductor with green insulation, should be secured into grounding lug located in wiring compartment.
3. Using Wiring Diagram Table B select applicable wiring diagram (Figure 2-9) for proper method of connecting heater.
4. Two or more Type HCH heaters may be controlled by a common fused disconnect switch providing total branch circuit current does not exceed 48 amperes according to National Electrical Code.

Wiring Diagrams — Table B

Model Number	120-V 1φ	208-V 1φ	208-V 3φ	240-V 1φ	240-V 3φ	277-V 1φ	480-V 1φ	480-V 3φ	480-V 3φ (3 Wire)	480-V 3φ (4 Wire)	550-V 3φ	575-V 3φ	575-V 3φ	600-V 3φ	600-V 3φ
	WIRING DIAGRAM FIGURE NUMBER														
HCH-031	2	8		8		2									
HCH-071	2	8		8		2									
HCH-101	2	8	4	8	4	2	3		9	6					
HCH-151	2	8	4	8	4	2	3		9	6		9		9	
HCH-201	2	8	4	8	4	2	3		9	6		9		9	
HCH-251	2	8	4	8	4	2	7	5		6		9		9	
HCH-301		8	4	8	4	2	7	5		6		9		9	
HCH-351		8	4	8	4	2	7	5		6	5		5		5
HCH-401		8	4	8	4	2	7	5		6	5		5		5
HCH-451		8	4	8	4	2	7	5		6	5		5		5
HCH-501		8	4	8	4	2	7	5		6	5		5		5

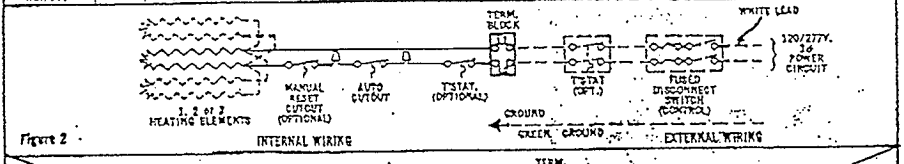


Figure 2

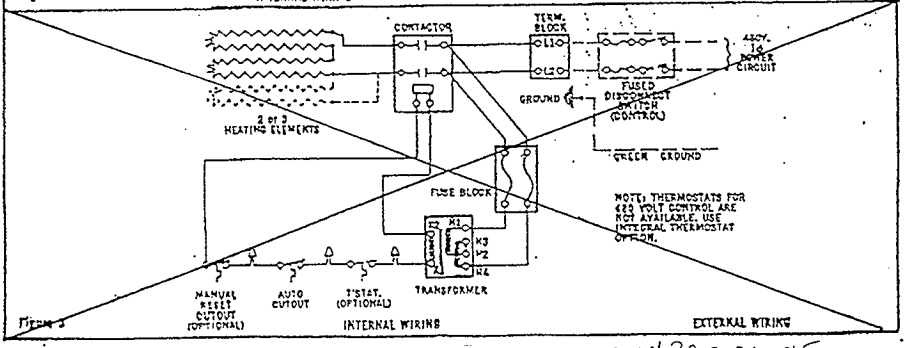


Figure 3

CALC. W320-31-015
ATTACHMENT: J
SH. 3 OF 4

RENEWAL PARTS IDENTIFICATION

HCH HEATER REPLACEMENT ELEMENTS — Part Number Prefix 118-026956

Catalog Number	HCH 051	HCH 071	HCH 101	HCH 151	HCH 201	HCH 281	HCH 301	HCH 351	HCH 401	HCH 451	HCH 501
Watts	500W	750W	1000W	1500W	2000W	2500W	3000W	3500W	4000W	4500W	5000W
Volts											
120V	001	005	001 (2)	005 (2)	015 (3)	021 (3)	——	——	——	——	——
208V	002	006	002 (2)	006 (2)	016 (3)	022 (3)	029 (3)	036 (3)	043 (3)	050 (3)	057 (3)
208V 3Ø Δ	—	—	006 (3)	002 (3)	016 (3)	022 (3)	029 (3)	036 (3)	043 (3)	050 (3)	057 (3)
240V	003	007	003 (2)	007 (2)	002 (3)	023 (3)	030 (3)	037 (3)	044 (3)	051 (3)	058 (3)
240V 3Ø Δ	—	—	010 (3)	003 (3)	002 (3)	023 (3)	030 (3)	037 (3)	044 (3)	051 (3)	058 (3)
277V	004	008	004 (2)	008 (2)	003 (3)	024 (3)	031 (3)	038 (3)	045 (3)	052 (3)	059 (3)
480V	—	—	003 (2)	007 (2)	017 (3)	025 (3)	032 (3)	039 (3)	046 (3)	053 (3)	060 (3)
480V 3Ø Δ	—	—	——	——	——	025 (3)	032 (3)	039 (3)	046 (3)	053 (3)	060 (3)
480V 3Ø Y	—	—	011 (3)	004 (3)	003 (3)	——	——	——	——	——	——
480V 3Ø Y N Wire	—	—	011 (3)	004 (3)	003 (3)	024 (3)	031 (3)	038 (3)	045 (3)	052 (3)	059 (3)
550V 3Ø Y	—	—	——	012 (3)	018 (3)	026 (3)	033 (3)	040 (3)	047 (3)	——	——
550V 3Ø Δ	—	—	——	——	——	——	——	——	——	054 (3)	061 (3)
575V 3Ø Y	—	—	——	013 (3)	019 (3)	027 (3)	034 (3)	041 (3)	048 (3)	——	——
575V 3Ø Δ	—	—	——	——	——	——	——	——	——	055 (3)	062 (3)
600V 3Ø Y	—	—	——	014 (3)	020 (3)	028 (3)	035 (3)	042 (3)	049 (3)	——	——
600V 3Ø Δ	—	—	——	——	——	——	——	——	——	056 (3)	063 (3)

When ordering element replacement parts use part number prefix No. 118-026956 then the element number, e.g. To replace an element in a 120V HCH 151 order 118-026956-005. The (2) or (3) following the element number designates the number of heating elements contained in the heater.

AUTOMATIC CUT-OFF REPLACEMENT

For HCH Heaters	Part Number
HCH 051 and HCH 051M thru HCH 201 and HCH 201M	300-024413-001
HCH 251 and HCH 251M thru HCH 351 and HCH 351M	300-024413-002
HCH 401 and HCH 401M thru HCH 501 and HCH 501M	300-024413-009

REPLACEMENT CONTACTOR

For HCH Heaters rated	Part Number
480V Single phase	072-052560-004
480V thru 600V 3 phase	072-052560-022
208V and 240V Single phase	072-052560-001
208V and 240V 3 phase	072-052560-003

REPLACEMENT TRANSFORMER

For HCH Heaters rated	Part Number
480V	315-052168-001
550V, 575V and 600V	315-052168-014

THERMOSTAT REPLACEMENT

For HCH Heaters	Part Number
All ratings	300-049197-001
Thermostat Knob	189-051208-001

REPLACEMENT FUSES FOR ALL TRANSFORMERS — TWO REQUIRED

For HCH Heaters rated	Part Number
480V, 550V, 575V and 600V	118-047763-011

MANUAL TEMPERATURE CONTROL REPLACEMENT

HCH OHO Heater	Part Number
HCH 051M thru HCH 201M	300-117647-003
HCH 251M thru HCH 351M	300-117647-002
HCH 401M thru HCH 501M	300-117647-008

LIMITED WARRANTY FOR CHROMALOX INDUSTRIAL PRODUCTS

The warranty below has been drafted to comply with the new Federal Law applicable to products manufactured after December 31, 1976. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state. The warranty in no manner reduces the coverage provided to you under the warranty it replaces.

Chromalox Warranty: Chromalox industrial products are warranted against defects in workmanship and materials. NO OTHER WARRANTIES, WRITTEN OR ORAL, INCLUDING, BUT NOT LIMITED TO, WARRANTIES OF MERCHANTABILITY AND WARRANTIES FOR A PARTICULAR PURPOSE, APPLY. No person is authorized to give any other warranty or assume any other liability except by written statement from an officer of the Edwin L. Wiegand Division, Emerson Electric Co.

Warranty Period: This warranty extends for twelve months from date of shipment from factory or authorized distributor.

Limitations: Products must be installed and maintained in accordance with Chromalox instructions. Users are responsible for the suitability of the products to their application. There is no warranty against damage resulting from corrosion, misapplication, improper specification or other operating conditions beyond our control. Claims against carriers for damage in transit must be filed by the buyer.

Remedy: Return the defective part or product, freight prepaid, to the location designated by Chromalox Product Service. All such items must be accompanied by a Material Return Authorization. This form, which includes a tear-out routing and identification label, should be obtained from your local Chromalox Sales Office.

Defective items will be repaired or replaced at our option. SUCH REPAIR OR REPLACEMENT IS THE EXCLUSIVE REMEDY AVAILABLE FROM EDWIN L. WIEGAND DIVISION, EMERSON ELECTRIC CO. WIEGAND IS NOT LIABLE FOR LABOR COSTS INCURRED IN REMOVAL, REINSTALLATION, OR UNAUTHORIZED REPAIR OF THE PRODUCT OR FOR DAMAGE OF ANY TYPE WHATSOEVER, INCLUDING INCIDENTAL OR CONSEQUENTIAL DAMAGE. Some states do not allow the exclusion or limitations of incidental or consequential damages, so the preceding limitation or exclusion may not apply to you.

W1208L

Chromalox
PRODUCT SERVICE
2150 N. RULON WHITE BLVD., OGDEN, UT 84404

EDWIN L. WIEGAND DIVISION
EMERSON ELECTRIC CO.

EMERSON

CALC. W320-31-015
ATTACHMENT: J
SH. 4 of 4
PL YR - T4

205

ACME ENGINEERING & MANUFACTURING CORP.
P.O. Box 978
MUSKOGEE, OKLAHOMA

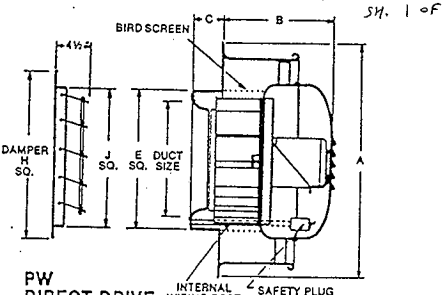
CALC. W320-31-015
ATTACHMENT: K
SH. 1 OF 4

CENTRIMASTER®
WALL EXHAUSTERS
Model PW & PWB
DIRECT & BELT DRIVEN

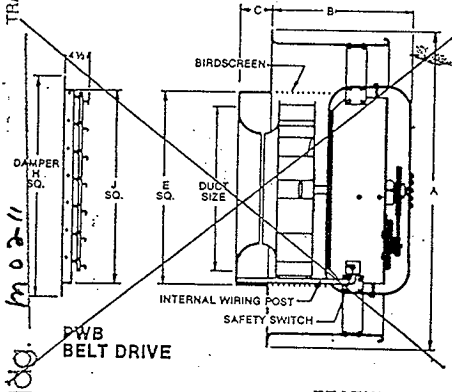
GEORGE A. GRANT, INC.
P.O. BOX 789 • RICHLAND, WASH.
CONTRACT NO. K-5420 (4320)
TRANSMITTAL NO. 4/3

VI. 22668 SUP/6
SHT. 154-182
BLDG. M021

Project	KEH-5420
Location	Richland, WA
Architect	
Engineer	Kaiser
Contractor	Randolph Sheet Metal
Submitted by	Mechanical Sales, Inc
Date	7-21-95



PW
DIRECT DRIVE



PWB
BELT DRIVE

Dimensions given on this sheet are correct within limits suitable for normal installation requirements.

MODEL NO.	DIMENSIONS A	B	C	E	H	J	DUCT SIZE	IMPELLER SIZE
PW100	20⅞	11	3	12	13	11	10	9¼"
PW110	20⅞	11	3	12	13	11	10	11"
PW118	23⅛	14	3¼	14	16	14	12	11¾"
PW126	23⅛	14	3¼	14	16	14	12	12¾"
PW135	26⅛	14½	3¾	16	18	16	14	13½"
PW145	26⅛	14½	3¾	16	18	16	14	14½"
PW163	30½	15¾	4	19	21	19	16	16½"
PW171	30½	15¾	4	19	21	19	16	17½"
PW200	40	18	4	22	24	22	18	20"
PWB200	40	18¾	4	22	24	22	20	20"
PWB223	46	20¼	3¾	25⅞	28	26	22	22½"
PWB245	46	20¼	4½	28⅛	30	28	24	24½"

■ ADD 4" for EXPLOSION PROOF ON PW FANS

WARNING! DO NOT use in HAZARDOUS ENVIRONMENTS where fans electrical system could provide ignition to combustible or flammable materials, unless unit is specifically built for hazardous environments.

CAUTION! Guards must be installed when fan is within reach of personnel or within seven (7) feet of working level or when deemed advisable for safety.

FEATURES

Aluminum housing and wheel with gauges from .050 to .125; steel wall plate and recessed orifice, finished with epoxy.

Backward curved non-overloading airfoil impeller, statically and dynamically balanced.

Hollow airfoil blades for quieter performance.

External drip ring prevents grease and other contaminants from running down wall.

Directs exhause air away from wall.

All motors have lubricated ball bearings and are available in single or two speed. Models PW100 and PW 110 have three speed motors.

LEGEND

O- Open (Dripproof)
(EX) Explosion Proof
2S- Two Speed
AW- Square Damper
RD- Round Damper
GR- Wall Grille
PWG- Inlet Guard

SPECIFICATIONS		FAN						MOTOR			OPTIONAL ACCESSORIES
Reference	Quan	Model	CFM	SP	RPM	TS fpm	Sound Rating ★	HP	Current	Type	
FN1363	1	PW118D4	478	3/8"	1750	5320	13.0	1/6	115/1/60	EX	
- WT = 45#											
- CL 1 Group D Explosion Proof											
- CSA Label											
- Choke Orifice											

★ Certified sound ratings in decibels for each of the 8 octave bands, in Lw(A) decibels and in Sones are shown in Acme Bulletin S13.

LICENSED MANUFACTURER IN CANADA: LISI AERO GUIDE INC., MONTREAL, PROV. QUE.

Litho in U.S.A.

ACME ENGINEERING & MANUFCTURING CORP.
P.O. Box 978
Muskogee, Oklahoma 74402
Telephone: 918/682-7791
FAX: 918-682-0134

INSTALLATION & MAINTENANCE INSTRUCTIONS

CENTRI MASTER® MODELS PW & PWB

RECEIVING AND INSPECTION

1. Immediately upon receipt of a shipment, carefully inspect for damage and shortage. Turn impeller by hand to see that it turns freely and does not bind. If any damage and/or shortage is detected or suspected the carrier must be asked to conduct an inspection. The consignee's representative should not accept shipment without a notation on the delivery receipt indicating items not delivered or apparent extent of damage.
2. When a shipment is opened and damage is found which was not evident externally (concealed damage), it is mandatory that the consignee request an immediate inspection by the carrier. Report damage to the carrier within 15 days. Failure to report damage within the above time limit will cause rejection of a claim.

HANDLING AND STORAGE

1. Units should be lifted using a sling or platform. Whenever possible, fans should be stored indoors in clean, dry locations. If storage outdoors is necessary, fans should be protected against the elements and accumulation of dirt and moisture. Special care must be taken to keep motors and bearing assemblies dry and clean. See Acme Form 833, *Proper Storage of Acme Fans.*

INSTALLATION

1. This unit has rotating parts and safety precautions should be exercised during installation, operation and maintenance.
2. WARNING! DO NOT USE IN HAZARDOUS ENVIRONMENTS WHERE THE FAN'S ELECTRICAL SYSTEM COULD PROVIDE IGNITION TO COMBUSTIBLE OR FLAMMABLE MATERIALS, UNLESS UNIT IS BUILT SPECIFICALLY FOR THE ENVIRONMENT.
3. Provide a square opening in the wall equal to the outside dimensions of fan wallplate.
4. Slide the fan into the framed opening in the wall. Securely fasten with lag bolts or screws provided by the installer.
5. CAUTION: GUARDS MUST BE INSTALLED WHEN FAN IS WITHIN REACH OF PERSONNEL OR WITHIN SEVEN (7) FEET (2.134 m) OF WORKING LEVEL OR WHEN DEEMED ADVISABLE FOR SAFETY.
6. Turn centrifugal impeller by hand to make sure it rotates freely. If impeller hits orifice, adjust as follows:

   Direct Driven Exhausters - Loosen set screws in impeller hub and move impeller back on motor shaft. The impeller of the PW200 unit is attached to a sleeve which is attached to the motor shaft. Remove the two socket head cap screws completely . This will allow the impeller to be removed from the shaft.

   Belt Driven Exhausters - The bearing support is slotted for up and down adjustment. Loosen bearing support bolts on both support channels and move bearing support up or down. If impeller continues to strike, move impeller and shaft back. (See Maintenance, Section 7 for bearing replacement).
7. CAUTION Before proceeding, make sure electrical service to fan is locked in "OFF" position. Run wires through the internal wiring post to the motor, to safety disconnect switch if used. On Belt Driven Exhausters leave enough slack in wiring to allow for motor movement when adjusting belt tension. Some fractional motors will have to be removed to make connection at terminal box on end of motor; remove bolts securing motor base to adjusting rails - do not take out motor bolts. Re-adjust belt tension.
8. All wiring should be in accordance with local ordinances and the National Electric Code.
9. WARNING! Check voltage at the fan to see if it corresponds with the motor nameplate; high or low voltage can seriously damage the motor Extra care should be taken when wiring two or three speed motors since improper connections will damage motor and void motor warranty.
10. Operate under power and compare rotation with directional arrow. WARNING! Do not operate at speeds higher than shown in catalog for this equipment. Operation in the wrong direction will deliver air but will overload the motor to the extent of blowing fuses or overload protection and could seriously damage the motor. In the case of three phase motors, the direction can be changed by interchanging any two of the three motor leads. In the case of single phase motors, the reversing instructions will appear on the wiring diagram in the motor wiring compartment or on the motor.

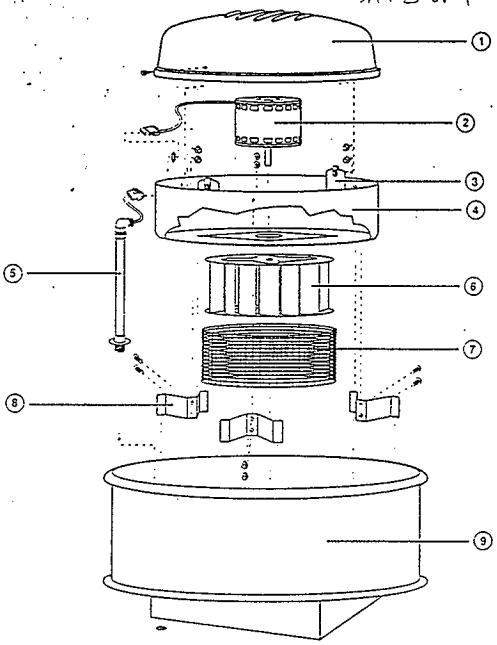
MAINTENANCE

1. No spare parts are recommended for one year normal service.
2. CAUTION: Before proceeding, make sure electrical service to fan is locked in "OFF" position.
3. Impeller shaft bearings on Belt Driven Exhausters are prelubricated and sealed; no service required.
4. Motor bearings are prelubricated. Consult information printed on motor for lubrication instructions.
5. On Belt Driven Exhausters check belt tension after first 48 hours of operation and thereafter annually. Belt should depress its width when pressed firmly inward at midway point between the pulleys. Too much tension will damage bearings; belt should be tight enough to prevent slippage. When replacing worn belt, replace motor pulley if "shoulder" is worn in groove. WARNING! Do not replace motor pulley with a larger diameter pulley. Do not replace the fan pulley with one smaller in diameter. The pulley ratios are set so that the motor will not be overloaded.
6. If impeller shaft bearings need replacement, replace with bearings comparable to original equipment. Install new bearings into neoprene rings, check correct position of impeller with orifice, position bearings in die formed recess and tighten set screws. Replace die formed bearing cap and tighten four bolts. NOTE: If locking collar type bearing is used, collar must first be positioned against inner race on bearing nearest impeller and turned in direction of impeller rotation with drift pin and hammer until it locks. Locking collars must be on inboard (facing) sides of the bearings. Secure bearing to shaft with set screw. Lock and secure other bearing to shaft in same manner. If pillow block type bearings are used, slide bearings on to shaft to desired location and bolt bearing block securely to support base.

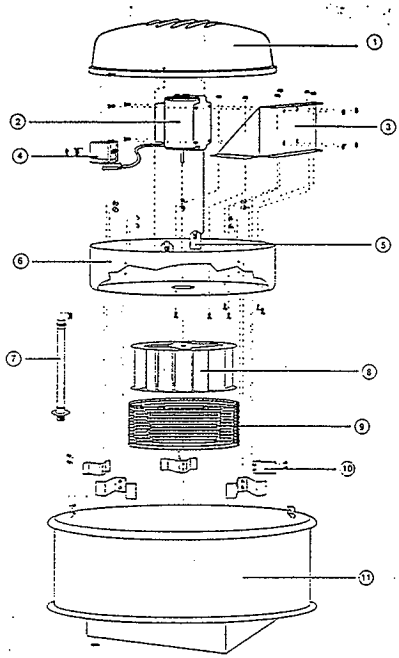
   Slide shaft back and forth in secured bearing (do not drive with hammer) and rotate to make certain it turns freely. Check correct position of impeller with inlet orifice. Then secure bearings to shaft by tightening set screws.

EXPLODED VIEW OF PW100 & 110

CALC. W320-31-015
ATTACHMENT: K
SH. 3 OF 4



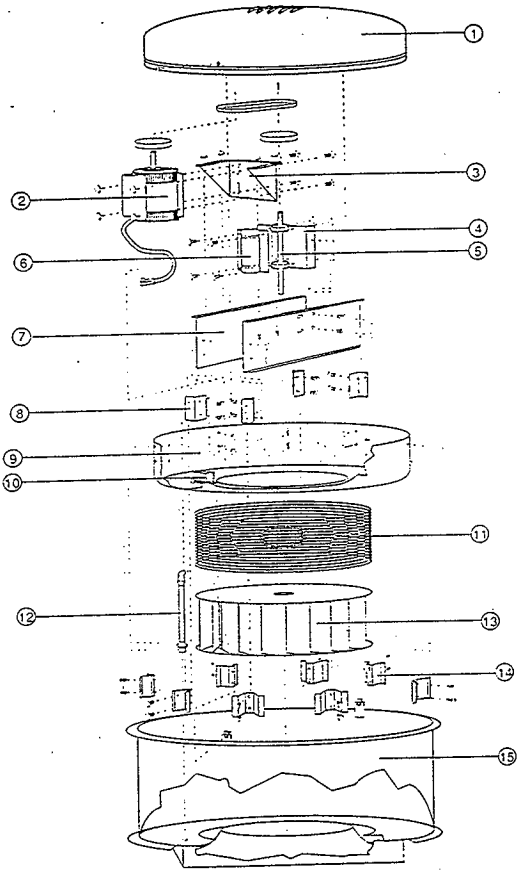
EXPLODED VIEW OF PW118-200



PARTS LIST LEGEND		
NO.	DESCRIPTION	QTY.
1	MOTOR ENCLOSURE COVER	1
2	MOTOR	1
3	MOTOR ENCLOSURE CLIPS	2
4	MOTOR ENCLOSURE	1
5	WIRING POST	1
6	IMPELLER	1
7	BIRDSCREEN	1
8	MOTOR ENCLOSURE SUPPORTS	3
9	TUBE & ORIFICE ASSEMBLY	1

PARTS LIST LEGEND		
NO.	DESCRIPTION	QTY.
1	MOTOR ENCLOSURE COVER	1
2	MOTOR	1
3	MOTOR BASE	1
4	DISCONNECT SWITCH	1
5	MOTOR ENCLOSURE CLIPS	2
6	MOTOR ENCLOSURE	1
7	WIRING POST	1
8	IMPELLER	1
9	BIRDSCREEN	1
10	MOTOR ENCLOSURE SUPPORTS	5
11	TUBE & ORIFICE ASSEMBLY	1

CALC. W320-31-015
ATTACHMENT: K
SH. 4 OF 4

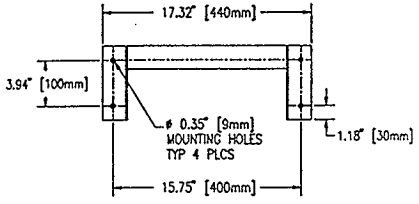


PARTS LIST LEGEND

NO.	DESCRIPTION	QTY.	NO.	DESCRIPTION	QTY.
1	MOTOR ENCLOSURE COVER	1	9	MOTOR ENCLOSURE	1
2	MOTOR	1	10	DISCONNECT SWITCH	1
3	MOTOR BASE	1	11	BIRDSCREEN	1
4	BEARING BASE	1	12	WIRING POST	1
5	SHAFT & BEARING ASSEMBLY	1	13	IMPELLER	1
6	BEARING CAP	1	14	MOTOR ENCLOSURE SUPPORTS	8
7	SUPPORT CHANNELS	2	15	TUBE & ORIFICE ASSEMBLY	1
8	CHANNEL SUPPORTS	4			

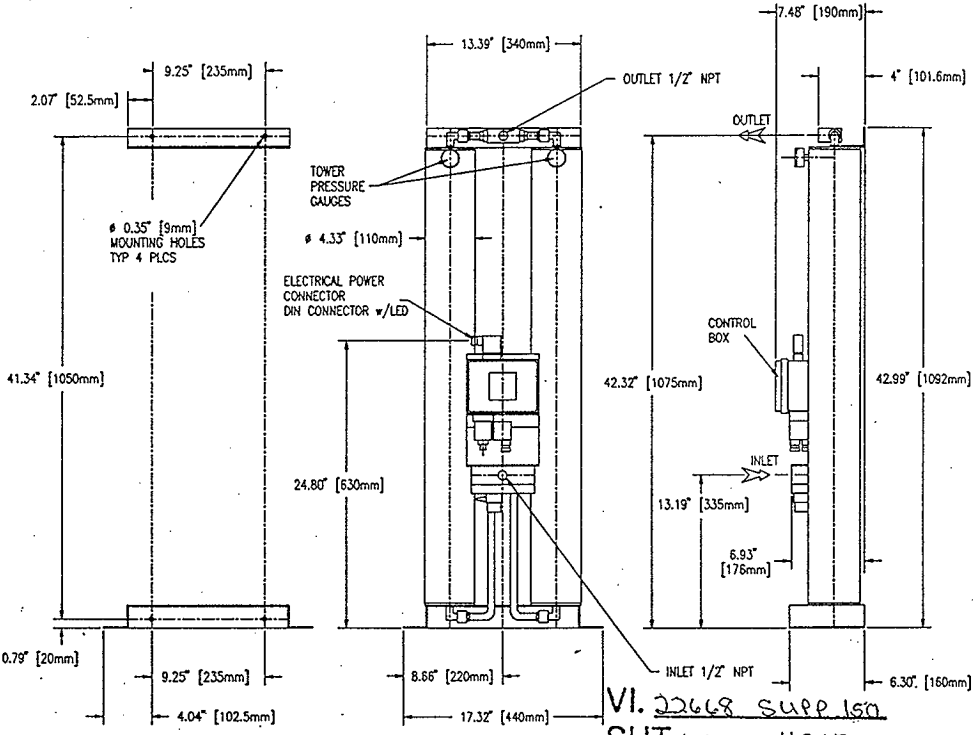
APP'L	DATE	LVL	REVISION
SCF	10/29/92	A	ECN: N0442

CALC. W320-31-015
ATTACHMENT: L
SH. 1 OF 2



FLOOR MOUNTING HOLE PATTERN DETAIL

SPECIFICATIONS
OPERATING PRESSURE RANGE: MINIMUM.....60 PSIG MAXIMUM....150 PSIG
OPERATING INLET AIR TEMPERATURE RANGE: MINIMUM.....40°F MAXIMUM....120°F
RATED INLET CONDITIONS: 25 SCFM 100°F @ 100 PSIG, 100% RH
ELECTRICAL POWER: 115/1/60
MAXIMUM AMP DRAW: 200mA
TOTAL DRYER WEIGHT: 70.55 LBS [32 KG]
TOTAL DESICCANT WEIGHT: 24.25 LBS [11 KG]



WALL MOUNTING HOLE PATTERN DETAIL

VI. 22668 SUPP 150
SHT. 4902-4927
Bldg. 241-C-73

REF A0416/REV A

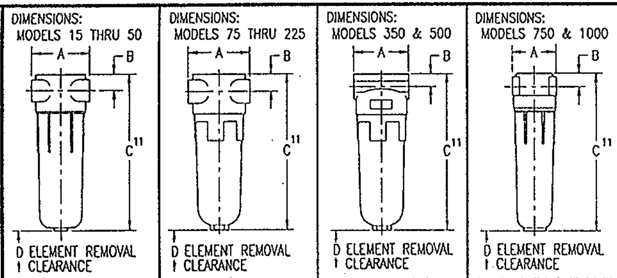
HME-25 ELECTRIC HEATLESS REGENERATIVE DRYER

DRWN BY: jc	DATE: 08/31/92	DRWG No. SD-12828	REV A
CHECKED: SCF	SCALE: none		
APPL: SCF			

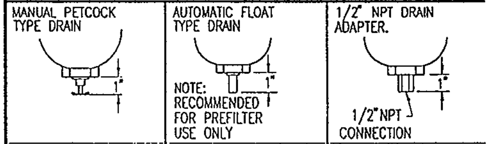
VAN AIR SYSTEMS INC
Lake City, PA 16423 (814)774-2631 Fax: 814/774-3482 Telex: 91-4548

VI. 33668 SWP 130
SHT. 4922-4927
Bldg 241-C-73
ATTACHMENT: 2
SH. 2 of 2

APP'L	DATE	LVL	REVISION:
DAF	11/3/93	B	ECN: F00134



OPTIONAL DRAIN CONFIGURATIONS & INSTALLED DIMENSIONS



MODEL SUFFIX: MD EXAMPLE: F100-15-C-MD

MODEL SUFFIX: AD EXAMPLE: F100-15-C-AD

MODEL SUFFIX: 1/2DA EXAMPLE: F100-15-C-1/2DA

MODEL	RATED FLOW (SCFM)	IN/OUT CONN (NPT)	REPLACEMENT ELEMENT	DIMENSIONS (IN.) A	B	C 11	D	UNIT WT. (LBS)
F100-15-(GRADE)1	15	1/4"	E100-15-(GRADE)2	3.50	1.31	7.50	3.00	2.20
F100-30-(GRADE)1	30	3/8"	E100-30-(GRADE)2	3.50	1.31	8.88	3.94	2.80
F100-50-(GRADE)1	50	1/2"	E100-50-(GRADE)2	3.50	1.31	10.75	3.94	3.30
F100-75-(GRADE)1	75	3/4"	E100-75-(GRADE)2	5.00	1.63	11.13	4.00	6.00
F100-100-(GRADE)1	100	1"	E100-100-(GRADE)2	5.00	1.63	11.13	4.00	6.00
F100-150-(GRADE)1	150	1"	E100-150-(GRADE)2	5.00	1.63	17.00	6.00	8.00
F100-225-(GRADE)1	225	1-1/4"	E100-225-(GRADE)2	5.00	1.63	17.00	6.00	8.00
F100-350-(GRADE)1	350	1-1/2"	E100-350-(GRADE)2	7.25	1.88	21.00	7.88	22.00
F100-500-(GRADE)1	500	2"	E100-500-(GRADE)2	7.25	1.88	21.00	7.88	22.00
F100-750-(GRADE)1	750	3"	E100-750-(GRADE)2	9.25	2.63	32.38	13.75	27.50
F100-1000-(GRADE)1	1000	3"	E100-1000-(GRADE)2	9.25	2.63	38.38	13.75	33.00

NOTES:

1) INCLUDE ELEMENT GRADE & DRAIN OPTION SUFFIX AS LISTED ABOVE FOR COMPLETE HOUSING MODEL NUMBER.
2) INCLUDE ELEMENT GRADE FOR COMPLETE ELEMENT MODEL NUMBER.
3) FLOW RATES GIVEN IN SCFM @ 100 PSIG OPERATING PRESSURE. TO FIND FLOW RATES AT OTHER OPERATING PRESSURES MULTIPLY RATED FLOW AT 100 PSIG BY CORRECTION FACTOR GIVEN IN CHART BELOW.
4) MAXIMUM WORKING PRESSURE: 250 PSIG @ 225°F.
5) REPLACE ELEMENTS WHEN PRESSURE DROP EQUALS OR EXCEEDS 10 PSID.
6) GRADE 'RD' ELEMENTS MUST NOT OPERATE IN OIL SATURATED CONDITIONS. REPLACE ELEMENT PERIODICALLY TO SUIT THE APPLICATION BUT CHANGE AT LEAST EVERY SIX MONTHS.
7) THE F100 SERIES FILTERS ARE NOT DESIGNED TO REMOVE CARBON MONOXIDE OR CARBON DIOXIDE.
8) ALL MODELS ARE FINISHED WITH WHITE EPOXY POWDERCOATING.
9) FOR BEST RESULTS MATCH FILTER INLET/OUTLET CONNECTION SIZE TO PIPE SIZE UNLESS ACTUAL FLOW EXCEEDS FILTER FLOW RATING.
10) ACCESSORIES AVAILABLE UPON REQUEST: MANIFOLDING KITS, MOUNTING BRACKETS, & DIFFERENTIAL PRESSURE GAUGES AND INDICATORS.
11) ADD 1" DRAIN DIMENSION FOR OVERALL LENGTH.

FLOW CORRECTION FACTORS FOR 250 PSIG (MWP) FILTERS

ACTUAL PRESSURE (PSIG)	10	20	30	40	50	60	70	80	90	100	125	150	175	200	225	250
X FLOW @ 100 PSIG	.21	.30	.39	.48	.56	.65	.74	.83	.92	1.00	1.22	1.44	1.65	1.87	2.09	2.31

ELEMENT GRADE	PURPOSE	FLOW DIRECTION	PARTICLE REMOVAL (MICROMETER)	EFFICIENCY %	MAX OIL CARRYOVER (PPM W/W)	RECOMMENDED INLET TEMP °F	MAX ALLOWABLE TEMP °F	CLEAN PRESSURE DROP DRY Δ P	OIL WET Δ P
AA5	EXTRA COARSE PREFILTER	IN/OUT	>25.0 µ	100 @ 25.0 µ	7.8	225	225	.40	.75
A5	COARSE PREFILTER	IN/OUT	>5.0 µ	100 @ 5.0 µ	3.9	225	225	.50	1.00
B5	GENERAL PURPOSE PREFILTER	IN/OUT	>1.0 µ	99.99 @ 0.6 µ	0.78	185	225	.75	1.50
C5	HIGH EFFICIENCY PREFILTER	IN/OUT	>.01 µ	99.9999 @ 0.6 µ	0.008	125	225	1.50	4.00
RAA5	EXTRA COARSE AFTERFILTER	OUT/IN	>25.0 µ	100 @ 25.0 µ	NA	225	225	.40	NA
RA5	COARSE AFTERFILTER	OUT/IN	>5.0 µ	100 @ 5.0 µ	NA	225	225	.50	NA
RB5	GENERAL PURPOSE AFTERFILTER	OUT/IN	>1.0 µ	99.99 @ 0.6 µ	NA	185	225	.75	NA
RC5	HIGH EFFICIENCY AFTERFILTER	OUT/IN	>.01 µ	99.9999 @ 0.6 µ	NA	125	225	1.50	NA
RD5	VAPOR ABSORBING	OUT/IN	>.01 µ	99.9999 @ 0.6 µ	0.0046	80	80	1.50	NA6

COMPRESSED AIR AND GAS FILTERS F100 SERIES

DRWN BY: RAF	DATE: 11/3/93	DRWG No. SD-80000	REV B
CHECKED: JAF	SCALE: NONE		
APPL:			

VAN AIR SYSTEMS INC

Lake City, PA 16423 (814)774-2631 Fax: 814/774-3482 Telex: 91-4548

CALC. W320-31-015
ATTACHMENT: M
SH. 1 OF 4

INGERSOLL-RAND
AIR COMPRESSORS

Air Compressor Group
Davidson Business Center
Ingersoll-Rand Company
800-D Beaty Street
P.O. Box 1840
Davidson, NC 28036
(704) 896-4000

March 4, 1996 FAX (3 Page)

TO: Cascade Machinery
Chuck Kroll

RE: Fax Dated 3/1/96

Hey-

I thought I would drop you a note to address the issues you inquired about in your fax that referenced order#005-52088, dated 3/1/96.

The three questions are valid and I would respond in the following manner:

1) As is true with any of our non-special electrical schematics, we show all of the options available so as to make one drawing good for a great number of applications. The drawings are designed so that the salesperson can cross out those options not being used and leave unmarked the items that apply to that particular application. When those types of drawings are not allowed and the customer requires specific, "as built" general arrangement drawings, the as builts are available for a fee. A HATS would not be standard on a package unless it was specifically requested.

2) I am pretty sure that the color lenses they are requesting are equal to what we supplied. I am attaching a copy of the Cutler Hammer pricebook page to give you the cat#'s for the replacement lenses. The lenses supplied should have been running-green, stop and all others-red.

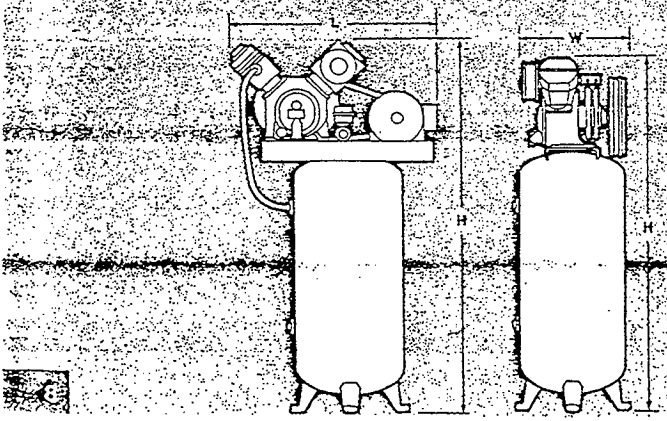
3) I would think that the relays would be available at just about any electrical supply house or through Cutler Hammer. If they specifically want the same as what was supplied on the panel, they should be able to dig up the catalogue number off of the contacts and give them to Cutler Hammer.

Richard L. Dye
Product Specialist
Small Compressor Division
PH# 704-896-4496
FX# 704-896-4433

CALC-W320-31-015
ATTACHMENT: M
SH. 2 OF 4

Performance Data and Dimensions

MODEL	BARE	HP	DISPL CFM	RCVR SIZE	RCVR CONFIG	LENGTH	WIDTH	HEIGHT	WEIGHT
234C1.5	234	1.5	6.5	60	Horizontal	51.25	22.81	40.25	337
234N1.5	234	1.5	6.5	80	Vertical	35.75	18.31	67.13	422
234C2	234	2	9.0	60	Horizontal	51.25	22.81	40.25	344
234N2	234	2	9.0	80	Vertical	35.75	18.31	67.13	429
234C3	234	3	11.4	60	Horizontal	51.25	22.81	40.25	362
234D3	234	3	11.4	80	Horizontal	67.00	22.81	41.00	447
234N3	234	3	11.4	80	Vertical	35.75	18.31	67.13	447
242D5	242	5	19.7	80	Horizontal	67.00	22.81	43.38	521
242N5	242	5	19.7	80	Vertical	36.14	21.69	69.13	521
242F6T	242	10(GAS)	20.0	30	Horizontal	43.75	24.0	44.75	500
2540D5	2540	5	19.9	80	Horizontal	67.31	29.00	46.96	680
2540D7.5	2540	7.5	32.8	80	Horizontal	67.31	29.00	46.96	724
2540N7.5	2540	7.5	32.8	80	Vertical	41.75	29.00	73.63	724
2540E7.5	2540	7.5	32.8	120	Horizontal	71.34	29.00	51.75	874
2540VE7.5	2540	7.5	32.8	120	Vertical	41.75	31.45	76.75	874
2540D10	2540	10	41.6	80	Horizontal	67.31	29.00	46.96	736
2540N10	2540	10	41.6	80	Vertical	41.75	29.00	73.63	736
2540E10	2540	10	41.6	120	Horizontal	71.34	29.00	51.75	886
2540VE10	2540	10	41.6	120	Vertical	41.75	31.45	76.75	886
7100D10	7100	10	44.0	80	Horizontal	68.59	27.31	52.00	935
7100E10	7100	10	44.0	120	Horizontal	71.34	27.31	56.75	1085



22.5 mm INDUSTRIAL PUSHBUTTONS AND INDICATING LIGHTS

10/26/92

Replacement Caps and Lenses

FILE E22

Description			Catalog Number	Price Each
Adapter Kit — Enables 22.5 mm operator to be mounted in a 30.5 mm mounting hole — panel thickness from 1/16" to 7/32"			E22ARK	$4.00
	Molded Black Bezel — For converting chrome bezel to black bezel — Suitable for Knob, Lever and Key Selector Switches		E22AZB	2.20
	Chrome Bezel — Suitable for Knob, Lever and Key Selector Switches		24-3318	2.20
Flush 25 mm Dia.	Lenses with Octagonal Bezel for 25 mm Diameter Flush Illuminated Pushbutton — 10 per package, min. order 10.	Red Green Blue Clear Amber White Yellow	E22ADR ADG ADY ADC ADA ADW ADY	5.70
Ext. 25 mm Dia.	Lenses with Octagonal Bezel for 25 mm Diameter Extended Illuminated Pushbuttons — 10 per package, min. order 10.	Red Green Blue Clear Amber White Yellow	E22AER AEG AEY AEC AEA AEW AEY	5.70
Std. Flush Button 25 mm Dia.	Color Caps with Octagonal Bezel for Standard Non-Illuminated 25 mm Diameter Flush Pushbuttons — 10 per package, min. order 10.	Red Green Blue White Yellow Black Gray Orange	E22ABR ABG ABV ABW ABT ABB ABE ABN	5.70
Std. Ext. Button 25 mm Dia.	Color Caps with Octagonal Bezel for Standard Non-Illuminated 25 mm Dia. Extended Pushbuttons — 10 per package, min. order 10.	Red Green Blue White Yellow Black Gray Orange	E22ACR ACG ACV ACW ACY ACB ACE ACH	5.70

REPLACEMENT LENSES — INDICATING LIGHTS

Color	Standard Indicating Light	For Use With Insert ❶	Price	Glass Lens	Price
	Catalog Number			Cat. No.	
Clear	E22AE0	E22AE0		E22AD0	
Red	AE2	AE2		AD2	
Green	AE3	AE3		AD3	
Yellow	AE4	AE4		AD4	
White	AE5	AE5	$3.10	AD5	$11.40
Blue	AE6	AE6		AD6	
Amber	AE9	AE9		AD9	

❶ Plastic indicating light lens with insert suitable for printed legends. For replacement Indicating Light Legend Inserts, order E22ALS. Price $0.50 each. Minimum order quantity 10 pieces.

DISCOUNT SCHEDULE 16D-1

Printed in U.S.A.
4/1/94

REPLACEMENT CAPS — PUSH-PULL

Description		Catalog Number 28.5 mm	Catalog Number 40 mm	Price
NON-ILLUMINATED				
	Black	E22AH31	E22AH1	
	Red	AH32	AH2	
	Green	AH33	AH3	
	Yellow	AH34	AH4	
	White	AH35	AH5	$3.10
	Blue	AH36	AH6	
	Gray	AH37	AH7	
	Amber	AH38	AH8	
	Red "Emergency" Stop	---	AH2K8	
ILLUMINATED				
	Clear	E22AF80	E22AF0	
	Red	AF82	AF2	
	Green	AF83	AF3	
	Yellow	AF84	AF4	
	White	AF85	AF5	9.10
	Blue	AF86	AF6	
	Amber	AF89	AF9	
	Red "Emergency" Stop	---	AF2K8	

REPLACEMENT SELECTOR SWITCH LEVERS & KNOBS

Color	Levers		Knobs		Price
	Catalog Number				
NON-ILLUMINATED					
Black	E22AY1	E22AW21	E22AX1	E22AXE1	
Red	AY2	AW22	AX2	AX22	
Green	AY3	AW23	AX3	AX23	
Yellow	AY4	AW24	AX4	AX24	
White	AY5	AW25	AX5	AX25	$3.10
Blue	AY6	AW26	AX6	AX26	
Gray	AY7	AW27	AX7	AX27	
Amber	AY9	AW29	AX8	AX28	
ILLUMINATED					
Clear	E22AW80	E22AW20	E22AR0	E22AR20	
Red	AW2	AW22	AR2	AR22	
Green	AW3	AW23	AR3	AR23	
Yellow	AW4	AW24	AR4	AR24	
White	AW5	AW25	AR5	AR25	9.10
Blue	AW6	AW26	AR6	AR26	
Amber	AW9	AW29	AR9	AR29	

For devic... contact your nearest Eaton Corp. Cutler-Ha... Service Center 1-...

CALC. W320-31-015
ATTACHMENT: M...
SH. 3 OF 4

CALC. W320-31-015
ATTACHMENT: M
SH. 4 OF 4

Accessories
AE18, AN18, AE58, AN58, CE15, CN15, CN35, CE55 and CN55

AUXILIARY CONTACTS — I.E.C. SIZES A-K, NEMA SIZES 00-2
(See following page for I.E.C. Sizes L-N and NEMA Sizes 3-5)

The auxiliary contacts listed below are designed for installation on Freedom Series starters and contactors. Snap-on design facilitates quick, easy installation.

These bifurcated design contact blocks, featuring silver cadmium alloy contacts, are well suited for use in very low energy (logic level) circuits.

Side Mounted

Top Mounted

MINIMUM RATINGS FOR LOGIC LEVEL AND HOSTILE ATMOSPHERE APPLICATION	
Minimum Amperes	20 mA
Minimum Volts	24 V ac/dc

Description	Catalog Number	Price
SIDE MOUNTED		
1 NO 1 NC	C320KEB81 K838	51B.
1 NO - 1 NC 2 NO 2 NC 1 NO - 1 NCI 1 NO (E.C.) - 1 NC (L.O.) 1 NCI	C320KGB3 K834 K835 K836 K837 K839	84.
TOP MOUNTED		
1 NO 1 NC	C320KGT1 K872	18.
1 NO - 1 NC 2 NO 2 NC 1 NO - 1 NCI 1 NO (E.C.) - 1 NO (L.O.) 1 NCI	C320KGT3 K874 K875 K876 K877 K878	84.
3 NO 2 NO - 1 NC 1 NO - 2 NC 3 NC 4 NO	C320KGT5 K8710 K8711 K8712 K8713	
3 NO - 1 NC 2 NO - 2 NC 1 NO - 3 NC 4 NC 3 NO - 1 NCI	C320KGT14 K8715 K8716 K8717 K8718	45.
2 NO - 1 NCI - 1 NC 2 NO - 1 NO (E.C.) - 1 NC (L.O.) 1 NO - 1 NC - 1 NO (E.C.) - 1 NC (L.O.)	C320KGT18 K8720 K8721	

NCI – Normally Closed early opening designed for use in reversing applications.
E.C. - Early Closing L.O. = Late Opening

AUXILIARY CONTACT RATINGS — A600 (Amperes)

Current	Ac Volts			
	120 V	240 V	480 V	600 V
Make & Interrupting	60	30	15	12
Break	6	3	1.5	1
Continuous	10	10	10	10

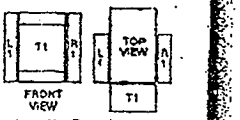
AUXILIARY CONTACT APPLICATION

Cat. No.	Size	Poles	AVAILABLE NTL. POSITIONS ❶❷❸	
			Open Type	NEMA 1 Enclosed
AE18 AN18	A-K 00	3 3	T1, L1, R1 T1, L1, R1	--- L1, R1
AE58	0-2 A-K	3 3	T1, L1, R1 L1, R1	L1, R1 ---
AN58 CE15	00-2 A-C D-K 0-2 0-J	5 2-4 3 4 5	T1, T2 T1, L1, R1 T1, L1, R1 T1, R1 T1	--- --- --- --- ---
CN15	00 0-2 1, 2 1, 2	2-4 2-3 4 5	T1, L1, R1 T1, L1, R1 T1, L1, R1 T1, L1, R1	L1 L1 --- ---
CN35	10 Ampere 20-60 Ampere 60 Ampere 60 Ampere	2-4 2-3 4 5	T1, L1, R1 T1, L1, R1 T1, L1, R1 T1, L1, R1	L1 L1 --- ---
CE55 CN55	A-K 00-2	3 3	L1, R1 T1, T2	--- ---

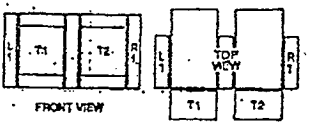
❶ Unless auxiliary contacts were ordered factory installed by inserting "S" or "T" in base catalog number.

❷ When a pneumatic timer is mounted on contactor, only side mounted auxiliary contact positions are available. The add-a-matic timer, when added, takes up side mounted auxiliary contact position.

❸ NEMA devices supplied with 1 NO holding circuit contact on right side as standard.



Non-Reversing Contactors & Starters



Reversing Contactors & Starters

W320-31-022

Control Circuit Sizing & Voltage Drop Analysis for Seismic Shutdown System (Class 1E)

Fluor Daniel Northwest	CALCULATION IDENTIFICATION AND INDEX	Page i of 13 Date 04/17/95

This sheet shows the status and description of the attached Design Analysis sheets.

Discipline Electrical WO/Job No. ER4319 Calculation No. W320-31-022

Project No. & Name W320, Tank 241-C-106 Sluicing

Calculation Item Control Circuit Sizing & Voltage Drop Analysis for Seismic Shutdown System (Class 1E)

These calculations apply to:

Dwg. No. H-2-818679, Sheets 1 & 2 Rev. No. 0

Dwg. No. H-2-818696, Sheets 1 & 2 Rev. No. 0

Other (Study, CDR) KGS-94-009 Project 93L-EW-329 Rev. No. NA

The status of these calculations is:

[] Preliminary Calculations

[X] Final Calculations

[] Check Calculations (On Calculation Dated)

[] Void Calculation (Reason Voided)

Incorporated in Final Drawings? [X] Yes [] No

This calculation verified by independent "check" calculations? [] Yes [X] No

Original and Revised Calculation Approvals:

	Rev. 0 Signature/Date	Rev. 1 Signature/Date	Rev. 2 Signature/Date
Originator	M. Khorsandian	K Khanawala 7/24/98	
Checked by	S. Najjar	7/24/98	
Approved by			
Checked Against Approved Vendor Data		K Khanawala 7/24/98	

INDEX

	Rev. 0 Signature/Date	Rev. 1 Signature/Date	Rev. 2 Signature/Date
Originator	M. Khorsandian		
Checked by	S. Najjar		

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C-1	Attachment C: 750 VA, Control Power Transformer (CPT) Impedance Data
D-1 to D-3	Attachment D: Bussman FNQ Type Fuse Data
E-1 to E-5	Attachment E: Cutler-Hammer 1025T and GE CR104P Indicating Light Data
F-1 to F-6	Attachment F: Rockbestos Firewall SIS Switchboard Wire data including ICEA S-68-516 Resistance and Okonite Temp. Correc. factors
G-1	Attachment G: Telephone conversation record with Kinemetrics, Inc.
H-1	Attachment H: Electronic I/O board digital output information

1.0 OBJECTIVE

The objective of this calculation is:

a. To determine the adequacy of voltage supplied by the electrical power distribution system to the contactor coil.

b. To size and select control loop cables supplying the contactor coil.

c. To size and select the cable connecting contactor control circuit to the "Emergency Trip" switch in control room.

d. To perform a voltage drop analysis of the control circuit and establish the minimum voltages allowed at the source terminal (secondary terminals of Transformer T1, or AY-PDP-1 distribution panel) in order to satisfy device pickup and holding voltages requirements. The calculated source voltage will be compared with the predicted steady-state and transient voltages in order to determine the adequacy of the circuits.

2.0 DESIGN INPUTS

a. KGS-94-009 Project 93L-EW-320, Tank 241-C-106 Sluicing, Letter of Instruction, Definitive Design, Rev. 6, April 1994.

3.0 CRITERIA AND SOURCE

a. WHC-SD-W320-FDC-001, Rev. 2; Functional Design Criteria for Tank 241-C-106 Waste Retrieval, Project W-320.

4.0 ASSUMPTIONS

a. The minimum Steady State voltage at source terminal is assumed to be 5% below its nominal voltage of 480 V; i.e. $480 \times 0.95 = 456$ V.

b. The minimum transient voltage at source terminal is assumed to be 25% below its nominal voltage of 480 V; i.e. $480 \times 0.75 = 360$ V. This value is typical for transient situations at power plants and power generators, and is based on industry experience.

c. The maximum Steady State voltage at source terminal is assumed to be 5% over its nominal voltage of 480 V; i.e. $480 \times 1.05 = 504$ V. This value is typical at power plants and power generators.

d. Loop conductors are considered to be #14 AWG unless otherwise noted in this calculation or on the drawing.

e. Resistance for loop conductors is based on 55°C. This value is the maximum anticipated ambient temperature, and is based on the consideration that these conductors are low current carrying conductors.

f. Cable reactance is assumed equal to zero since the resistive component of impedance is much larger than the reactive component of impedance for cable sizes utilized in this control loop.

g. Resistance of the cable connecting upstream transformer (transformer T1), or distribution panel (AY-PDP-1) to the contactor assembly is negligible due to insignificant length.

h. Percent impedance of a 750 VA Control Power Transformer is not published by the manufacturer. The %Z = 4.44 of a similar dry-type distribution transformer is used in this calculation. This value is typical for 750 VA transformers.

i. Indicating lights are transformer type, and have very high input impedance. Indicating lights impedances are assumed to be purely resistive.

j. The impedance of fuses larger than 3 amps is neglected.

k. Minimum pick up and hold in voltages of Westinghouse AR industrial relay is not published by the manufacturer. Therefore, it is conservatively assumed that relay minimum pick up and hold in voltages to be %85 of its nominal coil voltage, i.e.:

$$V_{min\ pick\ up} = V_{min\ hold\ in} = 120 \times 85\% = 102\ V$$

l. The most restrictive circuit device is the device being analyzed for pick-up and hold-in capabilities.

m. The impedance of panel wiring is assumed to be zero due to insignificant conductor lengths.

n. The impedance of circuit loads/devices is based on rated voltage and current.

o. The design data for Lamp No. 755 for Cutler-Hammer 10250T indicating lights is not provided by the vendor. Therefore, the data provided for the same lamp for GE CR104P indicating lights is used.

p. The Hold-in Wattage data for Westinghouse AR600 relay coils is not provided by the vendor. Therefore, the data provided for GE CR120B relay coil, which is similar, is used.

5.0 METHODS TO BE USED

1. For each utilization device, the minimum required terminal voltage for adequate operation of the device is obtained. For contactor coil and relays this will typically include a minimum pick-up voltage and a minimum hold-in voltage.

2. For each utilization device, the maximum power required by the device is obtained. For contactor coil and relays, this will normally include a momentary in-rush (pick-up) current and a steady state (hold-in) current.

3. Using transformer %R and %X, Control Power Transformer (CPT) impedance is calculated.

4. Using cable sizes and lengths, conductor impedances are calculated.

5. Impedance of each utilization device according to whether the device is drawing in-rush current or hold-in current is calculated.

6. From the control circuit diagram, the device alignment that yields the heaviest load on the CPT is determined. Based on this alignment the most restrictive device in the control circuit is determined. Due to large inrush and hold-in current, typically, contactor coil is among the most restrictive devices in the circuit.

7. A mathematical model using the values determined in previous steps is constructed, showing the worst case loop loading, the most restrictive device and minimum pick-up and drop-out voltages across this most restrictive device.

8. Using electrical circuit theory, the minimum pick-up and drop-out voltages required across the source terminal is calculated.

9. The required minimum pick-up and drop-out voltage values across source terminal will be compared with the minimum steady state and minimum transient voltage values to determine the adequacy of the control circuit.

6.0 REFERENCES

1. Westinghouse Catalog 25-000, 1993

2. Cutler-Hammer Quick Selector Catalog 25-000, 1995

3. Okonite Company Catalog,"Power, Control and instrumentation Cables", 1990.

4. Bussmann Fuse Catalog, Section 3

5. NFPA-70, National Electrical Code, 1993

6. Westinghouse Consulting Application Guide, 1991; Dry-Type Distribution Transformers technical Data

7. GE Electrical Distribution & Control Catalog, 1993

8. Ref. Standard ICEA S-68-516, WC 8-1988

7.0 CALCULATION

Seismic Shutdown System (SSS) is consisted of 2 sets of redundant contactor assemblies (Figures 1 and 2). Since all 4 contactors are identical, only one unit, seismic shutdown system #1, Figure #1 is analyzed.

7.1 CIRCUIT DATA

7.1.1 Westinghouse, size 6, 3 phase, 480 V contactor, Catalog # A201K6CA (Coil M1)
Coil data (Attachment A):

In-Rush VA	= 2900 VA
Hold-In VA	= 220 VA
Hold-In Watts	= 42 W
In-Rush P_f	= 0.0145
Hold-In P_f	= 0.19
Voltage Rating	= 120 VAC
Min. Pick-Up Voltage	= 84 V
Min. Hold-In Voltage	= 72 to 84 V

7.1.2 Westinghouse AR 600 Relay (Relay coils JXY1361, JXY1362, JXY0621, JXY0622, YY13650, YY13651, YY13652, YY13653, YY06210, YY06211, YY06212 and YY06213) coil data (Attachment B):

In-Rush VA	= 96 VA	
Hold-In VA	= 14 VA	
Hold-In Watts	= 7 W	
In-Rush P_f	= 0.0729	
Hold-In P_f	= 0.5	
Voltage Rating	= 120 VAC	
Min. Pick-Up Voltage	= 102 V	(Section 4.0-k)
Min. Hold-In Voltage	= 102 V	(Section 4.0-k)

7.1.3 Control Power Transformer (CPT)

A 750 VA CPT is selected
480/120 V, Single phase

% Z = 4.44 (Attachment C)

7.1.4 Fuse Data

"NUTHERM" has provided a 10 Amp control fuse for secondary side of transformer, and a 5 Amp fuse for isolation.
Since both these kinds of fuses are over 3 Amp the resistance is neglected.

$R_{FNQ-10} = 0\ \Omega$

$R_{FNQ-5} = 0\ \Omega$

7.1.5 Indicating Lights

Indicating lights provided are Cutler-Hammer 10250T transformer type (Attachment E).

Cutler-Hammer 10250T transformer secondary voltage = 6 V
Lamp No. 755

7.1.6 Seismic Switch Power Supply

Power supply unit rating is 120 VAC, 150 mA (Attachment G). For conservatism, it is assumed power supply has an input rating of 300 mA.

7.1.7 Cable Data

#14 AWG size is provided for loop conductors

$R_{\#14\ AWG\ @\ 25°C} = 2.79\ \Omega$ Per 1000 ft (Attachment F)

$R_{\#14\ AWG\ @\ 55°C} = R_{\#14\ AWG\ @\ 25°C} \times 1.115$
$= 2.79 \times 1.115$

$R_{\#14\ AWG\ @\ 55°C} \approx 3.11\ \Omega$ Per 1000 ft

12 AWG size is selected for cable from SSS cabinet to emergency stop switch in control trailer

$R_{\#12\ AWG\ @\ 25°C}$ = 1.75 Ω Per 1000 ft (Attachment F)

$R_{\#12\ AWG\ @\ 55°C}$ = $R_{\#12\ AWG\ @\ 25°C}$ × 1.115
= 1.75 × 1.115

$R_{\#12\ AWG\ @\ 55°C}$ ≈ 1.95 Ω Per 1000 ft

7.2 ANALYSIS

7.2.1 Cable:

Cable A: From SSS cabinet to emergency stop switch at control trailer, approximately 100 ft of #12 AWG;

$R_{Cable\ A}$ = 100 × 2 × (1.95 ÷ 1000)
= 0.39 Ω

Cable B: Seismic Switch power supply power cord, approximately 5 ft of #14 AWG;

$R_{Cable\ B}$ = 5 × 2 × (3.11 ÷ 1000)
= 0.031 Ω

Cable C: From "SET" (Start) switch to seismic switch relay contacts, approximately 5 ft of #14 AWG;

$R_{Cable\ C}$ = 5 × 2 × (3.11 ÷ 1000)
= 0.031 Ω

Cable D: From Seismic Switch relay contacts to temperature switch contacts, approximately 5 ft of #14 AWG;

$R_{Cable\ D}$ = 5 × 2 × (3.11 ÷ 1000)
= 0.031 Ω

Cable E: From temperature switch contacts to contactor coil terminals, approximately 5 ft of #14 AWG;

$R_{Cable\ E}$ = 5 × 2 × (3.11 ÷ 1000)
= 0.031 Ω

7.2.2 Transformer:

Per unit impedance of Control Power Transformer is:

$\%Z_T = 4.44$ (Attachment C & Section 4.0-8)

Conservatively assuming X = R

$Z^2 = X^2 + R^2 \Rightarrow R \approx 3.14\ \Omega,\ X \approx 3.14\ \Omega$

$Z_{Tpu} = 0.0314 + j\,0.0314$

7.2.3 Indicating Lights:

Indicating Lights YL13650B & YL13651B (YL13652B, YL13653B, YL06210B, YL06211B, YL06212B, YL06213B) are transformer type with the bulb rating of:

Lamp No. 755; Design Volt = 14 V, Design Amps = 0.15 A (Attachment E)

$R_{lamp} = 14 \div 0.15$
$\approx 93\ \Omega$

The current on the secondary side of indicating light transformer is:

$I_{secondary} = 6 \div 93$
$= 0.0645$ A

The current on the primary side of indicating light transformer can be determined as follows:

$I_{primary} = 0.0645 \times [\,6 \div 120\,]$
$= 0.0032$ A

Assuming the transformer has an efficiency rating of 50%, then:

$I_{primary} = 0.0064$ A

Therefore, the total resistive value of the indicating lights (IL) seen by the control circuit can be determined as follows:

$R_{IL} = 120 \div 0.0064$
$= 18.75\ K\Omega$

7.2.4 Pick-Up (In-Rush) scenario:

From the acquired data and referring to Figure 1 (Figure 2), the contactor coil is the most restrictive load since it has the largest in-rush current, and the longest cable loop . Loop loading for the pick-up circuit is based on the following:

a. Relay coil YY13650 (YY13652, YY06211 & YY06213) for remote "TRIP" indication is energized and it is drawing hold-in current.

b. Relay coil YY13651 (YY13653, YY06210 & YY06212) for remote "SET" indication is omitted since it would not be energized until contactor coil is energized.

c. Seismic Switch Power Supply (SSPS) is considered to be drawing hold-in current since it is in parallel with the contactor coil and does not pull current through the contactor loop. SSPS is always energized as long as control circuit is energized.

d. Relay coil JXY1361 (JXY1362, JXY0621 & JXY0622) for power failure indication is considered to be drawing hold in current since it is in parallel with contactor coil. This coil is always energized as long as control circuit is energized.

e. Relay coil AY1361A (AY1362A, AY0621A & AY0622A) is a 24 VDC battery powered, and it is considered to be internal to SSPS, therefore, it is not considered in pick-up scenario.

f. The current drawn by the indicating light units can be neglected since they are in parallel with the contactor coil, and their resistances are very high. There will be one indicating light lit at a given scenario.

7.2.4.1 Based on Step 7.2.4 scenario, the impedances of various devices are calculated:

$P_f = \text{Cos}\ \phi$

$Z = [\ V^2 \div VA\ ] \times [\ \text{Cos}\ \phi + j\ \text{Sin}\ (\text{Cos}^{-1}\ P_f)\ ]$

$Z_{M\ IR} = [\ (120)^2 \div 2900\ ] \times [\ 0.0145 + j\ \text{Sin}\ (\text{Cos}^{-1}\ 0.0145)\ ]$
$\approx 0.072 + j\ 4.96\ \Omega$

$Z_{SSPS} = 115 \div 0.3$
$\approx 380\ \Omega$

$Z_{JXY1361\ HI} = [\ (120)^2 \div 14)\ ] \times [\ 0.5 + j\ \text{Sin}\ (\text{Cos}^{-1}\ 0.5)\ ]$
$= 514.28 + j\ 890.77\ \Omega$

$Z_{YY13650\ HI} = 514.28 + j\ 890.77\ \Omega$

7.2.4.2 A mathematical model is constructed as shown on figure 3. Indicating lights are in parallel with contactor coil. Due to high impedances of indicating lights, the impedances contributed by these lights are omitted from the model.

The equivalent circuit is further reduced (Figure 4) using electrical circuit theory as follows:

$I_M = V_M \div Z_M$
$= 84 \div (0.072 + j\ 4.96)$
$= 0.245 - j\ 16.93$ A

$Z_3 = R_{IF1} + R_{IF2} + R_{Cable\ A} + R_{IF3} + R_{IF4} + R_{Cable\ C} + R_{Cable\ D} + R_{Cable\ E}$
$= 2 \times 0 + 0.39 + 2 \times 0 + 0.031 + 0.031 + 0.031$
$\approx 0.483\ \Omega$

$V_2 = I_M \times (Z_3 + Z_M)$
$= (0.245 - j\ 16.93) \times (0.483 + 0.072 + j\ 4.96)$
$= 84.11 - j\ 8.18$ V

$Z_2 = Z_{gsps} + R_{Cable\ B}$
$= 380 + 0.031$
$\approx 380\ \Omega$

$Z_1 = Z_2 \parallel Z_{IXY1361} \parallel Z_{YY13650}$
$= [380 \times (514.28 + j\ 890.77)] \div [(514.28 + j\ 890.77) + 2 \times 380]$
$\approx 227.76 + j\ 106.42\ \Omega$

$I_{Z1} = V_2 \div Z_1$
$= (84.11 - j\ 8.18) \div (228.58 + j\ 111.03)$
$= 0.2893 - j\ 0.1711$ A

$I_{TOT} = I_{Z1} + I_M$
$= 0.5343 - j\ 17.1$ A

$V_1 = V_2 + I_{TOT} \times R_{FU3}$
$= 84.11 - j\ 8.18 + (0.5343 - j\ 17.1) \times 0$
$= 84.11 - j\ 8.18$ V

$I_{TOT\ pu} = [(0.5343 - j\ 17.1) \times (120)] \div 750$
$= 0.0855 - j\ 2.74$

$$V_{1\,pu} = (84.11 - j\,8.18) \div 120$$
$$= 0.7 - j\,0.068$$

$$V_{MIN} = [\, I_{TOT\,pu} \times Z_{T\,pu} + V_{1\,pu} \,] \times 480$$
$$= [\, (0.0855 - j\,2.74) \times (0.0314 + j\,0.068) + 0.7 - j\,0.34 \,] \times 480$$
$$= [\, 0.7887 - j\,0.1514 \,] \times 480$$
$$= 378.6 - j\,72.6$$
$$= 385.5 \angle -11^\circ \text{ V}$$

$$\therefore \quad | V_{MIN\ pick\text{-}up} | = 385.5 \text{ V}$$

This value represents the minimum source voltage required to ensure that all devices can pick up.

Since $V_{MIN\ pick\text{-}up} < V_{LIMIT\ pick\text{-}up}$ ($V_{LIMIT\ pick\text{-}up}$ assumed to be 456 V in Section 4.0-1), the control loop is adequate. The most restrictive device, contactor coil, can pick up when the minimum source voltage, 456 V, is present at the secondary side of transformer T1.

7.2.5 Drop-Out (Hold-IN) Scenario:

From the acquired data and referring to Figure 1 (Figure 2), the contactor coil is again the most restrictive load since it has the largest hold-in current, and the longest cable loop. Loop loading for the drop-out circuit is based on the following:

a. Relay coil YY13651 (YY13653, YY06210 & YY06212) for remote "SET" indication is energized and it is drawing hold-in current.

b. Relay coil YY13650 (YY13652, YY06211 & YY06213) for remote "TRIP" indication is omitted since it would not be energized until contactor coil is de-energized.

c. Seismic Switch Power Supply (SSPS) is considered to be drawing hold-in current since it is in parallel with the contactor coil and does not pull current through the contactor loop. SSPS is always energized as long as control circuit is energized.

d. Relay coil JXY1361 (JXY1362, JXY0621 & JXY0622) for power failure indication is considered to be drawing hold in current since it is in parallel with contactor coil. This coil is always energized as long as control circuit is energized.

e. Relay coil AY1361A (AY1362A, AY0621A & AY0622A) is a 24 VDC battery powered, and it is considered to be internal to SSPS, therefore, it is not considered in drop-out scenario.

f. The current drawn by the indicating light units can be neglected since they are in parallel with the contactor coil, and their resistances are very high. There will be one indicating light lit at a given scenario.

7.2.5.1 Based on Step 7.2.5 scenario, impedances of various devices are calculated:

$Z_{M\,HI} = [\,(120)^2 \div 220)\,] \times [\,0.19 + j\,\text{Sin}\,(\text{Cos}^{-1}\,0.19)\,]$
$\approx 12.44 + j\,64.26\ \Omega$

$Z_{ssps} = 115 \div 0.3$
$\approx 380\ \Omega$

$Z_{JXY1361\,HI} = [\,(120)^2 \div 14)\,] \times [\,0.5 + j\,\text{Sin}\,(\text{Cos}^{-1}\,0.5)\,]$
$= 514.28 + j\,890.77\ \Omega$

$Z_{YY13651\,HI} = 514.28 + j\,890.77\ \Omega$

7.2.5.2 A mathematical model is again constructed as shown on figure 5. Indicating lights are in parallel with contactor coil. Due to high impedances of indicating lights, the impedances contributed by these lights are omitted from the model.

The equivalent circuit is further reduced (Figure 6) using electrical circuit theory as follows:

$I_M = V_M \div Z_M$
$= 84 \div (\,12.44 + j\,64.26\,)$
$= 0.24 - j\,1.26\ A$

$Z_3 = 0.483\ \Omega$

$V_2 = I_M \times (Z_3 + Z_M)$
$= (\,0.24 - j\,1.26\,) \times (\,0.483 + 12.44 + j\,64.26\,)$
$= 84.07 - j\,0.86\ V$

$Z_2 = 380\ \Omega$

$Z_1 = Z_2 \parallel Z_{JXY1361} \parallel Z_{YY13651}$
$\approx 227.76 + j\,106.42\ \Omega$

$I_{Z1} = V_2 \div Z_1$
$= (\,84.07 - j\,0.86\,) \div (\,227.76 + j\,106.42\,)$
$\approx 0.3015 - j\,0.1447\ A$

$$I_{TOT} = I_{Z1} + I_M$$
$$= 0.5415 - j\ 1.4047\ A$$

$$V_1 = V_2 + I_{TOT} \times R_{FU3}$$
$$= 84.07 - j\ 0.86 + (0.5415 - j\ 1.4047) \times 0$$
$$= 84.07 - j\ 0.86\ V$$

$$I_{TOT\ pu} = [(0.5415 - j\ 1.4047) \times (120)] \div 750$$
$$= 0.0866 - j\ 0.225$$

$$V_{1\ pu} = (84.07 - j\ 0.86) \div 120$$
$$= 0.7 - j\ 0.007$$

$$V_{MIN} = [I_{TOT\ pu} \times Z_{T\ pu} + V_{1\ pu}] \times 480$$
$$= [(0.086 - j\ 0.225) \times (0.0314 + j\ 0.0314) + 0.7 - j\ 0.007] \times 480$$
$$= [0.71 - j\ 0.011] \times 480$$
$$= 340.7 - j\ 5.5$$
$$= 340.7 \angle -0.9°\ V$$

$$\therefore \quad | V_{MIN\ drop\text{-}out} | = 340.7\ V$$

This value represents the minimum source voltage transient dip to ensure that all devices will not drop-out under bus voltage transient situation.

Since $V_{MIN\ drop\text{-}out} < V_{LIMIT\ drop\text{-}out}$ ($V_{LIMIT\ drop\text{-}out}$ assumed to be 360 V in Section 4.0-2), the control loop is adequate. The most restrictive device, contactor coil, will not drop-out when the source voltage dips into minimum 360 V transient, at the secondary side of transformer T1.

7.3 OVERVOLTAGE CONSIDERATION

When maximum steady state voltage of 504 is present at the primary side of CPT, the voltage at the secondary side is conservatively calculated as follows:

$$V_{max\ secondary} = 120 \times [504 \div 480]$$
$$= 126\ V$$

Assuming no voltage losses in contactor coil loop, the contactor coil is subjected to 126 V which is less than the maximum allowable voltage of 132 V (Attachment A), i.e.:

$$V_{max\ allowable} = 120 \times 110\%$$
$$= 132\ V$$

$V_{max\ secondary}$ = 126 V < $V_{max\ allowable}$ = 132 V

Therefore, contactor coil can safely operate under CPT primary voltage value of 504 V without injury to the operating coil.

7.4 FINDINGS AND CONCLUSIONS

1. The voltage supplied by the electrical power distribution system to the contactor coil is adequate.

2. #14 AWG cable is adequate for internal wiring of contactor assembly, and cables supplying seismic switch power supply.

3. #12 AWG cable to emergency stop switch in control room is adequate in size.

4. The voltage drop analysis of the control circuit shows that the minimum voltages allowed at the source for steady-state and transient conditions are adequate to satisfy the device pickup and holding voltage requirements.

This calculation shows that the control circuit of the size 6 contactor used in the Seismic Shutdown System is adequately sized. The contactor will pick up when worst case minimum bus voltage condition is present, and it will hold in during worst case minimum transient voltage situation. Nuisance tripping will not occur due to bus voltage normal fluctuations. Long lead cables and panel internal wiring sizes are adequately selected such that voltage drop will not adversely affect system operation.

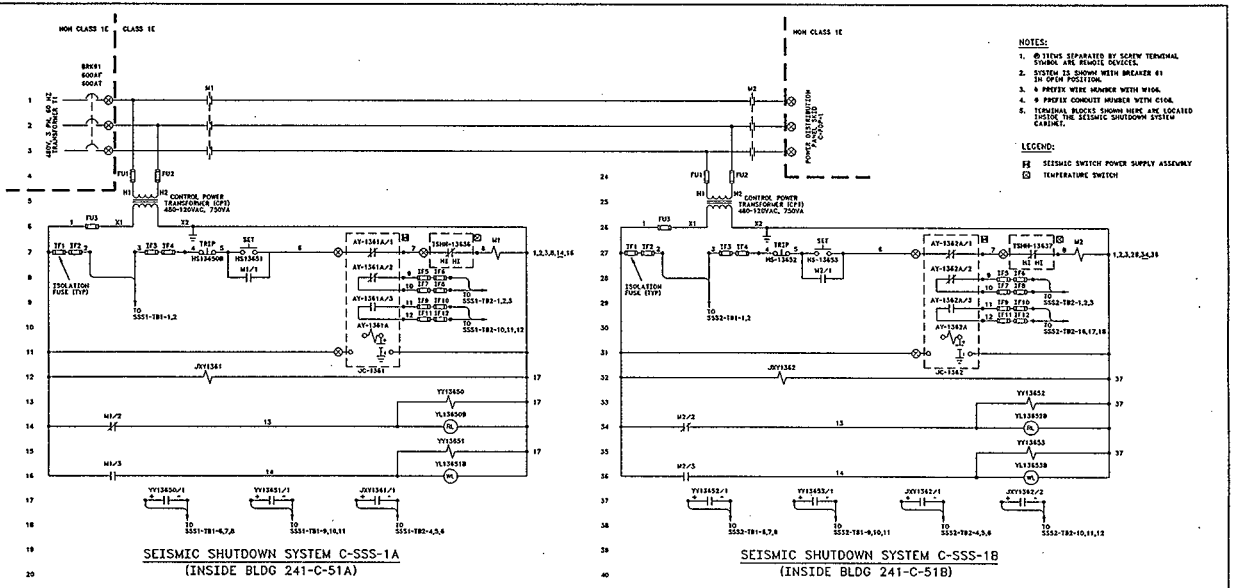

TABLE 1

FUSE ID #	RATING AMP.	FUSE TYPE	MANUFACTURER	AIC
FU1	1	FHG-1	BUSSMANN	10,000
FU2	3	FHG-3	BUSSMANN	10,000
FU3	3	FHG-3	BUSSMANN	10,000
IF1	2-1/2	FHG2-1/2	BUSSMANN	10,000
IF2	2-1/2	FHG2-1/2	BUSSMANN	10,000
IF3	2-1/2	FHG2-1/2	BUSSMANN	10,000
IF4	2-1/2	FHG2-1/2	BUSSMANN	10,000
IF5	1/2	FHG1/2	BUSSMANN	10,000
IF6	1/2	FHG1/2	BUSSMANN	10,000
IF7	1/2	FHG1/2	BUSSMANN	10,000
IF8	1/2	FHG1/2	BUSSMANN	10,000
IF9	1-1/2	FHG1-1/2	BUSSMANN	10,000
IF10	1-1/2	FHG1-1/2	BUSSMANN	10,000
IF11	1-1/2	FHG1-1/2	BUSSMANN	10,000
IF12	1-1/2	FHG1-1/2	BUSSMANN	10,000

CALC. W320-31-022
FIGURE 1

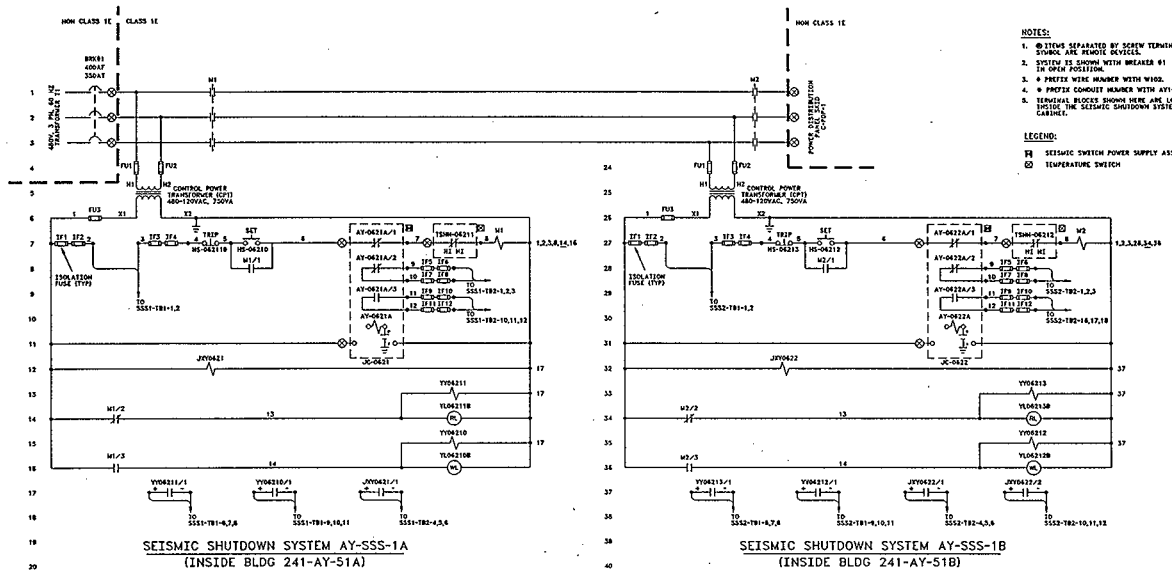

TABLE 1

FUSE ID #	RATING AMP.	FUSE TYPE	MANUFACTURER	AIC
FU1	3	FHO-3	BUSSMANN	10,000
FU2	3	FHO-3	BUSSMANN	10,000
FU3	3	FHO-3	BUSSMANN	10,000
1F1	3-1/2	FWO2-1/2	BUSSMANN	10,000
1F2	3-1/2	FWO2-1/2	BUSSMANN	10,000
1F3	2-1/2	FWO2-1/2	BUSSMANN	10,000
1F4	2-1/2	FWO2-1/2	BUSSMANN	10,000
1F5	1/2	FWO1/2	BUSSMANN	10,000
1F6	1/2	FWO1/2	BUSSMANN	10,000
1F7	1/2	FWO1/2	BUSSMANN	10,000
1F8	1/2	FWO1/2	BUSSMANN	10,000
1F9	1-1/2	FWO1-1/2	BUSSMANN	10,000
1F10	1-1/2	FWO1-1/2	BUSSMANN	10,000
1F11	1-1/2	FWO1-1/2	BUSSMANN	10,000
1F12	1-1/2	FWO1-1/2	BUSSMANN	10,000

CALC. W320-31-022
FIGURE 2

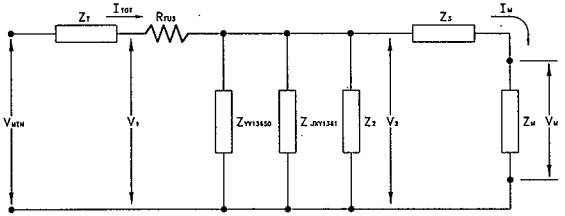

FIGURE 3

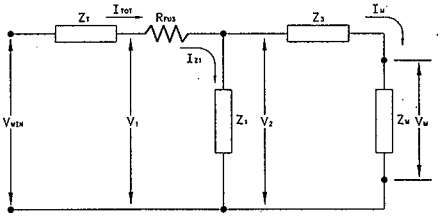

FIGURE 4

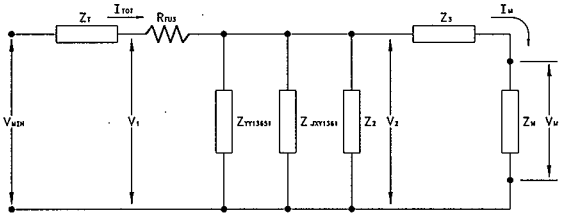

FIGURE 5

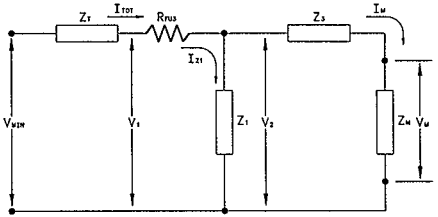

FIGURE 6

CONTACTORS, Full Voltage AC
Non-Reversing, Sizes 00-9
Class A201

ATTACHMENT: A
PAGE: A-1

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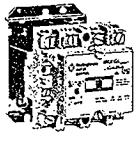
Page C-20

LIST PRICES AND CATALOG NUMBERS



A201 Size 1

Max. Hp.	Motor Volts	NEMA Size	Cont. Amps Encl.	Coil Volts	2 Poles				3 Poles				4 Poles				5 Poles			
					Open		Type 1 Encl.		Open		Type 1 Encl.		Open		Type 1 Encl.		Open		Type 1 Encl.	
					Cat. Number	List Price	Cat. Number	List Price	Cat. Number	List Price	Cat. Number	List Price	Cat. Number	List Price	Cat. Number	List Price	Cat. Number	List Price	Cat. Number	List Price
					A201		A201		A201		A201		A201		A201		A201		A201	
...	...	00	9	120	KABA	$ 120	SABA	$ 132	KACA	$ 138	SACA	$ 150	KADA	$ 186	SADA	$ 198	KAEA	$ 252	SAEA	$ 264
1½	200			208	KABB		SABB		KACB		SACB		KADB		SADB		KAEB		SAEB	
1½	230			240	KABW		SABW		KACW		SACW		KADW		SADW		KAEW		SAEW	
2	460			480	KABX		SABX		KACX		SACX		KADX		SADX		KAEX		SAEX	
2	575			600	KABE		SABE		KACE		SACE		KADE		SADE		KAEE		SAEE	
...	...	0	18	120	K0BA	156	S0BA	168	K0CA	174	S0CA	186	K0DA	222	S0DA	234	K0EA	288	S0EA	300
3	200			208	K0BB		S0BB		K0CB		S0CB		K0DB		S0DB		K0EB		S0EB	
3	230			240	K0BW		S0BW		K0CW		S0CW		K0DW		S0DW		K0EW		S0EW	
5	460			480	K0BX		S0BX		K0CX		S0CX		K0DX		S0DX		K0EX		S0EX	
5	575			600	K0BE		S0BE		K0CE		S0CE		K0DE		S0DE		K0EE		S0EE	
...	...	1	27	120	K1BA	186	S1BA	198	K1CA	204	S1CA	216	K1DA	252	S1DA	264	K1EA	318	S1EA	330
7½	200			208	K1BB		S1BB		K1CB		S1CB		K1DB		S1DB		K1EB		S1EB	
7½	230			240	K1BW		S1BW		K1CW		S1CW		K1DW		S1DW		K1EW		S1EW	
10	460			480	K1BX		S1BX		K1CX		S1CX		K1DX		S1DX		K1EX		S1EX	
10	575			600	K1BE		S1BE		K1CE		S1CE		K1DE		S1DE		K1EE		S1EE	
...	...	2	45	120	K2BA	348	S2BA	408	K2CA	372	S2CA	432	K2DA	480	S2DA	540	K2EA	720	S2EA	780
10	200			208	K2BB		S2BB		K2CB		S2CB		K2DB		S2DB		K2EB		S2EB	
15	230			240	K2BW		S2BW		K2CW		S2CW		K2DW		S2DW		K2EW		S2EW	
25	460			480	K2BX		S2BX		K2CX		S2CX		K2DX		S2DX		K2EX		S2EX	
25	575			600	K2BE		S2BE		K2CE		S2CE		K2DE		S2DE		K2EE		S2EE	
...	...	3	90	120	K3BA	552	S3BA	672	K3CA	600	S3CA	720	K3DA	768	S3DA	888	K3EA	1152	S3EA	1272
25	200			208	K3BB		S3BB		K3CB		S3CB		K3DB		S3DB		K3EB		S3EB	
30	230			240	K3BW		S3BW		K3CW		S3CW		K3DW		S3DW		K3EW		S3EW	
50	460			480	K3BX		S3BX		K3CX		S3CX		K3DX		S3DX		K3EX		S3EX	
50	575			600	K3BE		S3BE		K3CE		S3CE		K3DE		S3DE		K3EE		S3EE	
...	...	4	135	120	K4BA	1332	S4BA	1584	K4CA	1440	S4CA	1692	K4DA	2004	S4DA	2256	K4EA	2772	S4EA	3024
40	200			208	K4BB		S4BB		K4CB		S4CB		K4DB		S4DB		K4EB		S4EB	
50	230			240	K4BW		S4BW		K4CW		S4CW		K4DW		S4DW		K4EW		S4EW	
100	460			480	K4BX		S4BX		K4CX		S4CX		K4DX		S4DX		K4EX		S4EX	
100	575			600	K4BE		S4BE		K4CE		S4CE		K4DE		S4DE		K4EE		S4EE	
...	...	5	270	120	K5BA	2886	S5BA	3348	K5CA	3138	S5CA	3600	....	....	....	....	....	....	....	....
100	230			240	K5BW		S5BW		K5CW		S5CW		....		....		....		....	
200	460			480	K5BX		S5BX		K5CX		S5CX		....		....		....		....	
200	575			600	K5BE		S5BE		K5CE		S5CE		....		....		....		....	
...	...	6	540	120	K6BA	7344	S6BA	9378	K6CA	8568	S6CA	10602	....	....	....	....	....	....	....	....
200	230			240	K6BW		S6BW		K6CW		S6CW		....		....		....		....	
400	460			480	K6BX		S6BX		K6CX		S6CX		....		....		....		....	
400	575			600	K6BE		S6BE		K6CE		S6CE		....		....		....		....	
...	...	7	810	120	K7BJ	10722	S7BJ	12756	K7CJ	12228	S7CJ	14268	....	....	....	....	....	....	....	....
300	230			240	K7BK		S7BK		K7CK		S7CK		....		....		....		....	
600	460			480	K7BU		S7BU		K7CU		S7CU		....		....		....		....	
...	...	8	1215	120	K8BJ	17208	S8BJ	20529	K8CJ	18876	S8CJ	22212	....	....	....	....	....	....	....	....
450	230			240	K8BK		S8BK		K8CK		S8CK		....		....		....		....	
900	460			480	K8BU		S8BU		K8CU		S8CU		....		....		....		....	
...	...	9	2250	120	K9BJ	23040	S9BJ	25200	K9CJ	25410	S9CJ	28410	....	....	....	....	....	....	....	....

See Page 414 For Other Available Enclosures

LIST PRICES AND CATALOG NUMBERS

Rear Connected Contactors

120 Volt Rectified Coil/Open Only

Size	Cat. No.	List Price
7	A201K7CJZ9	$12928
8	A201K8CJZ9	19776
9	A201K9CJZ9	26610

FURTHER INFORMATION

ORDERING INFORMATION

Order by catalog number. Complete catalog number consists of **A201** in bold type in catalog number column, plus suffix letters KABA, etc. in catalog number column. Example: A201 + KABA = A201KABA

STARTERS AND CONTACTORS

ATTACHMENT: A
PAGE: A-2

Full Voltage AC, NEMA Sizes 00-9
Technical Data

TECHNICAL DATA Continued

Operating Coil Characteristics at Rated Coil Volts, Sizes 00-9
The following represent typical production test values and should not be interpreted as a guarantee of actual performance.

	Size 00,0,1	Size 2	Size 3	Size 4 ❷	Size 5	Size 6	Size 7	Size 8	Size 9
AC Coil									
Burden (Open VA)	160 VA	160 VA	625 VA	700 VA	1700 VA	2900 VA	(DC Operated	(DC Operated	(DC Operated
(Closed VA)	25 VA	25 VA	50 VA	64 VA	180 VA	220 VA	Only)	Only)	Only)
(Closed Watts)	7.8 W	7.8 W	18 W	21 W	32 W	42 W	.....	.....	.....
Pick-up Volts❶	85%	85%	85%	85%	78%	70%	.....	.....	.....
Drop-out Volts❶	40 – 60%	40 – 60%	40 – 60%	40 – 60%	65 to 75%	60 to 70%	.....	.....	.....
Pick-up Time Hz❷❸	1 – 1½	1½ – 2	2 – 2½	1 – 1½	1.5	4.0	.....	.....	.....
Drop-out Time Hz❸	¾ – 1	¾ – 1	¾ – 1	¾ – 1	0.75	0.75	.....	.....	.....
DC Coil									
Burden (Open VA)	17 VA	17 VA	35 VA	.....	600 VA	2120 VA	400 VA	400 VA	2100 VA
(Closed VA)	17 VA	17 VA	35 VA	.....	22 VA	21 VA	400 VA	400 VA	350 VA
(Closed Watts)	18 W	18 W	35 W	35 W	20 W	20 W	400 W	400 W	350 W
Pick-up Volts❶	80%	80%	80%	80%	64%	73%	45% – 65%❶	45% – 65%❶	50% – 65%❶
Drop-out Volts❶	5 – 10%	5 – 10%	5 – 10%	5 – 10%	18%	13%	30% – 45%❶	30% – 45%❶	40% – 50%❶
Pick-up Time❷	.....	25 – 75 MS	25 – 75 MS	25 – 75 MS	2.7 Hz❶	3 Hz❶	21 – 41 Hz❶❷	17 – 29 Hz❶❷	16 – 18 Hz❶❷
Drop-out Time❸	.....	16 – 25 MS	16 – 25 MS	16 – 25 MS	9.3 Hz❶	17.5 Hz❶	7 – 12 Hz❶❷	7 – 12 Hz❶❷	18 – 20 Hz❶❷

NEMA Std. ICS 2-110
Direct-current operated contactors shall withstand 110 percent of their rated voltage continuously without injury to the operating coils and shall close successfully at 80 percent of their rated voltage.

Alternating-current operated contactors shall withstand 110 percent of their rated voltage continuously without injury to the operating coils and shall close successfully at 85 percent of their rated voltage.

Mechanical Characteristics, Sizes 00-9

	Size 00,0,1	Size 2	Size 3	Size 4	Size 5	Size 6	Size 7	Size 8	Size 9
Dimensions – Inches									
Height	6.45 In.	7.16 In.	9.93 In.	9.93 In.	12.00 In.❹	13.50 In.❹	18.62 In.❹	19.25 In.❹	25.00 In.❹
Width	3.31	3.31	4.62	4.62	7.00❹	7.00❹	23.50❹	23.50❹	32.00❹
Depth	4.61	4.96	6.75	6.75	7.75❹	8.75❹	11.00❹	11.00❹	13.00❹
Panel Area – Square Inches	21.35	23.7	46.0	46.0	84.0	94.5	437.5	452.4	800
Weight – Pounds	3.5 Lbs.	3.5 Lbs.	11.5 Lbs.	11.5 Lbs.	25 Lbs.	42 Lbs.	215 Lbs.	265 Lbs.	315 Lbs.
Cable Connection	.....	.....	.....	.....	Front	Front	Front/Rear	Front/Rear	Front/Rear
Maximum Cable Size/Phase									
Copper (AWG/MCM)	#6	#3	1/0	4/0	1-500 MCM	2-500 MCM	3-500 MCM	4-500 MCM	8-500 MCM
Auxiliary Electrical Circuits									
Available	8	6	6	6	4	4	3	3	4
Latched Version Available	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Mechanical Interlock Combinations Available									
Sizes 00, 0, 1, 2, 3, 4	Vert., Horiz.	Vert., Horiz.	Vert., Horiz.	Vert., Horiz.	Vert., Horiz.	.....	.....	.....	.....
5	.....	.....	.....	.....	Vert., Horiz.	Vert., Horiz.	.....	.....	.....
6	.....	.....	.....	.....	Vert., Horiz.	Vert., Horiz.	Vertical	Vertical	.....
7, 8	.....	.....	.....	.....	.....	Vertical	Vertical	Vertical	Vertical
9	.....	.....	.....	.....	.....	.....	Vertical	Vertical	Vertical

Data From Tables 430 – 147 Through 150 of 1987 N.E.C.
Motor Amperes at Full Load❺, Three Phase AC

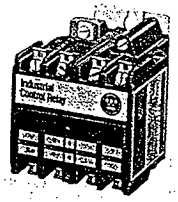
Hp	Single Phase AC		Squirrel Cage AC				DC	
	115 Volts	230 Volts	200 Volts	230 Volts	460 Volts	575 Volts	120 Volts	240 Volts
⅛	4.4	2.2	.....	.....	.....	.....	.....	.....
¼	5.8	2.9	1.1	1	.....	.....	3.1	1.6
⅓	7.2	3.6	.....	.....	.....	.....	4.1	2.0
½	9.8	4.9	2.3	2	1	.8	5.4	2.7
¾	13.8	6.9	3.2	2.8	1.4	1.1	7.6	3.8
1	16	8	4.1	3.6	1.8	1.4	9.5	4.7
1½	20	10	6.0	5.2	2.6	2.1	13.2	6.6
2	24	12	7.8	6.8	3.4	2.7	17	8.5
3	34	17	11	9.6	4.8	3.9	25	12.2
5	56	28	17.5	15.2	7.6	6.1	40	20
7½	80	40	25	22	11	9	58	29
10	100	50	32	28	14	11	76	38
15	....	....	48	42	21	17	....	55
20	....	....	62	54	27	22	....	72
25	....	....	78	68	34	27	....	89
30	....	....	92	80	40	32	....	106
40	....	....	120	104	52	41	....	140
50	....	....	150	130	65	52	....	173
60	....	....	177	154	77	62	....	206
75	....	....	221	192	96	77	....	255
100	....	....	230	248	124	99	....	341
125	....	....	360	312	156	125	....	425
150	....	....	414	360	180	144	....	506
200	....	....	552	480	240	192	....	675

❶ Percent of rated coil voltage.
❷ Lower figure when coil is cold. Higher figure when coil is hot.
❸ Drop-out time to clear arc. Time varies with type of load and contact wear.
❹ At 60 hertz base.
❺ To contact touch.
❻ For sizes 5-9 contactors only; for starter sizes 5-9, refer to Westinghouse.
❼ Data pertains to Model K; for Model J, refer to Westinghouse.
❽ These current values are for motors running at usual speeds and with normal torque characteristics. Motors for special low speed or high torque may require higher current. In all cases, heaters should be selected on basis of information on motor nameplate or motor card data.

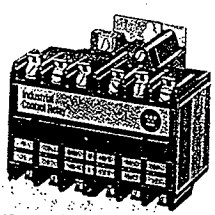
Types AR 600 Volt Ac, ARD 600 Volt Dc, Convertible Contacts

CALC. W320-51 022 ATTACHMENT: B PAGE : B-1

DESCRIPTION



AR 4 Pole



AR 6 Pole

Application
AR/ARD relays are designed for use on machine tools, process lines, conveyors, and similar automatic and semi-automatic equipment.

AR/ARD relays are electro-mechanical convertible contact relays. AR relays are Ac devices, and the ARD is for Dc applications.

Description
Available in either 4 or 6-pole configurations, AR relays are easily converted to 8 or 10 poles simply by adding a 4-pole deck. In addition, mechanical latch and pneumatic or solid state timer attachments are available for use with 4 and 6-pole relays.

Contacts are convertible from either NO to NC to provide any combination desired, up to a maximum of 10, except that for the ARD, the number of NC poles cannot exceed four in any pole configuration. Wide spacing of contacts simplifies installation, contact testing, and maintenance. Contacts are electrically and mechanically isolated from each other. Overlap contacts are also available in one or two sets. These contacts should be mounted in the center pole positions. Ac and Dc contact cartridges should not be used in the same relay.

APPLICATION DATA

Contact Ratings

600 Volt Ac Cartridges NEMA A600

Volts	Cont. Current	Max. Current		Max. VA	
		Make	Break	Make	Break
120	10	60	6	7200	720
240	10	30	3	7200	720
480	10	15	1.5	7200	720
600	10	12	1.2	7200	720

Dc Cartridges NEMA P600

Volts	Cont. Current	Max. Current	Max. VA
		Make or Break	Make or Break
125	5	1.1	138
250	5	.55	138
600	5	.20	138

Resistive Load
125V Dc: 3.0 amps
250V Dc: 1.5 amps

Coil Power Requirements
Ac: 96 VA open, 14 VA close
Dc: 14 watts open, 250 volts max.

ORDERING INFORMATION

- Order by catalog number. AR relays listed have 120/110 volt, 60/50 Hz coils, and ARD relays have 120 volt Dc coils.
- If a different coil voltage is required, select the catalog letter from the Coil Voltage Table below and substitute it for the SHADED letter in the catalog number.
- AR and ARD relays listed are supplied with NO contacts which are easily converted to NC. If both NO and NC poles are required, order by catalog number. Example: 4 pole relay with 1 NO and 3 NC contacts, order AR413A. Add $12 list per relay.
- SCREW Terminals – For ring-type connectors, add Suffix R to the catalog number. Example: AR420AR. No additional charge.
- OVERLAP Contacts – Overlap contacts for AR and ARD relays are designed so that a normally open contact closes before the corresponding normally closed contact opens. Overlap contacts come in NO/NC sets of two cartridges. Add catalog letter Suffix S to the catalog number. Example: AR420AS. Specify the number of sets required: S for one set and S2 for two sets. Add $12 list per set.

Coil Voltage Table

AR Coils			ARD Coils	
Volts Ac	Hz	Catalog Suffix	Volts Dc	Catalog Suffix
12	60	A	12	D
24	60	B	24	L
48	60	C	48	M
110	60	D	95	B
208	60	E	130	U
240/220	60/50	F	240	T
277	60	G		
440/380	60/50	H		
480/440	60/50	J		
550	60	K		
600/550	60/50	L		

LIST PRICES AND CATALOG NUMBERS

AR/ARD Relays

Number of Pole Spaces	Contacts NO	Contacts NC	Blank Cavities	AR 600 Volt Ac Relays 120/60, 110/50 Ac Coil Catalog Number	List Price	ARD 600 Volt Dc Relays 120 Volt Dc Coil Catalog Number	List Price
4	0	0	4	AR4A		ARD4S	
	2	0	2	AR420A		ARD420S	
	4	0	0	AR440A		ARD440S	
6	0	0	6	AR6A		ARD6S	
	4	0	2	AR640A		ARD640S	
	6	0	0	AR660A		ARD660S	
8❷	6	0	2	AR860A		ARD860S	
	8	0	0	AR880A		ARD880S	
10❷	10	0	0	AR10100A		ARD10100S	

Contact Cartridges

Type Terminal	Standard Contact Cartridges Catalog Number	List Price❶	Overlap Contact Cartridges Catalog Number❷	List Price❷
600 Volt Ac Cartridges				
With Clamp Terminals	ARC		AROC	
With Screw Terminals	ARCR		AROCR	
600 Volt Dc Cartridges				
With Clamp Terminals	ARDC		ARDOC	
With Screw Terminals	ARDCR		ARDOCR	

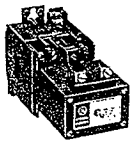
❶ Standard cartridges are sold in cartons of 4 cartridges. Catalog number and list price are for single cartridge.
❷ Overlap contact cartridges are sold in sets of 2 cartridges. Catalog number and list price are for sets of 2.
❸ Will not accept top mounted latch or timers.

FURTHER INFORMATION

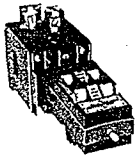
Discount C10-S12
UL File No. E19223
CSA File No. LR39402-6, LR54517, and LR54520

CR120B Machine-Tool and Industrial Relays

600 Volts
10 Amperes Continuous
50/60 Hertz



CR120BL latched relay



CR122B pneumatic time-delay relay

CR120BL Latched Relays

Forms listed below have captive terminal clamps and convertible contact modules. DC forms are available. Contact nearest GE Electrical Distribution & Control sales office for information.

No. of Poles①			Catalog Number AC Open Forms	List Price, GO-10G4
Total	NO	NC		
2	2	0	CR120BL020**	$156.00
	1	1	CR120BL011**	168.00
	0	2	CR120BL002**	168.00
3	3	0	CR120BL030**	168.00
	2	1	CR120BL021**	180.00
	1	2	CR120BL012**	180.00
	0	3	CR120BL003**	180.00
4	4	0	CR120BL040**	180.00
	3	1	CR120BL031**	192.00
	2	2	CR120BL022**	192.00
	1	3	CR120BL013**	192.00
	0	4	CR120BL004**	192.00
6	6	0	CR120BL060**	204.00
	5	1	CR120BL051**	216.00
	4	2	CR120BL042**	216.00
	3	3	CR120BL033**	216.00
	2	4	CR120BL024**	216.00
	1	5	CR120BL015**	216.00
	0	6	CR120BL006**	216.00
8	8	0	CR120BL080**	228.00
	7	1	CR120BL071**	240.00
	6	2	CR120BL062**	240.00
	5	3	CR120BL053**	240.00
	4	4	CR120BL044**	240.00
	3	5	CR120BL035**	240.00
	2	6	CR120BL026**	240.00
	1	7	CR120BL017**	240.00
	0	8	CR120BL008**	240.00

** AC Coil Suffix Table

(Insert where ** appears in Catalog Number, ac relays only)
AC coil suffixes are the same for ac relays, including standard, pneumatic time delay, and latch.

Frequency	24V	115V	120V	200V	208V	230V	460V	575V	600V
60 Hz	25	02	22①	23	24	03	04	05	06
	24V		110V	220V		380V	440V		550V
50Hz	26		07	08		04	09		10

① Coil 22 is dual rated for 120-Volts, 60-Hertz/110-Volts, 50-Hertz operation.

†† DC Coil Suffix Table

(Insert where †† appears in Catalog Number, dc relays only)

12V	24V	48V	64V	125V
44	48	49	45	41

Coil Data

	Inrush VA	Sealed VA	Sealed Watts
AC Relay coil	120	15	7
AC Unlatch coil	31	15	9.2
DC Relay coil	235	2.8	2.8

Contact Ratings — All Relays

Type of Contacts	Max. AC Voltage	Max. Continuous Rating Amps	Max. AC Vollampere Rating		Max. AC Rating Amps		Max. DC Rating Amps		Max. DC Vollampere Rating
			Make	Break	Make	Break	125V	250V	300V or less
Insl.②	600	10	7200	720	60	6	1.1	0.55	138
Delay	600	5	3600	360	30	3	0.5	–	–

② Use for CR120B and CR122BT contact rating.

CR122B Pneumatic Time-delay Relays

All Forms have 1NO-1NC time delay contacts③. Listed forms are field convertible from TDE to TDD and vice versa. DC forms are available. Contact nearest GE Electrical Distribution & Control sales office for information.

Number of Instantaneous Auxiliary Contacts			Catalog Number AC Forms				List Price, GO-10G4
			Time Delay on Energization		Time Delay on De-energization		
Total	NO	NC	Time Range 0.2-60 Seconds	Time Range 5-200 Seconds	Time Range 0.2-60 Seconds	Time Range 5-200 Seconds	
None	–	–	CR122B000**A	CR122B000**B	CR122B000**E	CR122B000**F	$216.00
2	2	0	CR122B020**A	CR122B020**B	CR122B020**E	CR122B020**F	240.00
	1	1	CR122B011**A	CR122B011**B	CR122B011**E	CR122B011**F	252.00
	0	2	CR122B002**A	CR122B002**B	CR122B002**E	CR122B002**F	252.00
3	3	0	CR122B030**A	CR122B030**B	CR122B030**E	CR122B030**F	252.00
	2	1	CR122B021**A	CR122B021**B	CR122B021**E	CR122B021**F	264.00
	1	2	CR122B012**A	CR122B012**B	CR122B012**E	CR122B012**F	264.00
	0	3	CR122B003**A	CR122B003**B	CR122B003**E	CR122B003**F	264.00
4	4	0	CR122B040**A	CR122B040**B	CR122B040**E	CR122B040**F	264.00
	3	1	CR122B031**A	CR122B031**B	CR122B031**E	CR122B031**F	276.00
	2	2	CR122B022**A	CR122B022**B	CR122B022**E	CR122B022**F	276.00
	1	3	CR122B013**A	CR122B013**B	CR122B013**E	CR122B013**F	276.00
	0	4	CR122B004**A	CR122B004**B	CR122B004**E	CR122B004**F	276.00

**Insert coil number from AC Coil Suffix Table to complete Catalog Number. ③Form Z contacts. Polarity must be observed.

References:
Instructions:
GEH-4115 (AC Relays)
GEH-4120 (Latch Relays)
GEH-4143 (DC Relays)

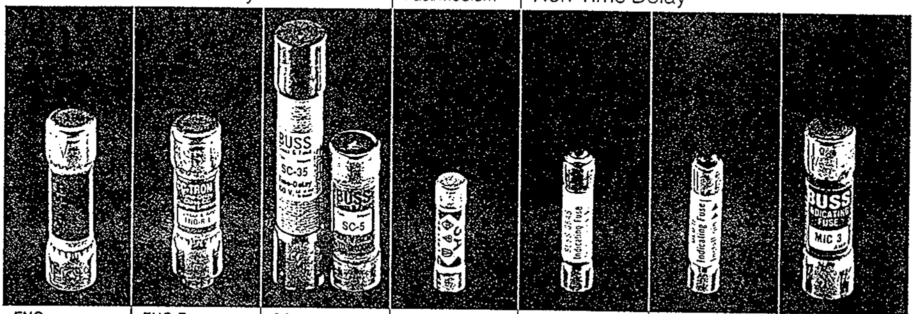
References:
Instructions: (Time-delay Relays)
GEH-4119 (CR122BT Relays)
GEH-4147 (CR122B Relays)

CALC. W320-31-022
ATTACHMENT : C
PAGE : C-1

Typical Data for 600 Volt Class Dry-Type Transformer

kVA	Type	Deg. C Rise	Dimensions, (In.)					Losses in Watts		Efficiency				% Regulation		
			Height	Width	Depth	Weight (Alum) Lbs.	Weight (Cu.) Lbs.	N.L.	Total	¼ Load	½ Load	¾ Load	Full Load	100% P.F.	80% P.F.	% Imp.
0.25	EP	80	7 1/16	4 7/8	4 3/8		12	13	36	80.0	82.0	85.0	87.5	9.2	8.0	9.24
0.5		80	7 1/16	4 7/8	4 3/8		13	20	45	85.2	90.5	91.6	91.8	5.07	4.54	5.12
0.75		80	8 3/8	6	5 1/2		20	21	54	89.1	92.8	93.5	93.3	4.14	3.33	4.44
1		80	8 3/8	6	5 1/2		30	29	71	95.2	96.0	96.0	95.1	4.09	3.62	4.18
1.5		80	10 1/2	6 3/8	6 1/8		40	37	92	94.5	95.5	95.1	94.3	3.83	3.60	3.70
2		80	10 1/2	6 3/8	6 1/8		40	37	97	95.4	96.5	96.4	96.0	3.18	3.30	3.42
3		115	14 1/4	7 11/16	8	65	69	74	144	95.0	96.3	96.3	95.9	3.25	3.50	3.53
5		115	16	10 3/8	9 1/8	113	120	104	201	96.6	97.35	97.2	96.85	2.58	2.50	2.64
7.5		115	16	10 3/8	9 1/8	123	133	149	271	97.0	97.65	97.5	97.15	2.31	2.50	2.54
10		115	19	13 3/8	10 1/2	193	208	160	317	96.1	97.3	97.4	97.25	1.95	2.10	2.18
15		115	19	13 3/8	10 1/2	216	235	230	454	97.6	98.15	98.1	97.8	1.71	1.80	1.85
25		115	22 5/16	16 3/8	14 1/8	385	414	284	550	97.3	98.0	98.0	97.8	1.18	1.63	1.65
3	EPT	115	13 3/8	15 13/16	8 5/16	116	123	121	189	94.2	94.75	94.0	92.9	6.73	7.9	7.93
6		115	15 7/8	16 1/2	9 7/8	143	153	140	288	93.6	95.3	95.2	94.8	3.35	3.6	3.7
9		115	15 7/8	16 1/2	9 7/8	166	178	199	412	96.0	96.8	96.7	96.2	3.07	3.4	2.96
15		115	17 3/8	19 1/16	10 7/16	275	300	216	534	96.9	97.5	97.4	97.0	2.38	2.91	2.8
30		115	26 5/8	25 1/8	12 3/4	422	504	229	681	96.7	97.8	97.9	97.8	1.51	2.12	2.14
25	DS-3	150	37 1/8	22 1/2	20	310	360	200	1050	96.1	96.8	96.6	96.0	3.5	4.0	4.0
37.5		150	43 3/4	22 1/2	20	375	450	250	1550	96.1	96.8	96.5	96.0	3.5	5.1	5.2
50		150	43 3/4	22 1/2	20	425	500	300	1950	96.8	97.2	96.8	96.2	3.5	5.9	6.6
75		150	52 1/8	26	24 3/4	635	725	350	2750	97.7	98.2	98.1	97.8	2.1	5.5	7.6
100		150	52 1/8	26	24 3/4	725	825	450	2850	97.7	97.9	97.6	97.5	2.7	5.7	7.3
167		150	62 1/8	30	34	1200	1350	750	3250	97.8	98.3	98.3	98.0	1.7	5.1	6.8
15	DT-3	150	25	20 1/8	14 1/8	152	172	150	875	95.0	95.5	95.3	94.5	4.8	5.0	5.2
30		150	30 1/8	20 1/8	14 1/8	230	300	200	1600	96.3	96.5	95.9	95.0	4.7	5.6	5.6
45		150	30 1/8	20 1/8	14 1/8	310	370	300	1900	96.5	96.9	96.5	96.1	3.7	4.5	4.5
75		150	37 1/8	26 1/8	19 1/8	480	550	400	3000	97.0	97.2	96.8	96.1	3.6	4.9	4.9
112.5		150	37 1/8	26 1/8	19 1/8	600	675	500	4900	97.3	97.2	96.6	95.8	3.9	5.8	5.9
150		150	46 1/2	26	20 3/16	760	850	600	6700	97.4	97.2	96.5	95.7	3.8	5.7	6.2
225		150	56	31 1/4	24 1/4	1100	1200	700	8600	97.9	97.7	97.0	96.3	3.7	6.0	6.4
300		150	56	31 1/4	24 1/4	1300	1750	800	10200	98.2	97.9	97.4	97.6	3.4	6.3	7.1
500		150	75	44 1/2	36	2400	3100	1700	9000	98.4	98.7	98.6	98.4	1.5	4.2	5.5
750		150	75	44 1/2	36	2900	3600	2200	11700	98.4	98.7	98.7	98.5	1.5	4.7	6.3
1000		150	75	47	41	4000	—	2800	13600	98.6	98.9	98.8	98.6	1.2	4.7	6.5
15		115	25	20 1/8	14 1/8	152	172	150	700	95.3	96.3	96.1	95.6	3.8	5.1	5.2
30		115	30 1/8	20 1/8	14 1/8	230	300	200	1500	96.4	96.6	96.1	95.3	4.3	4.5	5.3
45		115	30 1/8	20 1/8	14 1/8	310	370	300	1700	96.7	97.2	96.9	96.4	3.1	3.7	3.7
75		115	37 1/8	26 1/8	19 1/8	480	550	400	2300	97.3	97.7	97.5	97.0	2.6	4.0	4.6
112.5		115	37 1/8	26 1/8	19 1/8	600	675	500	3100	97.7	98.0	97.7	97.3	2.5	5.5	6.5
150		115	46 1/2	26	20 3/16	760	850	600	5900	97.8	97.9	97.5	97.1	3.8	5.9	6.2
225		115	56	31 1/4	24 1/4	1100	1200	700	6000	98.2	98.2	97.9	97.4	2.5	5.7	7.2
300		115	56	31 1/4	24 1/4	1300	1750	800	6600	98.4	98.5	98.2	97.9	2.1	5.0	6.3
500		115	75	44 1/2	36	2400	3100	1700	6800	98.4	98.8	98.8	98.7	1.2	4.1	5.5
15		80	30 1/8	20 1/8	14 1/8	230	300	200	500	94.5	96.4	96.8	96.8	2.0	2.2	2.3
30		80	30 1/8	20 1/8	14 1/8	310	370	300	975	95.5	96.8	97.0	96.8	2.3	2.9	2.9
45		80	37 1/8	26 1/8	19 1/8	480	550	300	1100	97.0	97.8	97.8	97.6	1.8	2.8	2.9
75		80	37 1/8	26 1/8	19 1/8	600	675	400	1950	97.5	97.9	97.8	97.4	2.2	3.5	3.7
112.5		80	46 1/2	26	20 3/16	750	850	600	3400	97.3	97.7	97.4	97.0	2.6	4.1	4.3
150		80	56	31 1/4	24 1/4	1100	1200	700	3250	97.8	98.2	98.1	97.9	1.8	3.6	4.1
225		80	56	31 1/4	24 1/4	1300	1750	800	4000	98.2	98.6	98.5	98.2	1.6	4.2	5.3
300		80	75	44 1/2	36	2400	3100	1700	4300	97.6	98.4	98.6	98.6	1.1	2.7	4.1
500		80	75	44 1/2	36	2900	3600	2000	5500	98.9	98.9	98.8	98.2	1.2	4.0	4.5

Selection Guide

Ferrule Fuses				Pin Indicating Type		
13/32" × 1½"		13/32" × Various Lengths	¼" × 1"	¼" × 1¼"		13/32" × 1½" (Power Electronics)
Dual Element Time-Delay			Fast/Medium	Non-Time Delay		
						
FNQ	FNQ-R	SC	TDC 180	GBA	GLD	MIC
For motor control transformers. Circuits with inrush I²t's. 10,000 AIC. Single element above 3 2/10A.	Ideal for Control Transformer Protection. UL Class CC, CSA HRCI-Misc. 200,000 AIC.	For branch circuits & supplementary protection. U.L. Class G (½ to 5A fuses do not have time delay). 100,000 AIC.	BS 1362 IEC 269-3A 6000 AIC.	Fibre. Highly visible red pin ejects when fuse opens.	Fibre. Silver-plated pin for positive signal activation when fuse opens.	Silver-plated pin for positive signal activation if fuse opens.
(page 40)	(page 40)	(page 41)	(page 42)	(page 43)	(page 43)	(page 43)
—	—	SC-½ 300V^{UC}	1A 240V^{BA}	GBA-½ 125V^{UC}	GLD-½ 125V^{UC}	MIC-1 250V^{U}
FNQ-1/10 500V^{UC}	—	SC-1 300V^{UC}	2A 240V^{BA}	GBA-¾ 125V^{UC}	GLD-¾ 125V^{UC}	MIC-2 250V^{U}
FNQ-1/8 500V^{UC}	—	SC-2 300V^{UC}	3A 240V^{BA}	GBA-1 125V^{UC}	GLD-1 125V^{UC}	MIC-3 250V^{U}
FNQ-15/100 500V^{UC}	—	SC-3 300V^{UC}	5A 240V^{BA}	GBA-1½ 125V^{UC}	GLD-1½ 125V^{UC}	MIC-5 250V^{U}
—	—	SC-4 300V^{UC}	7A 240V^{BA}	GBA-2 125V^{UC}	GLD-2 125V^{UC}	MIC-10 250V^{U}
FNQ-2/10 500V^{UC}	—	SC-5 300V^{UC}	10A 240V^{BA}	GBA-3 125V^{UC}	GLD-3 125V^{UC}	MIC-15 250V^{U}
FNQ-3/16 500V^{UC}	—	SC-6 300V^{UC}	13A 240V^{BA}	GBA-4 125V^{UC}	GLD-4 125V^{UC}	MIC-20 32V
FNQ-¼ 500V^{UC}	FNQ-R-¼ 600V^{UC}	SC-8 300V^{UC}		GBA-5 125V^{UC}	GLD-5 125V^{UC}	MIC-25 32V
FNQ-3/10 500V^{UC}	FNQ-R-3/10 600V	SC-10 300V^{UC}		GBA-6 125V	GLD-6 125V	MIC-30 32V
—	—	SC-15 300V^{UC}		GBA-8 125V	GLD-10 125V	—
FNQ-4/10 500V^{UC}	FNQ-R-4/10 600V	SC-20 300V^{UC}		GBA-10 125V	GLD-12 125V	—
FNQ-½ 500V^{UC}	FNQ-R-½ 600V^{UC}	SC-25 300V^{UC}		GBA-15 125V	GLD-15 125V	—
FNQ-6/10 500V^{UC}	FNQ-R-6/10 600V^{UC}	SC-30 300V^{UC}		—	—	—
—	FNQ-R-¾	SC-35 300V^{UC}		—	—	—
FNQ-8/10 500V^{UC}	FNQ-R-8/10 600V	SC-40 300V^{UC}		—	—	—
FNQ-1 500V^{UC}	FNQ-R-1 600V	SC-45 300V^{UC}	Various Sizes	—	—	—
—	FNQ-R-1 3/10 600V	SC-50 300V^{UC}		—	—	—
—	FNQ-R-1 4/10 600V	SC-60 300V^{UC}	Fast-Acting	—	—	—
FNQ-1⅛ 500V^{UC}	FNQ-R-1⅛ 600V	—		—	—	—
FNQ-1¼ 500V^{UC}	FNQ-R-1¼ 600V	—		—	—	—
FNQ-1½ 500V^{UC}	FNQ-R-1½ 600V	—		—	—	—
FNQ-1 6/10 500V^{UC}	FNQ-R-1 6/10 600V	—		—	—	—
—	FNQ-R-1 8/10 600V	—		—	—	—
FNQ-2 500V^{UC}	FNQ-R-2 600V^{UC}	—		—	—	—
FNQ-2¼ 500V^{UC}	FNQ-R-2¼ 600V	—		—	—	—
FNQ-2½ 500V^{UC}	FNQ-R-2½ 600V^{UC}	—		—	—	—
—	FNQ-R-2 8/10 600V	—		—	—	—
FNQ-3 500V^{UC}	FNQ-R-3 600V^{UC}	—		—	—	—
FNQ-3 2/10 500V^{UC}	FNQ-R-3 2/10 600V	—		—	—	—
FNQ-3½ 500V^{UC}	FNQ-R-3½ 600V	—		—	—	—
FNQ-4 500V^{UC}	FNQ-R-4 600V^{UC}	—		—	—	—
FNQ-4½ 500V^{UC}	—	—		—	—	—
FNQ-5 500V^{UC}	FNQ-R-5 600V^{UC}	—		—	—	—
FNQ-5 6/10 500V^{UC}	—	—		—	—	—
FNQ-6 500V^{UC}	FNQ-R-6 600V^{UC}	—		—	—	—
FNQ-6¼ 500V^{UC}	FNQ-R-6¼ 600V	—	TDC 119-122	—	—	—
FNQ-7 500V^{UC}	FNQ-R-7 600V	—	BS 1361, IEC 269-3 16,500 AIC.	—	—	—
—	FNQ-R-7½ 600V^{UC}	—		—	—	—
FNQ-8 500V^{UC}	FNQ-R-8 600V^{UC}	—		—	—	—
FNQ-9 500V^{UC}	FNQ-R-9 600V^{UC}	—		—	—	—
FNQ-10 500V^{UC}	FNQ-R-10 600V^{UC}	—	(page 42)	—	—	—
FNQ-12 500V^{UC*}	—	—	5A 240V	—	—	—
FNQ-15 500V^{UC}	—	—	15A 240V	—	—	—
FNQ-20 500V^{U}	—	—	20A 240V	—	—	—
FNQ-25 500V^{U}	—	—	30A 240V	—	—	—
FNQ-30 500V^{U}	—	—	45A 240V	—	—	—

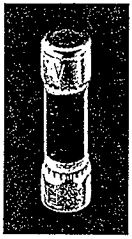
^{U}U.L. Listed; ^{C}CSA Certified. ^{B}British Standard Approval. ^{A}ASTA Approval.
*Also FNQ-14

ATTACHMENT : D
PAGE : D-2

Ferrule Type—Power Electronic

Type FNQ

$^{13}/_{32}$" × 1½" (10.3mm × 38.1mm)
Time-Delay

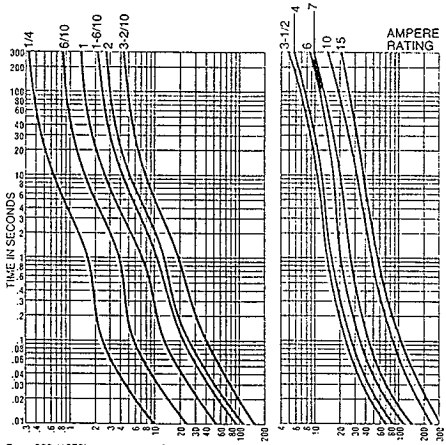


Fibre. For motor control transformers and other circuits with inrush currents. Interrupting rating—10,000AIC. Mount in Buss fuseholders, fuseblocks, and clips. Shipping weight per 100—1.5 lbs. (680g). U.L. File E19180; Guide JDYX. CSA File 53787; Class 1422-01.

Electrical Ratings (Catalog Symbol and Amperes)

500 Volts		500 Volts		500 Volts		500 Volts	
FNQ-1/10		FNQ-5/10		FNQ-3 2/10		FNQ-9	U.L. Listed & CSA
FNQ-1/8		FNQ-1		FNQ-3½		FNQ-10	
FNQ-1 5/100		FNQ-1¼		FNQ-4		FNQ-12*	
FNQ-2/10	U.L. Listed & CSA	FNQ-1¼	U.L. Listed & CSA	FNQ-4½	U.L. Listed & CSA	FNQ-15	
FNQ-3/16		FNQ-1½		FNQ-5		FNQ-20	
FNQ-¼		FNQ-1 9/10		FNQ-5 6/10		FNQ-25	
FNQ-3/10		FNQ-2		FNQ-6		FNQ-30	U.L. Listed
FNQ-4/10		FNQ-2¼		FNQ-6¼		—	
FNQ-½		FNQ-2½		FNQ-7		—	
FNQ-6/10		FNQ-3		FNQ-8		—	

*Also FNQ-14



Form 220 (1973)
Time-Current Curves—Typical

Form 221 (1973)

U.L. File E19180; CSA File 53787

Type FNQ-R

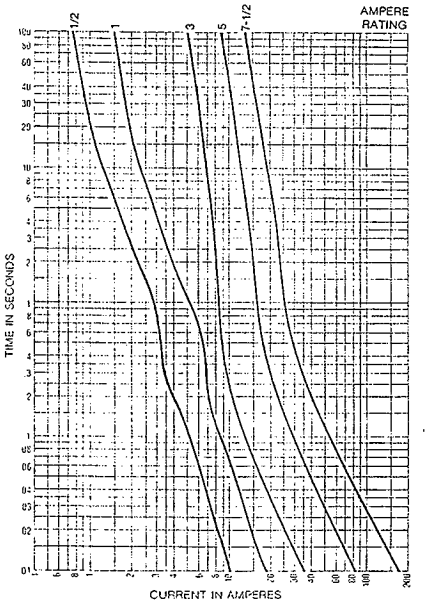
$^{13}/_{32}$" × 1½" (10.3mm × 38.1mm)
Time-Delay

The Bussmann CC-Tron™ (FNQ-R) was developed to meet a specific need in the industry—control circuit transformer protection. Its voltage rating, interrupting rating, time-delay, high degree of current limitation, and rejection feature uniquely qualify it for this task. Mount in Buss Class CC blocks page ___ UL Listed File E4273 Branch Circuit Fuse; Class CC; CSA File 53787—HRC-MISC

Electrical Ratings (Catalog Symbol and Amperes) 200K AIC

600 Volts	600 Volts	600 Volts	600 Volts
FNQ-R-½	FNQ-R-1 1/10	FNQ-R-1 7/10	FNQ-R-3½
FNQ-R-6/10	FNQ-R-1 9/10	FNQ-R-2[C]	FNQ-R-4[UC]
FNQ-R-¾	FNQ-R-1⅛	FNQ-R-2¼	FNQ-R-5[UC]
FNQ-R-½[UC]	FNQ-R-1¼	FNQ-R-2½[UC]	FNQ-R-6[UC]
FNQ-R-¾[UC]	FNQ-R-1½	FNQ-R-2 8/10	FNQ-R-6¼
FNQ-R-1[U]	FNQ-R-1⅞	FNQ-R-3[UC]	FNQ-R-7
FNQ-R-1	FNQ-R-1 9/10	FNQ-R-3 2/10	FNQ-R-7½[UC]

[U]U.L. Listed; [C]CSA Certified



TELEPHONE CONFERENCE MEMORANDUM

Company: ICF Kaiser Hanford Company Address: P.O. Box 888, Richland, WA 99352

[] INCOMING [X] OUTGOING DATE: 10/6/94 TIME: 9.00 AM

WITH: Dave Burnhard OF: Bussmann Fuse Co. PHONE: (314) 527-1224

WITH: OF: PHONE:

Copies to: Name: NA Address: NA

Subject: Fuse Resistances

Moe Khorsandian Engineering Services	W-320 Project, W320-31-022 Calculation	(509) 373-2331
Department		Telephone #

Summary of Conference

Per telephone conversation with Mr. Dave Burnhard, the resistance ranges of FNQ type, time delay, dual element fuses are as follows:

FNQ-1	0.0456	to	0.7	Ω
FNQ-2¼	0.08	to	0.114	Ω
FNQ-2½	0.073	to	0.093	Ω
FNQ-3	0.0395	to	0.056	Ω

54-7600-098 (5/90) (EF) GEF017
Telephone Conference Memorandum

TECHNICAL DATA

- Standards and approvals:
  UL 508
  I.E.C. 947-5-1, BS4794
  CSA. . . . . C22-2 No. 14

- Ingress Protection (IP ratings to I.E.C. 144 — BS5420):
  All operators ❶ . . . . UL Listed (NEMA) Type 1, 2, 3, 3R, 4, 4X, 12, 13 when mounted in enclosure rated for those same applications
  Pushbuttons when fitted with a rubber boot IP66
  Enclosures IP65

- Frequency of operation – maximum:
  All pushbuttons . . . . 6000 ops/hr.
  Key and lever selector switches . . . . 3000 ops/hr.
  Auto-latch devices . . . . 1200 ops/hr.

- Mechanical life:
  Pushbuttons . . . . 10×10^6 operations
  Contact blocks . . . . 10×10^6 operations
  PresTest units . . . . 10×10^6 operations
  Lever and key selector sws. . . . . 0.25×10^6 operations
  Twist to release pushbuttons . . . . . . 0.3×10^6 operations

- Climatic conditions:
  Operating . . . . maximum 60°C at 95% RH, Temperature -17°C to 66°C, altitude 2000 meters
  Storage . . . . maximum 60°C at 95% RH, Temperature -40°C to 80°C

- Shock resistance:
  Duration . . . . 20 mS ≥ 5g

- Electrical Ratings:
  Insulation. . . . . Ui = 660 V ac or dc
  Thermal. . . . . Ith = 10 amperes
  Short circuit (I.E.C. 947-5-1)
  . . . . 1000 A with a 6 A (NIT) fuse (to BS88)
  NEMA, UL rating. A600, P600
  Ac load life duty cycle 1200 operations/hour
  10A . . . . 110V pf 0.4 – 1×10^6 operations
  5A . . . . 250V pf 0.4 – 1×10^6 operations
  2A . . . . 660V pf 0.4 – 1×10^6 operations

- Switching capacity:
  AC15 rated make/break (11 x Ie at 1.1 x Ue)
  6A . . . . 120V pf 0.7
  4A . . . . 240V pf 0.7
  2A . . . . 660V pf 0.7

  DC13 rated make/break (1.1 x Ie at 1.1 x Ue)
  1.0A. . . . . 125 V L/R ≥ 0.95 at 300 mS
  0.55 A . . . . 250 V L/R ≥ 0.95 at 300 mS
  0.2A. . . . . 600 V L/R ≥ 0.95 at 300 mS
  10A . . . . 110 V pure resistive

- Light units:
  Transformers. . . . . will withstand short circuit for 1 hour per I.E.C. 947-5-1
  Bulbs – average life:
  Transformer type . . . . 20,000 hrs.
  Resistor/direct voltage type. . . . . 2500 hrs. minimum @ rated V

- Low voltage switching

  Conical shaped points or "reliability nibs" improve performance in dry circuit, corrosive, fine dust and other contaminated atmospheres. Under normal environmental conditions, the minimum operational voltage is 5 V and the minimum operational current is 1 mA, ac/dc.

- Contact operation

  Slow make and break. All normally closed contacts have positive opening operation, i.e., normally closed contacts are forced open in the event of contact weld or spring breakage.

- Terminal marking

  NC - NO on the contact block to meet the NEMA requirements. Dual marking system 1 - 2 for normally closed, 3 - 4 for normally open to meet BS5472 (Cenelec EN50 005).

- Terminal clamps

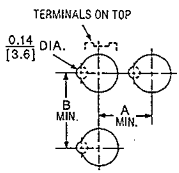
  Terminals are saddle clamp type for 1 x 22 AWG [0.5 sq. mm] to 2 x 12 AWG [3.0 sq. mm] conductors.

- Panel thickness
  Maximum. . . . . 0.25 in [8 mm] including legend plate
  Minimum . . . . 0.06 in [1.6 mm]

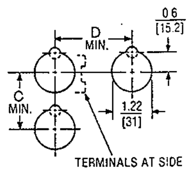
  Maximum can be increased to 0.375 in [15.9 mm] using optional retaining nut. See Page M-101 or catalog numbers.

- Mounting matrix

Legend Plate	Dimensions in Inches [mm]			
	A	B	C	D
Small	1.63 [41.3]	2.25 [57.2]	1.63 [41.3]	2.25 [57.2]
Medium	1.63 [41.3]	2.25 [57.2]	1.87 [47.6]	2.25 [57.2]
Large	2.13 [54.0]	2.31 [58.7]	2.3 [58.7]	2.25 [57.2]



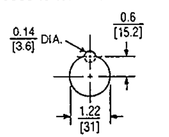
Horizontal Mounting



Vertical Mounting

Horizontal mounting means terminals are located top and bottom of contact block. Vertical mounting means terminals are left and right of contact block. This allows close spacing of adjacent operators with easy access to terminals.

NOTE: Locating nib hole or notch is .14" [3.6 mm] #29 drill. Alternate to drilling mounting hole, use Greenlee Tool Co., punch No. 730-S to punch the hole and follow with punch No. 730-K to cut the notch.



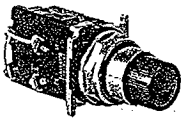
❶ Use NEMA 4X 10250T operators where exposed to Ultra Violet light, see Pages M-53 - M-84.

CALC-W320-31-0022
ATTACHMENT: E
PAGE : E-2

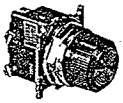
INDICATING LIGHT W/ LENS ASSEMBLED— UL (NEMA) Type 4, 4X, 13 Transformer Type, 120 V ac 50 or 60 Hz

PresTest Indicating Light — This device incorporates a PresTest feature whereby depressing the lens disconnects the light from the source being monitored and connects the lamp to a continuously energized circuit for immediate test for a faulty lamp.

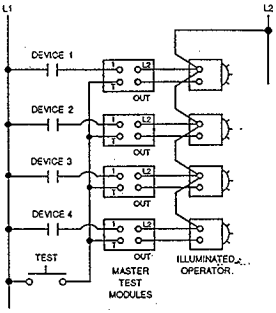
Master Test Indicating Light — Available with solid state isolation or with transformer/relay type isolation, these dual input light units can be energized either by a monitored signal or by an independent test signal. This permits testing the lamps on a group of Master Test type indicating lights from a single pushbutton or other switch. See wiring diagram below.



PresTest Indicating Light
Cat. No. 10250T74NR



Standard Indicating Light
Cat. No. 10250T34R



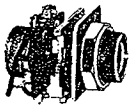
Master Test Wiring Diagram

Volts	Lamp Number	Lens Color	STANDARD UNIT Plastic Lens Cat. No. ❶	Price	PRES-TEST Plastic Lens ❶ Cat. No.	Price	Glass Lens ❶ Cat. No.	Price	MASTER TEST ❷ Plastic Lens Transformer Type with Relay ❶ Cat. No.	Price	Solid State Type (Uses a 120MB Lamp) Cat. No.	Price
120	#755 (Will Also Accept #44)	Red	10250T 34R		10250T 74NR		10250T 37NR		10250T 187R		10250T 189R	
		Green	34G		74NG		37NG		187G		189G	
		Amber	34A		74NA		37NA		187A		189A	
		Yellow	34Y		74NY		---		187Y		189Y	
		Blue	34B		74NB		37NB		187B		189B	
		Clear	34C		74NC		37NC		187C		189C	
		White	34W		74NW		37NW		187W		189W	

❶ For flashing lamp add letter "F" to listed catalog number and add $6.00 to price. Example: 10250T34RF, Price $70.20.
❷ The Transformer/Relay type puts out slightly more light because it operates on full wave.

POTENTIOMETER WITH KNOB AND STANDARD DIAL PLATE — Linear Type ±10%

Vertical or Horizontal One Hole Mounting



With Standard Dial Plate

Potentiometer Ohms	2 Watt (50 V Max.) Single Potentiometer NEMA 4, 13 ❸❹ Standard Dial Plate Cat. No.	Price
1000	10250T 331	
2500	332	
5000	338	
10000	333	
25000	334	
50000	335	
Operator Only ❺	330	84.

❸ Large dial plate with space for legend is available at no charge. To order, add suffix 36 to catalog number. Example: 10250T33136. To order separately, see footnote ❹ below.
❹ Large dial plate has space at top for 15 letters 3/32 inch high. For custom stamped legend plates, order legend plate as separate item 10250TR30 and specify stamping — Price $6. (without stamping — $1.80).
❺ For use with commercially purchased potentiometers having shaft dimensions per dimension drawing on Page M-81.

DIMENSIONS, Pages M-82 - M-84

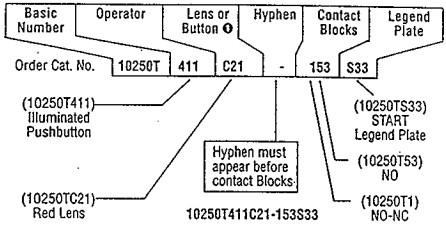
ORDERING COMPLETE UNASSEMBLED OPERATORS USING SINGLE COMPOSITE CATALOG NUMBER

For convenience — when ordering from the components listings — the individual component catalog numbers may be combined into a single catalog number. Individual components will be packed in a single box labeled with the combined identification number.

Example:
Component numbers for an illuminated pushbutton with red lens, a NO-NC contact block, a NO contact block and "START" legend plate.

10250T411 (illuminated pushbutton — Page M-63)
10250TC21 (red lens — Page M-63)
10250T1 (NO-NC contact block — Page M-62)
10250T53 (NO contact block — Page M-62)
10250TS33 ("START" legend plate — Page M-76)

Combined into a single catalog number (Any component may be omitted by merely collapsing the number to eliminate the space).



❶ When not included with operator.

ORDERING EXAMPLES:


Operator
10250T101


Contact Block
10250T1
(Page M-62)


Contact Block
10250T51
(Page M-62)

Legend Plate
10250TS33
(Pages M-76 - M-77)

For complete 10250T operators using single composite catalog number (Example: 10250T101-151S33), See Instruction Above.

PUSHBUTTON OPERATORS — Vertical or Horizontal Mounting — UL (NEMA) Type 4, 4X and 13

Color	Cat. No.	Price
Standard Button ❷		
	10250T	
Black	101	
Red	102	
Green	103	
Yellow	104	
Gray	105	
White	106	
Blue	108	
Orange	109	

Color	Cat. No.	Price
Extended Button		
	10250T	
Red	112	
Black	111	
Green	113	
Yellow	120	
White	116	
Blue	118	
Orange	119	

Color	Cat. No. Vert.	Cat. No. Horiz.	Price
Half Shrouded Button ❸			
	10250T	10250T	
Black	501	511	
Red	502	512	
Green	503	513	
Yellow	504	514	
Gray	505	515	
White	506	516	
Blue	508	518	
Orange	509	519	

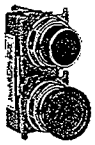
Color	Cat. No.	Price
Mushroom Head		
Black	121	
Red	122	
Green	123	
Yellow	124	
Blue	129	

Color	Cat. No.	Price
Jumbo Mushroom Head		
Black	171	
Red	172	
Red ❹	17213	
Green	173	
Yellow	174	

❸ If operators are to be mounted in a vertical row, specify VERT. for correct orientation of contact block terminals, See Page M-84 for mounting instructions.
❹ Emergency Stop.

❷ To order operator with factory assembled Extended Retaining Nut, 10250TA12, for thick panel applications, add suffix letter "E" to listed cat. no. Example: 10250T101E.

MAINTAINED PUSHBUTTON OPERATOR



Description	Catalog Number	Price
Minimum hole centers 1.62", maximum 2.50". Mounts in extra deep enclosures only.	10250	
Black flush and green flush	TA66	
Black flush and long red	TA67	
Black flush and red mushroom head	TA68	
Black flush and lock-down red mushroom head	TA69 ❺	
Black flush and red jumbo mushroom head	TA76	
Green flush and long red	TA72	
Black long and long red	TA73	
Green flush and red mushroom head	TA77	
Green flush and black flush	TA75	

❺ NC contacts must be mounted behind lock-down mushroom head operator to ensure lockout.

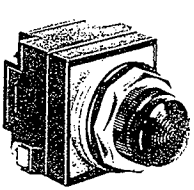
DISCOUNT SCHEDULE 1CD-1 DIMENSIONS, Pages M-82 - M-84

ATTACHMENT : E
PAGE : E-4

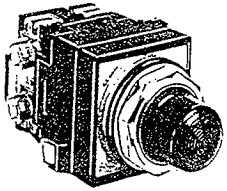
CR104P Heavy-Duty Indicating Lights

600 Volts Maximum AC/DC
10 Amperes Continuous
Suitable for Use in NEMA Type 1, 3, 3R, 4, 4X, 12 and 13 Applications①

Units are supplied factory assembled when ordered with lenses.



Standard indicating light



Push-to-Test Indicating light

Standard and Push-to-Test Indicating Light Units, Transformer Type

Transformer Type with 6-Volt Secondary, No. 755 Lamp

Operating Voltage	Color of Lens	Standard Unit Catalog Number② CR104	List Price, GO-10P1	Push-to-Test Unit Catalog Number② CR104	List Price, GO-10P1
120 Volts (60/50 Hz)	Red	PLG32R	$64.20	PLT32R	$82.20
	Green	PLG32G	64.20	PLT32G	82.20
	Amber	PLG32M	64.20	PLT32M	82.20
	Blue	PLG32L	64.20	PLT32L	82.20
	White	PLG32W	64.20	PLT32W	82.20
	Yellow	PLG32E	64.20	PLT32E	82.20
	Clear	PLG32C	64.20	PLT32C	82.20
	Less Lens③	PLG32	60.00	PLT32	78.00
240 Volts (60/50 Hz)	Red	PLG33R	64.20	PLT33R	82.20
	Green	PLG33G	64.20	PLT33G	82.20
	Amber	PLG33M	64.20	PLT33M	82.20
	Blue	PLG33L	64.20	PLT33L	82.20
	White	PLG33W	64.20	PLT33W	82.20
	Yellow	PLG33E	64.20	PLT33E	82.20
	Clear	PLG33C	64.20	PLT33C	82.20
	Less Lens③	PLG33	60.00	PLT33	78.00
480 Volts (60/50 Hz)	Red	PLG34R	64.20	PLT34R	82.20
	Green	PLG34G	64.20	PLT34G	82.20
	Amber	PLG34M	64.20	PLT34M	82.20
	Blue	PLG34L	64.20	PLT34L	82.20
	White	PLG34W	64.20	PLT34W	82.20
	Yellow	PLG34E	64.20	PLT34E	82.20
	Clear	PLG34C	64.20	PLT34C	82.20
	Less Lens③	PLG34	60.00	PLT34	78.00
600 Volts (60/50 Hz)	Red	PLG35R	64.20	PLT35R	82.20
	Green	PLG35G	64.20	PLT35G	82.20
	Amber	PLG35M	64.20	PLT35M	82.20
	Blue	PLG35L	64.20	PLT35L	82.20
	White	PLG35W	64.20	PLT35W	82.20
	Yellow	PLG35E	64.20	PLT35E	82.20
	Clear	PLG35C	64.20	PLT35C	82.20
	Less Lens③	PLG35	60.00	PLT35	78.00

Standard and Push-to-Test Indicating Light Units, Full Voltage

Resistor Type

Operating Voltage	Color of Lens	Standard Unit Catalog Number② CR104P	List Price, GO-10P1	Push-to-Test Unit Catalog Number② CR104P	List Price, GO-10P1
120 Volts (#1835 Lamp)	Red	LG42R	$52.20	LT42R	$70.20
	Green	LG42G	52.20	LT42G	70.20
	Amber	LG42M	52.20	LT42M	70.20
	Blue	LG42L	52.20	LT42L	70.20
	White	LG42W	52.20	LT42W	70.20
	Yellow	LG42E	52.20	LT42E	70.20
	Clear	LG42C	52.20	LT42C	70.20
	Less Lens③	LG42	48.00	LT42	66.00
240 Volts (#120PSB Lamp)	Red	LG43R	52.20	LT43R	70.20
	Green	LG43G	52.20	LT43G	70.20
	Amber	LG43M	52.20	LT43M	70.20
	Blue	LG43L	52.20	LT43L	70.20
	White	LG43W	52.20	LT43W	70.20
	Yellow	LG43E	52.20	LT43E	70.20
	Clear	LG43C	52.20	LT43C	70.20
	Less Lens③	LG43	48.00	LT43	66.00

Full Voltage Type

Operating Voltage	Color of Lens	Standard Unit Catalog Number② CR104	List Price, GO-10P1	Push-to-Test Unit Catalog Number② CR104	List Price, GO-10P1
6 Volt④ (#755 Lamp)	Red	PLG16R	$52.20	PLT16R	$70.20
	Green	PLG16G	52.20	PLT16G	70.20
	Amber	PLG16M	52.20	PLT16M	70.20
	Blue	PLG16L	52.20	PLT16L	70.20
	White	PLG16W	52.20	PLT16W	70.20
	Yellow	PLG16E	52.20	PLT16E	70.20
	Clear	PLG16C	52.20	PLT16C	70.20
	Less Lens③	PLG16	48.00	PLT16	66.00
12 Volts④ (#756 Lamp)	Red	PLG17R	52.20	PLT17R	70.20
	Green	PLG17G	52.20	PLT17G	70.20
	Amber	PLG17M	52.20	PLT17M	70.20
	Blue	PLG17L	52.20	PLT17L	70.20
	White	PLG17W	52.20	PLT17W	70.20
	Yellow	PLG17E	52.20	PLT17E	70.20
	Clear	PLG17C	52.20	PLT17C	70.20
	Less Lens③	PLG17	48.00	PLT17	66.00
24 Volts④ (#1819 Lamp)	Red	PLG18R	52.20	PLT18R	70.20
	Green	PLG18G	52.20	PLT18G	70.20
	Amber	PLG18M	52.20	PLT18M	70.20
	Blue	PLG18L	52.20	PLT18L	70.20
	White	PLG18W	52.20	PLT18W	70.20
	Yellow	PLG18E	52.20	PLT18E	70.20
	Clear	PLG18C	52.20	PLT18C	70.20
	Less Lens③	PLG18	48.00	PLT18	66.00
120 Volts④ (#120PSB Lamp)	Red	PLG22R	52.20	PLT22R	70.20
	Green	PLG22G	52.20	PLT22G	70.20
	Amber	PLG22M	52.20	PLT22M	70.20
	Blue	PLG22L	52.20	PLT22L	70.20
	White	PLG22W	52.20	PLT22W	70.20
	Yellow	PLG22E	52.20	PLT22E	70.20
	Clear	PLG22C	52.20	PLT22C	70.20
	Less Lens③	PLG22	48.00	PLT22	66.00

Notes: Catalog Number and price do not include nameplate. All nameplates must be ordered as a separate item from pages 7-26 and 7-27.
Resistor forms of standard and push-to-test indicating lights are available. Contact nearest GE Electrical Distribution & Control sales office for proper selection and pricing.

① When mounted in enclosures rated for those same applications. For some NEMA Type 4X applications, protective caps will improve corrosion resistance.
② "CR104PXG . . ." Catalog Number on light unit *label* identifies only the "power source" component of each complete unit listed above.
③ Select required lens from page 7-23 and order as a separate item.
④ 6-, 12-, and 24-Volt units have same lamp socket; lamps are therefore interchangeable for voltage change.

Nameplate Selection ..... **pages 7-26, 7-27**
Drilling Plan and Dimensions ..... **page 7-28**
Lamp Ordering Information ..... **page 7-24**

HNF-2488, Rev. 0
Page C-31

General Electric Miniature Lamps

PANEL, PILOT, FLASHLIGHT LAMPS

BULB SHAPE:

BASE:
Figs. 2-pin Screw Prof. Wedge Bay.

TYP. SIZES

Lamp No.	Bulb	Base*	Design Volts	Design Amps	Net per Box of 10
PR2	B-3½	S.C. min. flanged	2.38	.50	$ 6.30
PR3	B-3½	S.C. min. flanged	3.57	.50	6.60
PR4	B-3½	S.C. min. flanged	2.33	.27	6.60
PR6	B-3½	S.C. min. flanged	2.47	.30	6.60
PR7	B-3½	S.C. min. flanged	3.7	.30	7.40
PR9	B-3½	S.C. min. flanged	2.7	.15	9.10
PR12	B-3½	S.C. min. flanged	5.95	.50	6.60
PR13	B-3½	S.C. min. flanged	4.75	.50	8.50
PR15	B-3½	S.C. min. flanged	4.82	.50	8.50
PR18	B-3½	S.C. min. flanged	7.2	.55	7.90
PR20	B-3½	S.C. min. flanged	8.63	.50	9.70
PR30	B-3½	S.C. min. flanged	3.75	.86	7.20
6	S-8	D.C. bayonet	6.4	3.00	21.30
10	G-3½	Min. two-pin	2.5	.50	11.80
11	T-1¾	Wedge	2.5	.20	8.50
12	G-3½	Min. two-pin	6.3	.15	9.30
13	G-3½	Min. screw	3.7	.30	5.30
14	G-3½	Min. screw	2.47	.30	5.30
15	G-4½	Min. two-pin	7.0	.40	8.50
18	T-1¾	Wedge	14	.04	7.90
19	G-3½	Min. two-pin	14.4	.10	13.40
27	G-4½	Min. screw	4.9	.30	10.30
37	T-1¾	Subminiature wedge	14	.09	6.90
40	T-3¼	Min. screw	6.3	.15	5.60
43	T-3¼	Min. bayonet	2.5	.50	8.40
44	T-3¼	Min. bayonet	6.3	.25	4.50
47	T-3¼	Min. bayonet	6.3	.15	4.50
49	T-3¼	Min. bayonet	2.0	.06	9.60
51	G-3½	Min. bayonet	7.5 -	.22	5.90
53	G-3½	Min. bayonet	14.4	.12	5.90
53X†	G-3½	Min. bayonet	14.4	.12	7.90
55	G-4½	Min. bayonet	7.0	.41	7.50
56X	T-1¾	Wedge	5.0	.115	8.50
57	G-4½	Min. bayonet	14.0	.24	5.00
57X	G-4½	Min. bayonet	14	.24	7.90
63	G-6	S.C. bayonet	7.0	.63	6.90
64	G-6	D.C. bayonet	7.0	.63	9.90
67	G-6	S.C. bayonet	13.5	.59	6.00
68	G-6	D.C. bayonet	13.5	.59	10.60
70	T-1¾	Wedge	14	.15	10.40
73	T-1¾	Subminiature wedge	14	.08	6.20
74	T-1¾	Subminiature wedge	14	.10	5.90
75X	TL-1¾	Wedge	2.5	.35	17.90
79	T-1¾	Wedge	6.0	.22	8.10
81	G-6	S.C. bayonet	6.5	1.02	9.70
82	G-6	D.C. bayonet	6.5	1.02	7.80
84	T-1¼	Subminiature wedge	6.3	.04	7.50
85	T-1¾	Subminiature wedge	28	.04	6.30
86	T-1¾	Subminiature wedge	6.3	.20	7.50
88	S-8	D.C. bayonet	6.8	1.91	12.90
89	G-6	S.C. bayonet	13.0	.58	6.80
90	G-6	D.C. bayonet	13.0	.58	7.50
93	S-8	S.C. bayonet	12.8	1.04	10.60
94	S-8	D.C. bayonet	12.8	1.04	12.90
97	G-6	S.C. bayonet	13.5	.69	6.90
98	G-6	D.C. bayonet	13.5	.69	12.30
105	S-8	S.C. bayonet	12.8	.10	12.90
112	TL-3	Min. screw	1.2	.22	12.10
127	T-3¼	Wedge	2.47	.25	2.50
131	G-3½	Min. screw	1.3	.10	6.90
147	T-3¼	Wedge	7.0	.43	28.40
157	G-6	Min. screw	5.8	1.10	43.40
158	T-3¼	Wedge	14	.24	7.40
159	T-3¼	Wedge	6.3	.15	8.40
161	T-3¼	Wedge	14	.19	8.50
168	T-3¼	Wedge	14	.35	6.50
192	T-3¼	Wedge	13	.33	16.90
194	T-3¼	Wedge	14	.27	4.90
194A	T-3¼	Wedge	14	.27	6.00
194NA	T-3¼	Wedge	14	.27	13.50
211-2	T-3	Min. cap (round)	12.8	.97	10.60
212-2	T-3	Min. cap (round)	13.5	.74	12.90
214-2	T-3	Min. cap (round)	13.5	.50	15.30
222	TL-3	Min. screw	2.25	.25	7.40
222X	TL-3	Min. screw	2.25	.25	25.80
238	T-3¼	Mini bayonet	6.3	.5	17.30
243	TL-3	Min. screw	2.33	.27	8.70
245	G-3½	Min. screw	2.46	.50	24.70
251	T-1¾	S.C. mid. flanged	2.47	.30	82.30
252	TL-1½	S.C. mid. flanged	2.5	.35	47.80
253	TL-1¾	Midget grooved	2.5	.35	75.30
253X	TL-1¾	Midget grooved	2.5	.35	12.10
257	G-4½	Min. bayonet, flasher	14.0	.27	19.00
258	G-4½	Min. screw, flasher	14.0	.27	4.90
259	T-3¼	Wedge	6.3	.25	3.29

Lamp No.	Bulb	Base*	Design Volts	Design Amps	Net per Box of 10
261	TL-1¾	Midget grooved	2.5	.35	$121.70
265	G-3½	Min. bayonet	28	.08	37.90
267	T-3¼	Min. bayonet	6.3	.15	32.60
268	T-1¾	S.C. midget flanged	2.5	.35	8.70
280	T-3¼	Wedge	10	.13	6.80
285	T-3¼	Wedge	5.0	.09	6.80
293	G-4½	Min. bayonet	14	.33	6.80
301	G-5	S.C. bayonet	28	.17	19.10
302	G-5	D.C. bayonet	28	.17	17.30
303	G-6	S.C. bayonet	28	.30	17.10
304	G-6	D.C. bayonet	28	.30	19.60
305	S-8	S.C. bayonet	28	.51	19.00
305-AF	S-8	S.C. bayonet	28	.51	25.60
306	S-8	D.C. bayonet	28.0	.51	36.00
307	S-8	S.C. bayonet	28.0	.67	19.00
307-AF	S-8	S.C. bayonet	28	.67	27.50
307R†	S-8	S.C. bayonet	28	.67	48.20
307SB	S-8	S.C. bayonet	28	.67	127.20
308	S8	D.C. bayonet	28.0	.67	24.00
308-AF	S-8	D.C. bayonet	28	.67	24.70
309	S-11	S.C. bayonet	28	.90	27.30
309-AF	S-11	S.C. bayonet	28	.90	44.10
310	S-11	D.C. bayonet	28	.90	45.70
311	S-11	S.C. bayonet	28	1.29	28.10
311R†	S-11	S.C. bayonet	28	1.29	72.90
313	T-3¼	Min. bayonet	28	.17	8.70
315	S-8	S.C. bayonet	28	.90	41.00
316	T-3¼	Min. bayonet	6.0	.70	27.30
323	T-1¾	Special ind.	3	.19	34.30
325	T-1¾	Special ind.	3	.19	75.60
327	T-1¾	S.C. midget flanged	28	.04	7.20
327R†	T-1¾	S.C. midget flanged	28	.04	18.40
328	T-1¾	S.C. midget flanged	6	.20	7.20
330	T-1¾	S.C. midget flanged	14	.08	7.20
334	T-1¾	Midget grooved	28	.04	9.30
335	T-1¾	Midget screw	28	.04	24.00
336	T-1¾	Midget grooved	14	.08	11.20
344	T-1¾	S.C. midget flanged	10	.014	9.30
345	T-1¾	S.C. midget flanged	5	.04	9.70
352X	G-3½	Min. screw	3.0	.07	25.10
356	G-3½	Min. bayonet	28	.17	17.80
370	T-1¾	S.C. midget flanged	18	.04	12.30
378	T-1¾	Midget screw	6.3	.20	11.80
381	T-1¾	S.C. midget glanged	6.3	.20	8.70
382	T-1¾	S.C. midget flanged	14	.08	9.30
385	T-1¾	S.C. mid. flanged	28	.04	9.90
386	T-1¾	Mid. grooved	14	.08	11.50
387	T-1¾	S.C. midget flanged	28	.04	7.20
388	T-1¾	Mid. grooved	2812	.04	11.20
394	T-1¾	S.C. mid. flanged	3.0	.04	11.20
395X	B-3½	S.C. min. flanged	28	.07	18.20
400	T-3¼	Wedge	2.6	.10	9.30
406	G-4½	Min. screw, flasher	4.9	.30	18.90
407	G-4½	Min. screw, flasher	5.0	.30	11.00
425	G-4½	Min. screw	6.3	.50	10.90
447	T-3¼	Wedge	6.5	.15	2.50
455	G-4½	Min. bayonet, flasher	28	.50	18.00
456	G-4½	Min. bayonet	1.5	.17	20.80
464	T-3¼	Wedge	9.84	.17	9.30
500	T-4½	Min. screw	5.1	.50	62.30
502	G-4½	Min. screw	5.1	.15	5.50
503	G-4½	Min. bayonet	24	.15	9.60
509K	G-6	Candelabra screw	6.3	.18	13.70
555	T-3¼	Wedge	13	.25	6.00
558	T-3¼	Wedge	12.8	.34	13.40
561	T-3	Flat clip	13.5	.97	10.60
562	T-3	Flat clip	13.5	.74	12.90
585	T-3¼	Wedge	6.15	.04	12.30
605	G-4½	Min. screw	5.3	.50	15.40
612	G-3½	Min. two-pin	28	.25	15.40
623	G-6	S.C. bayonet	28	.37	23.10
624	G-6	D.C. bayonet	14	.37	40.50
631	G-6	S.C. bayonet	28	.63	14.80
656	T-3¼	Wedge	28	.08	6.80
657	T-3¼	Wedge	14	.06	6.80
658	T-3¼	Wedge	4.5	.08	7.80
673	T-1¾	Special	5.0	.29	72.80★
680	T-1	Wire terminal	5	.06	46.80★
683	T-1	Wire terminal	5	.06	46.50
685	T-1	Sub-midget flanged	28	.06	48.80★
705	S-8	S.C. bayonet	5.0	.51	48.70
715	T-1	Wire terminal	5	.115	65.10★
718	T-1	Sub-midget flanged	6.3	.115	48.80★
755	T-3¼	Min. bayonet	14	.15	8.70
756	T-3¼	Min. bayonet		.08	10.60
757	T-3¼	Min. bayonet	28	.08	9.30
767	T-2¼	Min. bayonet	6.0	2.0	217.00
773	T-2¾	Min. two-pin	12	.67	98.80
778	T-2¾	Min. two-pin	6.0	3.33	83.20
782	T-2¾	Min. two-pin	12	1.66	88.40
783	T-2¼	Min. two-pin	12	1.0	74.20

*S.C. single contact; D.C., double contact; Min., miniature; Mid., midget. †Outside coated red. §Outside coated green. ▲Outside coated amber. •Net per lamp, minimum quantity of 500 lamps.

CONTINUED ON FOLLOWING PAGE

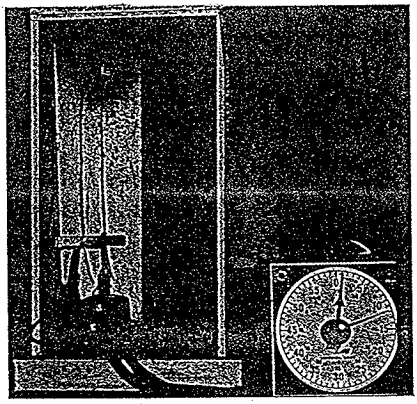
SEE PAGE 2 FOR YOUR NEAREST SOUTHEASTERN ELECTRONICS STORE

Rockbestos® Firewall® SIS Switchboard Wire

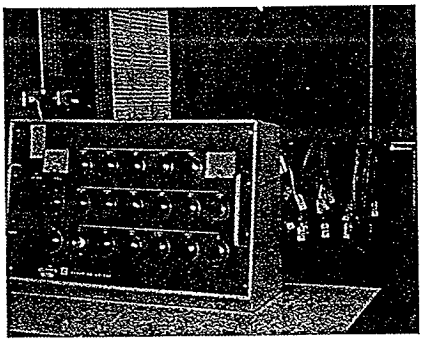
600 Volt – 90° C. (194° F.) UL Listed
For those customers who require more than the UL minimum

Utilities, industrials and other users of switchboard wires are becoming increasingly concerned with quality and performance. To satisfy these demands, Rockbestos offers its superior quality Firewall SIS Switchboard Wire, which is a specially compounded cross-linked polyolefin insulation that incorporates long-term moisture stability, radiation resistance, flame resistance and excellent aging properties.

Passes UL Vertical Test
(Not required by UL for Type SIS)



Long Term Stability in Water
(Not Required by UL for Type SIS)



Radiation Resistance

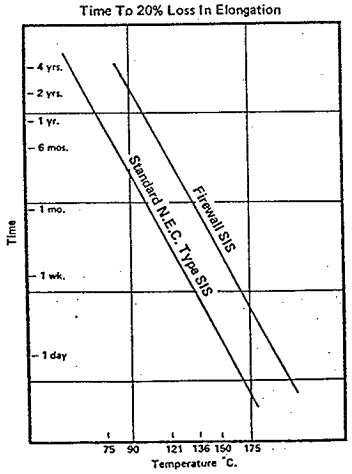
Dielectric Breakdown On Single Conductors

Single conductor samples were bent in a U shape around mandrels of the diameters shown and the U-shaped section then immersed in water. A.C. voltage was then applied until dielectric breakdown occurred. Values are shown only for the two severest bends, since less severe bends generally produced higher values.

Exposure Level	Mandrel Diameters 3X(.45")	1X(.15")
Unexposed	23KV	23KV
5×10^7	35KV	34KV
10^8	30KV	29KV
2×10^8	27KV	27KV

Serviceable After 2×10^8

Excellent Aging



CALC. W320-31-022
ATTACHMENT: F
PAGE: F-2

Dimensional Data

Construction: Solid, stranded or flexible stranded tinned copper insulated with heat, moisture and flame-resistant cross-linked polyolefin. Surface printed with size and UL listing.

Application: Recommended as a general purpose heat, moisture and flame resistant wire for use in wiring switchboards, panel boards or other electrical apparatus where superior performance is required.

Advantages: Resistant to moisture, abrasion, cut-through. In addition to meeting all UL requirements, it also passes UL 83 vertical flame test as a superior flame-resistant wire.

Stranded Conductor

Table SISS

Size	Stranding	Insulation Mils	Nominal O.D.	M Ft. Net Weight	Ampacity*
14	7/.0242	30	.140	20	25
12	7/.0305	30	.160	28	30
10	7/.0385	30	.180	42	40
8	7/.0486	45	.240	70	50
6	7/.0612	60	.320	113	70
4	7/.0772	60	.370	167	90
2	7/.0994	60	.430	251	120
1	19/.0664	80	.470	310	140
1/0	19/.0745	80	.545	398	155
2/0	19/.0837	80	.590	489	185
3/0	19/.0940	80	.640	604	210
4/0	19/.1055	80	.690	750	235

*Ampacity based on 3 conductors in conduit, or enclosed cabinet, 30°C. ambient, at 90°C. conductor temperatures.

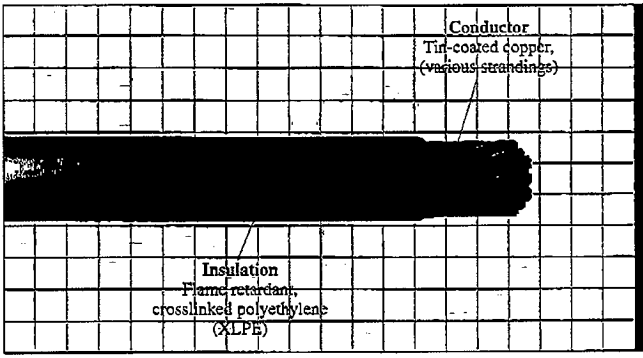
Flexible Stranded Conductor

Table SISF

Size	Stranding	Insulation Mils	Nominal O.D.	M Ft. Net Weight	Ampacity*
14	41/.010	30	.140	20	25
12	65/.010	30	.160	28	30
10	105/.010	30	.190	43	40
8	133/.0111	45	.270	75	50
6	133/.0140	60	.340	119	70
4	133/.0177	60	.400	170	90
2	133/.0223	60	.470	254	120
1	259/.0180	80	.515	326	140
1/0	259/.0202	80	.595	412	155
2/0	259/.0227	80	.650	508	185
3/0	259/.0255	80	.710	630	210
4/0	259/.0286	80	.770	780	235

*Ampacity based on 3 conductors in conduit, or enclosed cabinet, 30°C. ambient, at 90°C. conductor temperatures.

NOTE: Also available in solid conductor (Table SIS).



Firewall® SIS

Switchboard Wire

(XLPE)

90°C*, 600 Volt
Class 1E Nuclear
NEC Type SIS
UL Listed**

Spec. RSS-4-002

Scope

Firewall® SIS is a one conductor, unjacketed, nuclear Class 1E Switchboard Wire. Its tough thermoset construction allows for its use in demanding applications without additional jacketing protection. It is intended for low voltage applications and may be installed in switchboards, panel boards or other electrical apparatus where superior performance is required.

Features

- Thermoset insulation for enhanced thermal stability
- Specially formulated insulation for superior long term water resistance
- Extremely flame retardant
- Nuclear qualified with a minimum 40-year thermal life expectancy at 90°C
- Radiation resistant (up to 200 megarads)
- Full traceability
- Excellent mechanical properties
- Tin-coated copper conductors for improved terminations and corrosion resistance
- All cables pass a wet dielectric (tank) test to verify insulation integrity
- Easy strippability for installation ease
- Low surface coefficient of friction insures installation ease with reduced pulling tension required

Performance Standards

- Insulation in accordance with ICEA standards S-66-524
- Class 1E qualified in accordance with IEEE-383 and IEEE-323 (Rockbestos Reports QR-5804 or QR-5805)
- Wire passes the vertical flame tests specified in IEEE-383 para. 2.5.6 (ICEA S-19-81 Section 6.19.6) and UL VW-1
- Quality Assurance program in accordance with 10 CFR 50 Appendix B
- UL listed as Type SIS for sizes 14 AWG through 4/0 AWG (UL standard 44)

Construction

Conductor:
Annealed, tin-coated copper. (available in various stranding classifications)

Insulation:
Proprietary heat, moisture and radiation resistant, flame retardant crosslinked polyethylene

* Rated 90°C for normal operation in wet and dry locations, 130°C for emergency overload conditions, and 250°C for short circuit conditions. A 90°C dry rating must be used when the National Electrical Code applies.

** 14 AWG & Larger.

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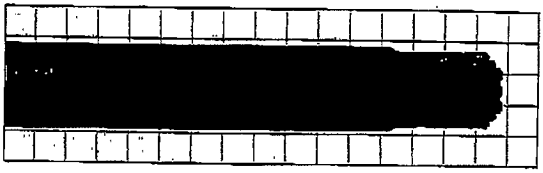
Firewall® SIS
Switchboard Wire
(XLPE)
90°C*, 600 Volt
Class 1E Nuclear
NEC Type SIS
UL Listed**

Spec. RSS-4-002



Stranded

Product Code	Conductor Size (AWG)	Number of Strands	Stranding Class	Insulation Thickness (Inch)	Insulation Thickness (mm)	Nominal Diameter (Inch)	Nominal Diameter (mm)	Approximate Net Weight (Lbs/M')
A82-1186	18	7	"B"	.030	7.62	.11	2.79	10
A82-0166	16	7	"B"	.030	7.62	.12	3.05	13
A82-0146	14	7	"B"	.030	7.62	.13	3.30	19
A82-0126	12	7	"B"	.030	7.62	.15	3.81	28
A82-0116	10	7	"B"	.030	7.62	.18	4.57	40
A82-1086	8	7	"B"	.045	11.43	.24	6.10	70
A82-1066	6	7	"B"	.060	15.24	.30	7.62	110
A82-1046	4	7	"B"	.060	15.24	.35	8.89	170
A82-1026	2	7	"B"	.060	15.24	.41	10.41	250
A82-1016	1	19	"B"	.080	20.32	.49	12.45	325
A82-1100	1/0	19	"B"	.080	20.32	.53	13.46	400
A82-1200	2/0	19	"B"	.080	20.32	.57	14.48	490
A82-1300	3/0	19	"B"	.080	20.32	.62	15.75	610
A82-1400	4/0	19	"B"	.080	20.32	.68	17.27	755

Flexible Strand

A83-0186	18	16	"K"	.030	7.62	.11	2.79	10
A83-0166	16	26	"K"	.030	7.62	.12	3.05	14
A83-0146	14	41	"K"	.030	7.62	.14	3.56	19
A83-0126	12	65	"K"	.030	7.62	.15	3.81	28
A83-0116	10	105	"K"	.030	7.62	.19	4.83	43
A83-0086	8	133	"H"	.045	11.43	.26	6.60	72
A83-0066	6	133	"H"	.060	15.24	.33	8.38	115
A83-0046	4	133	"H"	.060	15.24	.38	9.65	175
A83-0026	2	133	"H"	.060	15.24	.46	11.68	260
A83-0016	1	259	"H"	.080	20.32	.53	13.46	340
A83-0100	1/0	259	"H"	.080	20.32	.58	14.73	420
A83-0200	2/0	259	"H"	.080	20.32	.63	16.00	520
A83-0300	3/0	259	"H"	.080	20.32	.69	17.53	640
A83-0400	4/0	259	"H"	.080	20.32	.76	19.30	795

* Rated 90°C for normal operation in wet and dry locations, 130°C for emergency overload conditions, and 250°C for short circuit conditions. A 90°C dry rating must be used when the National Electrical Code applies.

** 16 AWG & Larger.

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Table 2-4

Nom. dc Resistance in ohms per 1000 ft.† at 25°C (77°F) of Solid & Concentric Lay Stranded Conductor

Conductor Size	Solid			Concentric Lay Stranded*				
	Aluminum	Copper		Aluminum	Copper			
AWG or kcmil		Uncoated	Coated	Class B, C, D	Uncoated	Coated		
					Class B, C, D	Class B	Class C	Class D
22	27.1	16 5	17.2	27.4	16.7	17.9	...	...
20	16.9	10 3	10.7	17.3	10.5	11.1	...	...
19	13.5	8 20	8.52	13.7	8.33	8.83	...	...
18	10.7	6 51	6.76	10.9	6.67	7.07	...	...
17	8.45	5 15	5.35	8.54	5.21	5.52	...	...
16	6.72	4 10	4.26	6.85	4.18	4.43	...	...
15	5.32	3 24	3.37	5.41	3.30	3.43	...	...
14	4.22	2 57	2.67	4.31	2.63	2.73	2.79	2.83
13	3.34	2 04	2.12	3.41	2.08	2.16	2.21	2.22
12	2.66	1 62	1.68	2.72	1.66	1.72	1.75	1.75
11	2.11	1 29	1.34	2.15	1.31	1.36	1.36	1.39
10	1.67	1 02	1.06	1.70	1.04	1.08	1.08	1.11
9	1.32	0 808	0.831	1.35	0.825	0.856	0.856	0.874
8	1.05	0 640	0.659	1.07	0.652	0.678	0.678	0.680
7	0.833	0 508	0.522	0.851	0.519	0.538	0.538	0.538
6	0.661	0 403	0.414	0.675	0.411	0.427	0.427	0.427
5	0.524	0 319	0.329	0.534	0.325	0.338	0.339	0.339
4	0.415	0 253	0.261	0.424	0.258	0.269	0.269	0.269
3	0.329	0 201	0.207	0.336	0.205	0.213	0.213	0.213
2	0.261	0 159	0.164	0.266	0.162	0.169	0.169	0.169
1	0.207	0 126	0.130	0.211	0.129	0.134	0.134	0.134
1/0	0.164	0 100	0.102	0.168	0.102	0.106	0.106	0.106
2/0	0.130	0 0794	0.0813	0.133	0.0810	0.0842	0.0842	0.0842
3/0	0.103	0 0630	0.0645	0.105	0.0642	0.0667	0.0669	0.0669
4/0	0.0819	0 0500	0.0511	0.0836	0.0510	0.0524	0.0530	0.0530
250	0.0694	...	...	0.0707	0.0431	0.0448	0.0448	0.0448
300	0.0578	...	...	0.0590	0.0360	0.0374	0.0374	0.0374
350	0.0495	...	...	0.0505	0.0308	0.0320	0.0320	0.0320
400	0.0433	...	...	0.0442	0.0269	0.0277	0.0280	0.0280
450	0.0385	...	...	0.0393	0.0240	0.0246	0.0249	0.0249
500	0.0347	...	...	0.0354	0.0216	0.0222	0.0224	0.0224
550	...	...	...	0.0321	0.0196	0.0204	0.0204	0.0204
600	...	...	...	0.0295	0.0180	0.0187	0.0187	0.0187
650	...	...	...	0.0272	0.0166	0.0171	0.0172	0.0173
700	...	...	...	0.0253	0.0154	0.0159	0.0160	0.0160
750	...	...	...	0.0236	0.0144	0.0148	0.0149	0.0150
800	...	...	...	0.0221	0.0135	0.0139	0.0140	0.0140
900	...	...	...	0.0196	0.0120	0.0123	0.0126	0.0126
1000	...	...	...	0.0177	0.0108	0.0111	0.0111	0.0112
1100	...	...	...	0.0161	0.00981	0.0101	0.0102	0.0102
1200	...	...	...	0.0147	0.00899	0.00925	0.00934	0.00934
1250	...	...	...	0.0141	0.00863	0.00888	0.00897	0.00897
1300	...	...	...	0.0136	0.00830	0.00854	0.00861	0.00862
1400	...	...	...	0.0126	0.00771	0.00793	0.00793	0.00801
1500	...	...	...	0.0118	0.00719	0.00740	0.00740	0.00747
1600	...	...	...	0.0111	0.00674	0.00694	0.00700	0.00700
1700	...	...	...	0.0104	0.00634	0.00653	0.00659	0.00659
1750	...	...	...	0.0101	0.00616	0.00634	0.00640	0.00640
1800	...	...	...	0.00982	0.00599	0.00616	0.00616	0.00622
1900	...	...	...	0.00931	0.00568	0.00584	0.00584	0.00589
2000	...	...	...	0.00885	0.00539	0.00555	0.00555	0.00560
2500	...	...	...	0.00715	0.00436	0.00448	...	...
3000	...	...	...	0.00596	0.00363	0.00374	...	...
3500	...	...	...	0.00515	0.00314	0.00323	...	...
4000	...	...	...	0.00451	0.00275	0.00283	...	...
4500	...	...	...	0.00405	0.00247	0.00254	...	...
5000	...	...	...	0.00364	0.00222	0.00229	...	...

*Concentric lay stranded includes compressed and compact conductors.

†Resistance values in milliohms per meter shall be obtained by multiplying the above values by 3.28.

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General Conductor Information

dc Resistance

Based on the resistance-temperature coefficient of copper of 100 percent conductivity and of aluminum 61 percent conductivity (international annealed copper standard) at 25C and the formulas:

R_1 = Resistance at 25C
R_2 = Resistance at desired temp. T_2
T_1 = 25C

Copper

$$R_2 = R_1 \left[\frac{234.5 + T_2}{234.5 + T_1} \right]$$

Aluminum

$$R_2 = R_1 \left[\frac{228.1 + T_2}{228.1 + T_1} \right]$$

Example:
R dc at 75C for 4/0 AWG uncoated copper = 0.0509 x 1.193 = .0607 ohms/1000 ft.

Resistance temperature correction factors

Copper Conductors

Table 1-4

Temp. C	0	1	2	3	4	5	6	7	8	9
0	.904	.908	.911	.915	.919	.923	.927	.931	.934	.938
10	.942	.946	.950	.954	.958	.961	.965	.969	.973	.977
20	.981	.985	.988	.992	.996	1.000	1.004	1.008	1.012	1.015
30	1.019	1.023	1.027	1.031	1.035	1.039	1.042	1.046	1.050	1.054
40	1.058	1.062	1.066	1.069	1.073	1.077	1.081	1.085	1.089	1.092
50	1.096	1.100	1.104	1.108	1.111	1.115	1.119	1.123	1.127	1.131
60	1.135	1.139	1.143	1.146	1.150	1.154	1.158	1.162	1.166	1.170
70	1.173	1.177	1.181	1.185	1.189	1.193	1.197	1.200	1.204	1.208
80	1.212	1.216	1.220	1.224	1.227	1.231	1.235	1.239	1.243	1.247
90	1.250	1.254	1.258	1.262	1.266	1.270	1.274	1.277	1.281	1.285
100	1.289	1.293	1.297	1.300	1.304	1.308	1.312	1.316	1.320	1.324
110	1.328	1.331	1.335	1.339	1.343	1.347	1.351	1.354	1.358	1.362
120	1.366	1.370	1.374	1.378	1.381	1.385	1.389	1.393	1.397	1.400
130	1.405	1.408	1.412	1.416	1.420	1.424	1.428	1.432	1.435	1.439
140	1.443	1.447	1.451	1.455	1.459	1.462	1.466	1.470	1.474	1.478
150	1.482	1.480	1.489	1.493	1.497	1.500	1.505	1.509	1.513	1.516

Aluminum Conductors

Temp. C	0	1	2	3	4	5	6	7	8	9
0	.901	.905	.909	.913	.917	.921	.925	.928	.932	.936
10	.940	.944	.948	.952	.956	.960	.964	.968	.972	.976
20	.980	.984	.988	.992	.996	1.000	1.004	1.008	1.012	1.016
30	1.020	1.024	1.028	1.032	1.036	1.040	1.044	1.048	1.052	1.056
40	1.060	1.064	1.068	1.072	1.076	1.080	1.084	1.088	1.092	1.096
50	1.100	1.104	1.108	1.112	1.116	1.120	1.124	1.128	1.132	1.136
60	1.140	1.144	1.148	1.152	1.156	1.160	1.164	1.168	1.172	1.176
70	1.180	1.184	1.187	1.191	1.195	1.199	1.203	1.207	1.211	1.215
80	1.219	1.223	1.227	1.231	1.235	1.239	1.243	1.246	1.250	1.254
90	1.258	1.262	1.266	1.270	1.274	1.278	1.281	1.285	1.289	1.293
100	1.297	1.301	1.304	1.308	1.311	1.315	1.319	1.324	1.328	1.332
110	1.336	1.340	1.343	1.347	1.351	1.355	1.359	1.362	1.366	1.370
120	1.374	1.378	1.381	1.385	1.389	1.393	1.397	1.401	1.405	1.409
130	1.413	1.417	1.420	1.424	1.428	1.432	1.436	1.440	1.444	1.448
140	1.452	1.456	1.459	1.463	1.467	1.471	1.475	1.479	1.483	1.487
150	1.491	1.495	1.498	1.502	1.506	1.510	1.514	1.518	1.522	1.526

TELEPHONE CONFERENCE MEMORANDUM

Company: ICF Kaiser Hanford Company Address: P.O. Box 888, Richland, WA 99352

[] INCOMING [X] OUTGOING DATE: 10/6/94 TIME: 9.00 AM

WITH: Vance Weaver OF: Kinemetrics, Inc. PHONE: (818) 795-2220

WITH: OF: PHONE:

Copies to:	Name	Address
	NA	NA

Subject: Kinemetrics SP-1 Power Supply

Moe Khorsandian	W-320 Project,	(509) 373-2331
Engineering Services	W320-31-022 Calculation	
Department		Telephone #

Summary of Conference

Per telephone conversation with Mr. Vance weaver, the amp rating of Kinemetrics SP-1 power supply is approximately 150 mA.

54-7600-098 (5/90) {EF} GEF017
Telephone Conference Memorandum

PERFORMANCE SPECIFICATIONS (Cont'd)

DC DIGITAL OUTPUTS (ISOLATED)

	5-60V dc	5-200V dc
Output voltage ranges		
Max Logic Low Input	1V dc	1V dc
Min Logic High Input	2.5V dc	2.5V dc
Max Input current	12 mA	12 mA
Max Output current	3A	1A
Response time	0.75 msec	0.75 msec

AC DIGITAL OUTPUTS (ISOLATED)

	12-140V ac	24-280V ac
Output voltage range		
Max Logic Low Input	1V dc	1V dc
Min Logic High Input	2.5V dc	2.5V dc
Max Input current	12 mA	12 mA
Max Output current	3A	3A
Response time	1/2 cycle	1/2 cycle

DIGITAL OUTPUTS (NONISOLATED)

Power supply range
+5V dc ±10%

Output voltage range
+5 to +24V dc

Max Logic Low Input
1.35V

Min Logic High Input
4.2V

Max Input current
1.5 mA dc

Max Output current
100 mA dc

Response time
100 usec

MECHANICAL RELAY OUTPUTS

Configuration
Dual relays (NO/NO, NC/NC, NO/NC) or Form C single relay

Power supply range
+ 5V dc ±10%

Max Input Current
-10.0 mA dc

Contact load
3A at 250V ac or 30V dc

Contact resistance
0.10 ohms maximum

Isolation
250V rms (contacts to coil)

Current rating
3A per relay

Response time
10 msec

DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution	JW Bailey	Date 25 July 1998
Project Title/Work Order		EDT No. 622246
Project W-320 Tank 106-C, HNF-2488, Electrical Calculations, Vol. 2		ECN No. n/a

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
JW Bailey	S2-48				
W-320 Project Files	R1-29				