FUSE SIZING

LOAD	AMOUNT
Resistive	115%
Single Motor	125%

Multiple Motors off same feed:
150% of largest + 100% of each other

Transformers	100%
Primary Service	125%

Table 310-16. Allowable Ampacities of Insulated Conductors Rated 0 through 2000 Volts, 60° to 90°C (140° to 194°F) Not More Than Three Current-Carrying Conductors in Raceway or Cable or Earth (Directly Buried), Based on Ambient Temperature of 30°C (86°F)

Size	Temperature Rating of Conductor. See Table 310-13.						Size
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
AWG kcmil	TYPES TW†, UF†	TYPES FEPW†, RH†, RHW†, THHW†, THW†, THWN†, XHHW† USE†, ZW†	TYPES TBS, SA SIS, FEP†, FEPB†, MI RHH†, RHW-2, THHN†, THHW†, THW-2†, THWN-2†, USE-2, XHH, XHHW† XHHW-2, ZW-2	TYPES TW†, UF†	TYPES RH†, RHW†, THHW†, THW†, THWN†, XHHW†, USE†	TYPES TBS, SA, SIS, THHN†, THHW†, THW-2, THWN-2, RHH†, RHW-2, USE-2, XHH, XHHW, XHHW-2, ZW-2	AWG kcmil
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
18	....	....	14	....	....	....	....
16	....	....	18	....	....	....	....
14	20†	20†	25†	....	....	....	....
12	25†	25†	30†	20†	20†	25†	12
10	30	35†	40†	25	30†	35†	10
8	40	50	55	30	40	45	8
6	55	65	75	40	50	60	6
4	70	85	95	55	65	75	4
3	85	100	110	65	75	85	3
2	95	115	130	75	90	100	2
1	110	130	150	85	100	115	1
1/0	125	150	170	100	120	135	1/0
2/0	145	175	195	115	135	150	2/0
3/0	165	200	225	130	155	175	3/0
4/0	195	230	260	150	180	205	4/0
250	215	255	290	170	205	230	250
300	240	285	320	190	230	255	300
350	260	310	350	210	250	280	350
400	280	335	380	225	270	305	400
500	320	380	430	260	310	350	500
600	355	420	475	285	340	385	600
700	385	460	520	310	375	420	700
750	400	475	535	320	385	435	750
800	410	490	555	330	395	450	800
900	435	520	585	355	425	480	900
1000	455	545	615	375	445	500	1000
1250	495	590	665	405	485	545	1250
1500	520	625	705	435	520	585	1500
1750	545	650	735	455	545	615	1750
2000	560	665	750	470	560	630	2000

CORRECTION FACTORS

Ambient Temp. °C	For ambient temperatures other than 30°C (86°F), multiply the allowable ampacities shown above by the appropriate factor shown below.						Ambient Temp. °F
21-25	1.08	1.05	1.04	1.08	1.05	1.04	70-77
26-30	1.00	1.00	1.00	1.00	1.00	1.00	78-86
31-35	.91	.94	.96	.91	.94	.96	87-95
36-40	.82	.88	.91	.82	.88	.91	96-104
41-45	.71	.82	.87	.71	.82	.87	105-113
46-50	.58	.75	.82	.58	.75	.82	114-122
51-55	.41	.67	.76	.41	.67	.76	123-131
56-60	....	.58	.71	....	.58	.71	132-140
61-70	....	.33	.58	....	.33	.58	141-158
71-80	....	....	.41	....	....	.41	159-176

†Unless otherwise specifically permitted elsewhere in this *Code*, the overcurrent protection for conductor types marked with an obelisk (†) shall not exceed 15 amperes for No. 14, 20 amperes for No. 12, and 30 amperes for No. 10 copper; or 15 amperes for No. 12 and 25 amperes for No. 10 aluminum and copper-clad aluminum after any correction factors for ambient temperature and number of conductors have been applied.

Table 310-16. Allowable Ampacities of Insulated Conductors Rated 0 through 2000 Volts, 60° to 90°C (140° to 194°F) Not More Than Three Current-Carrying Conductors in Raceway or Cable or Earth (Directly Buried), Based on Ambient Temperature of 30°C (86°F)

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AWG kcmil	TYPES TW†, UF†	TYPES FEPW†, RH†, RHW†, THHW†, THW†, THWN†, XHHW† USE†, ZW†	TYPES TBS, SA SIS, FEP†, FEPB†, MI RHH†, RHW-2, THHN†, THHW†, THW-2†, THWN-2†, USE-2, XHH, XHHW† XHHW-2, ZW-2	TYPES TW†, UF†	TYPES RH†, RHW†, THHW†, THW†, THWN†, XHHW†, USE†	TYPES TBS, SA, SIS, THHN†, THHW†, THW-2, THWN-2, RHH†, RHW-2, USE-2, XHH, XHHW, XHHW-2, ZW-2	AWG kcmil
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
18	....	....	14	....	....	....	....
16	....	....	18	....	....	....	....
14	20†	20†	25†	....	....	....	....
12	25†	25†	30†	20†	20†	25†	12
10	30	35†	40†	25	30†	35†	10
8	40	50	55	30	40	45	8
6	55	65	75	40	50	60	6
4	70	85	95	55	65	75	4
3	85	100	110	65	75	85	3
2	95	115	130	75	90	100	2
1	110	130	150	85	100	115	1
1/0	125	150	170	100	120	135	1/0
2/0	145	175	195	115	135	150	2/0
3/0	165	200	225	130	155	175	3/0
4/0	195	230	260	150	180	205	4/0
250	215	255	290	170	205	230	250
300	240	285	320	190	230	255	300
350	260	310	350	210	250	280	350
400	280	335	380	225	270	305	400
500	320	380	430	260	310	350	500
600	355	420	475	285	340	385	600
700	385	460	520	310	375	420	700
750	400	475	535	320	385	435	750
800	410	490	555	330	395	450	800
900	435	520	585	355	425	480	900
1000	455	545	615	375	445	500	1000
1250	495	590	665	405	485	545	1250
1500	520	625	705	435	520	585	1500
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CORRECTION FACTORS

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26-30	1.00	1.00	1.00	1.00	1.00	1.00	78-86
31-35	.91	.94	.96	.91	.94	.96	87-95
36-40	.82	.88	.91	.82	.88	.91	96-104
41-45	.71	.82	.87	.71	.82	.87	105-113
46-50	.58	.75	.82	.58	.75	.82	114-122
51-55	.41	.67	.76	.41	.67	.76	123-131
56-60	....	.58	.71	....	.58	.71	132-140
61-70	....	.33	.58	....	.33	.58	141-158
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the msac hot line

A monthly question-and-answer feature concentrating on actual field problems. Send your questions to the address given. An answer written by a member of the Manufacturers Service Advisory Council will be sent directly to you and then published in the magazine.

Wiring

Q. (By Brian Hall, Lewiston, NY) Could you please help me with a question I have about a 3-phase, 4-wire Delta connected transformer (Fig. 1).

L1 to L2 = 220 volts; L1 to L3 = 220 volts; L2 to L3 = 220 volts; L2 to N = 110 volts; and L3 to N = 110 volts.

I have been informed that the voltage between L1 and N equals 177 volts. Is this correct?

What formula is used to arrive at the figure of 177 volts or whatever voltage is between L1 and N?

A. (By Ray Mullin, Bussmann) Although your diagram shows voltages of 110 volts and 220 volts, I will use the voltages as referenced in Chapter 9 of the National Electrical Code book, namely, 120 volts and 240 volts.

I have marked the phased A, B, and C, and the grounded neutral point as N (Fig. 2).

Voltage from A to B = 240 volts.
Voltage from B to C = 240 volts.
Voltage from C to A = 240 volts.

When this 3-phase system is to supply 3-phase motor loads and 120/240-volt lighting loads, one of the transformers is 'center tapped.' This is a common transformer connection when the major portion of the load is 3-phase, and the smaller portion of the load is lighting.

Voltage from A to N = 120 volts.
Voltage from B to N = 120 volts.
Voltage from C to N = 208 volts.

The voltage C to N is calculated as 1.732 times the 120- volt reference points. Thus, 120 × 1.732 = 208 volts.

We could also calculate this by taking 240 volts times 86.6%. Thus, 240 × 0.866 = 208 volts. The computation could also be done with vectors in Fig. 3.

Section 215-8 of the NEC requires that the conductors for this 'high leg' (sometimes called the 'wild leg') be identified by using an orange insulated conductor or by tagging the conductor. This readily identifies the wire on which the higher voltage to ground appears.

A 3-phase, 4-wire Delta transformer bank is usually recognized by the fact that one of the transformers is

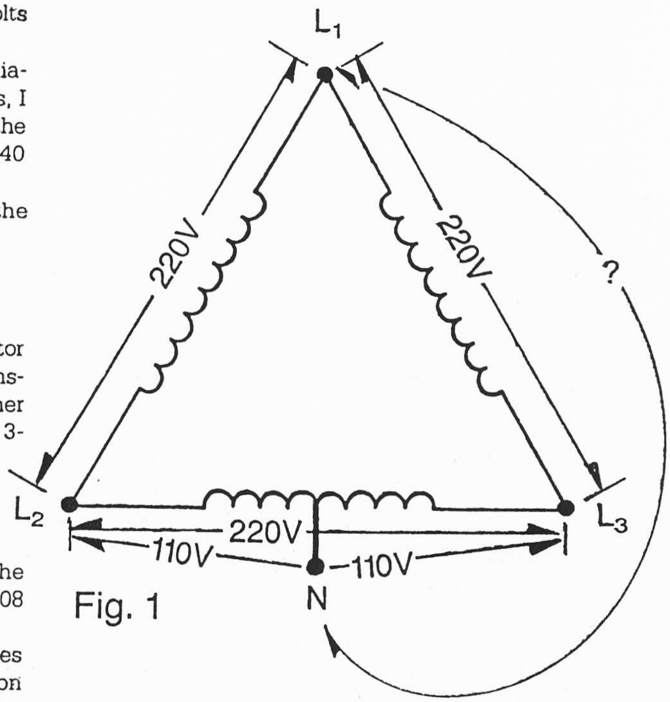


Fig. 1

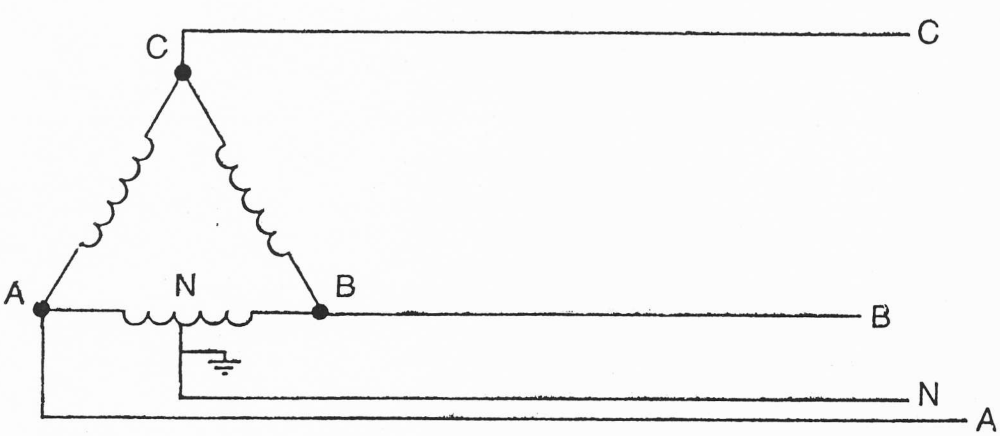


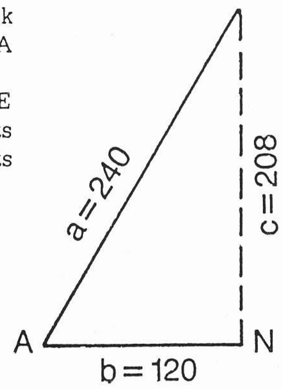
Fig. 2

larger than the other two transformers. This is because one of the transformers will be supplying 3-phase power loads only. For example, a typical transformer bank might have two 50 kVA transformers and one 100 kVA transformer.

Another 3-phase system is a 3-phase, 4-wire, WYE connected transformer bank. Here we have full 120 volts between each phase wire and the neutral, and 208 volts between phase conductors (Fig. 4).

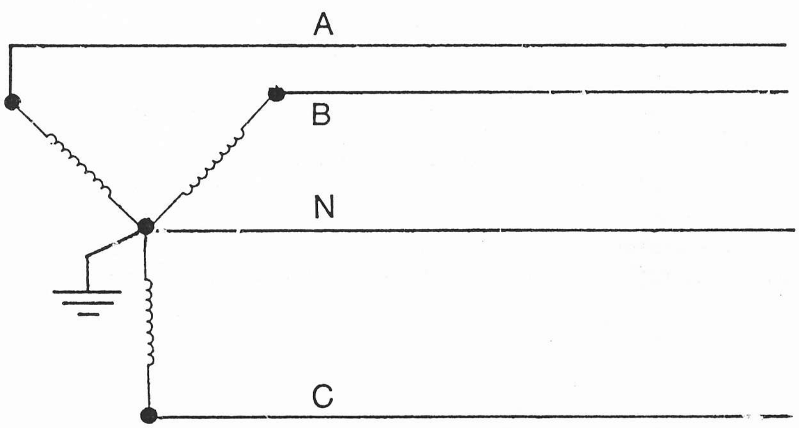
A to N = 120 volts.
B to N = 120 volts.
C to N = 120 volts.
A to B = 208 volts.
B to C = 208 volts.
C to A = 208 volts.

There is no 'high leg' in this system.



$$a^2=b^2+c^2$$
$$c^2=a^2-b^2$$
$$c=\sqrt{a^2-b^2}$$
$$c=\sqrt{240^2-120^2}$$
$$c=\sqrt{57600-14400}$$
$$c=\sqrt{43200}$$
$$c=207.846$$

Fig. 3



A to N = 120 volts
B to N = 120 volts
C to N = 120 volts
A to B = 208 volts
B to C = 208 volts
C to A = 208 volts

Fig. 4

Correct charges

Q. (By Enroch Smalls Jr., Mount Vernon, NY). How can you tell if you've got the correct charge in a system for low, medium, and high temperature refrigeration? I am familiar with charging by head pressure, and a combination of head pressure and amp draw using a charging cylinder. I am also aware that low side pressure will start out high. Then when the box pulls down to temperature, it will be a lower pressure. I thought a technician could just put on gauges and tell right away whether the pressure indicated an overcharge, undercharge, or correct charge.

A. (By Daniel Kramer P.E., consultant). You have a good question and you have asked it clearly. I hope I can answer it as clearly.

You ask: Can a skilled refrigeration technician put gauges on a system and from the gauge readings alone tell whether the system is overcharge, undercharged or has the correct charge?

The answer is no, not from gauge readings alone. However, if the pressures are reasonable, the sightglass is clear, the suction line cool, the receiver warm, the box or fixture temperature satisfactory, and the cycle times reasonable for the application, then the technician should not suspect over or undercharge.

But if the running times are long or continuous or the box temperature is too high and the receiver is cool compared with adjacent machines, and the head is unexpectedly high, then *even if the sightglass is bubbling*, the technician should suspect overcharge or noncondensibles.

Even if the highside pressure is too high, the technician will have to know more to tell whether the cause is overcharge. For instance, high head can also be caused by:

- Inoperative condenser fan (fan loose on shaft, wrong fan, undervoltage on fan motor, bad motor).
- Dirty condenser fins.
- Excessive air temperature (air recirculation from condenser discharge).
- Noncondensibles.
- Restricted capillary tube.
- Excessive suction pressure.

Further, noncondensibles and overcharge generally exhibit exactly the same symptoms.

Even if the lowside pressure is too low, the technician will still have to know more before being able to tell whether the system is overcharged. For instance, low larger than the other two transformers. This is because one of the transformers will be supplying 3-phase power loads only. For example, a typical transformer bank might have two 50 kVA transformers and one 100 kVA transformer.

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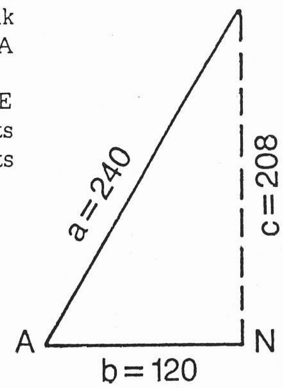
There is no 'high leg' in this system.



$$a^2=b^2+c^2$$
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$$c=\sqrt{a^2-b^2}$$
$$c=\sqrt{240^2-120^2}$$
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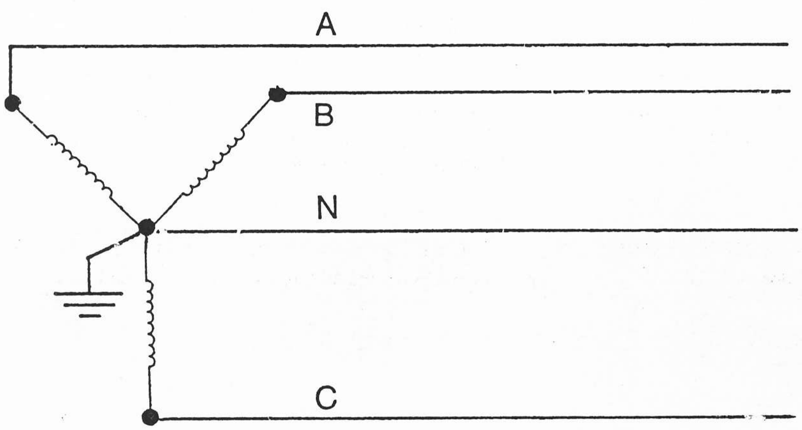
$$c=\sqrt{43200}$$
$$c=207.846$$

Fig. 3



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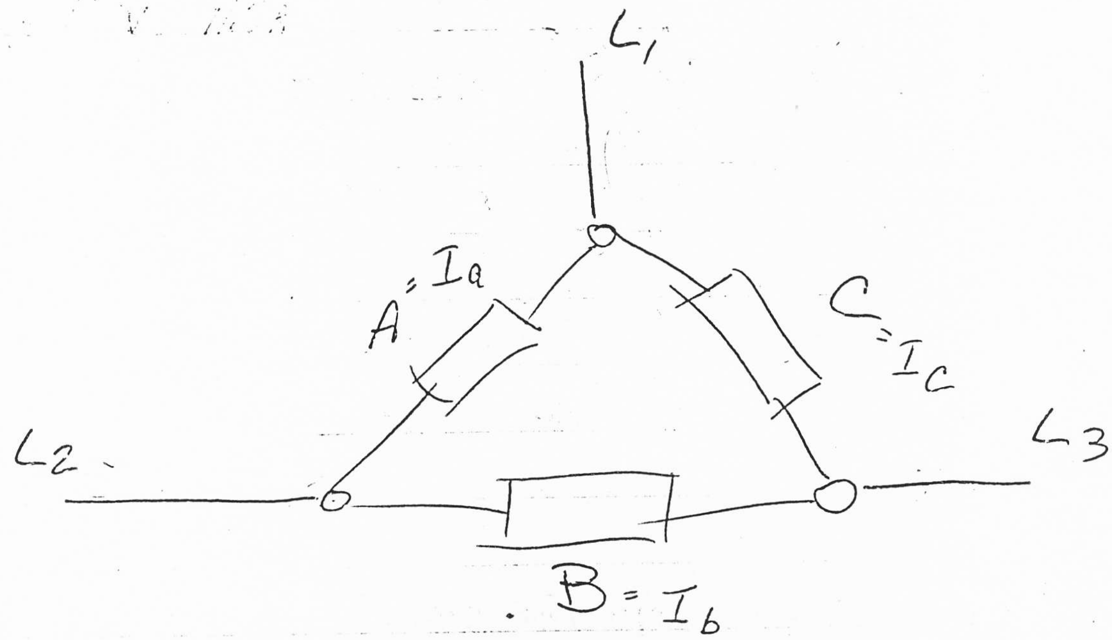
Even if the highside pressure is too high, the technician will have to know more to tell whether the cause is overcharge. For instance, high head can also be caused by:

- Inoperative condenser fan (fan loose on shaft, wrong fan, undervoltage on fan motor, bad motor).
- Dirty condenser fins.
- Excessive air temperature (air recirculation from condenser discharge).
- Noncondensibles.
- Restricted capillary tube.
- Excessive suction pressure.

Further, noncondensibles and overcharge generally exhibit exactly the same symptoms.

Even if the lowside pressure is too low, the technician will still have to know more before being able to tell whether the system is overcharged. For instance, low

3- PHASE CURRENT FORMULA



Amperage in each leg calculated using the following formulae:
(must know single phase current)

$L_1 = \sqrt{A^2 + C^2 + AC}$

$L_2 = \sqrt{A^2 + B^2 + AB}$

$L_3 = \sqrt{B^2 + C^2 + BC}$

Example 230V

$A = \frac{3000W}{230V} = 13.04A$

$B = \frac{3000W}{230V} = 13.04A$

$C = \frac{2000W}{230V} = 8.696A$

$L_1 = \sqrt{13.04^2 + 8.696^2 + (13.04)(8.69)}$

$L_1 = \sqrt{170.04 + 75.62 + 113.396}$

$L_1 = \sqrt{359.056} = \underline{18.95\,A}$

MAX. NO. OF CONDUCTORS IN CONDUIT

SIZE:	1/2"	3/4"	1"	1 1/4"	1 1/2"
CONDUCTOR SIZE					
#16	11	17	27	46	62
#14	9	15	25	44	60
#12	7	12	19	35	47
#10	5	9	15	26	36
# 8	2	4	7	12	17
# 6					
# 4					

WIRE AMPACITIES

CONDUCTOR SIZE	AMPS
#16	10
#14	15
#12	20
#10	30
# 8	40
# 6	55
# 4	70
# 3	85
# 2	95

MIDWEST EQUIPMENT COMPANY
6555 CORPORATE DRIVE
CINCINNATI, OHIO 45242

PHONE: 513-489-2060 FAX: 513-489-2140

QUOTE

TO:
WEBER MANUFACTURING CO.
8498 BROOKVILLE ROAD
INDIANAPOLIS, IN 46239

FAX# 317 357 8685

ATTENTION:
DAVID FOX

FROM: **RUSS FINERAN**

DATE: 1-16-97

NO. OF PAGES: 1

QTY	P/N	DESCRIPTION	UNIT PR	TOTAL
ALL	B9C-1	21 AMP IEC CONTACTOR, 9 AMP INDUCTIVE	$ 15.00	
ALL	B12C-1	21 AMP IEC CONTACTOR, 11 AMP INDUCTIVE	17.00	
ALL	B16C-1	21 AMP IEC CONTACTOR, 17 AMP INDUCTIVE	21.00	
ALL	B25C-1	33 AMP IEC CONTACTOR, 28 AMP INDUCTIVE	25.00	
ALL	B30C-1	45 AMP IEC CONTACTOR, 32 AMP INDUCTIVE	40.00	
ALL	B40C-1	65 AMP IEC CONTACTOR, 40 AMP INDUCTIVE	50.00	
ALL	B50C-1	65 AMP IEC CONTACTOR, 52 AMP INDUCTIVE	65.00	
ALL	B63C-1	85 AMP IEC CONTACTOR, 65 AMP INDUCTIVE	75.00	
ALL	T25DU__	OVERLOAD RELAYS - .1 THRU 32.0 AMPS	25.00	
ALL	T75DU__	OVERLOAD RELAY - 18.0 THRU80.0 AMPS	40.00	
		NOTE: HIGHER AMP RATING IS FOR RESISTIVE		
		TYPE LOADS. LOWER INDUCTIVE AMP		
		RATING IS FOR MOTOR TYPE LOADS.		
		ALL CONTACTORS COME STANDARD		
		WITH ONE N\O AUXILIARY CONTACT.		
	5271-K6		13.00	

M.E.C.

The Midwest Equipment Company, Inc.
6555 Corporate Drive
Cincinnati, OH 45242

PHONE: (513) 489-2060 FAX: (513) 489-2140

QUOTE

Bill To:

WEBER MANUFACTURING CO., INC.
P.O. BOX 19449
INDIANAPOLIS, IN 46219

ATTENTION: DAVID FOX

Ship To:

WILL ADVISE

FROM: RUSS FINERAN

DATE: MAY 7, 1996

QTY	DESCRIPTION		UNIT PR
ALL	6R30A3SP, 3 POLE FUSE BLOCK	REJECTION TYPE	$ 8.30
ALL	6R30A2SP, 2 POLE FUSE BLOCK	REJECTION TYPE	6.52
ALL	R30A3SP, 3 POLE FUSE BLOCK	REJECTION TYPE	5.30
ALL	R30A2SP, 2 POLE FUSE BLOCK	REJECTION TYPE	3.85
ALL	6F30A3SP, 3 POLE FUSE BLOCK	NON-REJECTION TYPE	8.75
ALL	6F30A2SP, 2 POLE FUSE BLOCK	NON-REJECTION TYPE	6.75
ALL	F30A3SP, 3 POLE FUSE BLOCK	NON-REJECTION TYPE	5.25
ALL	F30A2SP, 2 POLE FUSE BLOCK	NON-REJECTION TYPE	3.75
	MC MOUNTING CLAMP		0.35
	RR2P-U-AC120	2 POLE PIN RELAY	$ 8.20
	RR2P-UL-AC120	2 POLE PIN RELAY w/LIGHT	$ 11.84
	RR3P-UL-AC120	3 POLE PIN RELAY w/LIGHT	$ 14.07
	SR2P-06	8 PIN BASE	$ 2.75
	RR3P-U-AC120	3 POLE PIN RELAY	$ 10.50

M.E.C.

The Midwest Equipment Company, Inc.
6555 Corporate Drive
Cincinnati, OH 45242

PHONE: (513) 489-2060 FAX: (513) 489-2140

QUOTE

Bill To:

WEBER MANUFACTURING CO., INC.
P.O. BOX 19449
INDIANAPOLIS, IN 46219

ATTENTION: DAVID FOX

Ship To:

WILL ADVISE

FROM: **RUSS FINERAN**

DATE: APRIL 11, 1996

QTY	DESCRIPTION	UNIT PR
ALL	RTE-B11-AC120 TIMING RELAY	$ 36.00
ALL	RTE-B12-AC120 TIMING RELAY	38.75
ALL	RR3B-ULAC120 3 POLE RELAY	8.90/9.33
ALL	SR3B-05 3 POLE SOCKET	3.00/2.40
ALL	RH3B-ULAC120 3 POLE RELAY	8.50
ALL	RH4B-ULAC120 4 POLE RELAY	10.50
ALL	SH3B-05 3 POLE SOCKET	3.50
ALL	SH4B-05 4 POLE SOCKET	4.55
ALL	RY4S-ULAC120 4 POLE RELAY	8.00
ALL	SY4S-05 4 POLE SOCLET	5.45
ALL	RTE-P11-120 TIMING RELAY	32.00
ALL	RTE-P12-120 TIMING RELAY	35.00
ALL	SR2P-06 8 PIN SOCKER	2.75
ALL	6H38TSKK-C TERMINAL BLOCK	.50
ALL	6H38-E-C END SECTION	.40
ALL	MPC-6 6 FOOT MOUNTING RAIL	~~8.00~~ 8.50
ALL	6R30A3SP CLASS R 600 VOLT 3 POLE FUSE BLOCK	8.30
ALL	R30A3SP CLASS R 250 VOLT 3 POLE FUSE BLOCK	5.30
ALL	320 20 POLE TERMINAL STRIP	9.50
ALL	1103P TERMINAL STRIP	4.90
ALL	1423570 DISTRIBUTION BLOCK	10.18
ALL	1433555 DISTRIBUTION BLOCK	22.50
ALL	1443560 DISTRIBUTION BLOCK	40.25

Russ Fineran