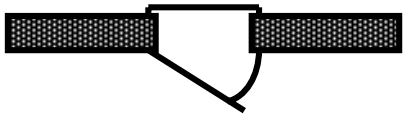
ENCO U-20B01

DESIGN INTERIOR ELECTRICAL WIRING SYSTEMS WORKBOOK

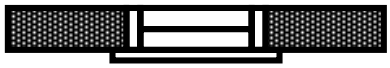
CONSTRUCTION SYMBOLS

INTERIOR SINGLE HINGE DOOR



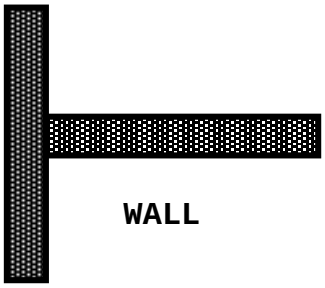
EXTERIOR SINGLE HINGE DOOR

SLIDING DOORS

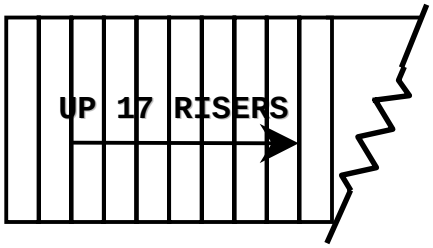


DOUBLE HUNG WINDOW

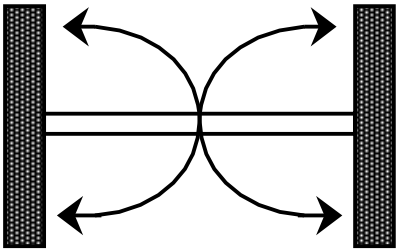
FOLDING DOORS



WALL



STEPS OR STAIRS



SWINGING DOORS

ELECTRICAL SYMBOLS

CEILING OUTLET

P LAMPHOLDER WITH A PULL SWITCH (PULLCHAIN)

F FAN OUTLET

WIRES CROSSING (NOT CONNECTED)

D DRYER OUTLET

DUPLEX OUTLET

SPLIT CIRCUIT OUTLET (SPLIT WIRED RECEPTACLE)

GROUND FAULT CIRCUIT INTERRUPT OUTLET

SWITCH AND FUSE

FLUORESCENT FIXTURE

WALL MOUNTED OUTLET

FLOOR OUTLET

WIRES CROSSING (CONNECTED)

R RANGE OUTLET

SPECIAL PURPOSE 240V OUTLET

GR GROUNDING TYPE DUPLEX OUTLET

WP WEATHERPROOF DUPLEX OUTLET

BATTERY

FUSE

S_1 OR S SINGLE POLE SWITCH

S_D DOOR SWITCH

S_3 THREE WAY SWITCH

S_P SWITCH WITH PILOT

BUZZER

OR CH CHIME

M MOTOR

ANNUNCIATOR

GROUND CONNECTION

HOME RUN

DOUBLE HOME RUN

OR BRANCH CIRCUIT WIRING

S_2 DOUBLE POLE SWITCH

S_4 FOUR WAY SWITCH

PUSH BUTTON SWITCH

BELL

C OR CLOCK

J JUNCTION BOX

CIRCUIT BREAKER

OR PANELBOARD

CIRCUIT NUMBER

NUMBER OF CONDUCOTRS CONTAINED IN A RACEWAY

WORKSHEET FOR A ONE FAMILY DWELLING
STANDARD CALCULATION FOR SERVICE EQUIPMENT
EXAMPLE - CHAPTER 9 APPENDIX D PAGE 609

1. Square footage of the structure.
   Sqft = length x width
2. General lighting load - Table 220 - 3 (a)
   _____sqft. x 3VA = _____VA
3. Minimum number of branch circuits required
   use ohm's law **A = VA ÷ V**
   _____VA ÷ 120V = _____A
   Then divide the answer by 15 and 20 ____15A
   to find the minimum number of branch circuits ____20A
4. Small Appliance loads - 210 - 11 (c) (1) & 220 - 16 (a)
   1500VA x _____# of circuits = _____VA
5. Laundry load - 210 - 11 (c) (2) & 220 - 16 (b)
   1500VA x _____# of circuits = _____VA
6. Find total general lighting and small appliance/laundry load
   add 2,4,5 (total) _____VA
7. Apply demand factors to find **NET** general lighting and small appliance/laundry load - Table 220 - 11
   First 3000 VA x 100% = _____VA
   Next _____VA x 35% = _____VA
   Remaining _____VA x 25% = _____VA
   (Total) _____ VA = **NET**

USE NET FOR REMAINING CALCULATIONS

NET _____VA

8. Cooking Equipment Load Table - 220 - 19 (notes)
   Column A _____VA demand = _____VA
   Column B _____VA x _____% = _____VA
   Column C _____VA x _____% = _____VA
   (Total) _____VA RANGE _____VA
9. Dryer load - 220 - 18; Table 220 - 18
   5000VA or Nameplate (table only applies if there are 5 or more) DRYER _____VA
10. Fixed Appliances - 220 - 17 (demand only applies if there are4 or more)
    Dishwasher = _____VA
    Disposal = _____VA
    Compactor = _____VA
    Water heater = _____VA
    _____ = _____VA
    _____ = _____VA
    _____= _____VA
    _____ = _____VA
    (total) _____VA x 75% = FIXED APPLIANCES _____VA
11. Heating or A/C load - 220 - 21
    Heating unit = _____VA
    A/C unit = _____VA
    Heat pump = _____VA (largest heat or A/C load)_____VA
12. Largest motor load - 220 - 14 ; 430 - 24
    _____VA x 25% = LARGEST MOTOR _____VA

TOTAL= _____VA

13. Use ohm's law to figure out total amperage. **A = VA ÷ V**

TOTAL _____VA ÷ 240V = Total Amps_____A

14. Go to Table 310 - 15 (b) (6) to find sizes for service panel and ungrounded conductors.

SERVICE PANEL_____AMPERES

ALUMINUM UNGROUNDED CONDUCTORS_____(AWG OR KCMIL)

15. Find the size of the grounded (neutral) conductor. 220 - 22

NET_____VA

RANGE_____VA x 70% =_____VA

RANGE _____VA

DRYER_____VA x 70% =_____VA

DRYER _____VA

16. Fixed Appliances - 220 - 17 (demand only applies if there are4 or more)

(FOR NEUTRAL CALCULATION USE ONLY 120V LOADS)

Dishwasher = _____VA
Disposal = _____VA
Compactor = _____VA
Water heater = _____VA
_____ = _____VA
_____ = _____VA
_____= _____VA
_____ = _____VA
(total) _____VA x 75% =

FIXED APPLIANCES _____VA

17. Heating or A/C load - 220 - 21

Heating unit = _____VA
A/C unit = _____VA
Heat pump = _____VA

(largest heat or A/C load)_____VA

18. Largest motor load - 220 - 14 ; 430 - 24

_____VA x 25% =

LARGEST MOTOR _____VA

TOTAL = _____VA

19. Use ohm's law to figure out total amperage. **A = VA ÷ V**

TOTAL _____VA ÷ 240V = Total Amps _____A

20. Demand for neutrals over 200amps

First 200amps x 100% = _____A
Remainder x 70% = _____A
Total = _____A

21. Select the size of the grounded (neutral) conductor. Table 310 - 16

If size of the panel is 100amps or smaller use 60 °c column.
If size of the panel is over 100amps use 75 °c column.

ALUMINUM GROUNDED CONDUCTOR_____(AWG OR KCMIL)

22. Size the Grounding Electrode Conductor. Table 250 - 66 ; 250 - 50

COPPER GROUNDING ELECTRODE CONDUCTOR_____(AWG OR KCMIL)

SUPPLEMENTAL GROUNDING ELECTRODE CONDUCTOR_____(AWG OR KCMIL)

WORKSHEET FOR ELECTRIC RANGES ART. - 220-19

COLUMN A

EXAMPLE # 1.
ONE RANGE 11KW - USE THE DEMAND FACTOR IN COLUMN A FOR ONE RANGE
DEMAND FACTOR = 8KW

EXAMPLE # 2.
TWO RANGES; 10KW, 11KW - USE THE DEMAND FACTOR IN COLUMN A FOR TWO RANGES **DEMAND FACTOR = 11KW**

PROBLEMS USE TABLE 220-19, COLUMN A TO FIND THE DEMAND FACTOR FOR EACH PROBLEM.

1. ONE RANGE 12KW = _____DEMAND FACTOR

2. TWO RANGES; 11KW EACH = _____DEMAND FACTOR

3. THREE RANGES; 10KW EACH = _____DEMAND FACTOR

4. ONE RANGE 11.2KW = _____DEMAND FACTOR

5. ONE RANGE 9.2KVA = _____DEMAND FACTOR

6. TWO RANGES; 9,500W EACH = _____DEMAND FACTOR

7. FIVE RANGES; 12KW EACH = _____DEMAND FACTOR

8. TWO RANGES; 10KW, EACH = _____DEMAND FACTOR

9. THREE RANGES; 11KW EACH = _____DEMAND FACTOR

10. ONE RANGE 9.3KW = _____DEMAND FACTOR

220-19 NOTE (1)
ALL OF SAME RATING

EXAMPLE # 1.
ONE RANGE 16KW
(1) 16KW (2) 4 x 5% = 20%
-12KW
4

(3) ADD 20% TO THE DEMAND FACTOR FOR ONE RANGE IN COLUMN A 8KW x 20% = 1600VA
8,000VA + 1600VA = **9,600VA DEMAND FACTOR**.

EXAMPLE # 2.
TWO RANGES 15KW EACH
(1) 15KW (2) 3 x 5% = 15%
-12KW
3

(3) ADD 15% TO THE DEMAND FACTOR FOR TWO RANGES IN COLUMN A 11KW x 15% = 1650VA
11,000VA + 1650VA = **12,650VA DEMAND FACTOR**.

PROBLEMS USE TABLE 220-19 AND NOTE (1) TO FIND THE DEMAND FACTOR FOR EACH PROBLEM. USE THE BACK OF THIS SHEET AND SHOW ALL WORK.

1. ONE RANGE 20KW = _____DEMAND FACTOR

2. TWO RANGES 13KW EACH = _____DEMAND FACTOR

3. FOUR RANGES 19KW EACH = _____DEMAND FACTOR

4. ONE RANGE 26KW = _____DEMAND FACTOR

5. ONE RANGE 22KW = _____DEMAND FACTOR

6. TWO RANGES 21KW EACH = _____DEMAND FACTOR

7. THREE RANGES 12.8KW EACH = _____DEMAND FACTOR

8. SIX RANGES 16.9KW EACH = _____DEMAND FACTOR

9. TWO RANGES 17KW EACH = _____DEMAND FACTOR

10. THREE RANGES 14.1KW EACH = _____DEMAND FACTOR

220-19 NOTE (2)

EXAMPLE # 1.
TWO RANGES 16KW, 14KW

(1) 16KW	(2) 30	(3) 15	(4) 3 x 5% = 15%
+14KW	÷ 2	- 12	
30	15 .	3	

(5) ADD 15% TO THE DEMAND FACTOR FOR TWO RANGES IN COLUMN A
11KW x 15% = 1650VA 11,000VA + 1650VA = **12,650VA DEMAND FACTOR**

EXAMPLE # 2.
THREE RANGES 15KW, 20KW, 17KW

(1) 15KW	(2) 52	(3) 17	(4) 5 x 5% = 25%
17KW	÷ 3	- 12	
+20KW	17.3	5	
52KW			

(5) ADD 25% TO THE DEMAND FACTOR FOR THREE RANGES IN COLUMN A
14KW x 25% = 3500VA 14,000VA + 3500VA = **17,500VA DEMAND FACTOR**

PROBLEMS USE TABLE 220-19 AND NOTE (2) TO FIND THE DEMAND FACTOR FOR EACH PROBLEM. USE THE BACK OF THIS SHEET AND SHOW ALL WORK.

1. TWO RANGES 20KW, 15KW = _____DEMAND FACTOR

2. TWO RANGES 13KW, 16KW = _____DEMAND FACTOR

3. FOUR RANGES 19KW, 23KW, 16KW, 17KW = _____DEMAND FACTOR

4. TWO RANGES 14KW, 15KW = _____DEMAND FACTOR

5. TWO RANGES 18KW, 22KW = _____DEMAND FACTOR

6. TWO RANGES 21KW, 13KW = _____DEMAND FACTOR

7. THREE RANGES 12KW, 8KW, 10KW = _____DEMAND FACTOR

8. THREE RANGES 16KW, 11KW, 19KW = _____DEMAND FACTOR

9. TWO RANGES 17KW, 22KW = _____DEMAND FACTOR

10. THREE RANGES 14KW, 9KW, 18KW = _____DEMAND FACTOR

220-19 NOTE (3)
COLUMN B AND C

EXAMPLE # 1.
ONE RANGE 5KW
(1) USE COLUMN **C** AND APPLY DEMAND FACTOR FOR ONE RANGE
(2) 5KW x 80% = **4KW**

EXAMPLE # 2.
TWO RANGES 2KW EACH
(1) ADD RANGES 2KW + 2KW = 4KW
(2) USE COLUMN **B** AND APPLY DEMAND FACTOR FOR TWO RANGES
(3) 4KW x 75% = **3KW**

EXAMPLE # 3.
THREE RANGES 2KW, 5KW, 7KW
(1) FIND THE TOTAL KW'S THAT FALL UNDER COLUMN B = 2KW
(2) USE COLUMN B AND APPLY DEMAND FACTOR FOR ONE RANGE
(3) 2KW x 80% = 1.6KW
(4) FIND THE TOTAL KW'S THAT FALL UNDER COLUMN C = 5KW + 7KW = 12KW
(5) USE COLUMN C AND APPLY DEMAND FACTOR FOR TWO RANGES
(6) 12KW x 65% = 7.8KW
(7) ADD DEMANDS OF BOTH COLUMNS TOGETHER
(8) 1.6KW + 7.8KW = **9.4KW**

PROBLEMS USE TABLE 220-19 AND NOTE (3) TO FIND THE DEMAND FACTOR FOR EACH PROBLEM. USE THE BACK OF THIS SHEET AND SHOW ALL WORK.

1. ONE RANGE 4KW = _____DEMAND FACTOR

2. TWO RANGES 6KW EACH = _____DEMAND FACTOR

3. FOUR RANGES 2KW, 3KW, 5KW, 6KW = _____DEMAND FACTOR

4. ONE RANGE 7KW = _____DEMAND FACTOR

5. ONE RANGE 2.5KW = _____DEMAND FACTOR

6. TWO RANGES 4.5KW EACH = _____DEMAND FACTOR

7. THREE RANGES 3KW, 2.5KW, 3.5KW = _____DEMAND FACTOR

8. SIX RANGES 4KW, 5KW, 6KW, 2KW, 7KW, 3KW = _____DEMAND FACTOR

9. TWO RANGES 5KW, 6KW = _____DEMAND FACTOR

10. THREE RANGES 6KW EACH = _____DEMAND FACTOR

WORKSHEET FOR ELECTRIC CLOTHES DRYERS ART. - 220-18

EXAMPLE # 1
ONE DRYER 3900VA = **5000VA DEMAND FACTOR**

EXAMPLE # 2
ONE DRYER 7500VA = **7500VA DEMAND FACTOR**

EXAMPLE # 3
FIVE DRYERS @ 3500VA EACH
(1) 5 x 5000 = 25,000VA
(2) 25,000 x 80% = **20,000VA DEMAND FACTOR**

PROBLEMS USE ARTICLE AND TABLE 220-18 TO FIND THE DEMAND FACTOR FOR EACH PROBLEM. USE THE BACK OF THIS SHEET AND SHOW ALL WORK.

1. ONE DRYER 3.8KW = _____ DEMAND FACTOR

2. ONE DRYER 6.5KW = _____ DEMAND FACTOR

3. ONE DRYER 5000VA = _____ DEMAND FACTOR

4. ONE DRYER 2500VA = _____ DEMAND FACTOR

5. ONE DRYER 9000VA = _____ DEMAND FACTOR

6. ONE DRYER 6.2KVA = _____ DEMAND FACTOR

7. TWO DRYERS 3.8KW EACH = _____ DEMAND FACTOR

8. SIX DRYERS 6000VA EACH = _____ DEMAND FACTOR

9. TEN DRYERS, 5 @ 4KVA AND 5 @ 6.5KVA = _____ DEMAND FACTOR

10. ONE DRYER 5100VA = _____ DEMAND FACTOR

WORKSHEET FOR ELECTRIC APPLIANCE LOAD ART. - 220-17

EXAMPLE # 1

DISHWASHER	=	1,000VA
DISPOSAL	=	750VA
COMPACTOR	=	1,500VA
WATER HEATER	=	4,500VA
(TOTAL)		7,750VA x 75% = **5,812.5VA DEMAND FACTOR**

EXAMPLE # 2

DISPOSAL	=	750VA
COMPACTOR	=	1,500VA
WATER HEATER	=	4,500VA
(TOTAL)		**6,750VA DEMAND FACTOR**

PROBLEMS USE ARTICLE 220-17 TO FIND THE DEMAND FACTOR FOR EACH PROBLEM. **(FOR UNGROUNDED CONDUCTORS)** USE THE BACK OF THIS SHEET AND SHOW ALL WORK.

1. DISHWASHER @ 1250VA, WATER HEATER @ 4000VA, DISPOSAL @ 900VA, COMPACTOR @ 1200VA, ATTIC FAN @ 1000VA = _____VA DEMAND FACTOR

2. DISHWASHER @ 1000VA, WATER HEATER @ 4800VA, DISPOSAL @ 700VA, COMPACTOR @ 1500VA = _____VA DEMAND FACTOR

3. WATER HEATER @ 4200VA, DISPOSAL @ 1200VA, COMPACTOR @ 1.2KVA, ATTIC FAN @ 1300VA = _____VA DEMAND FACTOR

4. DISHWASHER @ 1050VA, WATER HEATER @ 4KVA, DISPOSAL @ 800VA, COMPACTOR @ 1120VA, ATTIC FAN @ 1100VA = _____VA DEMAND FACTOR

5. DISPOSAL @ 875VA, COMPACTOR @ 1000VA, ATTIC FAN @ 900VA = _____VA DEMAND FACTOR

6. DISHWASHER @ 1350VA, WATER HEATER @ 4050VA, DISPOSAL @ 950VA, COMPACTOR @ 1275VA, ATTIC FAN @ 1050VA = _____VA DEMAND FACTOR

7. WATER HEATER @ 4.8KVA, DISPOSAL @ .9KVA, COMPACTOR @ 1100VA, ATTIC FAN @ 1.5KVA = _____VA DEMAND FACTOR

8. DISHWASHER @ 1300VA, WATER HEATER @ 5500VA, DISPOSAL @ 875VA, COMPACTOR @ 1250VA = _____VA DEMAND FACTOR

9. DISHWASHER @ 1600VA, WATER HEATER @ 4900VA = _____VA DEMAND FACTOR

10. WATER HEATER @ 4900VA = _____VA DEMAND FACTOR