CONTENT

Preface

The writing of this book is an accumulation of over 65 years electrical experience working as an apprentice electrician, journeyman electrician, industrial electrician, construction electrician, master electrician, electrical inspector, author of over 100 books, and over 28 years as an electrical instructor preparing over 22,000 electricians throughout the U.S.A. for their electrical license examination.

I have learned how broad the term "electrician" can be in the specialized world we work in today.

I consider myself very fortunate to have been able to work in several of the "electrician" categories. Starting in 1956 as an apprentice electrician on diesel locomotives, I learned the DC theory, generation, and horsepower. Later I worked as a railway signalman, a job that involves the climbing of poles and maintenance of cross-arms, towers, and gates. In the automated industry you are the "control electrician", the troubleshooter and maintainer. As a construction electrician, you are the installer. At Disney World, I was a monorail electrician working on everything from the sophisticated control systems to the traction motors. As a master electrician, I was the electrical contractor involved with the electrical permits, design and running the job. As an electrical inspector, you become the authority on the rules. As the electrical instructor and author, you never stop learning or studying and researching the exceptions and the fine print notes.

My objective in writing this book is to make the electrical exam calculations easier for the "electrician."

The electrical examination is something that will follow some electricians throughout their career.

An electrical license is required by most cities, counties, and states (which generally do not reciprocate). This requires taking electrical exams in different areas as you travel in your electrical work.

I have found in my experiences that test-taking by the electrician is difficult for the simple reason that an electrician is working from a blueprint where the calculations were performed by an electrical designer. Often in the field, we use a slide for determining how many conductors can be installed in a certain size conduit or what size overloads are required for a motor, etc. The electrical exam requires the electrician, with the Code Book, to determine the maximum fill permitted in the conduit, the minimum size overloads, and to design the electrical system to the Code minimum requirements, which requires applying all the rules and demand factors that apply.

For some contractors, it has been twenty years or more since they have used math formulas, theory, and calculations. For most, the last time was an apprenticeship class. Now, for the exam, we are required to be an expert in the reading of the Code and in applying all of the tables and demand factors to the calculations.

In the exam preparation classes we teach, we're continually mentioning the “careful reading of each word” in the exam calculation question. You must first understand what the question is asking before you can accurately solve the calculation.

The key to the exam is that the student must first **understand** the question, which requires **careful reading of each word.**

Read this sentence:

FINISHED FILES ARE THE RE-
SULT OF YEARS OF SCIENTIF-
IC STUDY COMBINED WITH THE
EXPERIENCE OF YEARS.

Now read it once more, and count the **F’s** in the sentence. How many did you find?

(a) 3 (b) 4 (c) 5 (d) 6

If you are a careful reader, you will find all **6** F’s.

If I had to select one key word, it would be the word **minimum**. Keep in mind that the Code is the minimum requirement. In reality, we often exceed the Code minimum requirements as we design for the future and a more economical and efficient electrical system. Exam calculations will require determining the minimum conductor size, minimum size service, etc. To find the minimum, we must apply each demand factor and Code rule that is applicable.

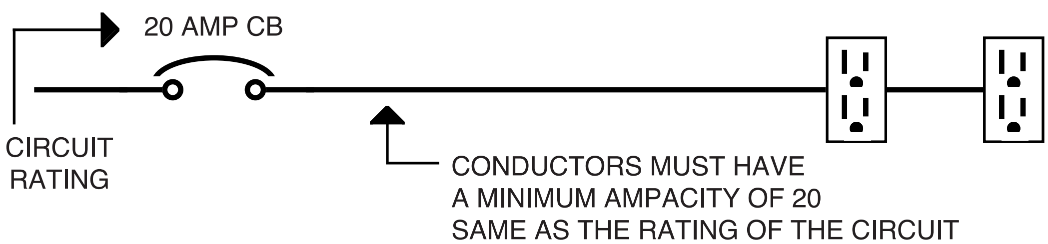
As you read the exam question, circle key words such as: copper or aluminum, single-phase or three-phase, branch-circuit or feeder, minimum or maximum, grounded or ungrounded conductor, fuse or circuit breaker, metallic or nonmetallic, neutral or ungrounded conductor, demand load or connected load, continuous load or noncontinuous load, THW or THHN insulation type, RHH with an outer cover or without an outer cover, dwelling or nondwelling occupancy, general or optional method of calculation. As you can see, the changing of **one word** in a question can change the answer. As you study from the book, learn to circle each key word in the calculation question. Never memorize answers! Learn from this book the proper way to prepare for your electrical examination.

CONDUCTORS - MINIMUM SIZE AMPACITY

To properly solve branch-circuit sizing calculations, you must meet the conductor ampacity requirements.

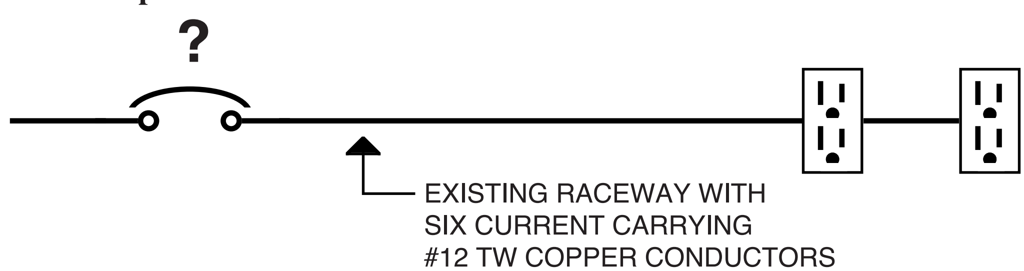
Section 210.19(A)(1). Branch-circuit conductors shall have an ampacity not less than the maximum load to be served. Where a branch circuit supplies continuous loads or any combination of continuous and noncontinuous loads, the minimum branch-circuit conductor size, before the application of any adjustment or correction factors, shall have an allowable ampacity equal to or greater than the noncontinuous load plus **125% of the continuous load**.

210.19(A)(2). Conductors of **branch circuits** supplying **more than one receptacle** for **cord-and plug-connected** portable loads shall have an ampacity of not less than the **rating** of the branch circuit.



A #14 TW conductor has an **ampacity** of 15, and the * asterisk, which refers you to the bottom of Table 310.16 states a #14 conductor can only be fused at a maximum of 15 amps (240.4D). A #12 TW with an ampacity of 20 would be protected at 20 amps and would be the correct selection of conductor for this receptacle circuit.

What is the maximum size circuit breaker permitted for the following **branch circuit** that supplies **more than one receptacle**?



Branch circuits rated 10 amperes shall not supply receptacle outlets.

Section 310.15(C)(1) requires an ampacity adjustment factor for more than three current carrying conductors, for **six** current carrying conductors, a reduction in ampacity of 80% is required.

Table 310.15(C)(1). Ampacity Adjustment Factors.
(a) More than Three Current Carrying Conductors in a Raceway or Cable. Where the number of conductors in a raceway or cable exceeds three, the ampacities shall be reduced as shown in the following table:

Number of Conductors	Percent of Values in Tables as Adjusted for Ambient Temperature if Necessary
4 through 6	80
7 through 9	70
10 through 20	50
21 through 30	45
31 through 40	40
41 through 60	35

Table 310.16: A #12 TW has an ampacity of 20. The 310.15(C)(1) factor requires the 20 ampacity to be reduced 80%. 20a x 80% = 16 ampacity and maximum load permitted on this conductor.

Section 240.4(B)(2) states the next **higher** size overcurrent protective device can be used where the ampacity of the conductor does not correspond with the standard size overcurrent device.

The reduced ampacity is 16 amps which is not a standard size fuse or breaker. The next higher standard size from Table 240.6(A) is 20 amps. If the conductor is **not** part of a **branch circuit supplying more than one receptacle for cord and plug connected portable loads**, then 20 amps is permitted per Section 240.4(B)(3).

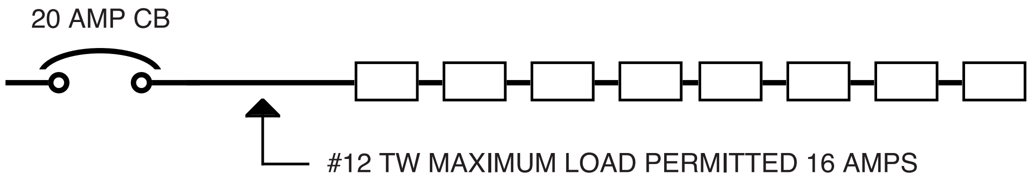
Since this example shows the branch circuit supplying receptacles, the maximum size overcurrent device would be 15 amp. A 15 amp overcurrent device would protect the conductors at 15 amp. **If** a 20 amp overcurrent device was installed, loads could be plugged into the receptacles loading the circuit to the maximum rating of 20 amp. This would be in **excess** of the 16 ampacity or maximum loading which would result in exceeding the insulation rating of the conductor. This will be explained in full detail in Chapter 2.

If the loads on this branch circuit were **hard wired** instead of plug and cord connected receptacles, then the next higher overcurrent device 20 amp is permitted.

The electrical designer or electrician designing a lighting branch circuit could encounter this very same example.

A raceway containing six #12 TW current carrying conductors to light fixtures. The reduced ampacity and maximum load permitted on these conductors is 16 amps. If each light fixture has a load of 2 amps, 16 ÷ 2 = 8 or a maximum of 8 lights at 2 amps each = 16 amps which would not exceed the maximum load permitted of 16.

If eight light fixtures at 2 amps each (known loads) are **hard wired** to the branch circuit, the next higher standard size 20 amp overcurrent device is permitted per Section 240.4(B)(1).



The designer of this circuit must limit the connected load to 16 amps or less.

As an electrical inspector, this is what I would explain to the electrician in the field when he said "I'm only adding **one** light to the existing circuit." As you can see in the example **one** more light would exceed the maximum load permitted on the existing conductors.

CONTINUOUS LOAD

Article 100 - Definition of Continuous Load: A load where the maximum current is expected to continue for **three** hours or more.

Article 100 - Definition of Ampacity: The maxium current in amperes a conductor can carry **continuously** under the conditions of use without exceeding its temperature rating.

Section 210.20(A). The rating of the branch-circuit overcurrent device serving continuous loads shall not be less than the noncontinuous load plus **125% of the continuous load.** The minimum branch-circuit conductor size, without the application of any adjustment or correction factors, shall have an allowable **ampacity equal to or greater than** the noncontinuous load plus 125% of the continuous load.

Continuous loads shall not exceed 80% of the rating of the branch circuit. The reason for limiting the load to 80% is **not** that the conductors can't carry the continuous load. The 80% is a current limitation on the **overcurrent device** to limit the **heat**. Remember, the overcurrent device **not** the conductors.

The **80%** limitation is based on the **inability** of the overcurrent device itself to handle continuous load without overheating.

Neutral conductor loads would **not** be calculated at continuous. The neutral conductor that is not connected to an overcurrent device has **no heating effect to the overcurrent device**. Same with service conductors. The **line** side service conductors are not calculated at continuous, they don't connect to overcurrent devices so there is no heating effect.

220.41 Dwelling Units, Minimum Unit Load.
In one and two family, and multifamily dwellings, the minimum unit load shall not be less than **3 volt-amperes** per square foot.

Table 220.45 Lighting Load Demand Factors

Type of Occupancy	Portion of Lighting Load to Which Demand Factor Applies (volt-amperes)	Demand Factor Percent
Dwelling Units	First 3000 or less at	100
	From 3001 to 120,000 at	35
	Remainder over 120,000 at	25
Hotels and Motels — Including Apartment Houses without Provisions for Cooking by Tenants*	First 20,000 or less at	60
	From 20,001 to 100,000 at	50
	Remainder over 100,000 at	35
Warehouses (Storage)	First 12,500 or less at	100
	Remainder over 12,500 at	50
All Others	Total Volt-amperes	100

* The demand factors of this table shall **not** apply to the calculated load of feeders or sevices supplying areas in hotels, and motels where the entire lighting is likely to be used at one time, as in ballrooms, or dining rooms.

Determining the Minimum Number of Lighting Branch Circuits for a 1500 square foot One-Family Dwelling

•Example D1(a) page 834

General Lighting Load	1500 x 3va (220.41) = 4500va
General Lighting Load	4500va ÷ 120 volts = 38 amps
This requires	Three 15 amp or two 20 amp branch circuits

Section 220.45 states the demand factors from Table 220.45 shall **not** apply when determining the number of branch circuits for general illumination.

Good judgement and common sense will answer most of the exam questions on continuous loading.

220.41 Dwelling occupancies are **not** considered continuous lighting loads due to the small loading.

CONDUCTOR TERMINATIONS

The frequent misapplication of conductor temperature ratings occurs when the rating of the equipment is ignored when connecting the conductor. One must follow the rules of section 110.14(C)(1).

Shown below are the ampacities and temperature ratings for a #10 conductor.

#10 TW 30 ampacity
60°C - 140°F temperature rating

#10 THW 35 ampacity
75°C - 167°F temperature rating

#10 THHN 40 ampacity
90°C - 194°F temperature rating

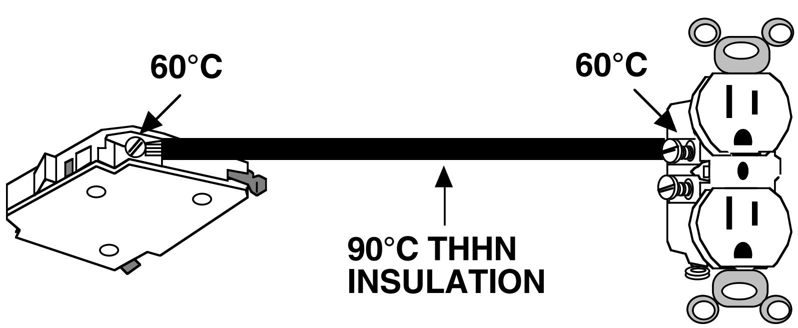
Conductors carry a specific temperature rating based on the *type* of insulation on the conductor.

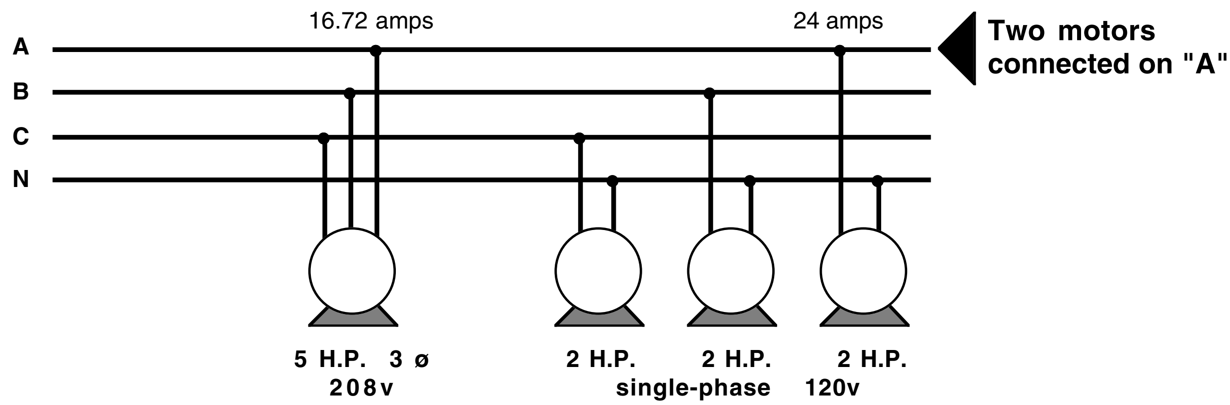
Conductor sizing must be determined to where the conductors will terminate and the rating of the termination.

If a termination is rated for 60°C, this means that the temperature at that termination may rise up to 60°C when the equipment is loaded to its *ampacity*. Any additional heat at the connection above the 60°C conductor insulation rating could cause damage to the conductor insulation.

When a conductor is chosen to carry a specific load, the electrician must know the termination ratings of the equipment in the entire circuit.

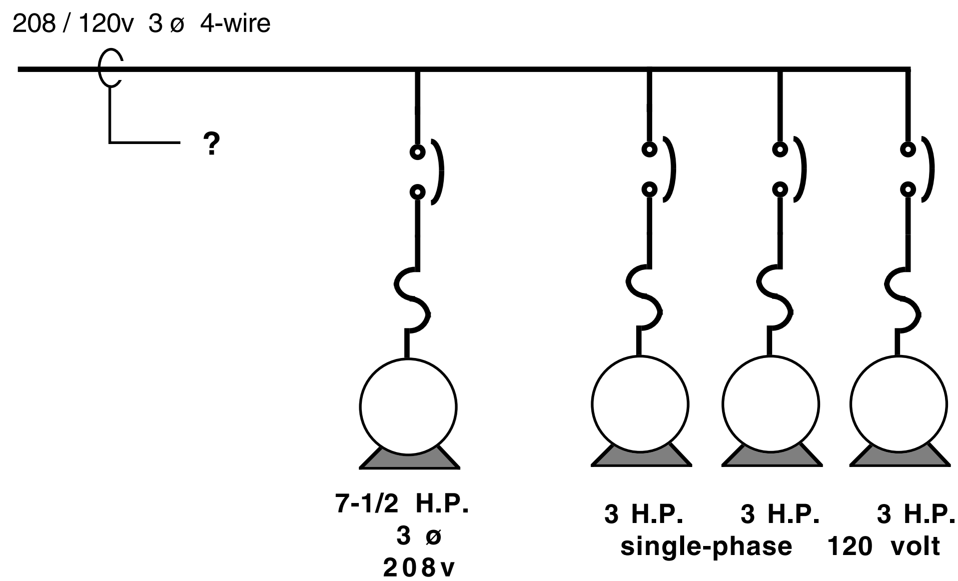
When connecting the 90°C THHN insulation to 60°C rated equipment, the THHN cannot be loaded over the 60°C ampacity.



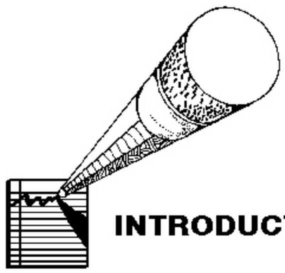


When the exam question mentions a three-phase motor with **single-phase 120 volt motors**, draw a sketch and make the motor connections for the proper voltages (208v is line to line and 120v is line to neutral). Now count how many motors you have on the **SAME** conductor. This is the **key** in answering this type of question. The error generally made is counting four motors instead of **two**.

Example: What is the minimum size copper feeder conductor using TW insulation for a 7 1/2 hp, three-phase, 208v motor and three - 3 hp, single-phase, 120v motors?



Solution: Table 430.250: 7 1/2 hp, 208v F.L.C. = 24.2 amps. Table 430.248: 3 hp, 120v F.L.C. = 34 amps. The largest motor is the 3 hp at 34 amps. 34 amps x 125% = 42.5 amps + 24.2 amps = 66.7 required ampacity. Table 310.16 would require a #4 TW copper conductor minimum.



INTRODUCTION

MOTOR CONTROLS

The intent of Chapter 3-A is to familiarize you with the type of exam questions on motor controls.

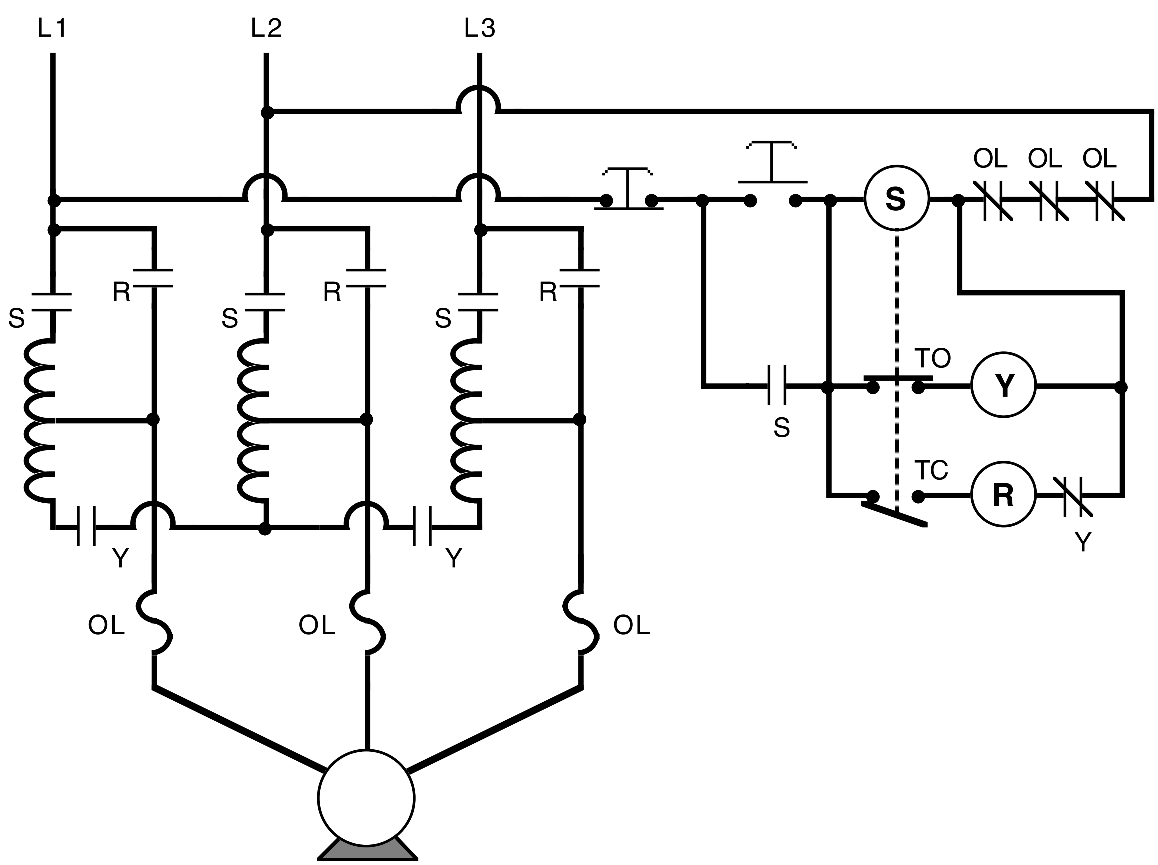
Some electrical exams ask for the sequence from stop to full run position, requiring a detailed **show your work** type answer. Whereas other exams ask a **multiple choice** type question from a **part** of the sequence, or a question from general motor control wiring knowledge.

Motor control type questions generally are asked on a Master examination and not Journeyman.

The following examples will cover both types of questioning.

The intent of this Chapter is not to teach you motor controls, but to familiarize you with exam questioning on motor controls. If motor controls and reading schematics is a problem for you, **I strongly recommend our book and DVD on motor controls**.

Example: In your own words, using the following diagram, list the sequence from **stop** position to **full run** position.



Solution:

2 - #12 black conductors = 2 conductors
2 - #12 white conductors = 2 conductors
2 - #12 bare conductors = 1 conductor
1 - receptacle strap = 2 conductors
2 - cable clamps = 1 conductor
8 - #12 conductors = 8 x 2.25 cubic inches = 18 cubic inches

1 - #14 black conductor = 1 conductor
1 - #14 white conductor = 1 conductor
1 - switch strap = 2 conductors
1 - #14 bare conductor = 0 counted as a #12 (314.16)(B)(5)
1 - cable clamp = 0 counted as a #12 (314.16)(B)(2)
4 - #14 conductors = 4 x 2 cubic inches = 8 cubic inches

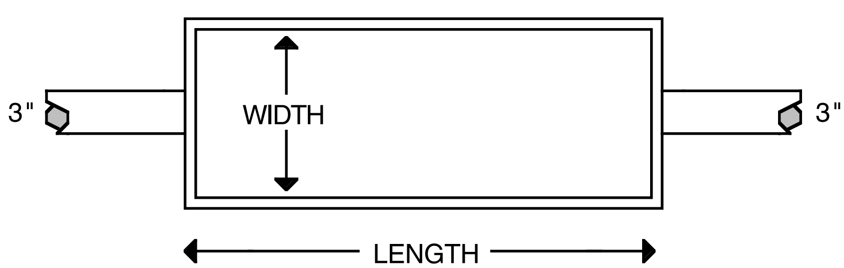
18 cubic inches + 8 cubic inches = **26 cubic inch box required minimum**.

Table 314.16(A) and Table 314.16(B)(1) show conductor sizes **through #6**. For conductor sizes **#4 and larger** 314.28 is used for calculations.

CONDUCTORS #4 and LARGER

314.28(A). Minimum size. For raceways 3/4 inch trade size or larger, containing conductors of #4 or larger, and for cables containing conductors #4 or larger, the minimum dimensions of pull or junction boxes installed in a raceway or cable run shall comply with the following:

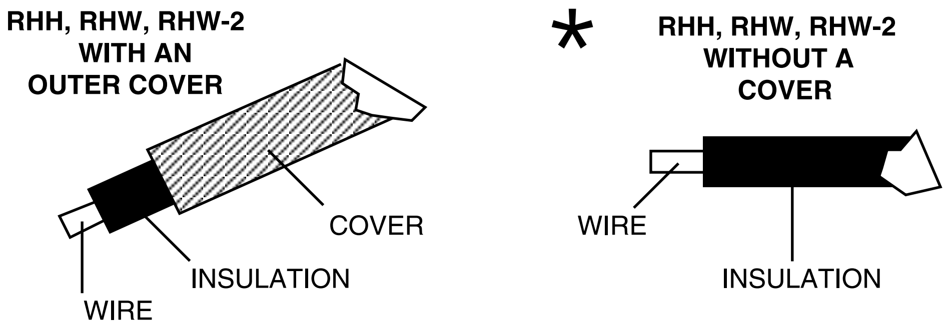
(1) **Straight Pulls**. In straight pulls, the length of the box or conduit body shall not be less than **eight times** the trade diameter of the largest raceway.



LENGTH = 3" conduit x 8 = 24" minimum.

WIDTH - The box must be wide enough to provide proper installation of the conduit locknuts and bushings within the box.

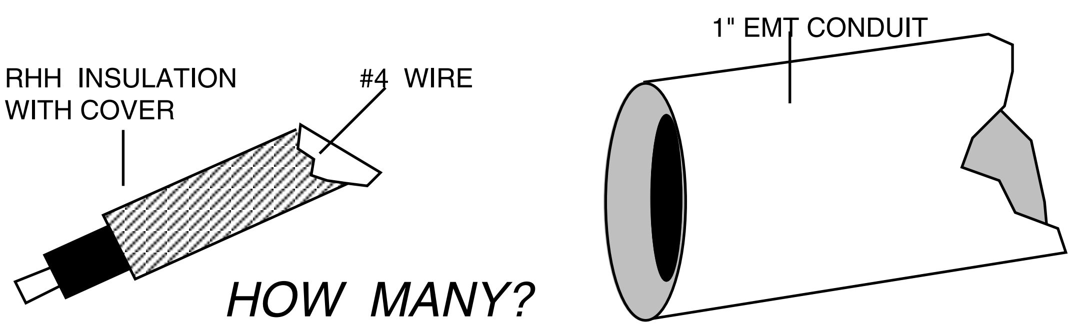
RHH, RHW, RHW-2 SUMMARY



Example: What is the area square inch for a #12 RHW conductor without an outer covering?

Solution: Table 5 lists a #12 RHW* conductor without an outer covering at **.0260 sq.in.**

Example: How many #4 RHH conductors with an outer covering can you install in a 1" EMT conduit?

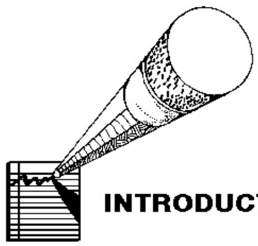


Solution: Use Tables 4 & 5 for this calculation.

Table 4 - 1" EMT conduit 40% fill = .346 square inch
Table 5 - #4 RHH conductor = .1333 square inch

.346 ÷ .1333 = 2.59 or **2 conductors.**

CHAPTER 5 COOKING EQUIPMENT DEMAND FACTORS



INTRODUCTION

Demand Factor: The ratio of the maximum demand of a system, or part of a system, to the total connected load of a system or the part of the system under consideration.

When an exam question asks for the **minimum** size conductor or service size, you must apply all the **demand factors** that can be applied to the calculation. If you forget one demand, then you never reach the **minimum**.

A demand factor is a reduction in conductor size. When calculating demand factors, you should think of the lowest amount, smallest size, the **minimum** permitted is your best deal, as copper is money $$$.

Starting in this Chapter with Cooking Equipment Demands and following in the next two chapters with feeder-service demands in dwelling and commercial occupancies, we will be applying the various demand factors allowed to the equipment.

The Code permits a demand factor (reduction) to be used in certain areas of a system. Lighting, receptacles, cooking equipment, clothes dryers, fastened in place appliances, to which the Code allows a demand factor to be applied.

The reason for allowing these demand factors, **all** the lights won't be on at the **same** time, nor will **all** the receptacles be **fully** loaded at the **same** time, etc.

Example: Section 220.60. Electric heat and air conditioning shouldn't **both** be on at the **same** time, the Code allows the **smallest** load to be omitted in the feeder or service calculation.

Throughout Article 220 you are permitted a demand factor on certain parts of the system.

T.220.55 DEMAND LOADS HOUSEHOLD COOKING EQUIPMENT

Table 220.55. Demand loads for household electric ranges, wall-mounted ovens, counter-mounted cooking units, and other household cooking appliances over **1 3/4 kW** rating. 1 3/4 kW = 1750 watts.

The first column of Table 220.55 shows **Number of Appliances**. The column lists 61 and over, a student once asked "How can I get 61 ranges in one kitchen in my house"? Table 220.55 as well as all the demand factors are applied to the **feeder or service** loads. The **service** will carry **all** the appliances. Example, a 60 unit apartment complex, each unit has an electric range, the service will carry this load. Whereas the **branch circuit** would carry the load for one unit.

When calculating demand factors, remember they are for feeder and service loads, the **only** demand factor permitted for a **branch circuit** is Note 4 to Table 220.55.

Example: Using the Optional Method, calculate the minimum service size for the following dwelling.

30' x 60' outside dimensions (living area)
24' x 30' garage
6' x 20' open porch
The dwelling has the following equipment:
12 kW total heat 240v (six - 2000w separately controlled units)
4.5 kW air conditioning unit 240v
4.5 kW water heater 240v
1500w dishwasher 120v
6 kW clothes dryer 240/120v
4 kW cooktop 240/120v
5 kW oven 240/120v

	LINE
1800 sq.ft. x 3va (30' x 60')	5400
Small appliance 2 x 1500va	3000
Laundry 1 x 1500va	1500
4.5 kW water heater	4500
1500w dishwasher	1500
6 kW clothes dryer	6000
4 kW cooktop	4000
5 kW oven	5000
	30,900va total "General Load"

220.82(B) Demand Factor:	
First 10 kVA **General Load** @ 100%	10000
Remaining 20,900va **General Load** @ 40%	8360
Heat 12000 @ 40%	4800
•Omit A/C load @ 4500, heat is the larger.	
	23,160va total load

23,160va ÷ 240v = 96.5 amps 240.6 - Use 100 amp service
T. 310.12(A) = #4 copper @ 75°C.

JOURNEYMAN EXAM 1 - 30 QUESTIONS - TIME LIMIT 3 HOURS

1. The overcurrent protection of a #10 THW conductor, when there are not more than three conductors in a raceway, and the ambient temperature is 28°C, would be ___ amps.

(a) 30 (b) 25 (c) 20 (d) 16

2. A box contains the following conductors, the minimum cubic inch capacity required is ____.

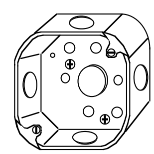
4 - #14 grounded conductors	4 - #14 ungrounded conductors
4 - #12 grounded conductors	4 - #12 ungrounded conductors
4 - Clamps	*10 - #12 equipment grounding conductors (2 isolated EGCs)

(a) 25.75 (b) 39.625 (c) 54.25 (d) 61

3. How much space remains to be filled without exceeding the percentage allowed when nine #12 XHHW conductors are placed in a 1-inch EMT conduit?

(a) 0.0181 sq. in. (b) 0.1831 sq. in. (c) 0.4497 sq. in. (d) none of these

4. What size octagon box is required for 5 - #12 and 4 - #14 conductors?



(a) 1 1/4" (b) 1 1/2" (c) 2" (d) 2 1/8"

5. What size dual-element fuse does the Code require for a 2 hp, 208 volt, single-phase motor?

(a) 20 amp (b) 30 amp (c) 35 amp (d) 40 amp

6. Assuming that the area of all the conductors (over 4 conductors) to be installed in a 1" EMT conduit is 0.30 sq. in., which of the following is true?

(a) The conductors' area is greater than the allowable area of tubing fill.
(b) The conductors' area is less than the allowable area of tubing fill.
(c) It is necessary to select another trade size.
(d) It is necessary to change the THW conductors to RHW.

7. When sizing the service conductors for an apartment complex, the minimum demand load in kW for eight 4 kW ranges would be ____kW.

(a) 11.52 (b) 16.96 (c) 32 (d) None of these

8. The ampacity of a #14 THW conductor, when there are six conductors in a conduit and the temperature is 30° C, would be ___ amps.

(a) 25 (b) 22 (c) 20 (d) 16

9. How many #1 wires can you install in parallel?

(a) 0 (b) 2 (c) 4 (d) 6

10. In a custom house, the demand load (load applied for service calculation) for a 12 kW range and a 4 kW oven is ____ kW.

(a) 11 (b) 11.2 (c) 12 (d) 16

11. You are wiring a house that has 2200 square feet under the roof. The living area accounts for 2000 square feet of this space. The minimum general lighting load for this dwelling would be ___ va.

(a) 6000 (b) 6600 (c) 7700 (d) 8000

12. The ampacity of a #12 TW conductor when there are not more than three conductors in a raceway and the ambient temperature is 36° C would be ___ amps.

(a) 25 (b) 22 (c) 16.4 (d) 16

13. The branch circuit conductor supplying a 3/4 hp, 1ø 115 volt motor shall have an ampacity of at least ___.

(a) 13.8 amps (b) 17.25 amps (c) 20 amps (d) 21.3 amps

14. The volume required for two #12 TW grounding conductors and two #12 TW conductors in a box would be ___ cubic inches.

(a) 9 (b) 6.75 (c) 6 (d) 4.5

15. The demand on the service for six - 6 kW ranges in a sixplex apartment would be ____ kW.

(a) 21 (b) 30.96 (c) 15.48 (d) none of these

16. What is the minimum size copper equipment grounding conductor required for a 80 amp circuit breaker?

(a) #12 (b) #10 (c) #8 (d) #6

17. When sizing the service conductors for an apartment complex, the minimum demand load in kW for eight 5 kW ranges would be ___ kW.

(a) 11.52 (b) 16.96 (c) 32 (d) None of these

18. When sizing the service on a dwelling unit, the small appliance load plus laundry load should be computed at ___ va.

(a) 1,500 (b) 3,000 (c) 4,500 (d) 6,000

19. What is the minimum number of 20 amp branch circuits required for a 1500 sq.ft. house?

(a) 3 (b) 4 (c) 5 (d) 6

20. What is the maximum size overload relay permitted for protection against overload for a 1 ø, 2 hp, 208 volt motor?

(a) 15.18 (b) 16.5 (c) 17.16 (d) none of these

21. #2/0 THW copper service conductors would require a grounding electrode conductor of ____.

(a) #6 (b) #4 (c) #3 (d) #2

22. The feeder carrying two single phase, 1 1/2 hp, 230v motors would be required to have a load current rating of ___ amps.

(a) 12 (b) 16 (c) 22.5 (d) 30

23. What is the allowable ampacity of a #12 TW copper conductor in a raceway with an ambient temperature of 75°F?

(a) 20 amps (b) 25 amps (c) 21.6 amps (d) 30 amps

24. The branch-circuit protection for a 1ø, 115v, 3 hp motor would normally be ___ using dual element time delay fuses.

(a) 35 amps (b) 40 amps (c) 60 amps (d) 90 amps

25. Using the standard method, what would the demand load on the service be for a 1500 sq. ft. house with the following:

1-12 kW range
1-dryer
1-6 kW waterheater
1-washer rated 10 amps (full load)

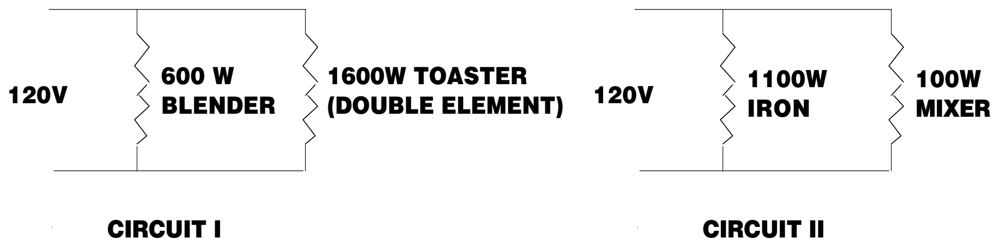
(a) at least 20 but less than 22 kW
(b) at least 22 but less than 24 kW
(c) at least 24 but less than 26 kW
(d) at least 26 but less than 28 kW

26. The ampacity of a #14 THW conductor, when there are six conductors in a conduit and the temperature is 30°C, would be ____ amps.

(a) 25 (b) 22 (c) 20 (d) 16

THE NEXT TWO QUESTIONS (27 - 28) refer to the following diagram and general information

GENERAL NOTE. **<u>Circuits 1 and 2 feed a kitchen.</u>** **The loads are plugged into the small appliance circuits.**



27 Which of the following statements can be inferred from the Circuit I diagram?

(a) Circuit I does not meet the Code.
(b) Circuit I does not meet the Code but will operate.
(c) Circuit I does meet the Code but will not operate.
(d) Circuit I does meet the Code and will operate.

28. The total current in Circuit II is ___ ampere(s).

(a) 10.0 (b) 17.5 (c) 9.20 (d) 0.83

29. The maximum motor-running overload protection would be ___ amps for a 3 hp 1 ø 230V motor.

(a) 15 (b) 20 (c) 22.1 (d) 29.1

30. The correction factor (C.F.) for 104°F is ___ for a 60°C insulated conductor.

(a) 0.80 (b) 0.82 (c) 0.91 (d) 0.90

MASTER EXAM 1 - 30 QUESTIONS - TIME LIMIT 3 HOURS

1. What is the demand on a three-phase, 4-wire feeder for the following single-phase household ranges?

4 - 12 kW ranges
8 - 16.5 kW ranges

(a) 180 kW (b) 27 kW (c) 26.45 kW (d) 31.05 kW

2. What is the horsepower of a 230 volt, single-phase motor that draws 8 amps, with an efficiency of 40.5%?

(a) 1 hp (b) 1 1/2 hp (c) 2 hp (d) 3 hp

3. What is the minimum demand on the service for 300 receptacles in a Category 1 Patient Care Area?

(a) 54,000va (b) 44,000va (c) 18,500va (d) 7,500va

4. What is the efficiency of a three-phase motor whose input is 42 amps on 230v, and whose output is 15 hp?

(a) 66.88 (b) 1.43 (c) 82.8 (d) 1.20

5. If 20% of a 1 1/2" EMT conduit was already occupied by #8 XHHW conductors, what is the maximum number of #8 XHHW's you can add to this conduit?

(a) 7 (b) 8 (c) 9 (d) none of these

6. The demand for ten 1200va dishwashers in a ten unit apartment would be ____ kVA. Use the optional method of calculation.

(a) 12 (b) 9 (c) 5.16 (d) none of these

7. The branch circuit protection using dual element fuses would be ____ amperes for a 30 hp, squirrel-cage, 460v, three-phase motor.

(a) 70 (b) 80 (c) 100 (d) 125

8.The demand on the feeder for a 16 kW household range 230/115v would be ____ amperes.

(a) 9.6 (b) 8 (c) 41.7 (d) none of these

9. An apartment building with 200 dwelling units, each unit has a 4 kW clothes dryer. The load added to the service after demand factors would be ____ kW. Use general method of calculation.

(a) 200 (b) 250 (c) 800 (d) 1000

10. One 20 hp, 208v, three-phase motor and three - 2 hp, 120v, single-phase motors are connected on the same feeder. The maximum size inverse time breaker for the feeder protection would be ____ amperes.

(a) 150 (b) 175 (c) 200 (d) 225

11. A 60 unit apartment building, each unit has a 4 kW clothes dryer. What is the minimum demand on the feeder? Use optional method of calculation.

(a) 180 kW (b) 75 kW (c) 60 kW (d) 57.6 kW

12. What is the maximum demand on the service for 55 - 16 kW household ranges?

(a) 66.25 kW (b) 79.5 kW (c) 41.25 kW (d) none of these

13. How many #8 RHH conductors without outer covering can be installed in a 1 1/2" ENT (electrical non-metallic tubing) conduit?

(a) 13 (b) 14 (c) 17 (d) 22

14. The minimum ampacity required for a feeder that supplies one - 3 hp, 208v, three-phase motor and one - 2 hp, 208v, three-phase motor would be ____ amperes.

(a) 21 (b) 22 (c) 18 (d) 19

15. What is the demand on a three-phase, 4 - wire feeder for ten - 14 kW single-phase household ranges?

(a) 25 kW (b) 27.5 kW (c) 25.3 kW (d) 34.5 kW

16. The maximum ampacity of a copper #10 RHW is ____ when there are four current-carrying conductors in a conduit and the ambient temperature is 80°F.

(a) 28 (b) 30 (c) 35 (d) 40

17. What is the va to a fully-loaded 5 hp 208v three-phase motor?

(a) 3000 - 4000 (b) 4000 - 5000 (c) 5000 - 6000 (d) 6000 - 7000

18. The approximate area in square inches of a #14 RHH conductor without outer covering is ____ square inches.

(a) 0.0209 (b) 0.0327 (c) 0.0230 (d) 0.0135

19. What is the minimum size branch circuit conductor required for a 10 hp, 230v, three-phase motor? Use 60°C insulation.

(a) #10 (b) #8 (c) #6 (d) #4

20. What is the minimum size PVC schedule 40 conduit required for the following conductors?

6 - #3 THWN
3 - #8 THW
2 - #10 THW

(a) 2" (b) 2 1/2" (c) 1 1/2" (d) 3"

21. What is the ampacity of each conductor of a group of twenty-five #14 copper RHH. All are carrying current and installed in one conduit with an ambient temperature of 45°C?

(a) 25a (b) 21.75a (c) 15a (d) 9.7875a

22. If two-25 hp, 208v, three-phase motors are fed by the same feeder, the feeder conductors would be required to carry a minimum of ____ amperes.

(a) 100 (b) 150 (c) 170 (d) 200

23. Each unit of a six unit all electric apartment complex contains a 4.5 kW clothes dryer. Using the optional method of calculation for multi-family dwellings, these six dryers would have a total connected load of ____ kW.

(a) 11.88 (b) 13.2 (c) 18 (d) 27

24. What is the feeder neutral demand for two - 4 kW wall-mounted ovens and one - 5 kW counter-mounted cooking unit in a dwelling?

(a) 5.005 kW (b) 7.15 kW (c) 13 kW (d) none of these

25. In a 60 unit apartment building, each dwelling unit has a 6 kW water heater. What is the demand on the service for these water heaters? Do not use optional method.

(a) 360 kW (b) 86.4 kW (c) 270 kW (d) 189 kW

26. What is the demand for a 25,000 sq.ft. school building with a total connected load of 600 kVA? Use optional method.

(a) 402,809 va (b) 418,750 va (c) 526,719 va (d) none of these

27. What is the cross-sectional area of a 2" flexible metal conduit?

(a) 3.629 (b) 3.269 (c) 1.307 (d) 1.452

28. In a 50 unit apartment building, each unit has a 14 kW range. What is the demand on the service for these ranges using the optional method of calculation?

(a) 700 kW (b) 400 kW (c) 182 kW (d) 68.75 kW

29. If ten - #8 RHH conductors with outer cover are installed in a 2" PVC schedule 80 conduit, how many #8 XHHW conductors could be added to this conduit?

(a) 8 (b) 9 (c) 7 (d) 11

30. What is the demand load for the following household ranges?

6 - 9 kW
4 - 12 kW
10 -15 kW

(a) 35 kW (b) 38.5 kW (c) 54.70 kW (d) none of these

CHAPTER 1 TEST 1 BRANCH CIRCUITS

1. (c) 6'	210.50(C)
2. (b) 6' 6" = 6 1/2'	210.52(E)(1)
3. (d) 18"	210.62
4. (b) single contact device DEF 100 receptacle	
5. (a) I only	210.23(D)
6. (c) III only	210.5(B) 250.119

CHAPTER 1 TEST 2 BRANCH CIRCUITS

1. (d) 125%	210.19(A)(1)
2. (d) 20 amps	Table 210.24(1)
3. (c) I and III only	
4. (d) 20 amps	The **circuit** can be loaded to 20 amps, the A/C load cannot exceed 10a or 50%
5. (d) IV	17 amps exceeds the 80% rating of one plug-cord connected appliance

CHAPTER 2 TEST 1 AMPACITY

1. (a) 13.65a	#12 THHN = 30a x 50% (T.310.15(C)(1) = 15a x .91 (40°C) = 13.65a
2. (c) 24 amps	#12 THHN = 30a x 80% (T.310.15(C)(1) = 6 wires) = 24 amps
3. (a) 150.9 amps	#4/0 THWN = 230a x 80% (T.310.15(C)(1) = 184a x .82 (45°C) = 150.88a
4. (d) not required	310.15(C)(1(b) does NOT require derating a nipple nor does 27°C from Table 310.16 require a correction factor.
5. (d) 176a	#3/0 THWN = 200a x .88 (104°F) T.310.15(C)(1) = 176a
6. (a) 10%	310.14(A)(2) ex.

CHAPTER 2 TEST 2 AMPACITY

1. (c) #4	110.14(C)(1)
2. (b) #6 THWN	50a load ÷ .80 (6 wires) = 62.5 required ampacity T. 310.16
3. (d) 41.6 amps	T. 310.16 = 40 ampacity x 1.04 correction factor = 41.6a
4. (b) 6	Count 3 black and 3 red wires
5. (b) 7 amps	Table 400.5(A)(1)
6. (c) 110 amps	T. 310.17 Free Air 125a x .88 = 110

CHAPTER 6 TEST 7 DWELLINGS

1. **30.4 kW** 20 x 4 kW = 80 kW x 38% (T.220.84) = 30.4 kW.
2. **33.75 kW** 30 x 1.5 kW = 45 kW x 75% (220.53) = 33.75 kW.
3. **27 kW** **Connected Load** not demand load! 6 x 4.5 kW = 27 kW.
4. **238 amps**

	NEUTRAL
15 x 750 sq.ft. x 3va	33750va
Small appliance 30 x 1500va	45000
Laundry 15 x 1500va	22500
	101,250va
Table 220.45 Lighting Demand:	
First 3000va @ 100%	3000va
Remaining 98,250va @ 35%	34388
	37388va
15 - 12 kW ranges T.220.55 Col. C = 30 kW x 70%	21000
	58,388va

Neutral = 58,388va ÷ 230v = 253.8 or 254 amps (220.61B2) First 200a @ 100% = 200a
Next 54a @ 70% = 38a
238a

5. **52.5 kW** 35 x 5 kW = 175 kW x 30% (T.220.84) = **52.5 kW.**
6. **129.6 kW** 60 x 4 kW = 240 kW + 60 x 5 kW = 300 kW. 540 kW x 24% (T.220.84) = **129.6 kW**.

CHAPTER 6 TEST 8 DWELLINGS

	LINE
900 sq.ft. x 3va x 24 units	64800va
Small appliance 2 x 1500va x 24 units	72000
6 kW heat 6 kW x 24 units	144000
(omit A/C load)	
4 kW cooktop 4 kW x 24 units	96000
3 kW oven 3 kW x 24 units	72000
4.5 kW water heater 4.5 kW x 24 units	108000
1.2 kW dishwasher 1.2 kW x 24 units	28800
	585,600va

Table 220.84 Demand:

24 units = 35% 585,600va x 35% =	204,960va
Laundry on premises 1500 x 24 units =	36,000
	240,960va total demand

LINE = $\frac{240{,}960\text{va}}{208\text{v} \times 1.732}$ = 669 amps.

CHAPTER 8 JOURNEYMAN EXAM 2 30 CALCULATIONS

1. **(a) 6 kW** Note 5 Branch Circuit - Nameplate rating for **one**

2. **(d) 33.6 amps** 24a (T.430.248) x 140% (430.32(C) maximum) = 33.6

3. **(d) 200 watts** the unbalance 1200 - 1000 = 200

4. **(d) .3802 sq.in.** Table 5 - #8 XHHW = .0437 x 6 = .2622
   #6 XHHW = .0590 x 2 = .118
   .3802

5. **(c) 4 amps** the unbalance 7 - 3 = 4

6. **(c) 79 amps** the maximum on the neutral would be if line one is off 9500 ÷ 120v = 79

7. **(d) 18 cu.in.** 314.16(B) 2-white, 2-black, 1-bare, 1-clamps, 2-duplex = 8 wires
   Table 314.16(B1) 8 wires x 2.25 cubic inch = 18

8. **(c) .1921 sq.in.** Table 4 - 1" rigid metal = .355 Table 5 - #12 XHHW = .0181 x 9 = .1629
   .355 - .1629 = .1921

9. **(c) 35 amps** 28a (T.430.250) x 125% (430.22) = 35

10. **(d) 13** Table 4 - 1" IMC = .959 (100% csa) x 60% (nipple fill) = .575
    Table 5 - #8 TW = .0437 .575 ÷ .0437 = 13

11. **(d) 15.65 amps** 1800 ÷ 115v = 15.65

12. **(a) 21 amps** #12 THHN = 30a x 70% T.310.15(C)(1) = 21

13. **(d) 7** Example D1A and 210.11(C) 1800 sq.ft. x 3va = 5400 ÷ 120v = 45 amp = 3 - 20a circuits
    small appliance = 2 laundry = 1 bathroom = 1 for a total of seven

14. **(d) .0209** Table 5

15. **(c) .6141**

#14 TW = .0139 x4	=	.0556
#12 THW = .0181 x 3	=	.0543
#14 RHW (without) .0209 x 12	=	.2508
#12 TW = .0181 x 14	=	.2534
		.6141

CHAPTER 8 MASTER EXAM 1 30 CALCULATIONS

1. **(c) 26.45 kW**

4 - 12 kW	=	48 kW
8 - 16.5 kW	=	132 kW
12		180 kW

180 kW ÷ 12 = 15 kW average

15 kW - 12 kW = 3 kW x 5% = 15% Column C increase, single-phase ranges on a three-phase system=

A Phase	B Phase	C Phase
4	4	4

4 x 2 = 8 appliances Col.C = 23 kW x 1.15 = 26.45 kW.

2. **(a) 1 hp** $\text{hp} = \frac{\text{E x I x Efficiency}}{\text{746 watt}}$ $\frac{\text{230v x 8a x 40.5\%}}{\text{746w}}$ = .998 or 1 hp.

3. **(c) 18,500va** Table 220.110(1) Demand: First 5,000va @ 100% = 5,000va
300 receptacles x 180va = 54,000va
Next 5,000va @ 50% = 2,500va
Next 44,000va @ 25% = 11,000va
18,500va.

4. **(a) 66.88** $\text{Efficiency} = \frac{\text{output}}{\text{input}}$ $\frac{\text{15 hp x 746}}{\text{230v x 42a x 1.732}} = \frac{11,190}{16,731.12}$ = 66.88%

5. **(c) 9** Table 4 1 1/2" = .814 40% fill, half of .814 = .407 ÷ .0437 (#8 XHHW) = 9.3 or 9.
6. **(c) 5.16** 10 x 1200va = 12,000va x 43% (T.220.84) = 5160va ÷ 1000 = 5.16 kva.
7. **(a) 70** T.430.250 F.L.C. = 40a x 175% (T.430.52(C)(1) = 70.

8. **(c) 41.7 amps** 16 kW - 12 kW = 4 kW x 5% = 20% Column C = 8 kW x 1.20 = 9.6 kW or 9600w
9600w ÷ 230v = 41.7 amperes.

9. **(b) 250** 200 x 5 kW (minimum 5 kW) = 1000 kW x 25% (T.220.54) = 250 kW.

10. **(a) 150** First step find branch circuit CB size: Largest motor 59.4a x 250% = 148.5 or 150 amp B.C. breaker size. Feeder CB = 150a CB + 24a F.L.C. = 174 amp can**not** go up = 150a.

11. **(d) 57.6 kW** 60 x 4 kW = 240 kW x 24% (T.220.84) = 57.6 kW.

12. **(b) 79.5 kW** T.220.55 Column C = 25 kW + 41.25 kW (55 x .75 kW) = 66.25 kW
16 kW - 12 kW = 4 kW x 5% = 20% Column C = 66.25 kW x 1.20 = 79.5 kW.

13. **(b) 14** Table 4 - 1 1/2" ENT = .794 Table 5 - #8 RHH (without) = .0556 .794 ÷ .0556 = 14