Fuse

What is Fuses

- A fuse is a device that protects a circuit from an over current condition only. It has a fusible link directly heated and destroyed by the current passing through it. A fuse contains a current- carrying element sized so that the heat generated by the flow of normal current through it does not cause it to melt the element; however, when an over current or short-circuit current flows through the fuse, the fusible link will melt and open the circuit.
- A device that protects a circuit by fusing opens its current-responsive element when an over-current passes through it. An over-current is either due to an overload or a short circuit condition.
- The Underwriter Laboratories (UL) classifies fuses by letters e.g. class CC, T, K, G, J, L, R, and so forth. The class letter may designate interrupting rating, physical dimensions, and degree of current limitation.
- As per NEC and ANSI/IEEE standard 242 [2] – A current limiting fuse is a fuse that will interrupt all available currents above its threshold current and below its maximum interrupting rating, limit the clearing time at rated voltage to an interval equal to or less than the first major or symmetrical loop duration, and limit peak let-through current to a value less than the peak that would be possible with the fuse replaced by a solid conductor of the same impedance.

Fuse Construction:

- The typical fuse consists of an element which is surrounded by filler and enclosed by the fuse body. The element is welded or soldered to the fuse contacts (blades or ferrules).
- The element is a calibrated conductor. Its configuration, mass and the materials employed are selected to achieve the desired electrical and thermal characteristics.
- The element provides the current path through the fuse. It generates heat at a rate dependent on its resistance and the load current.
- The heat generated by the element is absorbed by the filler and passed through the fuse body to the surrounding air. The filler material, such as quartz sand, provides effective heat transfer and allows for the small element cross-section typical in modern fuses.
- The effective heat transfer allows the fuse to carry harmless overloads .The small element cross section melts quickly under short-circuit conditions. The filler also aids fuse performance by absorbing arc energy when the fuse clears an overload or short circuit.
- When a sustained overload occurs, the element will generate heat at a faster rate than the heat can be passed to the filler. If the overload persists, the element will reach its melting point and open. Increasing the applied current will heat the element faster and cause the fuse to open sooner. Thus, fuses have an inverse time current characteristic: that is, the greater the over current, the less time required for the fuse to open the circuit.
- This characteristic is desirable because it parallels the characteristics of conductors, motors, transformers, and other electrical apparatus. These components can carry low-level overloads for relatively long periods without damage. However, under high-current conditions, damage can occur quickly. Because of its inverse time current characteristic, a properly applied fuse can provide effective protection over a broad current range, from low-level overloads to high-level short circuits.

Commonly used terms for Fuse

- **I2t (Ampere Square second):** A measure of the thermal energy associated with current flow.I2t is equal to (I RMS) 2 X t, where is the duration of current flow in seconds.A measure of thermal energy associated with current flow. It can be expressed as melting I2t, arcing I2t or the sum of them as *Clearing I2t*. Clearing I2t is the total I2t passed by a fuse as the fuse clears a fault, with *t* being equal to the time elapsed from the initiation of the fault to the instant the fault has been cleared. Melting I2t is the minimum I2t required to melt the fuse element
- **Interrupting Rating (Abbreviated I.R.)**Same as breaking capacity or short circuit rating. The maximum current a fuse can safely interrupt at rated voltage. Some special purpose fuses may also have a “Minimum Interrupting Rating”. This defines the minimum current that a fuse can safely interrupt. Safe operation requires that the fuse remain intact. Interrupting ratings may vary with fuse design and range from 35 amperes AC for some 250V metric size (5 x 20mm) fuses up to 200,000 amperes AC for the 600V industrial fuses (for example, ATDR series).
- **Clearing I2t:** The total I2t passed by a fuse as the fuse clears a fault, with being equal to the time elapsed from the initiation of the fault to the instant the fault has been cleared.
- **Melting I2t**: The minimum I2t required melting the fuse element.
- **Ampere Rating**: The continuous current carrying capability of a fuse under defined laboratory conditions. The ampere rating is marked on each fuse.
- **Available Fault Current:** The maximum short-circuit current that can flow in an unprotected circuit.
- **Coordination**: The use of over current protective devices that will isolate only that portion of an electrical system that has been overloaded or faulted.
- **Current limiting Range**: currents a fuse will clear in less than ½ cycles, thus limiting the actual magnitude of current flow.
- **Element:** A calibrated conductor inside a fuse that melts when subjected to excessive current. The element is enclosed by the fuse body and may be surrounded by an arc quenching medium such as silica sand. The element is sometimes referred to as a link.
- **Fast acting Fuse:** This is a fuse with no intentional time-delay designed into the overload range. It is sometimes referred to as a “single-element fuse” or “non-delay fuse.”
- **Fault Current**: Short-circuit current that flows partially or entirely outside the intended normal load current path of a circuit component. Values may be from hundreds to many thousands of amperes.

1. **Ferrule:** copper mounting terminals of fuses with amp ratings up to 60 amperes. The cylindrical terminals at each end of a fuse fit into fuse clips.

- **Current limiting Fuse:** A fuse that meets the following three conditions:

1. 1. interrupts all available over currents within its interrupt rating.
1. 2. Within its current limiting range, limits the clearing time at rated voltage to an interval equal to, or less than, the first major or symmetrical current loop duration.
1. 3. Limits peak let-through current to a value less than the available peak current. The maximum level of fault current that the fuse has been tested to safely interrupt.

- **Arcing time**The amount of time from the instant the fuse link has melted until the over current is interrupted, or cleared.
- **Clearing time** The total time between the beginning of the over current and the final opening of the circuit at rated voltage by an over current protective device. Clearing time is the total of the melting time and the arcing time.

- **Fast acting fuse** A fuse which opens on overload and short circuits very quickly. This type of fuse is not designed to withstand temporary overload currents associated with some electrical loads. UL listed or recognized fast acting fuses would typically open within 5 seconds maximum when subjected to 200% to 250% of its rated current.IEC has two categories of fast acting fuses:

1. F= quick acting, opens 10x rated current within 0.001 seconds to 0.01 seconds
1. FF = very quick acting, opens 10x rated current in less than 0.001 seconds

- **Overload** Can be classified as an over current which exceeds the normal full load current of a circuit by 2 to 5 times its magnitude and stays within the normal current path.
- **Resistive load** An electrical load which is characterized by not drawing any significant inrush current. When a resistive load is energized, the current rises instantly to its steady state value, without first rising to a higher value.
- **RMS Current** The R.M.S. (root mean square) value of any periodic current is equal to the value of the direct current which,flowing through a resistance, produces the same heating effect in the resistance as the periodic current does.
- **Short circuit** An over current that leaves the normal current path and greatly exceeds the normal full load current of the circuit by a factor of tens, hundreds, or thousands times.
- **Time delay fuse** A fuse with a built-in time delay that allows temporary and harmless inrush currents to pass without operating, but is so designed to open on sustained overloads and short circuits. UL listed or recognized time delay fuses typically open in 2 minutes maximum when subjected to 200% to 250% of rated current. IEC has two categories of time delay fuses:

1. T= time lag, opens 10x rated current within 0.01 seconds to 0.1 seconds
1. TT = long time lag, opens 10x rated current within 0.1 seconds to 1 second

- **Voltage rating** A maximum open circuit voltage in which a fuse can be used, yet safely interrupt an over current. Exceeding the Voltage rating of a fuse impairs its ability to clear an overload or short circuit safely.
- **Over current** A condition which exists in an electrical circuit when the normal load current is exceeded. Over currents take on two separate characteristics-overloads and short circuits.
- **Threshold Current:** The magnitude of symmetrical RMS available current at the threshold of the current-limiting range, where the fuse becomes current-limiting when tested to the industry standard.
- **Threshold ratio:** A threshold ratio is a relationship of threshold current to a fuse's continuous current rating.

  Threshold Ratio = Fuse Threshold Current / Fuse Continuous Current.

Maximum threshold ratio for various types of fuses:

Fuse Class	Ratio
CLASS RK5	65
CLASS RK1	30
CLASS J	30

CLASS CC	30
CLASS L	30 (601-1200 Amps)
CLASS L	35(1201-2000 Amps)
CLASS L	40 (2001-4000 Amps)

- A current limiting fuse may be current limiting or may not be current limiting. The current limiting characteristic depends on the threshold ratio and available fault current.
- Let's consider an example of 1500 kVA radial service feeding a fusible switchboard with 2000 amps class L fuses. As per ANSI C 57 [3] standard, a typical impedance value for this size of a transformer is 5.75%; this value is a key factor in calculating the short circuit current.
- All utility's network provides a specific fault current at a specific location which depends on various factors, e.g.; cable lengths, cable size, X/R ratio and etc. If we ignore this limitation and assume that there is an unlimited fault current available from a utility, then let's calculate short circuit current from a 1500 kVA transformer at 480 volts
- The formula to calculate short circuit current (I_{sc})
- ISC = (KVA X 10,000) / (1.732 X VOLT X %Z).
- ISC = 1500 X 10,000 / 1.732 X 480 X 5.75
- ISC = 31378.65 Amp.

Type of Fuse:

- A fuse unit essentially consists of a metal fuse element or link, a set of contacts between which it is fixed and a body to support and isolate them. Many types of fuses also have some means for extinguishing the arc which appears when the fuse element melts. In general, there are two categories of fuses.

1. Low voltage fuses.
2. High voltage fuses.

- Usually isolating switches are provided in series with fuses where it is necessary to permit fuses to be replaced or rewired with safety.
- In absence of such isolation means, the fuses must be so shielded as to protect the user against accidental contact with the live metal when the fuse is being inserted or removed.

LOW VOLTAGE FUSES

- Low voltage fuses can be further divided into two classes namely

1. Semi-enclosed or Rewire able type.
2. Totally enclosed or Cartridge type.

(1) Re Wire able Fuse:

- The most commonly used fuse in 'house wiring' and small current circuit is the semi-enclosed or rewire able fuse. (also sometime known as KIT-KAT type fuse). It consist of a **porcelain base** carrying the fixed contacts to which the incoming and outgoing live or phase wires are connected and a **porcelain fuse carrier** holding the fuse element, consisting of one or more strands of fuse wire, stretched between its terminals.

- The fuse carrier is a separate part and can be taken out or inserted in the base without risk, even without opening the main switch. If fuse holder or carrier gets damaged during use, it may be replaced without replacing the complete unit.
- The fuse wire may be of lead, tinned copper, aluminum or an alloy of tin lead.
- The actual fusing current will be about twice the rated current. When two or more fuse wire are used, the wires should be kept apart and a de rating factor of 0.7 to 0.8 should be employed to arrive at the total fuse rating.
- The specification for re wire able fuses are covered by IS: 2086-1963. Standard ratings are 6, 16, 32, 63, and 100A.
- A fuse wire of any rating not exceeding the rating of the fuse may be used in it that is a 80 A fuse wire can be used in a 100 A fuse, but not in the 63 A fuse. On occurrence of a fault, the fuse element blows off and the circuit is interrupted. The fuse carrier is pulled out, the blown out fuse element is replaced by new one and the supply can is resorted by re-inserting the fuse carrier in the base.
- Though such fuses have the advantage of easy removal or replacement without any danger of coming into the contact with a lie part and negligible replacement cost but suffers from following disadvantages:

1. Unreliable Operations.
2. Lack of Discrimination.
3. Small time lag.
4. Low rupturing capacity.
5. No current limiting feature.
6. Slow speed of operations.

(2) Totally Enclosed Or Cartridges Type Fuse:

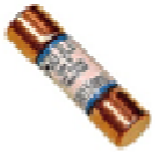
- The fuse element is enclosed in a totally enclosed container and is provided with metal contacts on both sides. These fuses are further classified as

1. D-type.
2. Link type.

- Link type cartridges are again of two type's viz. Knife blade or bolted type.

A) D- Type Cartridges Fuses

- It is a non interchangeable fuse comprising s fuse base, adapter ring, cartridge and a fuse cap. The cartridge is pushed in the fuse cap and the cap is screwed on the fuse base. On complete screwing the cartridge tip touches the conductor and circuit between the two terminals is completed through the fuse link. The standard ratings are 6, 16, 32, and 63 amperes.



- The breaking or rupturing capacity is of the order of 4k A for 2 and 4 ampere fuses the 16k A for 63 A fuses.
- D-type cartridge fuse have none of the drawbacks of the re wire able fuses. Their operation is reliable. Coordination and discrimination to a reasonable extent and achieved with them.

B) Link type Cartridge or High Rupturing Capacity (HRC)

- Where large numbers of concentrations of powers are concerned, as in the modern distribution system, it is essential that fuses should have a definite known breaking capacity and also this breaking capacity should have a high value. High rupturing capacity cartridge fuse, commonly called HRC cartridge fuses, have been designed and developed after intensive research by manufactures and supply engineers in his direction.

- The usual fusing factor for the link fuses is 1.45. the fuses for special applications may have as low as a fusing factor as 1.2.
- The specification for medium voltage HRC link fuses are covered under IS: 2202-1962.

(A) Knife Blade Type HRC Fuse:

- It can be replaced on a live circuit at no load with the help of a special insulated fuse puller.

(B) Bolted Type HRC Link Fuse:

- it has two conducting plates on either ends. These are bolted on the plates of the fuse base. Such a fuse needs an additional switch so that the fuse can be taken out without getting a shock.
- Preferred ratings of HRC fuses are 2, 4, 6, 10, 16, 25, 30, 50, 63, 80, 100, 125, 160, 200, 250, 320, 400, 500, 630,800, 1000 and 1,250 amperes.

Fuse Selection Guide

- The fuse must carry the normal load current of the circuit without nuisance openings. However, when an over current occurs the fuse must interrupt the over current, limit the energy let-through, and withstand the voltage across the fuse during arcing. To properly select a fuse the followings must be considered:
- Normal operating current (The current rating of a fuse is typically de rated 25% for operation at 25C to avoid nuisance blowing. For example, a fuse with a current rating of 10A is not usually recommended for operation at more than 7.5A in a 25C ambient.)
- Overload current and time interval in which the fuse must open.
- Application voltage (AC or DC Voltage).
- Inrush currents, surge currents, pulses, start-up currents characteristics.
- Ambient temperature.
- Applicable standards agency required, such as UL, CSA, and VDE.
- Considerations: Reduce installation cost, ease of removal, mounting type/form factor, etc

Recommended UL Current Limiting Fuse Classes:

TIME DELAY FUSE TYPE		
Class	**Voltage**	**Current**
Class-L (LCL)	600V AC	601 – 6000A
Class RK1 (LENRK)	250V AC	0.6 -600A
Class RK1 (LESRK)	600V AC	0.5 -600A
Class RK5 (ECNR)	250V AC	0.1 -600A
Class RK5 (ECSR)	600V AC	0.1 -600A
Class J (JDL)	600V AC	1 -600A
Class CC (HCTR)	600V AC	0.25 -10A

FAST ACTING TYPE FUSE(Non/time-delay)		
Class	**Voltage**	**Current**
Class-T (TJN)	300V AC	1 – 800A
Class-T (TJS)	600V AC	1 – 800A
Class-L (LCU)	600V AC	601– 6000A
Class-RK1(NCLR)	250V AC	1 – 600A
Class-RK1(SCLR)	600V AC	1 – 600A
Class J (JFL)	600V AC	1 -600A
Class CC (HCLR)	600V AC	0.1 -30A

Fuse Class:

(1) Class L, fuses

- They provide a minimum time delay of 4 seconds at 500% of their rated current to handle harmless inrush currents, plus they are 20% more current limiting than any other Class L fuse.
- That means optimal over current protection for service entrances, large motors, feeders and other circuits.
- Range from 601 to 6000 amperes, 600V AC, 300kA
- I.R., and an exclusive 500V DC, 100kA I.R., through 3000A.

Features

- Fastest operation under short circuit conditions
- Most current limiting for lowest peak let-thru current
- Replaces all older Class L fuses
- Pure silver links for long fuse life
- AC and DC ratings
- High-grade silica filler for fast arc quenching

Applications

- Mains and feeders

- Large motors
- Lighting, heating and general loads
- Power circuit breaker backup
- UPS DC links, battery disconnects and other DC applications

Application notes

- Mains and feeders — Can size at 100% of expected full load, unless equipment manufacturers specify
- Motor starters — Consult your motor control manufacturer's recommendations.
- Lighting, heating and general loads — Can size at 100% to 125%, depending on load make-up.
- Transformers — Due to the high inrush currents that can be experienced with transformers, size fuse to carry 12 times transformer full load for 0.1 second and 25 times full load for 0.01 second.

(2) Class J, fuses

- The most current-limiting UL-class fuse, provide optimal performance, prevent interchangeability with old fuses, and save valuable panel space. So you can use smaller, more economical fuse blocks and IEC contactors to provide superior protection for dedicated or combined motor, lighting, heating and transformer loads.
- Plus their time delay characteristic allows for use in a wide range of applications.
- Rated from 1 to 600 amperes, 600V AC, 300kA I.R., and 500V DC, 100kA I.R., listed to UL 248-8, they're the right fuses for any new installation.

Features

- Most current-limiting UL-class fuses
- Timesaving Smart Spot™ indicator
- Unique dimensions prevent misapplications
- Optional mechanical indicator available on 70A to 600A AJT fuses

Applications

- Motor circuits
- Mains and feeders
- Branch circuits
- Lighting, heating and general loads
- Transformers and control panels
- Circuit breaker backup
- Bus duct
- Load centers

Application notes

- Mains and feeders: Can size at 125% of load for NEC and CEC code compliance.
- Motor starters: For typical starting duty and optimal coordination, fuse rating should not exceed 150% of motor FLA. Where "no-damage" tests have been conducted, follow the control gear manufacturer's fuse ampere rating recommendations.
- Lighting, heating and general loads: Can size at 125% of combined load for NEC and CEC code compliance.
- Transformers: Due to the high inrush currents that can be experienced with transformers, size fuse to carry 12 times transformer full load for 0.1 second and 25 times full load for 0.01 second.

(3) Class RK1 fuses:

- Significantly more current limiting than Class RK5, K and H fuses, upgrading your existing feeder and branch circuits to arc flash category “0”. They also offer plenty of application flexibility, with ratings from 1/10A to 600A (250V or 600V), 300kA I.R.

Features

- Highly current limiting to achieve HRC “0”
- Timesaving Smart Spot™ indicator
- Brass end caps (blade style) for cooler operation and superior performance
- Rejection-style design

Applications

- Motors
- Safety switches
- Transformers
- Branch circuit protection
- Disconnects
- Control panels
- General-purpose circuits

Application notes

- Mains and feeders: Can size at 125% of load for NEC and CEC code compliance.
- Motor starters: For typical starting duty and optimal coordination, fuse rating should not exceed 150% of motor FLA. Where “no damage” tests have been conducted, follows the control gear manufacturer’s fuse ampere rating recommendations.
- Lighting, heating and general loads: Can size at 125% of combined load for NEC and CEC code compliance.
- Transformers :Due to the high inrush currents that can be experienced with transformers, size fuse to carry 12 times transformer full load for 0.1 second and 25 times full load for 0.01 second.

(4) Class CC, fuses

- Choose our highly current-limiting fuses when you need maximum fault protection for sensitive branch circuit components and small motors. They deliver the best time delay characteristics and exceptional cycling ability for frequent motor starts and stops without nuisance opening. They’re available in 1/4A to 30A, 600VAC, 200kA I.R.

Features

- Highly current limiting
- Best time-delay characteristics in a Class CC fuse
- Exceptional cycling ability for frequent motor stops and starts
- Rejection-style design

Applications

- Small motors
- Contactors
- Branch circuit protection

Application notes

- Motor starters: for typical starting duty. Where "no damage" tests have been conducted, follows the control gear manufacturer's fuse ampere rating recommendations.
- Lighting, heating and general loads: Can size at 125% of combined load for NEC and CEC code compliance.

(5) Class CC, fuses

- Class CC fuses provides the time delay needed to handle the high inrush currents of control transformers, solenoids, and similar inductive loads.
- They're available in 1/10A to 30A, 600V AC, 200kA I.R.

Features

- Highly current limiting
- Rejection-style design
- Special time-delay characteristics for transformer loads

Applications

- Control transformers
- Solenoids
- Inductive loads
- Branch circuit protection

Application notes

- Control transformers, solenoids and similar inductive loads: For control transformers 600V AC or less with ratings up to 2000VA.fuses are designed to handle 40 times the transformer's primary full load amperes for 0.01 second.
- Lighting, heating and general loads: Can size at 125% of combined load for NEC and CEC code compliance.

(6) Class RK5, fuses:

- **Voltage / Ampere:** 250V (1A to 200Amp), 600V (3A to 200A)

Description:

- The time delay characteristics of these fuses typically allows them to be sized closer to the running ampacity of inductive loads to reduce cost and improve over current protection

Application:

- Use in AC power distribution system mains, feeders, and branch circuits.
- Recommended for high inrush inductive loads, like motors and transformers, and non inductive loads like lighting, and heating loads.

(7) Class Midget fuses (600V, 0.5To 50A):

Description:

- Provides supplemental protection to end-use equipment with a 100KA interruption rating, 600VAC. Fast acting design responds quickly to both overloads and short-circuit protection.

Application:

- Recommended for control circuits, street lighting, HID lighting, and electronic equipment protection

(8) Class Midget fuses (250V, 0.5To 50A)

Description:

- Provides supplemental protection to end-use equipment with a 10,000A interruption rating, economical laminated paper tube

Application:

- Recommended to use as supplemental protection for non inductive control loads and lighting circuits

(9) Class Midget fuses (500V, 0.25To 30A)

Description:

- Provides supplemental protection to high inrush loads. has a 10,000A interruption rating, 500VAC. Fiber tube construction.

Application:

- Recommended to use as supplemental protection for inductive control loads such as transformers and solenoids.

(10) Class Midget fuses (250V, 0.5To 30A)

Description:

- Provides supplemental protection to high inrush loads. has a 10,000A interruption rating, fiber tube construction. Dual element allows harmless inductive surges to pass without opening

Application:

- Recommended to use as supplemental protection for inductive control loads such as transformers and solenoids

(11) Class 1 1/4″ x 1/4″ Ceramic (250,125V, 0.5To 30A)

Description:

- Fast acting 1/4″ x 1-1/4″ ceramic tube construction.

Application:

- Recommended to use as supplemental protection for inductive control loads such as transformers and solenoids.

(12) Class 1 1/4″ x 1/4″ Glass (250,32V, 0.5To 30A)

Description:

- Fast acting 1/4″ x 1-1/4″ glass tube construction.

Application:

- Recommended as supplemental protection for electronic applications.

(13) Class 5mmx20mm Glass (250,125V, 0.063To 15A)

Description:

- Fast acting 5mmx20mm glass tube construction.

Application:

- Recommended as supplemental protection for electronic applications.

(14) Class 5mmx20mm Glass (250,125V, 0.5To 10A)

Description:

- Medium Time Delay 5mm x 20mm glass tube construction.

Application:

- Recommended as supplemental protection for electronic applications.

(15) Class 1 1/4″ x 1/4″ Ceramic (250, 0.5To 20A)

Description:

- Time Delay 1/4″ x 1-1/4″ ceramic tube construction.

Application:

- Recommended as supplemental protection for electronic applications.

(16) Class 1 1/4″ x 1/4″ Glass (250,32V, 0.0625To 20A)

Description:

- Time Delay 1/4″ x 1-1/4″ glass tube construction.

Application:

- Recommended as supplemental protection for electronic applications

(17) Class 5mmx20mm Glass (250, 0.5To 10A)

Description:

- Fast acting 5mm x 20mm glass tube construction

Application:

- Recommended as supplemental protection for electronic applications.

(18) Class 5mmx20mm Glass (250, 0.25To 6.3A)

Description:

- Time Delay 5mm x 20mm glass tube construction.

Application:

- Recommended as supplemental protection for electronic applications.

Selection of Fuse for Main and Branch Circuits:

1 Main Service Conductor Cable Limiters (NEC 240,230.82):

- Select by cable size and mounting terminal configurations required.

2 Main Service Circuit Fuses–Mixed Loads:

- Size fuses same as item 6.

3 Transformer Circuit Fuses (NEC 450.3b, 240.3, 240.21, 430.72 (c) as required):*

- (a) PRIMARY FUSES: Size fuses not over 125%. As exceptions exist, refer to the appropriate NEC® paragraphs.
- Recommended fusesL Time Delay- Class RK1, Class RK5, Class L, Class J)
- (b) SECONDARY FUSES (Sum of following): **125% of the continuous load + 100% of non-continuous load.**Fuse size not to exceed 125% of transformer secondary rated amps.
- RECOMMENDED FUSES: Class RK1, Class RK5, ClassJ LENRK, ECNR, NCLR, JDL or LCU.

4 Branch Circuit Fuse Size, No Motor Load (NEC 240.3, 210.20):

- **100% of non-continuous load, +125% of continuous load.**
- *Do not exceed conductor ampacity. Recommended fuses: LENRK, ECNR, NCLR, JDL, LCU, or LCL.

5 Branch Circuit Fuse Size, No Motor Load (NEC240.3, 210.20):

- 100% of non-continuous load, + 125% of continuous load. Fuse may be sized 100% when used with a continuous rated switch. Recommended fuses same as 4.

6 Feeder Circuit Fuse Size, Mixed Load (NEC 240.3, 430.63, 430.24):

- (a) **100% of non-continuous, non-motor load + 125% of continuous, non-motor load.**
- (b) Determine non-continuous motor load (NEC430.22 (e).1.) Add to “a” above.
- (c) Determine A/C or refrigeration load. (NEC 440.6). Add to “a” above.
- (d) Feeder protective device shall have a rating or setting not greater than the rating of the largest branch device and sum of the FLCs of the other motors.(NEC 430.62)
- (e) Recommended fuses: LENRK/LESRK, JDL, ECNR/ECSR, LCU, LCL.

7 Feeder Circuit Fuse Size, 100% Motor Load (NEC 240.3, 430.62 (a).

- (a)Determine non-continuous motor load (NEC430.22 (e).
- (b)Determine load of A/C or refrigeration equipment (NEC 440.6). Add to “a” above.
- (c) Feeder protective device shall have a rating or setting not greater than the rating of the largest branch device and sum of the FLCs of the other motors.(NEC 430.62)
- (d) Recommended fuses: LENRK/LESRK, JDL, ECNR/ECSR or LCL.

8 Branch Circuit Fuse Size, Individual Motor Load, With Fuse Overload Protection (No Starter Overload Relays): (NEC 430.32, 430.36):

- (a) Motors with 1.15 Service Factor or temperature rise not over 40 Degrees C., size fuses at not more than 125% of the motor nameplate current rating.
- (b) For all other A-C motors, size fuses at not more than 115 %.
- (c) Best protection is obtained by measuring motor running current and sizing fuses at 125% of measured current for normal motor operation. Reference to “Average Time/Current Curves” is recommended.
- (d) Recommended Fuses: LENRK/LESRK, JDL, or ECNR/ECSR

.**9 Branch Circuit Fuse Size, Individual Motor Load, With Starter Overload Relays:** (NEC 430.32, 430.52):

- (a) For “back-up” NEC® overload, ground fault and short circuit protection size the fuses the same as (8 a, b) above, or the next standard size larger.
- (b) The fuse sizes in a) above may be increased as allowed by NEC® references. Generally, dual element fuses should not exceed 175% of motor nameplate F.L.A. and non-UL defined time-delay fuses not more than 300 %.
- (c) Recommended fuses: LENRK/LESRK, JDL, ECNR/ ECSR or LCL.

10 Fuse Sizing for Individual Large Motors With F.L.A. Above 480 Amps or Otherwise Require Class L Fuses –(NEC 430.52):

- **Application Tips:**
- Size fuses as closely as practical to the ampacity of the protected circuit components without the probability of unnecessary fuse opening from harmless, transient current surges. This usually requires a choice between time-delay and non-time-delay fuses.
- Use Class R fuse clips with Class R fuses to prevent installation of fuses with less interrupting rating or current limitation. Class H fuse reducers cannot be used with Class R fuse clips.
- When a conductor is oversized to prevent excess voltage drop, size the fuses for the ampacity of protected circuit components instead of over sizing fuses for the larger conductor.

Selection of Fuse for Motor Protection:

- Group installation is an approach to building multi-motor control systems in accordance with Section 430-53 of the National Electrical Code. The selection of components used in group installations is a simple process which consists of several steps.
- First is the selection of the appropriate fuse as Branch Circuit Protective Device (BCPD).
- Second is the selection of the appropriate motor starter and protector.
- Third, the selected MMP must be checked for UL listing with the selected BCPD and the available short circuit current at the application location.

1. Fused disconnect

- Calculate maximum fuse size according to NEC 430-53 (c).
- Imax (fuse size) =175% x FLC (full load current for largest motor) + the sum of FLC (full load current for largest motor) + the sum of FLC values for other motors on that branch using NEC Table 430-150 on the right.
- Select fuse from NEC Table 240-6 below. Where Imax falls between two fuse ampere ratings NEC 430-53 (c) permits going to the next high ampere rating.

2. Motor protector selection

- Select the proper MMP catalog number for each motor load from the based on the actual motor full load current (FLA) using the “Thermal setting range” column for reference.

3. MMP Interruption ratings

- Using the interruption ratings table on the next page, identify the system application voltage and interrupting capacity for the type of fuse selected in step1 above.
- **NEC 240-6 Standard fuse amperes 15, 20, 25, 30, 40, 45, 50, 60, 70, 80, 90, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 700, 800, 1000, 1200, 1600**
- Examples: Select components for protecting the following 3-phase, 460VAC, squirrel cage induction motors. The nameplate data are: 1/2 HP, 1.0 FLA; 3 HP, 4.8 FLA; 5 HP, 7.6 FLA; 7.5 HP, 11 FLA; 10 HP, 14 FLA.
- Example: using fused disconnect

- Imax = 175% x 14 + (11 + 7.6 + 4.8 + 1) = 48.9A
- Fuse rating using Table NEC 240-6 = 50A
- Minimum disconnect size = 115% x Total FLA
- NEC 430-150 table = 115% x (14+ 11 + 7.6 + 4.8 + 1) = 44.16
- Disconnect for 50A fuses is ok
- **NEC Table 430-150 full load current, 3ph AC motor**

H.P	Induction Type Motor (Squirrel Cage, Wound Type)		
	230V Amp	460V Amp	575V Amp
½	2	1	0.8
¾	2.8	1.4	1.1
1	3.6	1.8	1.4
1.5	5.2	2.6	2.1
2	6.8	3.4	2.7
3	9.6	4.8	3.9
5	15.2	7.6	6.1
7.5	22	11	9
10	28	14	11
15	42	21	17
20	54	27	22
25	68	34	27

Fuse Ratings

- Fuses with an A-C voltage rating may be applied at system voltages below the fuse voltage rating, but not at voltages above the fuse voltage rating.
- The other A-C fuse ratings remain the same at applied voltages below the fuse voltage rating.
- A-C rated fuses should not be applied in D-C voltage circuits unless D-C application ratings are provided by the fuse manufacturer.
- Except for some special purpose fuses, D-C ratings are not usually shown on fuse labels.
- The operating frequency (Hertz) will affect fuse characteristics in various ways.
- Time/Current Curves will not shift and fuse ratings will not change from 1-100 Hertz in normal applications. If ferrous hardware is used to mount the fuses, eddy current heating could alter the ratings.
- Above 100 Hertz, "skin effect" could alter the fuses' rating characteristics. This effect must be analyzed on an individual application basis.

Source: http://electricalnotes.wordpress.com/2011/04/21/fuse/