

Optimum Safety, Reliability and Electrical System Performance Through Balanced Selective Coordination and Protection

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Abstract

Selective coordination is a valuable safety asset in the lower current range where overloads most often occur. However, the National Electric Code® (NEC®) continues to expand the mandate for TOTAL Selective Coordination for ALL current ranges. At first thought, this seems to be a worthy effort in support of the stated goal of increasing the reliability and safety of the electrical system. It is certainly true that selective coordination in the lower overload current range is beneficial because it provides effective overload isolation. It is also true that equipment ground fault selectivity is very beneficial because faults normally occur in this range. However, with singularly focused mandated selective coordination on overcurrents throughout the entire fault current range, safety can be diminished. This is due to increased hazardous arc flash energy with increased equipment damage and potential fire initiation, decreased reliability, and extended downtime before service restoration. Increased equipment size and increased cost also need to be considered. It is also noted that faults in the high current range are very rare and typically occur on start up. This paper will explain the value of selective coordination in the lower current range and will then explain several of the implications resulting from mandating a TOTAL selective approach to coordination throughout the current range. The history of how these requirements came into the NEC will be discussed.

It is recommended that those involved in determining codes and standards study and consider all the ramifications so that they can provide the safest and most practical options, without detrimental restrictions. TOTAL Selectivity code requirements will not always provide the optimum safety solution. Such a solution requires the expertise and judgment of a Professional Engineer who can balance the design, safety and operating requirements in order to determine the optimum design for each specific facility. These considerations include balancing arc flash energies with their possibility of initiating building fires, appropriate codes and standards, and application requirements.

I. NEC CHANGES MANDATE TOTAL SELECTIVE COORDINATION

Article 100 of the 2005 National Electric Code (NEC) defines Coordination (Selective) as "Localization of an overcurrent condition to restrict outages to the circuit or equipment affected, accomplished by the choice of overcurrent protective devices and their ratings or settings." Previous editions of the NEC mandated TOTAL selective coordination for elevators circuits only (as presently stated in Article 620.62). The 2005 edition greatly expanded this comprehensive mandate to Emergency Systems (by adding Article 700.27), Legally Required Standby Systems (by adding Article 701.18), and also to the essential electrical system of Healthcare facilities (through Article 517.26 reference to Article 700).

II. LACK OF SUBSTANTIATION FOR TOTAL SELECTIVE COORDINATION

A. History Of NEC Selective Coordination Requirements

As recorded in the Report of Proposals (ROP) for the 1993 edition of the NEC, proposal #12-84 required that the elevator "disconnecting means shall be selectively coordinated." The Code Making Panel (CMP) statement supporting this proposal said: "This language correlates with the Canadian Electrical Code C22.1 Section 38-034(3)." This proposal was subsequently readdressed in the comment stage as recorded in the Report of Comments (ROC). Comments 12-42, 12-43 and 12-44 requested this NOT be accepted. The initial substantiation was based upon the theory that "valuable time is lost" during troubleshooting by sometimes having to locate an additional upstream device that may be opened. It should be noted that there was absolutely no substantiation offered to confirm any real-world problem. The selective coordination mandate for elevators was accepted into the 1993 edition of the NEC as a new Article 620.51-a (and later relocated to 620.62 in the 1996 edition), apparently solely based upon it already being a Canadian requirement.

As recorded in the ROP for the 2005 edition of the NEC, proposal #13-135 required that "All overcurrent protective devices in emergency systems shall be selectively coordinated..." In the substantiation provided by the submitter, Mr. Todd Lottmann, an employee of Cooper Bussmann, provided the theoretical advantage of having a localized outage on systems of such a critical nature. He also stated that both fuses & circuit breakers could accomplish this. The CMP statement supporting the proposal said: "The panel agrees that selective coordination of emergency system overcurrent devices...will provide for a more reliable emergency system." This proposal was subsequently readdressed as recorded in the ROC, comments 13-87, 13-88 and 13-89 which requested that this NOT be accepted. It should be noted that even though there was again absolutely no substantiation offered to confirm any real-world problem, the selective coordination mandate for emergency systems was accepted into the 2005 edition of the NEC as a new Article 700.27. Mr. Lottmann of Cooper Bussmann submitted a near duplicate proposal (13-145) to mandate selective coordination for Legally Required Standby Systems. Similar comments (13-99 & 13-100) requested that this NOT be accepted either. Again, with absolutely no substantiation offered to confirm any real-world problem, selective coordination became mandated for Legally Required Standby systems in the 2005 edition of the NEC as a new Article 701.18. Additionally, Article 517.26 requires that "The essential electrical system shall meet the requirements of Article 700, except as amended by Article 517." Therefore by omission, selective coordination also became mandated for the essential electrical system of Healthcare facilities without any additional proposal being accepted into the 2005 NEC's Article 517.

Proposals for the 2008 edition of the NEC have been discussed and voted upon during the January 2006 ROP meetings. Eleven Proposals (13-135, 13-137, 13-139 through 13-147) suggested chang-

ing the mandate for TOTAL selective coordination for Emergency Systems in Article 700.27. Several of these proposals suggested restricting the selective coordination requirement to the real-world overload current range. Although both NEMA and UL supported this approach, the initial Panel Action was to overwhelmingly reject these proposals with their statement including "The instantaneous portion of the time current curve is no less important than the long time portion." The authors of this paper disagree with this position and this paper will identify several additional implications that must be considered from using this approach, including a possible reduction in safety.

Another 9 Proposals (13-159 through 13-167) suggested restricting or removing the selective coordination mandate for Legally Required Standby Systems in Article 701.18. Again, even though both NEMA and UL supported this approach, the initial Panel Action was to overwhelmingly reject these proposals too. Lastly, since there were no proposals submitted to specifically address Selective Coordination in Article 517, whatever is decided in Article 700 will also automatically pertain to the essential electrical system of Healthcare facilities.

B. Lack Of Field Problems To Justify The NEC Changes

The authors have conducted an exhaustive investigation into possible field problems. Published sources were consulted in broad-ranging research databases such as Lexis-Nexis, EBSCO Host, MasterFile Premier and Newspaper Source as well as in individual targeted publications such as Consulting Specifying Engineer, Facilities Management and Buildings.com. In addition, searches were conducted through web news aggregators and other trade publication search engines including areas specific to healthcare and critical care facilities. These results produced no evidence to substantiate "real-world" problems resulting from a lack of selective coordination in higher current ranges of Emergency or Legally Required Standby Systems.

III. MANDATING TOTAL SELECTIVE COORDINATION AFFECTS THE ENGINEERING ANALYSIS AND SELECTION OF THE OVERCURRENT DEVICES

To meet the 2005 NEC mandated selective coordination requirements for elevator, emergency, and health care essential systems, a more detailed engineering analysis is required. TOTAL selective coordination requires that all overcurrent protective devices upstream of the device nearest to the overload/fault point remain closed (in the case of fuses, not blow) for a period of time adequate for the protective device nearest the fault to open. The design engineer must have a full understanding of the operation of the overcurrent protective devices utilized in the electrical distribution system, and how they will perform throughout the entire range of available overload/fault current at their point of application. However, beyond the normal overload region, this becomes complex.

More practically, unless the use of calculator charts clearly demonstrate coordination, the design engineer will have to provide a full and stringent coordination and short circuit study for each and every project containing these circuits affected by the NEC 2005. Complicating that, the designer will have to do so for each manufacturer whose equipment is approved since each manufacturer has different TC curves; settings and ranges of settings (not to mention differing degrees of current limitation). Similarly, fuse selective coordination ratio tables must be reviewed for each specified manufacturer. Providing a study based on only one manufacturer and attempting to extrapolate it to others could well increase the liability of the designer should coordination not be achieved.

TOTAL selective coordination may also involve the selection of Low-Voltage Power Circuit Breakers (LVPCBs) rather than Molded Case Circuit Breakers (MCCBs). A clear understanding of their protective features in relationship to selective coordination is required.

MCCBs are manufactured and tested to the UL-489 standard. Their thermal magnetic trip units are such that the magnetic pick-up maximum setting is approximately 10 times the trip rating. Electronic trip units are typically furnished with a fixed instantaneous override of approximately 10 to 15 times the breaker frame, or trip unit rating. Thus for MCCBs, any load side fault above the magnetic pick-up or fixed instantaneous override will cause the breaker to open within 1 cycle or less. The exact magnitude of current which will cause the MCCB to open, and its exact opening time, will vary by 1) circuit breaker manufacturer, 2) circuit breaker frame rating, 3) type of trip unit, 4) type/vintage of MCCB, 5) Manufacturer's curve tolerances. The manufacturer's actual data should be used to determine these values. It is noted that some MCCBs are equipped with electronic trip units that have adjustable "short delay" functions. When the electronic trip is in the short-time pickup range (below 13 times frame size), they can typically be adjusted up to a maximum short-time delay setting of approximately 18 cycles (300 ms). However, they also typically have either an adjustable instantaneous trip (typically with a maximum setting of 10 times trip ampere) or a fixed instantaneous override (of 13 times the frame ampere rating).

Low-Voltage Power Circuit Breakers (LVPCBs) are manufactured and tested to the UL 1066 Standard and applicable ANSI C37 standards. The ability of LVPCBs to stay closed during fault conditions is typically referred to as their ShortTime rating: "A rating applied to a circuit breaker that, for reason of system coordination, causes tripping of the circuit-breaker to be delayed beyond the time when tripping would be caused by an instantaneous element." The short-time rating of the breaker can be broken down into two facets: 1) Short-time current rating – The current carried by the circuit breaker for a specified interval, or the maximum current magnitude under a fault condition for which the circuit breaker can stay closed and 2) Short-time delay rating – an intentional time delay in the tripping of a circuit-breaker between the overload and the instantaneous pickup setting. LVPCBs are capable of keeping their contacts closed for up to 30 cycles (0.50 s) of fault current, at levels up to their maximum short-time current rating (very high short-time current ratings of approximately 85kA to 100 kA are typically available).

Care must also be exercised in the selection of current limiting overcurrent protective devices (fuses and current limiting circuit breakers) when utilized in selectively coordinated systems. Current limiting overcurrent protective devices are available as specifically marked circuit breakers, or as fuses. These devices have characteristics that, when operating within their current-limiting range, limit both the let-through I^2t and I peak to values less than the I^2t and I peak of a $\frac{1}{2}$ cycle wave of the symmetrical prospective current. The let-through I peak and I^2t values can be used for comparing against a device's static parameters, such as bus bracing withstand and thermal capability. A current limiting device can be used on the load side of a circuit breaker to obtain selective coordination. It is necessary to know the let-through I peak of the current limiting device for comparison to the instantaneous setting/override of the upstream breaker. If the let-through I peak, when converted to an equivalent rms value, is less than the instantaneous setting/override, the devices will selectively coordinate.

Care must be exercised in the selection of fuses in regards to selective coordination. Low-voltage fuse manufacturers publish time-current curves for each fuse class and rating. Some of these time-current curves show only the fuse's average melt time, while others include both melting and total clearing times. It is important to understand that the fuse's total clearing time is the sum of both the melting and arcing times. The total clearing time and melting time curves are typically used for selective coordination purposes. The maximum total clearing time of the downstream fuse must always be less than the minimum melt time of the next upstream fuse for every level of overload or fault current. While this method is valid for determining selective coordination for overload or lower fault currents, it is NOT valid for high fault currents (typically 10-15 times the fuse's rating). At high fault currents, current limiting fuses clear in less than 1 cycle (0.016 ms). Typical published time-current curves do not properly address this region (nor do most commercially available software programs which are based upon the published time-current curve data). In order to address this issue, some fuse manufacturers have published "Selectivity Ratios." This application information recommends sizing the ampere rating of the upstream fuse using a specified "selectivity ratio" in order to maintain selective coordination with a specified downstream fuse. It is critical to understand that these ratios vary significantly, and are valid only between fuses of the class & type specified. Also, since they are NOT based on worst-case "umbrella" values, they vary from manufacturer to manufacturer. Therefore selectivity ratios are recommended only for application of fuses from the same manufacturer. Furthermore, the restriction remains that only fuses from the specified manufacturer should be utilized throughout that entire electrical circuit.

It is vital that these overcurrent protective device concepts be fully understood before attempting to properly design a system that meets the NEC mandate for TOTAL selective coordination. It is also noted that, in addition to the cost of the selective coordination study, it is likely that a totally selectively coordinated system will result in larger distribution equipment, requiring greater space, and higher cost. In a recent actual hospital design, it was calculated that an electrical system designed to provide the NEC mandated TOTAL selective coordination resulted in an additional

increase of over \$500,000 versus the same design without this specific mandate. In addition, the approximate physical space required by the resultant electric equipment was an increase of 30%. These impacts must be weighed against any potential theoretical benefit gained.

IV. MANDATING TOTAL SELECTIVE COORDINATION CAN RESULT IN DECREASED SAFETY BY INCREASING HAZARDOUS ARC FLASH ENERGY

Typical electrical system design results in the selection of the overcurrent protective devices (both circuit breakers and fuses) based primarily on the determined load current required. In many cases the typically selected devices, although providing excellent overload/fault protection, will not meet the NEC mandated TOTAL selective coordination requirements for elevator, emergency, legally required standby or health care essential systems. In order to achieve this mandate, in many cases the devices must additionally be selected as follows:

1. Utilize a different upstream overcurrent protective device:
 - a. A higher ampere rated / frame of MCCB will typically provide a higher level of magnetic pick-up or instantaneous override (increased short time capability) thus, providing selective coordination at higher fault current levels.
 - b. A higher ampere rated fuse or different type/class of fuse will typically allow a higher level of I^2t let through energy before becoming damaged and/or opening thus, providing selective coordination at higher fault current levels.
2. Select LVPCBs (in lieu of MCCBs) to obtain increased short-time capability.

The intent of TOTAL selective coordination is to assure that the upstream overcurrent protective devices ALWAYS remain closed for a period of time adequate for the protective device nearest the fault to open. When the upstream devices are selected to increase the time they remain closed, it results in correspondingly higher I^2t let through energy. It must be understood that this has the additional unwanted consequence of increasing the hazardous arc flash energy, which is directly proportional to I^2t let through energy, which may result in reducing safety to personnel and increasing potential fire damage and/or potential equipment damage.

For example, refer to Figure 1: Consider Example 1 consisting of a branch panelboard, which is part of an emergency system. Example 1 illustrates fuses, which were chosen by the consulting engineer, without regard for TOTAL selective coordination, but based upon the best protection for the maximum available fault current level of 8200A at the panelboard bus. The panelboard main fuse was selected as a 400A class RK1 based upon providing very good short circuit protection with reduced arc fault energy at the

maximum available fault current. Branch fuse F-1 was chosen as a 200A class RK-5 based primarily on the motor load current. Reference the minimum melting time and total clearing times for these fuses as shown in Example #1. As can be seen from this example, in the normal overload range (below 6 times the 400A fuse or 2400A), these fuses provide selective coordination. However, at approximately 3000 amperes and above, they do not. In this area and above, the 400A main RK1 fuse total clearing time is faster than the branch RK5 fuse minimum melting time. Based on industry acceptance and the consultant's personal experience of the real world, all overloads, as well as the vast majority of fault conditions in this example, would typically occur in this 2400A and below level. Thus, PARTIAL selective coordination would occur covering almost all real world situations. The design preference was to utilize a main RK1 fuse because: 1) Should the extremely rare maximum 3 phase bolted fault actually occur, it provides lower arc-fault energy with better safety to personnel and a reduction in potential equipment damage and/or potential for starting a fire, and 2) A three phase bolted fault or very high level arcing fault is a highly unlikely occurrence.

However, based on the mandated 2005 NEC requirement for TOTAL selective coordination, this would require either a much higher ampere rated main RK1 fuse (an 8:1 ratio according to one manufacturer's recommended Selectivity Ratio with corresponding larger switch and cable sizes) or a change to an RK5 fuse. See Example 2: In this example the decision was to use a main 400A RK5 fuse, which meets the manufacturer's recommended Selectivity Ratio of 2:1. In this case TOTAL selective coordination is achieved. However, consideration should be given to the resulting larger arc flash energy levels with potential hazard to personnel, as well as to the increased potential of fire danger.

This balance between protection and overall safety is also recognized in ANSI/IEEE® Std. 242-2001 - IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems, (IEEE Buff Book) which explains that: "Electrical systems should be protected against the highest short-circuit currents that can occur; however, this maximum fault protection may not simultaneously provide adequate protection against lower current faults, which may involve an arc that is potentially destructive. Ground faults comprise the majority of all faults that occur in industrial and commercial power systems." (2001 Edition, Section 1.2, Page 4)

Recognizing the need to balance arc flash energy reduction against selectivity an arc flash study must be performed. These studies have been performed for the previous examples using IEEE 1584, Arc Flash Calculation Guide. Consider an arcing fault that occurs on the load side of Main Fuse M-1 but line side of branch fuses (Panelboard Bus). On a 480V system, IEEE 1584 determines that a 8200 ampere available fault current will produce a reduced arcing current of between 5500 and 4700 amperes, due to the added impedance of the arc (the lower range is also included because of arcing variability). Since class RK-1 fuses are included in the IEEE 1584 model, the 8200A bolted fault current value is entered, and according to IEEE 1584, this calculates to an incident energy of 0.7 calorie/cm², resulting in a minimal Category 0 level of Personal Protective Equipment (PPE) required.

However, when the main fuse is changed to a 400A class RK-5 due to the 2005 NEC mandate for TOTAL selective coordination the resultant energy must be recalculated. An 8200 ampere available fault current produces a reduced arcing current of between 5500 and 4700 amperes. Since a class RK-5 fuse is not included in the IEEE 1584 model, the total clearing times as determined from the published time-current curve are utilized in the calculation. One manufacturer's time-current curve for a 400A class RK-5 fuse indicates that at 5500 amperes the total clearing time is 0.3 seconds, and at 4700 amperes the total clearing time increases to 0.57 seconds (see Example 2). Using 0.57 seconds, IEEE 1584 calculates an incident energy of 8.4 calories/cm². This equates to a required Category 3 level of Personal Protective Equipment (PPE), a greatly increased risk! Additionally, there exists a higher potential for equipment damage and initiation of fires external to the equipment.

For comparison purposes, a 400 ampere molded case circuit breaker was substituted for the previously described 400 ampere Class RK-5 fuse. One manufacturer's published time current curve for a 400 ampere molded case circuit breaker indicates that at 5500 amperes the total clearing time is 0.02 seconds, and at 4700 amperes the total clearing time is 0.025 seconds (see Example 3). According to IEEE 1584, this calculates to an incident energy of 0.4 calorie/cm², resulting in a minimal Category 0 level of Personal Protective Equipment (PPE) required.

The results of these calculations are summarized in Chart 1. The point is to illustrate that overcurrent protective devices (both fuses and circuit breakers) will readily selectively coordinate in the lower current range where overloads most often occur. However, when selected specifically to remain closed for an extended period of time to assure TOTAL selective coordination for all current ranges, this will result in a corresponding increase in hazardous arc flash energy!

**Chart 1:
 Summary of Arc Flash Implications Due to
 NEC Mandated FULL Selective Coordination**

	Scenario 1	Scenario 2	Scenario 3
	PARTIAL Selective Coordination	NEC Mandated TOTAL Selective Coordination	For Comparison Purposes
	400 Ampere Class RK 1	400 Ampere Class RK 5	400 Ampere Molded Case
Description	Main Fuse	Main Fuse	Main Circuit Breaker
Available Fault Current	8200A	8200A	8200A
IEEE 1584 Calculated Incident Energy, Cal/cm ²	0.7	8.4	0.4
Category PPE Required	0	3	0

To visually illustrate the potential hazards associated with real world level arcing faults, Eaton Corporation conducted testing based upon the [“Arcs in a box”](#) setup that was used to establish IEEE 1584. A 400 ampere class RK-1 fuse, a 400 ampere class RK-5 fuse, and a 400 ampere molded case circuit breaker were each tested at 3000 amperes available fault current at 480 volts ac.

[Click here to view video](#)

V. MANDATING TOTAL SELECTIVE COORDINATION CAN RESULT IN INCREASED DOWNTIME AND TO THE CHOICE OF PROTECTIVE DEVICES WITH REDUCED FEATURES

Faced with the new 2005 NEC mandates for TOTAL selective coordination for all current ranges, many engineers are under the mistaken belief that fuses are the “silver bullet” answer. These engineers may be driven to specify fuses in lieu of low-voltage circuit breakers due to a perceived ease of application, and without fully understanding the many consequences associated with doing so. As previously explained, when fuses open (blow) to clear the more realistic and common lower level arcing fault condition, the fault current is typically below the fuse’s current limiting range, with the resultant arc flash energy escalating to very dangerous levels. An extended outage then occurs because it takes more time to physically replace the fuses, as compared to resetting a circuit breaker. In addition, the blowing of the fuse on a common overload condition would typically require extended outage time for fuse replacement as compared to just resetting a circuit breaker. This could actually result in more potential danger to health care patients. The outage is extended considerably further for the all-too-common situation where the proper replacement fuse is not readily on-hand. (Remember that the replacement fuse must be from the exact manufacturer originally used for determining its selective coordination ability.) Even worse, in order to quickly restore power, a hazardous situation is created if the wrong replacement fuse type is installed, simply because it was on-hand. Additionally, if the electrician has not taken the appropriate safety precautions, a dangerous situation may occur if exposed to energized parts during the fuse replacement.

In addition to reduced downtime, the numerous advantages of circuit breakers listed below, would be eliminated by the exclusive use of fuses:

- Simultaneous opening of all 3 phases, preventing single-phasing of motors. By comparison, the blowing of one fuse, thus single phasing of an emergency and essential system motor, could result in the increased possibility of motor damage and extended replacement time.
- Easy incorporation of accessories such as under-voltage devices, shunt trips, etc needed to respond to special requirements of the emergency or essential systems.
- Easy incorporation of ground fault protection to detect the vast majority of real world low level ground faults and their potential to initiate external fires.
- Ability to incorporate electronics, with resulting diagnostics through communication – quick knowledge of problem (where and when) for quick correction of problems occurring in the emergency and essential system.
- Ability to check settings throughout the circuit breaker’s life.
- Eliminates the concern that all 3 fuses were changed after a fault as recommended by fuse manufacturers (and hence the required selectivity may not be maintained).
- Ability to incorporate metering of all electrical parameters to provide data to quickly identify and correct problems (such as harmonics) in the emergency or essential system.
- Ability to adjust tripping characteristics to provide customized protection for changing load requirements.
- Ability to provide zone selective interlocking on phase and ground protection.

VI CONFLICTS ASSOCIATED WITH THE NEW NEC MANDATES

Various governing bodies and standards organizations have recognized that PARTIAL selective coordination may be desirable over TOTAL selective coordination. The following are just a few examples.

A. Conflicts in Florida & Washington State

Since 2002 the Florida Agency for Healthcare Administration (ACHA) has accepted that their selective coordination requirement is met by reviewing only the region where the overcurrent protective devices operate at a minimum time of 0.1 seconds or longer. This is consistent with the realization that true 3-phase bolted faults typically occur on electrical systems during initial energization, or upon start up after a system modification. In these situations, selective coordination is NOT desired because it is preferred that all overcurrent devices open as quickly as possible to limit system damage. The design engineer must consider the ease of determining selective coordination over the realistic application range, versus the previously documented consequences of designing a system to assure selective coordination throughout the total range of theoretical available fault current.

On May 31, 2006, the Chief Electrical Inspector for the State of Washington, Mr. Ron Fuller, issued an emergency order exempting existing buildings undergoing modification or renovation from the requirements for selective coordination for emergency and legally required standby systems. The Emergency Rule overrides the requirements in 700.27 and 701.18 of the 2005 Edition of the National Electrical Code and was immediately effective. This may evolve into a “jurisdiction by jurisdiction” addressing of the problem.

B. Conflicts with standards

The ANSI/IEEE Std. 242-2001 (IEEE Buff Book) Chapter 15, page 576 states: “In applying protective devices, it is occasionally necessary to compromise between protection and selectivity. While experience may suggest one alternative over another, the preferred approach is to favor protection over selectivity. Which choice is made, however, is dependent on the equipment damage and the effect on the process.” This nationally recognized standard acknowledges that the design engineer should be permitted to determine the best design choices for a particular application.

Additionally, the ANSI/IEEE Std. 242-2001 (IEEE Buff Book) Section 15.72-h, Page 615 states: “In this example, loss of selectivity is a better choice than installing a larger fuse because a larger fuse would compromise adequate transformer protection.” This provides confirmation that TOTAL selective coordination is NOT always the most important design consideration.

VII. CONCLUSION

Regardless of the fact that no data was submitted to substantiate existing real-world problems, the 2005 edition of the NEC greatly expanded the TOTAL selective coordination mandate to include Emergency Systems, Legally Required Standby Systems, and the essential electrical system of Healthcare facilities. Mandating se-



lective coordination across the total range of overcurrents results in several system "trade-offs" that must be fully understood & considered: increased sizing of the overcurrent protective device, decreased safety (resulting from increasing hazardous arc flash energy), extended downtime before service restoration and increased equipment size and cost. Contrary to the belief by many, there are no "silver bullet" solutions. Experience indicates that selective coordination across the realistic & common real-world overload current range is a "common sense" approach. Codes & Standards should NOT mandate selective coordination across the total range of overcurrents because it prevents the Professional Engineer from fulfilling their responsibility to determine the best design choices for a particular application. Further mandating TOTAL selective coordination may be inconsistent with NEC Article 90.1 (C), which states: "This Code is not intended as a design specification nor an instruction manual for untrained persons." The NEC CMP 13 should reconsider and accept proposals 13-137 and 13-159 (which would remove the mandate for TOTAL selective coordination from Articles 700 and 701, and subsequently 517 too). As an alternative, the CMP could move these statements to a Fine Print Note.

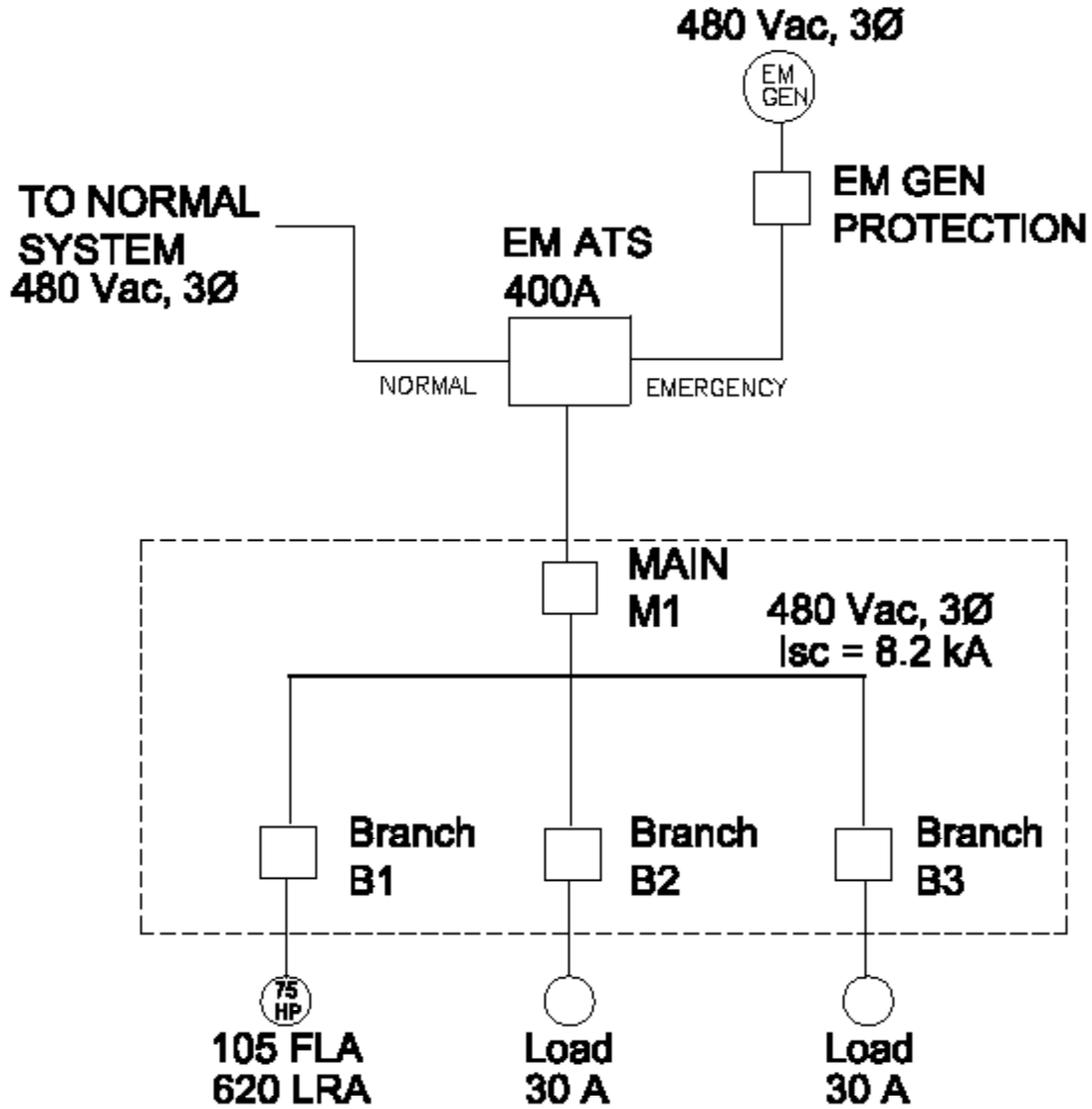
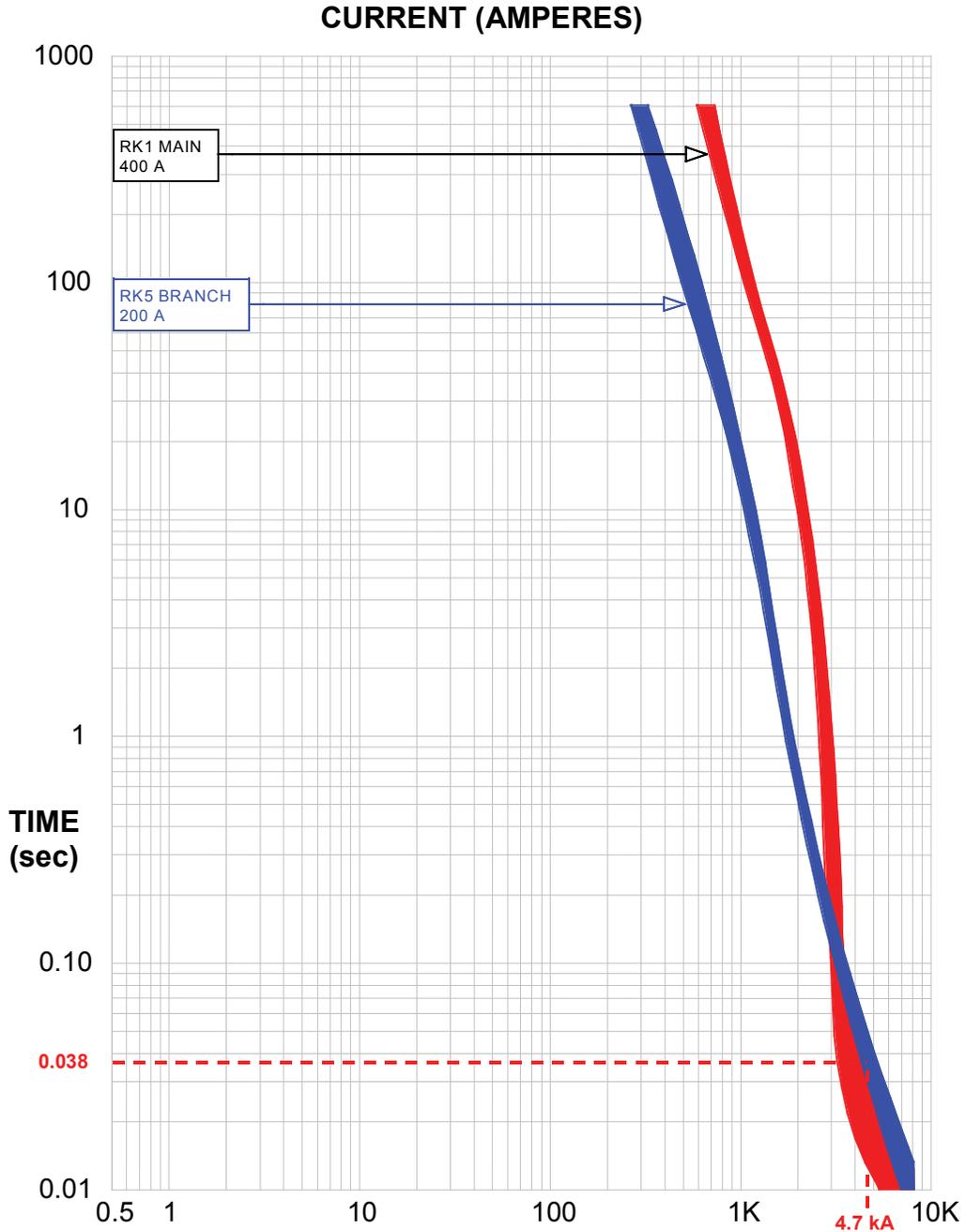
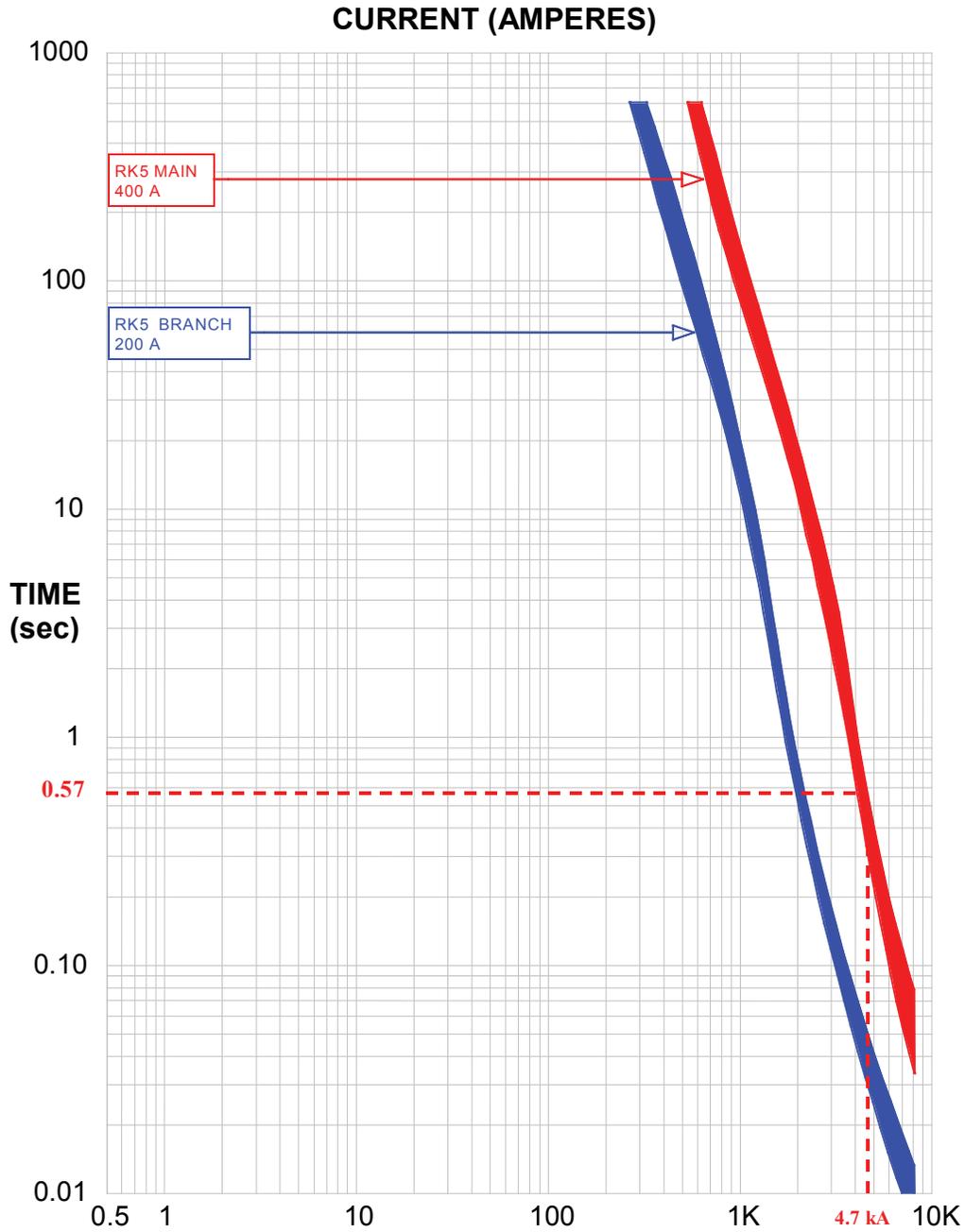


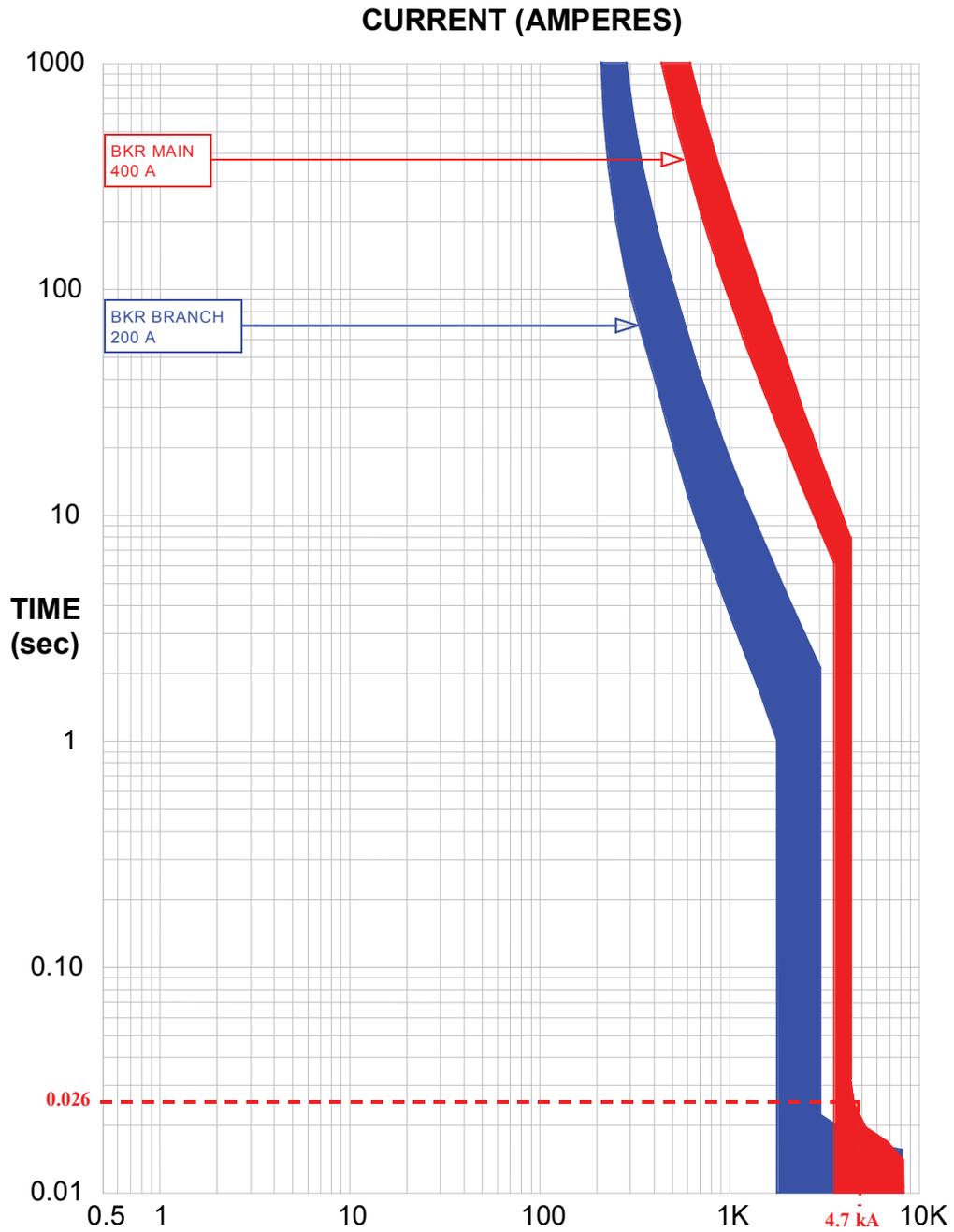
FIGURE 1



Branch Panelboard TCC - Example 1



Branch Panelboard TCC – Example 2



Branch Panelboard Breaker TCC – Example 3



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BIOGRAPHIES

CHARLES J. NOCHUMSON, PE — NATIONAL APPLICATION ENGINEER Charles J. Nochumson is an Application Engineer for Eaton Corporation and was previously an Application Engineer with Westinghouse Electric Corporation in their Distribution and Control Business Unit for 29 years. Mr. Nochumson is co-author of an IEEE paper on "Transfer Considerations in Standby Generator Application," author of a TAPPI and IEEE paper on "Application of New Technologies in Power Circuit Breakers with Higher Interrupting Capacity and Short Time Ratings." Chuck has written and presented a paper at the IEEE/IAS Pulp & Paper 2001 Conference on "Considerations in Application and Selection of Unit Substation Transformers" which was selected for publication in IEEE Transactions. He has also been a guest speaker for Plant Services magazine and the International Association of Electrical Inspectors-Chicago Division. He has written an article on "Basic Electrical Distribution Systems" for Electrical Distributor magazine and also authored articles in Plant Engineering magazine. In addition, Chuck has been a speaker numerous times at Chicago IEEE-IAS meetings on a variety of technical topics and has been an instructor at their yearly February Technical Seminars. In addition he has been a past speaker at IAEI Chicago Division meetings, latest topic on Motor Protection. Besides providing technical and application information on Cutler-Hammer products for consulting and design engineers, he provides technical direction for the committee that publishes Eaton's Consulting Application Guide and its Product Specification Guide. Mr. Nochumson is a Professional Engineer and Senior Member of IEEE, as well as an Associate Member of IAEI. He was inducted into the Chicago Electric Association Hall of Fame in 2005. He is presently located in Phoenix as Eaton's National Application Engineer.

KEVIN J. LIPPERT — MANAGER OF CODES & STANDARDS

Kevin J. Lippert is the Manager, Codes & Standards with Eaton in Pittsburgh, PA. He began his career in 1986 with Westinghouse Electric Corp., which was acquired by Eaton Corp. (1994). He is heavily involved with the National Electrical Manufacturer's Association and has held Chairmanships of several NEMA Low Voltage Distribution Equipment committees. He is a member of several Underwriters Laboratories (UL) Standards Technical Panels (STP) and is a U.S. Representative to several International Electrotechnical Commission (IEC) Subcommittees. Kevin is an alternate member of National Electrical Code Making Panel 8. He has published industry articles, IEEE White Papers, and is a Senior member of IEEE.

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