LISTEN. THINK. SOLVE.®

Overview on North American Standards

March 22nd - Olomouc (Czech Rep.) - Stefano Muraro

PUBLIC

Allen-Bradley • Rockwell Software

Rockwell Automation

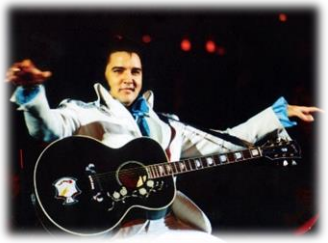
North American Standards (NAS) – The presenter

Rockwell Automation

- Stefano Muraro: Product Manager Industrial Control - EMEA Region
- Joined RA in 1991
- Positions covered in the past:
  - Commercial Engineer Industrial Control - Italian Region
  - Commercial Engineer Low Voltage Motor Control Center - EMEA Region
- Team Member of «North American Standards Overview», initiative launched in Italy back in 2002
- Location of work: Milan, Italy
- Contacts:
  - Office +39 02 33447.241
  - Mobile +39 348 3208021
  - email smuraro@ra.rockwell.com

North American Standards (NAS) – The Presenter

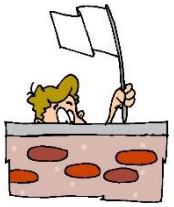
- This seminar is not intended as a «one man show»...



- ...Feel free to interrupt me asking questions and clarification at anytime...

- ...I know I am going to bore you for the next few hours but...

- ...Please do not shoot on the pianist

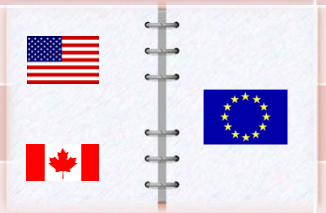


Disclaimer

- Rockwell Automation assumes no liability for the correctness or completeness of the information included in this seminar
- The information are intended to support the Engineering Teams in charge of design Electrical Industrial Control Panel to respect the North Amarican Standards but they are not intended to be comprehensive
- For certification purposes, it is mandatory to rely on the most up-to-date original text of the English language Standards

Agenda

08:00 – 09:00	Registration	Controltech
09:00 – 09:15	**Welcome and Company presentation**	FS
09:15 – 10:00	**Introduction to North American Standards - Terms and Definition**	SM
10:00 – 10:30	Coffe Break	
10:30 – 11:15	**North American Standards – UL standards vs IEC**	SM
11:15 – 12:30	**Branch and Feeder Circuits**	SM
12:30 – 13:30	Lunch	
13:30 – 14:30	**Control Circuits**	SM
14:30 – 15:30	**Example of Panel sizing/SCCR**	SM
15:30 – 15:45	Coffe Break	
15:45 – 16:45	**Rockwell Automation Products to fit North American Standards**	SM
16:45 ...	Wrap-up	Controltech



Seminar Goals

Rockwell Automation

- We accomplish or goals by sharing Rockwell Automation competency about...
  - The comprehension of the NA regulatory system
  - The most important Laws, Regulation and Standards
  - The Entities involved
  - Wording
  - Where to find relevant information
  - How to properly select products for the engineering of Industrial Control Panels
  - How to avoid most common errors
  - How to dial with NA counter parts (customers, supplier, co-worker)
  - What are the right questions to ask
  - How to understand both the answers and manufacturing specifications
  - And more....

Seminar target audience

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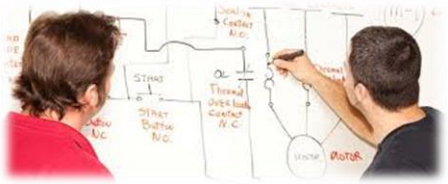
- Panel Builders ✓✓✓
- OEMs ✓✓
- End Users ✓
- Electrical Engineers ✓✓✓
- Decision Makers ✓✓✓



Question for the audience

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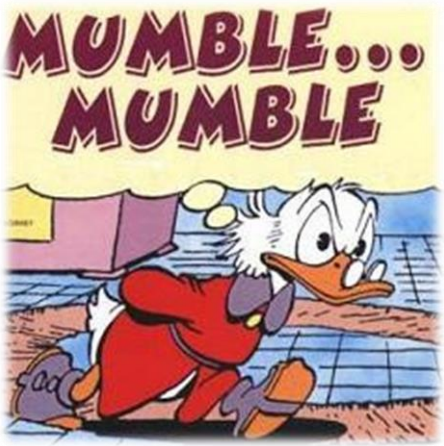
What's the easiest to understand?

1. NFPA 70 is a National Consensous Standard incorporated by reference in the Code of Federal Regulation and is the standard used by the Authority Having Jurisdiction to inspect electrical installations

2. Disconnect swithes are sized based on 115% of Full Load Ampere

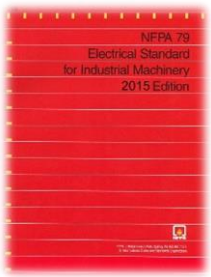


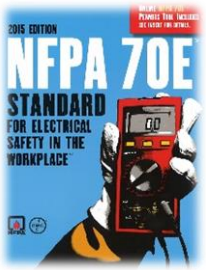
Seminar Contents

- NA regulatory system Vs European

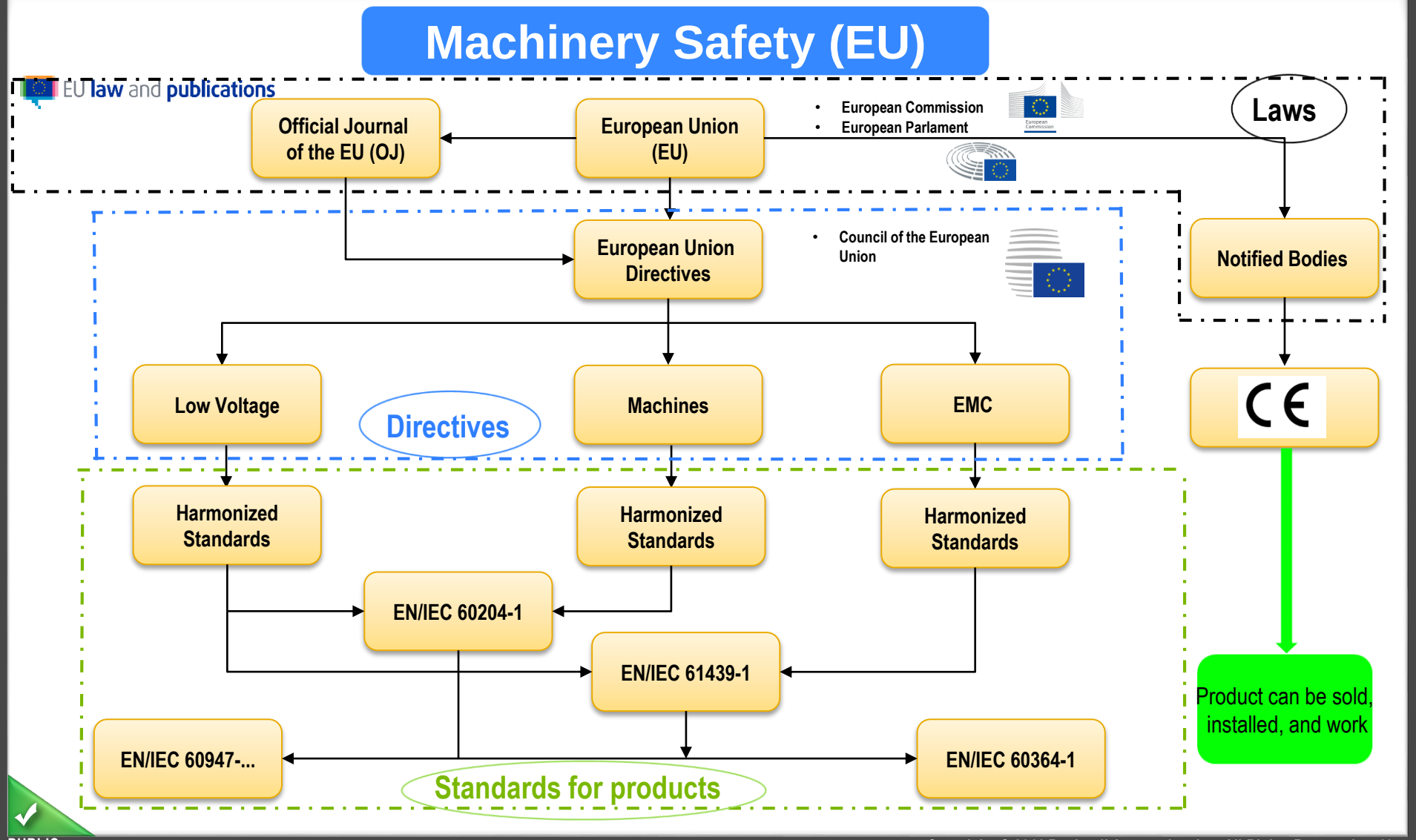
- Industrial Control Panel - Analysis

- National Electrical Code, Industrial Machinery, Electrical Safety in the Workplace - Overview





EU - Approach



EU - Standards

- Every EU directive has a list of Harmonized Standards
- The Standards are published by CENELEC and are referred as European Norm or EN Standard
- These standards are called 'Harmonized' because they are identical to the published IEC (approx. 75%)

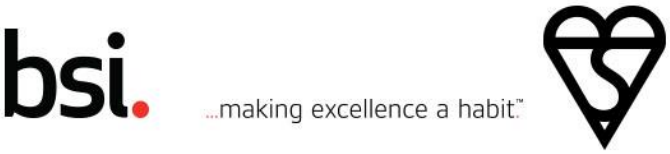
EU – Notified Body

- An entity accredited by a Member State and authorized to asses whether a product meets certain preordained standards
- Assessment can include inspection and examination of, design, engineering and production
- With the assessment completed the product gets the Declaration of Conformity, therefore the manufacturer can label the product with the CE Mark which is mandatory to sale the product in the EU
- The CE Mark is the passport for the free circulation of the product within the EU

EU – Notified Body

New Approach Notified and Designated Organizations

- Examples of NB (complete list under NANDO web site)




KEMA Quality

ATTESTATION OF CONFORMITY

Issued to:	Rockwell Automation 1201 South Second Street WI 53204 Milwaukee United States Of America
For the product:	Low voltage switchgear and control gear assembly
Trade name:	Allen-Bradley
Type/Model:	CENTERLINE 2500
Ratings:	Ue = 690 V, Ui = 1000 V, Uimp = 12 kV, 50/60 Hz, Ie (main busbar system) = 1250 A
Manufactured by:	Rockwell Automation 1201 South Second Street WI 53204 Milwaukee United States Of America
Subject:	Design verification
Requirements:	Clause 10.10 of IEC 61439-2:2009
Remark:	Date of performance of tests: January 2007

This Attestation is granted on account of an examination by DEKRA, the results of which are laid down in a confidential test report no 2103078.02-QUA/INC issued on 16 April, 2007.

The examination has been carried out on one single specimen of the product, submitted by the manufacturer. The Attestation does not include an assessment of the manufacturer's production. Conformity of his production with the specimen tested by DEKRA is not the responsibility of DEKRA.

Arnhem, 11 April 2011 Number: 2144035.02A

DEKRA Certification B.V.

H.L. Schendstok

Certification Manager

NA – Laws, Regulation, Standards

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- **Laws**
  - National, State and County level
  - Proposed and approved by the Congress
  - Laws are rules that are issued by governing body stating what can be done and what cannot
- **Regulations**
  - Those are usually National, but can be receipt at State or even at County level
  - Proposed and approved by Federal Agencies
  - Regulation is the process of monitoring and enforcing the Laws stating how things shall be done or not done
- **Standards and National codes**
  - National Level
  - Approved and published by recognized standardization bodies
  - Include detailed requirements regarding safety and performances and are established by private organizations

NA - Approach

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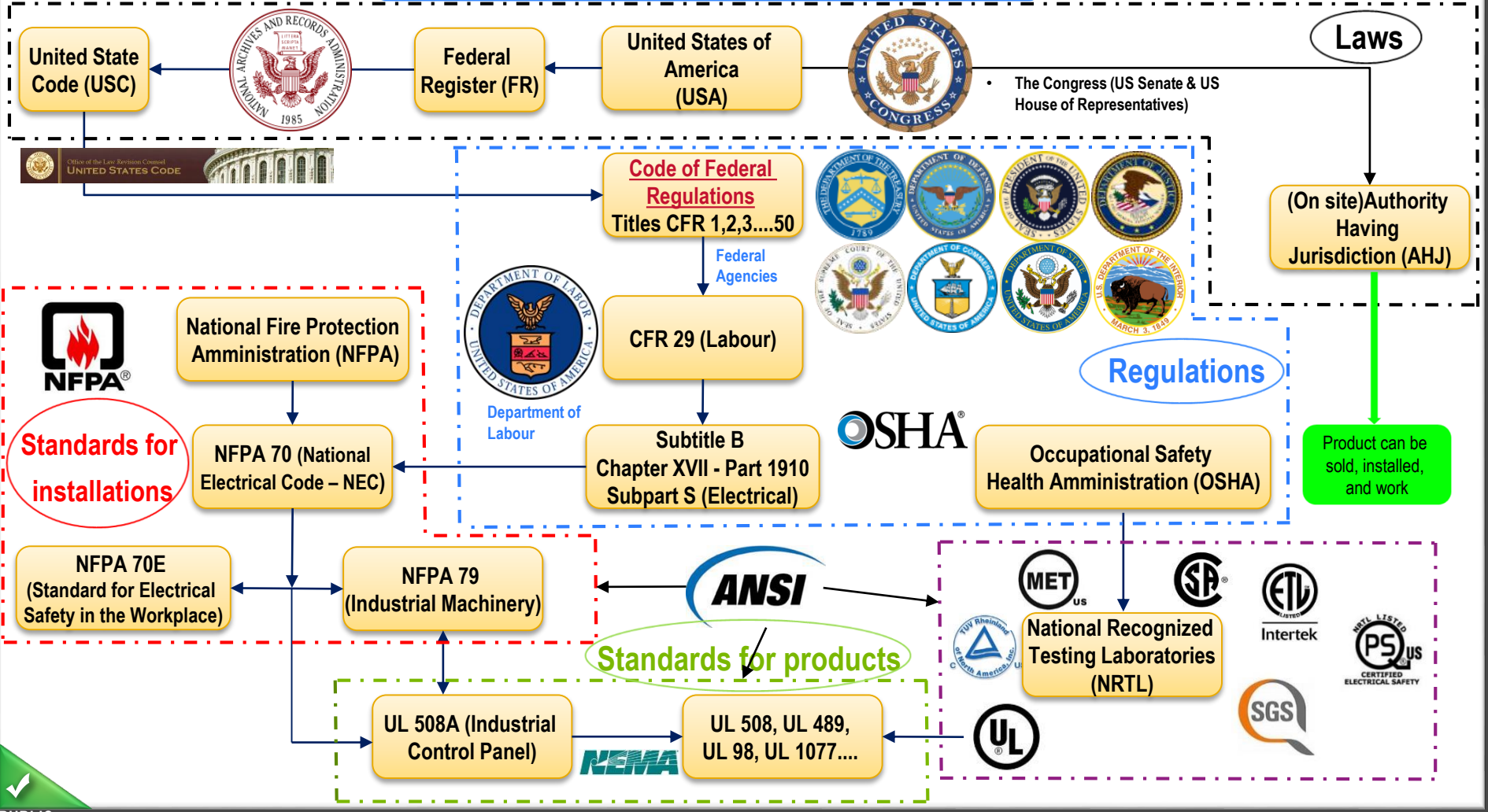
Machinery Safety (USA)



NA United States Code and Federal Register

- USC is the official Journal of the Federal Government of the United States that contains government laws
  - Compiled by the Office of the Federal Register within the National Archives and Record Administration, directly controlled by The Congress

- FR is the official compilation and codification of the general and permanent federal statutes of the United States
  - Collects all the USC laws

NA Code of Federal Regulation

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- Is the codification of the Regulations to enforce Unites State Code (USC)
  - No law is «active» till this is receipt by the CFR
- Organized in 50 «Titles» numbered from 1 t 50 to represent broad areas subject to federal regulation
  - Every Title includes a variable number of «Subtitles» dedicated to a specific topic
  - One or more Federal Agency is responsible for the Subparts
  - Each Subtitle is splitted in «Parts», «Sections» and «Paragraphs»
- Updated every year in four shots in printed hardcopies volumes (every Title is made by 1 or more volume)
- The digital version is named e-CFR and is updated daily

Electronic Code of Federal Regulations
e-CFR ™

NA Federal Agency

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- The FA are unique governmental bodies, capable of exercising powers characteristic of all three branches of the Unites States Federal Governament
  - Judicial
  - Legislative
  - Executive
- Those are entities which propose and establish Regulation to enforce Laws
- An individual agency typically will possess only the power of the branch that set it up, or possibly powers characteristic of two branches, but the Separation of Powers doctrine dictates that all three powers should not be vested in one body
- The Administrative Procedure Act (APA), Pub.L. 79-404, 60 Stat. 237, enacted June 11, 1946, is the United States Federal Statute that governs the way in which Federal Administrative Agencies of the Federal Governament of Unites States of America may propose regulations

NA Federal Agency

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Legislative Branch	Juducial Branch	Executive Branch
Architect of the Capitol	Administrative Office of the United States Courts	Executive Office of the President
United States Botanic Garden	Federal Judicial Center	United States Department of Agriculture
Congressional Budget Office	Judicial Conference of the United States	United States Department of Commerce
Government Accountability Office	Office of Probation and Pretrial Services	United States Department of Defense
Government Publishing Office	United States Sentencing Commission	United States Department of Education
Library of Congress		United States Department of Energy
Congressional Research Service		United States Department of Health and Human Services
United States Copyright Office		United States Department of Homeland Security
Office of Compliance		United States Department of Housing and Urban Development
United States Capitol Guide Service		United States Department of the Interior
United States Capitol Police		United States Department of Justice
		United States Department of Labor
		United States Department of State
		United States Department of Transportation
		United States Department of the Treasury
		United States Department of Veterans Affairs

NA Federal Agency and Code of Federal Regulations

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- Where possible, Federal Agency promulgates National Consensus Standards[1] or established Federal Standards as Safety Standards
  - The mandatory provisions of the Standards, Incorporated by Reference[2], have the same force and effects as the Standards listed in Part 1910
  - For example, the National Consensus Standard NFPA 70 is listed as a reference document in Appendix A of Subpart S-Electrical of Part 1910 of 29 CFR
  - NFPA 70 is a voluntary Standard, which was developed by the National Fire Protection Association (NFPA) and is also known as the National Electric Code (NEC).
  - By incorporation through Reference, all the mandatory requirements in the NEC are mandatory by OSHA

1) See next slides
2) Is the act of including a second document within another document by only mentioning the second document. This act, if properly done, makes the entire second document a part of the main document

NA National Consensous Standards

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- Defined by 29 USC § 652 (9) (Title 29. Labor; Chapter 15 Occupational Safety and Health)
  - The term “National Consensus Standard" means any occupational safety and health standard or modification thereof which:
    - (1) has been adopted and promulgated by a nationally recognized standards-producing organization under procedures whereby it can be determined by the Secretary* that persons interested and affected by the scope or provisions of the standard have reached substantial agreement on its adoption
    - (2) was formulated in a manner which afforded an opportunity for diverse views to be considered
    - (3) has been designated as such a standard by the Secretary, after consultation with other appropriate Federal Agencies

*Labour Secretary

NA National Consensous Standards

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- Consensus Standards are seen as generally accepted engineering practices and can be used for litigation purposes when entered as evidence in a legal proceeding
- In case of an incident where litigation is involved, the design and safety practices used are compared with these standards
- In some cases, this type of enforcement is more critical than if the government were the enforcing agent Federal agencies
- Are normally written by volunteers and published by standards producing organizations
- The content is the result of work done by a blue-ribbon panel of experts and defines the industry's best generally available knowledge.
- Fall into several different classes oriented to:
  - Product
  - Testing
  - Installation
  - Design
  - People
- Many become legally mandated by governmental organizations

NA OSHA

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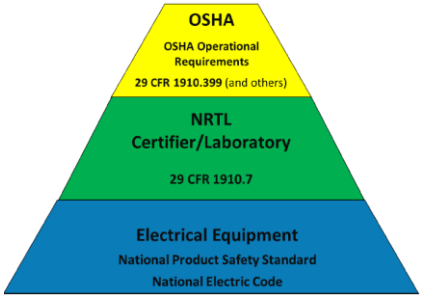
OSHA

Occupational Safety and Health Association

Federal agency that adopts regulations for safety in the workplace

OSHA audits NRTLs, National Recognized Testing Laboratories (e.g. UL)



Canadian Standards Association (CSA)
- 178 Rexdale Boulevard
- Etobicoke, Ontario M9W 1R3
- Canada

Curtis-Straus LLC (CSL)
- One Distribution Center Circle, Suite#1
- Littleton, Massachusetts 01460
- United States

FM Approvals LLC (FM)
- 1151 Boston-Providence Turnpike
- Norwood, Massachusetts 02062
- United States

Intertek Testing Services NA, Inc. (ITSNA)
- 545 East Algonquin Road, Suite F
- Arlington Heights, Illinois 60005
- United States

International Association of Plumbing and Mechanical Officials EGS (IAPMO)
- 5001 East Philadelphia Street
- Ontario, CA 91761
- United States

MET Laboratories, Inc. (MET)
- 914 West Patapsco Avenue
- Baltimore, Maryland 21230
- United States

Nemko-CCL (CCL)
- 1940 West Alexander Street
- Salt Lake City, Utah 84119
- United States

NSF International (NSF)
- 789 North Dixboro Road
- Ann Arbor, Michigan 48105
- United States

QAI Laboratories, LTD (QAI)
- #16-211 Schoolhouse Street
- Coquitlam, British Columbia V3K 4X9
- Canada

QPS Evaluation Services Inc.
- 81 Kelfield Street, Unit 8
- Toronto, Ontario, M9W 5A3
- Canada

SGS North America, Inc.
- 620 Old Peachtree Road
- Suwanee, Georgia 30024
- United States

Southwest Research Institute
- 6220 Culebra Road
- Post Office Drawer 28510
- San Antonio, Texas 78238
- United States

TUV Rheinland of North America, Inc.
- 12 Commerce Road
- Newtown, Connecticut 06470
- United States

TÜV SÜD America Inc.
- 10 Centennial Drive
- Peabody, Massachusetts 01960
- United States

TÜV SÜD Product Services GmbH
- Ridlerstrasse 65
- D-80339 Munich
- Germany

Underwriters Laboratories Inc.
- 333 Pfingsten Road
- Northbrook, Illinois 60062
- United States

NA CFR in details - Titles

Title 1: General Provisions	Title 26: Internal Revenue (also known as the Treasury Regulations)
Title 2: Grants and Agreements	Title 27: Alcohol, Tobacco Products and Firearms
Title 3: The President	Title 28: Judicial Administration
Title 4: Accounts	Title 29: Labor
Title 5: Administrative Personnel	Title 30: Mineral Resources
Title 6: Domestic Security	Title 31: Money and Finance: Treasury
Title 7: Agriculture	Title 32: National Defense
Title 8: Aliens and Nationality	Title 33: Navigation and Navigable Waters
Title 9: Animals and Animal Products	Title 34: Education
Title 10: Energy	Title 35: Reserved (formerly Panama Canal)
Title 11: Federal Elections	Title 36: Parks, Forests, and Public Property
Title 12: Banks and Banking	Title 37: Patents, Trademarks, and Copyrights
Title 13: Business Credit and Assistance	Title 38: Pensions, Bonuses, and Veterans' Relief
Title 14: Aeronautics and Space (also known as the Federal Aviation Regulations)	Title 39: Postal Service
Title 15: Commerce and Foreign Trade	Title 40: Protection of Environment
Title 16: Commercial Practices	Title 41: Public Contracts and Property Management
Title 17: Commodity and Securities Exchanges	Title 42: Public Health
Title 18: Conservation of Power and Water Resources	Title 43: Public Lands: Interior
Title 19: Customs Duties	Title 44: Emergency Management and Assistance
Title 20: Employees' Benefits	Title 45: Public Welfare
Title 21: Food and Drugs	Title 46: Shipping
Title 22: Foreign Relations	Title 47: Telecommunication
Title 23: Highways	Title 48: Federal Acquisition Regulations System
Title 24: Housing and Urban Development	Title 49: Transportation
Title 25: Indians	Title 50: Wildlife and Fisheries

NA Path inside 29 CFR

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- The path that connects (Incorporating by Reference) the CFR to Electrical Standards is:
  - Title 29 - Labour
    - Subtitle B - Regulation related to Labour
      - Chapter 17 – Occupational Safety and Health Administration, Department of Labour
        - Part 1910
          - Subpart S – Electrical
            - Appendix A to Subpart S OF Part 1910 - Reference for Further Information

Incorporation by Reference

NA Path inside 29 CFR

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e-CFR data is current as of March 9, 2016

Title	Volume	Chapter	Browse Parts	Regulatory Entity
Title 29 Labor	1	Subtitle A—Office of the Secretary of Labor		
			0-99	OFFICE OF THE SECRETARY OF LABOR
	2	Subtitle B—Regulations Relating to Labor		
		I	100-199	NATIONAL LABOR RELATIONS BOARD
		II	200-299	OFFICE OF LABOR-MANAGEMENT STANDARDS, DEPARTMENT OF LABOR
		III	300-399	NATIONAL RAILROAD ADJUSTMENT BOARD
		IV	400-499	OFFICE OF LABOR-MANAGEMENT STANDARDS, DEPARTMENT OF LABOR
	3	V	500-899	WAGE AND HOUR DIVISION, DEPARTMENT OF LABOR
	4	IX	900-999	CONSTRUCTION INDUSTRY COLLECTIVE BARGAINING COMMISSION
		X	1200-1299	NATIONAL MEDIATION BOARD
		XII	1400-1499	FEDERAL MEDIATION AND CONCILIATION SERVICE
		XIV	1600-1699	EQUAL EMPLOYMENT OPPORTUNITY COMMISSION
	5	XVII	1901.1-1910.999	OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION, DEPARTMENT OF LABOR
	6		1910.1000-1910.1499	
	7		1911-1925	
	8		1926	
	9		1927-1999	
		XX	2200-2499	OCCUPATIONAL SAFETY AND HEALTH REVIEW COMMISSION
		XXV	2500-2599	EMPLOYEE BENEFITS SECURITY ADMINISTRATION, DEPARTMENT OF LABOR
		XXVII	2700-2799	FEDERAL MINE SAFETY AND HEALTH REVIEW COMMISSION
		XL	4000-4999	PENSION BENEFIT GUARANTY CORPORATION

NA Path inside 29 CFR

e-CFR data is current as of March 9, 2016

Title 29 → Subtitle B → Chapter XVII

TITLE 29—Labor

Subtitle B—REGULATIONS RELATING TO LABOR (CONTINUED)

CHAPTER XVII—OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION, DEPARTMENT OF LABOR

Part	*Table of Contents*	*Headings*
1900-1901		[RESERVED]
1902	1902.1 to 1902.53	STATE PLANS FOR THE DEVELOPMENT AND ENFORCEMENT OF STATE STANDARDS
1903	1903.1 to 1903.22	INSPECTIONS, CITATIONS AND PROPOSED PENALTIES
1904	1904.0 to 1904.46	RECORDING AND REPORTING OCCUPATIONAL INJURIES AND ILLNESSES
1905	1905.1 to 1905.51	RULES OF PRACTICE FOR VARIANCES, LIMITATIONS, VARIATIONS, TOLERANCES, AND EXEMPTIONS UNDER THE WILLIAMS-STEIGER OCCUPATIONAL SAFETY AND HEALTH ACT OF 197
1906		[RESERVED]
1908	1908.1 to 1908.11	CONSULTATION AGREEMENTS
1910	1910.1 to 1910.901-1910.999	OCCUPATIONAL SAFETY AND HEALTH STANDARDS

NA Path inside 29 CFR

Rockwell Automation

e-CFR data is current as of March 9, 2016

Title 29 → Subtitle B → Chapter XVII → Part 1910

Browse Previous | Browse Next

Title 29: Labor

PART 1910—OCCUPATIONAL SAFETY AND HEALTH STANDARDS

Contents

NA Path inside 29 CFR

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Subpart S—Electrical

GENERAL

§1910.301 Introduction.

DESIGN SAFETY STANDARDS FOR ELECTRICAL SYSTEMS

§1910.302 Electric utilization systems.
§1910.303 General.
§1910.304 Wiring design and protection.
§1910.305 Wiring methods, components, and equipment for general use.
§1910.306 Specific purpose equipment and installations.
§1910.307 Hazardous (classified) locations.
§1910.308 Special systems.
§§1910.309-1910.330 [Reserved]

SAFETY-RELATED WORK PRACTICES

§1910.331 Scope.
§1910.332 Training.
§1910.333 Selection and use of work practices.
§1910.334 Use of equipment.
§1910.335 Safeguards for personnel protection.
§§1910.336-1910.360 [Reserved]

SAFETY-RELATED MAINTENANCE REQUIREMENTS

§§1910.361-1910.380 [Reserved]

SAFETY REQUIREMENTS FOR SPECIAL EQUIPMENT

§§1910.381-1910.398 [Reserved]

DEFINITIONS

§1910.399 Definitions applicable to this subpart.
Appendix A to Subpart S of Part 1910— References for Further Information

NA Path inside 29 CFR

Appendix A to Subpart S of Part 1910— References for Further Information

The references contained in this appendix provide nonmandatory information that can be helpful in understanding and complying with subpart S of this Part. However, compliance with these standards is not a substitute for compliance with subpart S of this Part.

ANSI/API RP 500-1998 (2002) *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I Division 1 and Division 2.*

ANSI/API RP 505-1997 (2002) *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1 and Zone 2.*

ANSI/ASME A17.1-2004 *Safety Code for Elevators and Escalators.*

ANSI/ASME B30.2-2005 *Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist).*

ANSI/ASME B30.3-2004 *Construction Tower Cranes.*

ANSI/ASME B30.4-2003 *Portal, Tower, and Pedestal Cranes.*

ANSI/ASME B30.5-2004 *Mobile And Locomotive Cranes.*

ANSI/ASME B30.6-2003 *Derricks.*

ANSI/ASME B30.7-2001 *Base Mounted Drum Hoists.*

ANSI/ASME B30.8-2004 *Floating Cranes And Floating Derricks.*

ANSI/ASME B30.11-2004 *Monorails And Underhung Cranes.*

ANSI/ASME B30.12-2001 *Handling Loads Suspended from Rotorcraft.*

ANSI/ASME B30.13-2003 *Storage/Retrieval (S/R) Machines and Associated Equipment.*

ANSI/ASME B30.16-2003 *Overhead Hoists (Underhung).*

ANSI/ASME B30.22-2005 *Articulating Boom Cranes.*

ANSI/ASSE Z244.1-2003 *Control of Hazardous Energy Lockout/Tagout and Alternative Methods.*

ANSI/ASSE Z490.1-2001 *Criteria for Accepted Practices in Safety, Health, and Environmental Training.*

ANSI/IEEE C2-2002 *National Electrical Safety Code.*

ANSI K61.1-1999 *Safety Requirements for the Storage and Handling of Anhydrous Ammonia.*

ANSI/UL 913-2003 *Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1, Hazardous (Classified) Locations.*

ASTM D3176-1989 (2002) *Standard Practice for Ultimate Analysis of Coal and Coke.*

ASTM D3180-1989 (2002) *Standard Practice for Calculating Coal and Coke Analyses from As-Determined to Different Bases.*

NFPA 20-2003 *Standard for the Installation of Stationary Pumps for Fire Protection.*

NFPA 30-2003 *Flammable and Combustible Liquids Code.*

NFPA 32-2004 *Standard for Drycleaning Plants.*

NFPA 33-2003 *Standard for Spray Application Using Flammable or Combustible Materials.*

NFPA 34-2003 *Standard for Dipping and Coating Processes Using Flammable or Combustible Liquids.*

NFPA 35-2005 *Standard for the Manufacture of Organic Coatings.*

NFPA 36-2004 *Standard for Solvent Extraction Plants.*

NFPA 40-2001 *Standard for the Storage and Handling of Cellulose Nitrate Film.*

NFPA 58-2004 *Liquefied Petroleum Gas Code.*

NFPA 59-2004 *Utility LP-Gas Plant Code.*

NFPA 70-2002 *National Electrical Code. (See also NFPA 70-2005.)*

NFPA 70E-2000 *Standard for Electrical Safety Requirements for Employee Workplaces. (See also NFPA 70E-2004.)*

NFPA 77-2000 *Recommended Practice on Static Electricity.*

NFPA 80-1999 *Standard for Fire Doors and Fire Windows.*

NFPA 88A-2002 *Standard for Parking Structures.*

NFPA 91-2004 *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids.*

NFPA 101-2006 *Life Safety Code.*

NFPA 496-2003 *Standard for Purged and Pressurized Enclosures for Electrical Equipment.*

NFPA 497-2004 *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas.*

NFPA 505-2006 *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operation.*

NFPA 820-2003 *Standard for Fire Protection in Wastewater Treatment and Collection Facilities.*

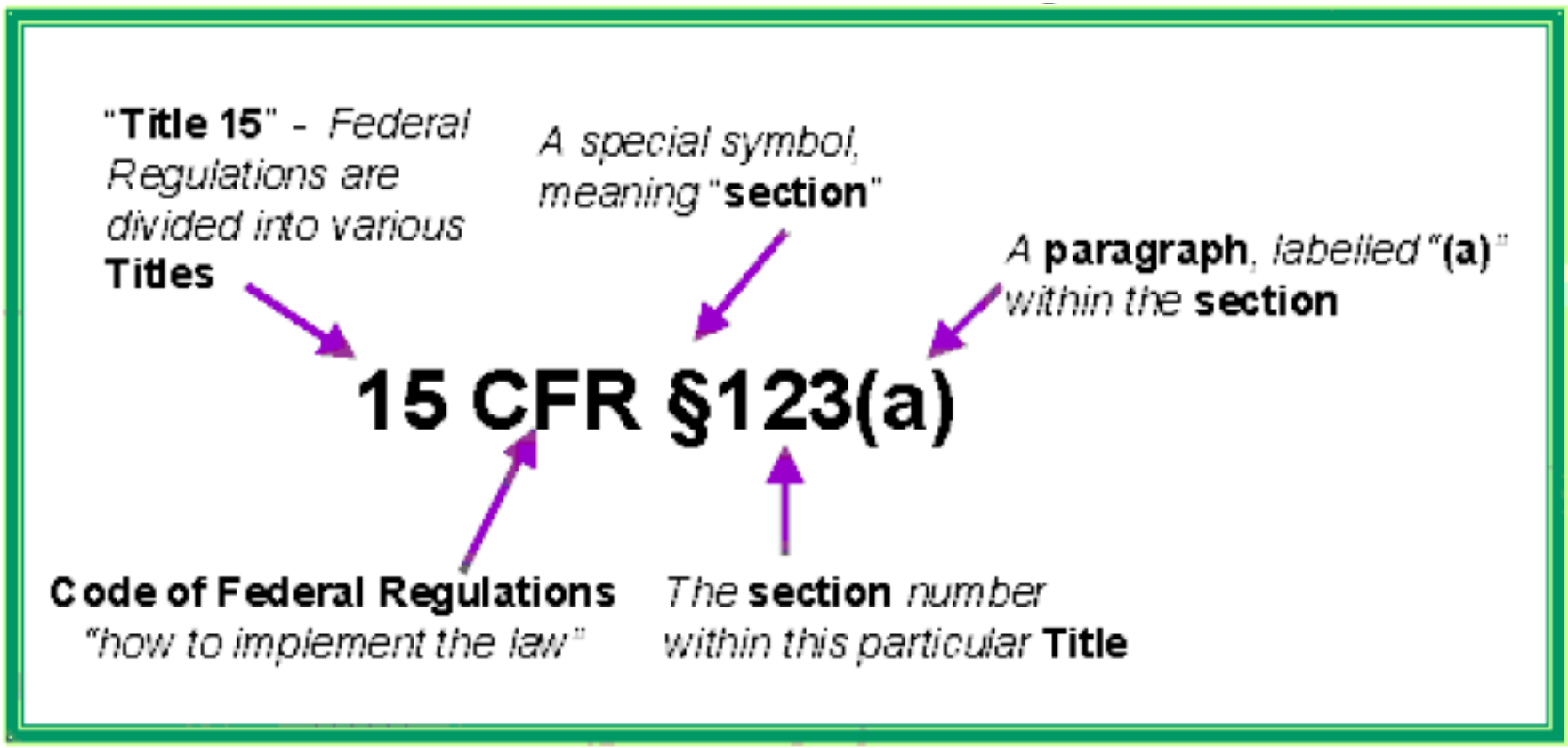
NMAB 353-1-1979 *Matrix of Combustion-Relevant Properties and Classification of Gases, Vapors, and Selected Solids.*

NMAB 353-2-1979 *Test Equipment for Use in Determining Classifications of Combustible Dusts.*

NMAB 353-3-1980 *Classification of Combustible Dust in Accordance with the National Electrical Code.*

[72 FR 7221, Feb. 14, 2007]

NA CFR reference



NA National Fire Protection Association

Rockwell Automation

- Trade association that adopts and write safety Codes and Standards fire related
- Every building, process, installation and service is affected by the NFPA's Codes and Standards
- The NFPA is not a Federal Agency, but is responsible for codes and standards which are required by other institutions (e.g. insurance companies) or by national or local law

NA National Electrical Code NFPA 70

- The NEC is the code for Eectrical Installation in the USA
- All electricall installations shall comply with this code
- It is also the basis for the assessment by the AHJs
- It has legal status and is adopted into local law by local governments, sometimes with local additions
- The NEC also requires the approval of devices and systems by an NRTL National Recognized Testing Laboratory
- Most important Articles are:
  - 90 Introduction (incorporates by reference IEC 60364-1) and enforcement of the Code through AHJ
  - 100 Definition
  - 409 Industrial Control Panels (incorporates by reference UL 508A)
  - 430 Motors, Motor Circuits, Controllers
  - 630 Industrial Machinery (incorporates by reference NFPA 79 and UL 508A)

NA Authority Having Jurisdiction

Rockwell Automation

NFPA 70 (National Electrical Code) – Article 100 – Paragraph I

Authority Having Jurisdiction. The organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.

FPN: The phrase “authority having jurisdiction” is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

NA Authority Having Jurisdiction

Rockwell Automation

NFPA 70 (National Electrical Code) – Article 80

80.13 Authority. Where used in this article, the term *authority having jurisdiction* shall include the chief electrical inspector or other individuals designated by the governing body. This *Code* shall be administered and enforced by the authority having jurisdiction designated by the governing authority as follows.

(1) The authority having jurisdiction shall be permitted to render interpretations of this *Code* in order to provide clarification to its requirements, as permitted by 90.4.

(2) When the use of any electrical equipment or its installations is found to be dangerous to human life or property, the authority having jurisdiction shall be empowered to have the premises disconnected from its source of electric supply, as established by the Board….

NA Authority Having Jurisdiction

- AHJs are organizations – or even individuals – which/who have the legal authority and responsibility to make decisions about installation acceptance at state and local level. They are responsible for approving all electrical systems.
- AHJs are for example:
  - Local Building Inspectors
  - Fire Marshals
  - Sheriff

NA NEC Adoption – Nov.2015-Feb.201

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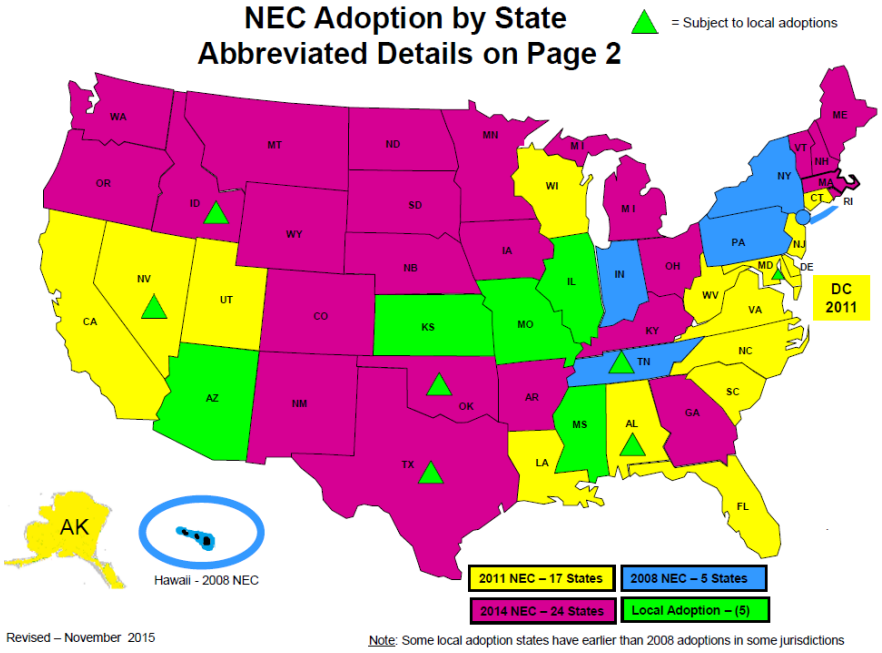
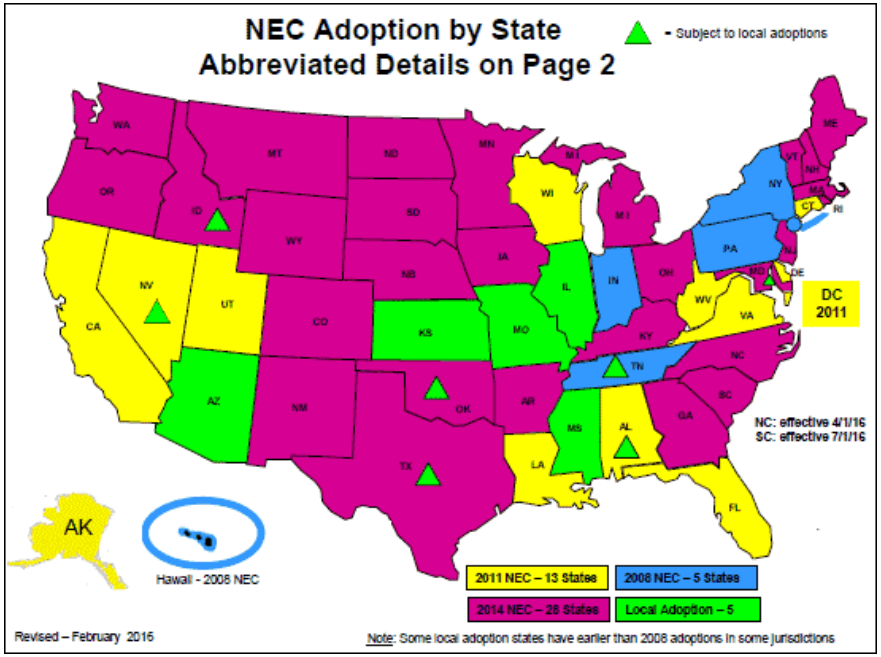


Revised – November 2015

Note: Some local adoption states have earlier than 2008 adoptions in some jurisdictions

Alabama	AL	Indiana	IN	Nebraska	NE	South Carolina	SC
Alaska	AK	Iowa	IA	Nevada	NV	South Dakota	SD
Arizona	AZ	Kansas	KS	New Hampshire	NH	Tennessee	TN
Arkansas	AR	Kentucky	KY	New Jersey	NJ	Texas	TX
California	CA	Louisiana	LA	New Mexico	NM	Utah	UT
Colorado	CO	Maine	ME	New York	NY	Vermont	VT
Connecticut	CT	Maryland	MD	North Carolina	NC	Virginia	VA
Delaware	DE	Massachusetts	MA	North Dakota	ND	Washington	WA
Florida	FL	Michigan	MI	Ohio	OH	West Virginia	WV
Georgia	GA	Minnesota	MN	Oklahoma	OK	Wisconsin	WI
Hawaii	HI	Mississippi	MS	Oregon	OR	Wyoming	WY
Idaho	ID	Missouri	MO	Pennsylvania	PA		
Illinois	IL	Montana	MT	Rhode Island	RI		

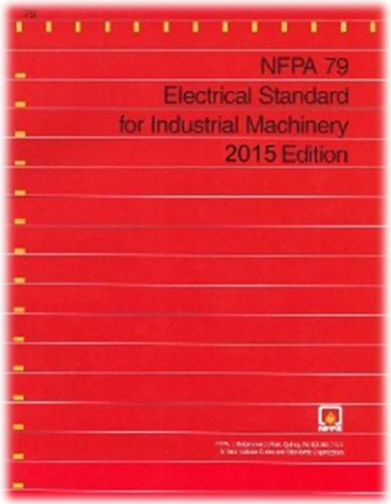


Revised – February 2016

Note: Some local adoption states have earlier than 2008 adoptions in some jurisdictions

NA Electricla Standard for Industrial Machinery NFPA 79

- NFPA 79 defines specific requirements for the installation of Industrial Electrical Machinery and is used to supplement the NEC
- Its counterpart for EU is IEC 60204-1 Safety of machinery



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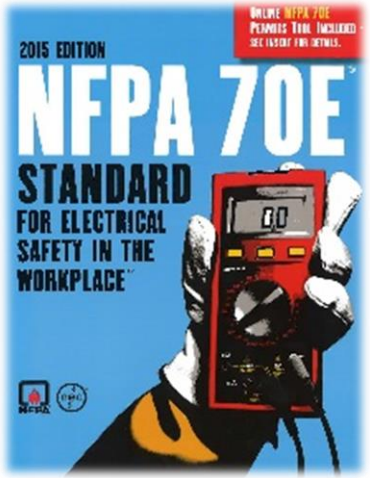
NFPA 70E – Electrical Safety Requirements for Employee Workplaces

- Determining the hazard level when working on live parts of a system
- Defining hazard/access areas
- Measures for preventing hazards (shock-hazards and arc-flashes)
- Selecting appropriate protective clothing
- Requirements for marking



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Examples of Arc Flashes

Rockwell Automation

Example: Arc Flash Calculation

Equation for Arc in Open Air

NFPA eq.

D_A = distance from arc electrodes, **inches** (for distances 18 in. and greater) — 18 inches

t_A = arc duration, **seconds** (cycles / 60 cycles) — 0,06666 seconds

F = bolted fault short circuit current, in **kA** (for the range of 16 to 50kA) — 20 kA

B - 5.1

$$E_{MA} = 5271 \times D_A^{-1.9593} \times t_A \times (0.0016 \times F^2 - 0.0076 \times F + 0.8938)$$

E_{MA} = maximum open arc **incident energy**

ANSWER: 1,686 cal/cm^2

NA Institutions, standards and conformity markings

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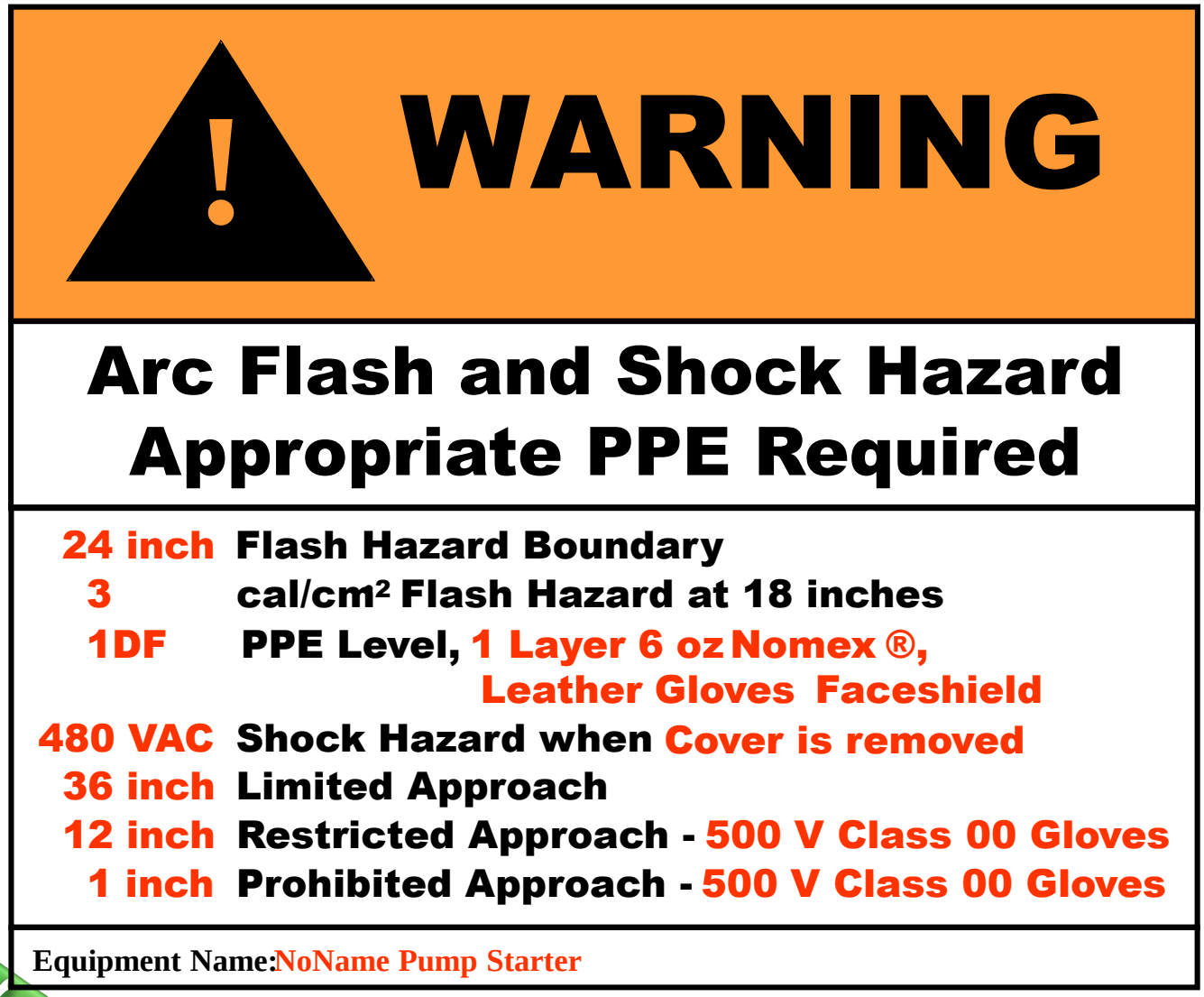


PPE = Personal Protection Equipment

Rockwell Automation

National Electrical Manufacturers Association

- Manufacturer trade organization that publishes market data, standardizes products and develops standards, particularly for the US market
- Several Standards are based on NEMA
- Examples: NEMA 250 (Enclosure Type Rating) - NEMA power ratings

Table 1
[From NEMA 250-2003]
Comparison of Specific Applications of Enclosures for Indoor Nonhazardous Locations

Provides a Degree of Protection Against the Following Conditions	Type of Enclosure									
	1 *	2 *	4	4X	5	6	6P	12	12K	13
Access to hazardous parts	X	X	X	X	X	X	X	X	X	X
Ingress of solid foreign objects (falling dirt)	X	X	X	X	X	X	X	X	X	X
Ingress of water (Dripping and light splashing)	...	X	X	X	X	X	X	X	X	X
Ingress of solid foreign objects (Circulating dust, lint, fibers, and flyings **)	...	...	X	X	...	X	X	X	X	X
Ingress of solid foreign objects (Settling airborne dust, lint, fibers, and flyings **)	...	...	X	X	X	X	X	X	X	X
Ingress of water (Hosedown and splashing water)	...	...	X	X	...	X	X	...	...	...
Oil and coolant seepage	...	...	...	..	...	...	...	X	X	X
Oil or coolant spraying and splashing	...	...	...	...	...	...	...	...	...	X
Corrosive agents	...	...	...	X	...	...	X	...	...	...
Ingress of water (Occasional temporary submersion)	...	...	...	...	...	X	X	...	...	...
Ingress of water (Occasional prolonged submersion)	...	...	...	...	...	...	X	...	...	...

Table 2
[From NEMA 250-2003]
Comparison of Specific Applications of Enclosures for Outdoor Nonhazardous Locations

Provides a Degree of Protection Against the Following Conditions	Type of Enclosure									
	3	3X	3R*	3RX*	3S	3SX	4	4X	6	6P
Access to hazardous parts	X	X	X	X	X	X	X	X	X	X
Ingress of water (Rain, snow, and sleet **)	X	X	X	X	X	X	X	X	X	X
Sleet ***	...	...	...	...	X	X	...	...	...	...
Ingress of solid foreign objects (Windblown dust, lint, fibers, and flyings)	X	X	...	...	X	X	X	X	X	X
Ingress of water (Hosedown)	...	...	...	...	...	...	X	X	X	X
Corrosive agents	...	X	...	X	...	X	...	X	...	X
Ingress of water (Occasional temporary submersion)	...	...	...	...	...	...	...	...	X	X
Ingress of water (Occasional prolonged submersion)	...	...	...	...	...	...	...	...	...	X

NA NEMA

Rockwell Automation

Example: NEMA 250 (Enclosure Type Rating) NFPA 70 (NEC)Table 430.91

Table 1
[From NEMA 250-2003]
Comparison of Specific Applications of Enclosures for Indoor Nonhazardous Locations

Provides a Degree of Protection Against the Following Conditions	Type of Enclosure									
	1 *	2 *	4	4X	5	6	6P	12	12K	13
Access to hazardous parts	X	X	X	X	X	X	X	X	X	X
Ingress of solid foreign objects (falling dirt)	X	X	X	X	X	X	X	X	X	X
Ingress of water (Dripping and light splashing)	...	X	X	X	X	X	X	X	X	X
Ingress of solid foreign objects (Circulating dust, lint, fibers, and flyings **)	...	...	X	X	...	X	X	X	X	X
Ingress of solid foreign objects (Settling airborne dust, lint, fibers, and flyings **)	...	...	X	X	X	X	X	X	X	X
Ingress of water (Hosedown and splashing water)	...	...	X	X	...	X	X	...	...	...
Oil and coolant seepage	...	...	...	..	...	...	...	X	X	X
Oil or coolant spraying and splashing	...	...	...	...	...	...	...	...	...	X
Corrosive agents	...	...	...	X	...	...	X	...	...	...
Ingress of water (Occasional temporary submersion)	...	...	...	...	...	X	X	...	...	...
Ingress of water (Occasional prolonged submersion)	...	...	...	...	...	...	X	...	...	...

Table 2
[From NEMA 250-2003]
Comparison of Specific Applications of Enclosures for Outdoor Nonhazardous Locations

Provides a Degree of Protection Against the Following Conditions	Type of Enclosure									
	3	3X	3R*	3RX*	3S	3SX	4	4X	6	6P
Access to hazardous parts	X	X	X	X	X	X	X	X	X	X
Ingress of water (Rain, snow, and sleet **)	X	X	X	X	X	X	X	X	X	X
Sleet ***	...	...	...	...	X	X	...	...	...	...
Ingress of solid foreign objects (Windblown dust, lint, fibers, and flyings)	X	X	...	...	X	X	X	X	X	X
Ingress of water (Hosedown)	...	...	...	...	...	...	X	X	X	X
Corrosive agents	...	X	...	X	...	X	...	X	...	X
Ingress of water (Occasional temporary submersion)	...	...	...	...	...	...	...	...	X	X
Ingress of water (Occasional prolonged submersion)	...	...	...	...	...	...	...	...	...	X

Table 430.91 Motor Controller Enclosure Selection

For Outdoor Use

Provides a Degree of Protection Against the Following Environmental Conditions	Enclosure Type Number[1]									
	3	3R	3S	3X	3RX	3SX	4	4X	6	6P
Incidental contact with the enclosed equipment	X	X	X	X	X	X	X	X	X	X
Rain, snow, and sleet	X	X	X	X	X	X	X	X	X	X
Sleet[2]	—	—	X	—	—	X	—	—	—	—
Windblown dust	X	—	X	X	—	X	X	X	X	X
Hosedown	—	—	—	—	—	—	X	X	X	X
Corrosive agents	—	—	—	X	X	X	—	X	—	X
Temporary submersion	—	—	—	—	—	—	—	—	X	X
Prolonged submersion	—	—	—	—	—	—	—	—	—	X

For Indoor Use

Provides a Degree of Protection Against the Following Environmental Conditions	Enclosure Type Number[1]									
	1	2	4	4X	5	6	6P	12	12K	13
Incidental contact with the enclosed equipment	X	X	X	X	X	X	X	X	X	X
Falling dirt	X	X	X	X	X	X	X	X	X	X
Falling liquids and light splashing	—	X	X	X	X	X	X	X	X	X
Circulating dust, lint, fibers, and flyings	—	—	X	X	—	X	X	X	X	X
Settling airborne dust, lint, fibers, and flyings	—	—	X	X	X	X	X	X	X	X
Hosedown and splashing water	—	—	X	X	—	X	X	—	—	—
Oil and coolant seepage	—	—	—	—	—	—	—	X	X	X
Oil or coolant spraying and splashing	—	—	—	—	—	—	—	—	—	X
Corrosive agents	—	—	—	X	—	—	X	—	—	—
Temporary submersion	—	—	—	—	—	X	X	—	—	—
Prolonged submersion	—	—	—	—	—	—	X	—	—	—

NA NEMA

Example: Rating and overall dimension of Contactors NEMA ICS-2

NA Underwriters Laboratory

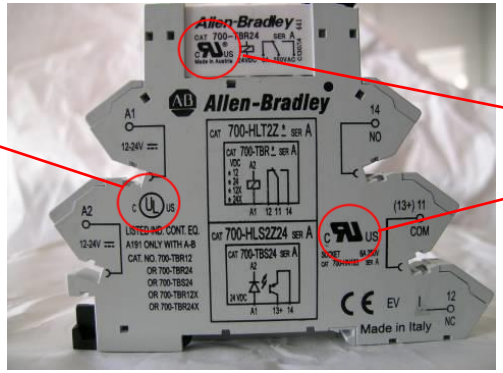
Rockwell Automation

- UL is an American worldwide safety consulting and certification company headquartered in Northbrook, Illinois
- Established in 1894 as the Underwriters' Electrical Bureau (a bureau of the National Board of Fire Underwriters) it was known throughout the 20th century as Underwriters Laboratories and participated in the safety analysis of many of that century's new technologies, most notably the public adoption of electricity and the drafting of safety standards for electrical devices and components
- Provides safety-related certification, validation, testing, inspection, auditing, advising and training services to a wide range of clients, including manufacturers, retailers, policymakers, regulators, service companies, and consumers
- Is one of several companies approved to perform safety testing by the US Federal agency OSHA which are known as National Recognized Testing Laboratories
- The majority of the AHJs interviewed indicated that UL markings of products at their place of intended use is sufficient proof that US installation requirements have been met and are therefore approved for the intended place of use.

NA Underwriters Laboratory

- Essentially there are two markings on most products
  - UL Listed are products that meet the UL safety requirements and may be used as a stand-alone product immediately and in the intended fashion.
  - UL Recognized Are products that are components of a system or that have technical or structural limitations, so that they may not be used as an independent product.
    - The Conditions of Acceptability (CA) explain what can be done to complete the product and/or what its limitations of use are

The combination is Listed



Single component is Recognized

NA Marking

Explanation of the symbols

UL listed for the USA

UL listed for Canadian standards

UL listed for USA and Canada

UL recognized for USA

UL recognized for Canadian standards

UL listed for USA and Canada

NA Category Control Number and File Number

Rockwell Automation

CCN - Category Control Number

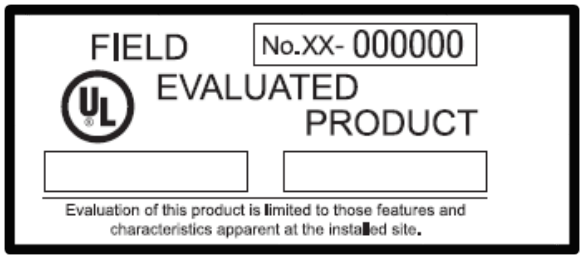
- This is a UL system for labeling and identifying individual categories. (e.g. Magnetic=contactor)
  - **UL/ cULus** - four letters (for example NLDX)
  - **cUL** - four letters followed by a 7 (for example NLDX7)
  - **UR** - four letters followed by a 2 (for example NLDX2)
  - **cUR** - four letters followed by a 8 (for example NLDX8)

File Number

- The individual products are listed in the UL File Numbers
  - Example E3125 (Magnetic Motor Controller)

NA UL 508A Marking

Panel in an enclosure

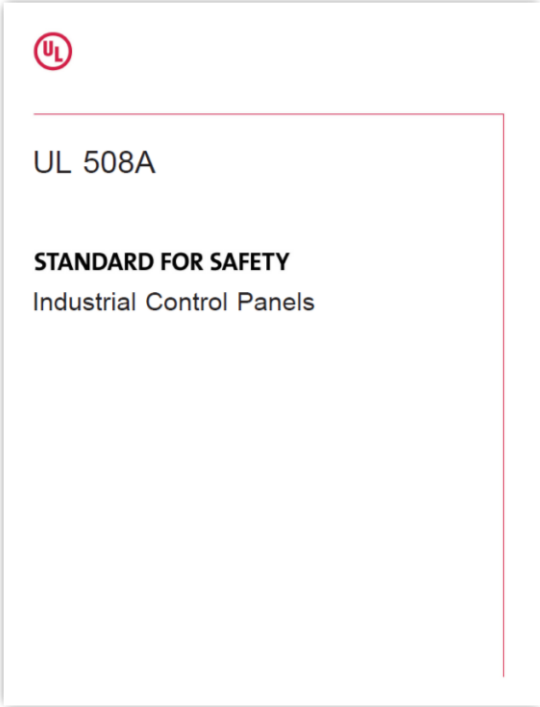


Field Evaluation

NA UL 508A

Rockwell Automation

- UL 580A is the Standard for Industrial Control Panel, incorporated by reference in the NFPA 70 National Electrical Code
- The last edition of the Standard became effective December 20, 2013, with additional requirements effective on May 30, 2014
- The scope of UL 508A covers general and special use panels and panel enclosures rated 600V or less, for use in ordinary locations per NFPA 70 in a 40°C ambient (as defined by the NEC)
- This equipment consists of assemblies of two or more power circuit components, such as motor controllers, overload relays, fused disconnect switches, and circuit breakers, or control circuit components, such as pushbuttons, pilot lights, selector switches, timers, and control relays, or a combination of power and control circuit components, with associated wiring, and terminals. These components are mounted on, or contained within, an enclosure, or are mounted on a sub-panel
- Panels specifically not covered by the Standard are for those use in hazardous locations, motor control centers or fire pump controllers (Example UL 845 cover MCC)

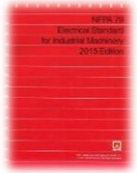


NA Summary - Standards

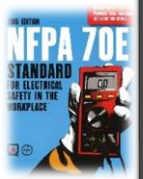
Rockwell Automation

- NFPA 70 NEC is the code for Eectrical Installation in US is included by reference in the CFR
  - This is the Standard used from AHJs to check out non conformity at installation level
  - Its counterpart for EU is IEC 60364-1 Low-voltage electrical installations
  - It is not a must have document but important to know what it is and is/what edition is in use in each State

- NFPA 79 Industrial Electrical Machinery defines specific requirements for the installation of Machinery and is included by reference in the NEC
  - Its counterpart for EU is IEC 60204-1 Safety of machinery
  - This is a must have document for OEMs but it is recomended also for for PBs



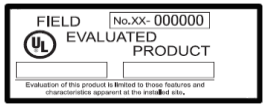
- NFPA 70E Electrical Safety Requirements for Employee Workplaces is included by reference in the NEC
  - This is a must have document for EUs



- UL 508A Standard for Industrial Control Panel is included by reference in the NEC
  - Its counterpart for EU is IEC 61439-1 Safety of machinery
  - This is a must have document for PBs but it is recomended also for for OEMs

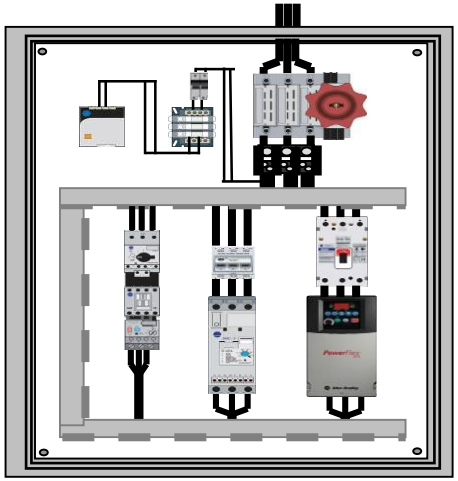
NA Summary – Option to export

- The ICP is:
  - produced by you and approved and listed by a NRTL receiving a listing label
    - A) One shot, unique listing for unique Panel
  - by you after you got the UL508A Certification
    - B) Your process is certified and quarterly inspected
  - is produced by using a third party Panel Builder
    - A) or B)
  - No local listing, the cabinet needs to have full acceptance in NA by an AHJ



LISTEN. THINK. SOLVE.®

UL508A Industrial Control Panels – Power Circuits – Feeder and Branch



PUBLIC

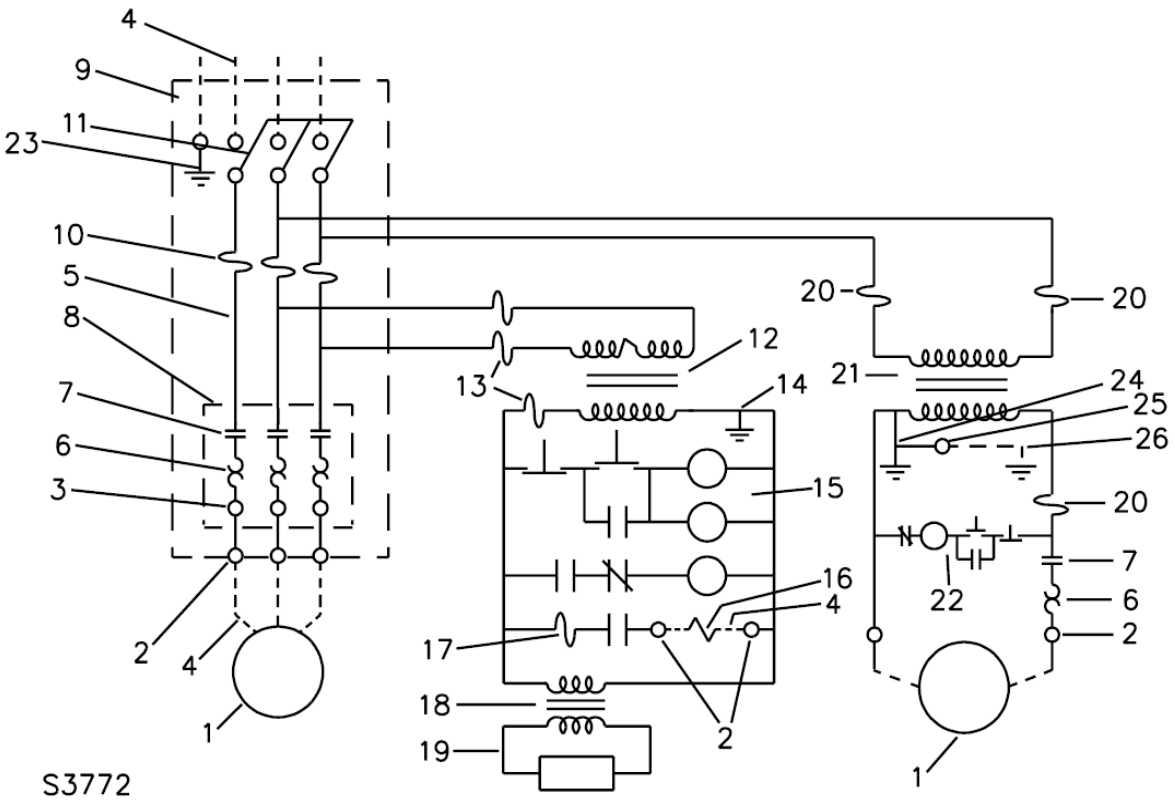
Allen-Bradley • Rockwell Software

Rockwell Automation

Description Of Terminology

1 - Load (provided in field)
2 - Field wiring terminals
3 - Alternate field terminals
4 - Field wiring
5 - Power circuit internal wiring
6 - Overload relay & heater elements
7 - Contactor/Controller
8 - Starter
9 - Combination motor controller
10 - Branch circuit protection
11 - Fused disconnect switch or circuit breaker
12 - Control transformer
13 - Control transformer fuse/supplementary protection
14 - Control transformer ground (for 1000 VA max)
15 - Control circuit devices and wiring / Class 1 circuit
16 - Solenoid or other control device
17 - Supplementary protection
18 - Class 2 transformer
19 - Class 2 circuit
20 - Power transformer fuse/branch circuit protection
21 - Power transformer – for motor load and control circuit
22 - Control circuit/Class 1 circuit/common control circuit
23 - Equipment ground and equipment ground terminal
24 - Bonding conductor/bonding jumper
25 - Grounding electrode conductor terminal
26 - Grounding electrode conductor (provided in field)

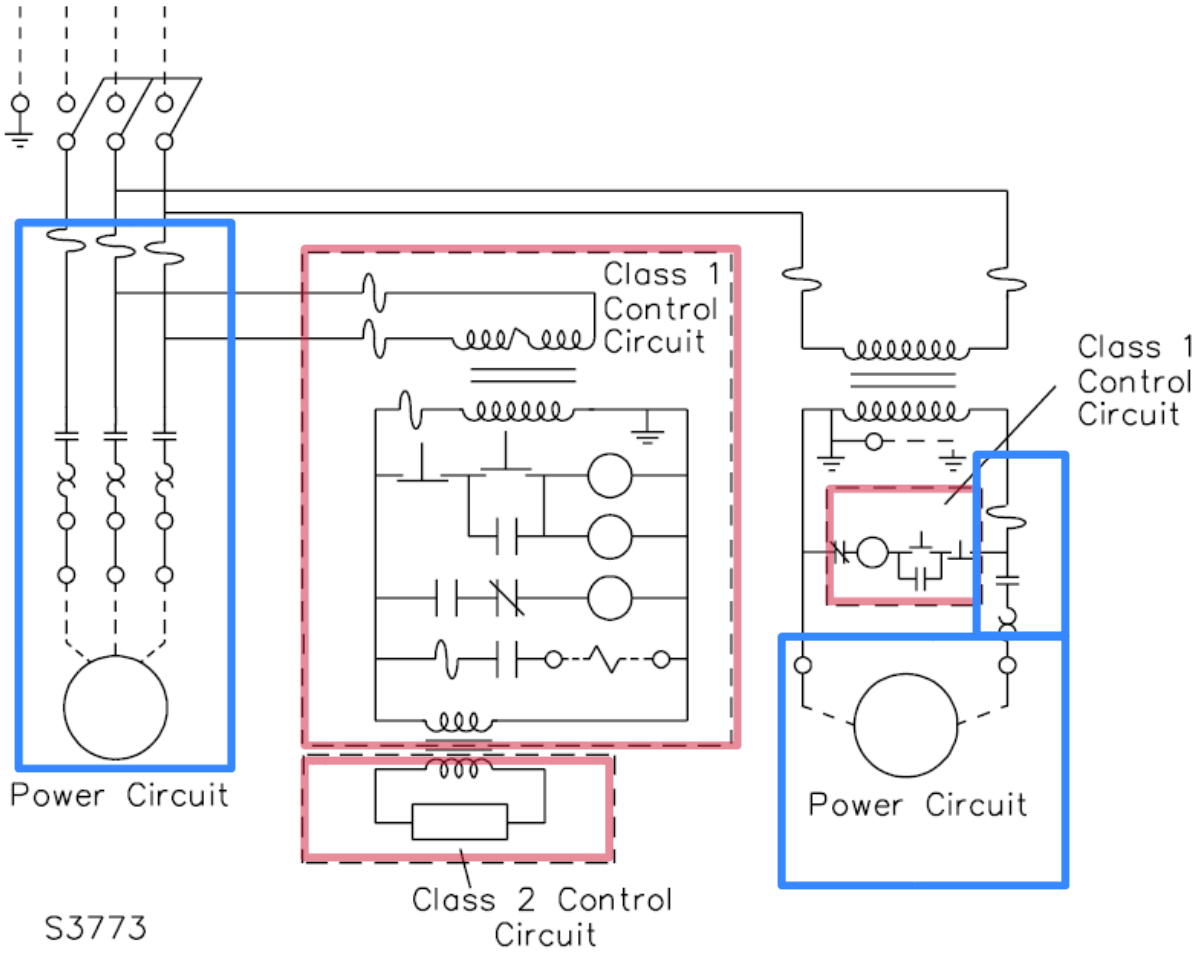
Figure 6.1
Description of terminology



Description Of Control & Power Circuits

Rockwell Automation

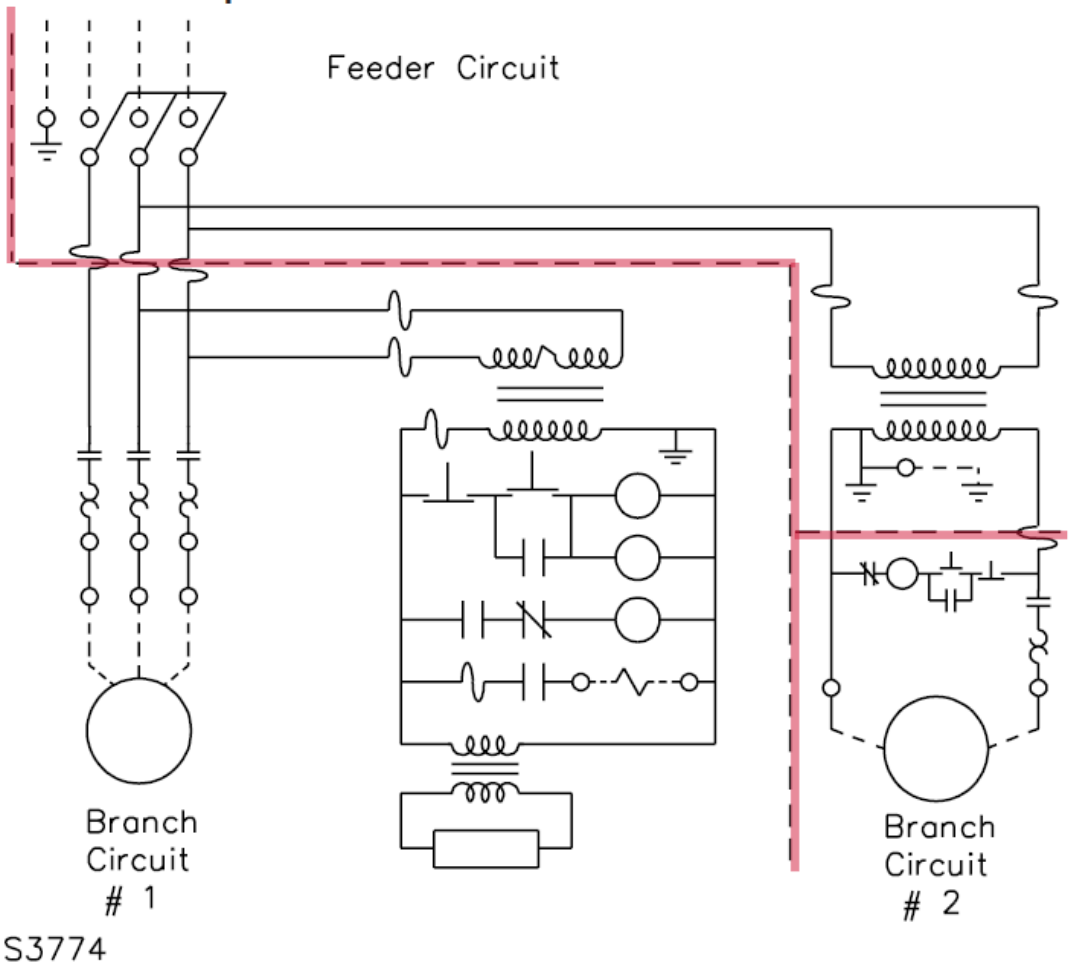
Figure 6.2
Description of control circuits and power circuits



Description Of Branches & Feeders

Rockwell Automation

Figure 6.3
Description of branch circuits and feeder circuits



Construction Details

Rockwell Automation

- This section covers the requirements for:
  - Protection Against Corrosion – all parts must be protected against corrosion, with some exceptions
  - Support and Securement of Live Parts – parts may not be secured by the fasteners within a device itself and must be prevented from rotating
  - Spacings - Use Tables 10.1 & 10.2
  - Insulating Barriers – Insulating materials may be used in lieu of spacing
  - Grounding - Sizing and Identification, as includes transformer grounding requirements (see next slides)

Required Spacing – Table 10.1 & 10.2

Table 10.1
Minimum required spacings in branch and control circuits

Potential involved in volts rms ac or dc		Minimum spacing, inch (mm)					
		A			B		C
		General industrial control equipment			Devices having limited ratings[a]		All circuits[d]
		51 – 150	151 – 300	301 – 600	51 – 300	301 – 600	0 – 50
Between any uninsulated live part and an uninsulated live part of opposite polarity, uninsulated grounded part other than the enclosure, or exposed metal part[f,g]	Through air or oil	1/8[b] (3.2)	1/4 (6.4)	3/8 (9.5)	1/16[b] (1.6)	3/16[b] (4.8)	1/16[b] (1.6)
	Over surface	1/4 (6.4)	3/8 (9.5)	1/2 (12.7)	1/8[b] (3.2)	3/8 (9.5)	1/16[b] (1.6)
Between any uninsulated live part and the walls of a metal enclosure including fittings for conduit or armored cable[c,e]	Shortest distance	1/2 (12.7)	1/2 (12.7)	1/2 (12.7)	1/4 (6.4)	1/2 (12.7)	1/4 (6.4)

NOTES –

1 A slot, groove, or similar gap, 0.013 inch (0.33 mm) wide or less in the contour of insulating material is to be disregarded for the purpose of measuring over surface spacings.

2 An air space of 0.013 inch (0.33 mm) or less between a live part and an insulating surface is to be disregarded for the purpose of measuring over surface spacings.

[a] See 10.5.

[b] The spacing between field wiring terminals of opposite polarity and the spacing between a field wiring terminal and a grounded dead metal part shall be at least 1/4 inch (6.4 mm) when short-circuiting or grounding of such terminals results from projecting strands of wire. For circuits involving no potential greater than 50 volts rms ac or dc, spacings at field wiring terminals are able to be 1/8 inch (3.2 mm) through air and 1/4 inch (6.4 mm) over surface.

[c] For the purpose of this requirement, a metal piece or component attached or mounted to the enclosure is evaluated as a part of the enclosure when deformation of the enclosure reduces the spacings between uninsulated live parts or between uninsulated live parts and metal parts.

[d] Spacings do not apply within a low-voltage limited energy circuit or a Class 2 circuit.

[e] Applicable to devices with sheet metal enclosures regardless of wall thickness and cast metal enclosures with a wall thickness of less than 1/8 inch (3.2 mm).

[f] These spacings are also applicable between any uninsulated live parts and the walls of a cast metal enclosure with a wall thickness of minimum 1/8 inch (3.2 mm) for devices with a limited rating complying with 10.5.

[g] These spacings are also applicable between an insulated live part and the wall of a metal enclosure to which the component is mounted. Deformation of the enclosure shall not reduce spacings.

Table 10.2
Spacings in feeder circuit

Voltage involved	Minimum spacing, inch (mm)		
	Between live parts of opposite polarity		Between live parts and grounded metal parts, through air and over surface
	Through air	Over surface	
125 or less	1/2 (12.7)	3/4 (19.1)	1/2 (12.7)
126 – 250	3/4 (19.1)	1-1/4 (31.8)	1/2 (12.7)
251 – 600	1 (25.4)	2 (50.8)	1[a] (25.4)[a]

NOTE – An isolated dead metal part, such as a screw head or a washer, interposed between uninsulated parts of opposite polarity or between an uninsulated live part and grounded dead metal is evaluated as reducing the spacing by an amount equal to the dimension of the interposed part along the path of measurement.

[a] The through-air spacing shall not be less than 1/2 inch between live parts of a circuit breaker or fusible disconnecting means and grounded metal, and between grounded metal and the neutral of an industrial control panel rated 277/480 volt, 3-phase, 4-wire.

- Keep at least 1/2 inch spacing for branch and control circuits.
- Keep at least 1” - 2” – 1” spacing in feeder circuits
- Or…insulate if you can’t keep the spacing

Enclosed Panels – Overview of Sections

Rockwell Automation

- Section 18 – Enclosures for open or partial assemblies.
- Section 19 – Enclosure Openings and Type Ratings.
- Section 20 – Accessibility of live parts related to openings.
- Section 21 – Enclosure ventilation openings, locations and construction.
- Section 22 – Barriers for ventilation openings near arcing sources.
- Section 23 – Enclosure observation windows
- Section 24 – Bonding for enclosures made with insulated materials.
- Section 25 – Wire bending space for Field Wiring.
- Section 26 – Enclosure environmental control (A/C, fans, heaters, etc.)
- Section 27 – Enclosure maintenance lighting

Enclosure Openings – Section 19

Rockwell Automation

- **This section addresses maintaining the proper 'Type' rating of enclosure openings for conduit connections and device mounting.**

Table 19.1
Openings for conduit connections in enclosures with environmental rating other than Type 1

Enclosure type (Column 1)	Required construction (Column 2)
2, 3R, 3RX	a) All holes for conduit shall be below all uninsulated live parts; or b) Conduit openings above the lowest uninsulated live parts shall be provided with conduit fittings having an environmental rating that complies with Table 19.2; or c) The enclosure shall be marked as in 53.2 with instructions for the installer to apply fittings complying with (a) or (b).
3, 3S, 3SX, 3X, 4, 4X, 5, 12, 12K	d) All holes for conduit shall be provided with conduit fittings having an environmental rating that complies with Table 19.2 or as specified by the enclosure manufacturer; or e) The enclosure shall be marked as in 53.3 with instructions to apply fittings complying with (d).
6, 6P	f) All holes for conduit shall be provided with conduit fittings having an environmental rating that complies with Table 19.2.
13	g) All holes for conduit shall be provided with conduit fittings having an environmental rating that complies with Table 19.2; or h) No conduit openings shall be provided.

Table 19.2
Openings for components in enclosures with environmental rating other than Type 1

Enclosure type (Column 1)	Openings are able to be closed by equipment marked (Column 2)
2[a]	2, 3, 3R, 3RX, 3S, 3SX, 3X, 4, 4X, 5, 6, 6P, 12, 12K, 13, "Wet Location", or "Raintight"
3	3, 3S, 3SX, 3X, 4, 4X, 6, 6P
3R[b]	3, 3R, 3RX, 3S, 3SX, 3X, 4, 4X, 6, 6P, "Wet Location," or "Raintight"
3RX	3RX, 3SX, 3X, 4X
3S[c]	3, 3S, 3SX, 3X, 4, 4X, 6, 6P
3SX[c]	3SX, 3X, 4X
3X	3SX, 3X, 4X
4	4, 4X, 6, 6P
4X	4X
5	3, 3R, 3RX, 3S, 3SX, 3X, 4, 4X, 5, 6, 6P, 12, 12K, 13, "Wet Location," or "Raintight"
6	6, 6P
6P	6P
12, 12K	12, 12K, 13
13	13

[a] Type 1 components, ventilation openings, or observation windows are able to be installed when their profile outside the enclosure is completely protected by the drip shield from water dripping vertically downward from above.

[b] Components marked "Weatherproof" or "Rainproof" are able to be installed below all other live parts within the enclosure.

[c] Components with external operating mechanisms shall be Type 3S or 3SX for use on a Type 3S enclosure, or Type 3SX for use on a Type 3SX enclosure.

Make sure to use proper Type rated conduit hubs and operator devices for your application. Otherwise, you have to default to Type 1.

Power Circuits – Overview of Sections

Rockwell Automation

- Section 28 – Field Wiring
- Section 29 – Internal Wiring
- Section 30 – Disconnect Switches
- Section 31 – Branch Circuit Protection
- Section 32 – Overcurrent Protection of the Feeder
- Section 33 – Load Controllers
- Section 34 – Overload Protection of Motor Loads
- Section 35 – Power Transformers
- Section 36 – Other Circuit Components

Power Circuit Field Wiring – Section 28

Rockwell Automation

- Power wiring connections to/from the control panel are typically done in the field and can be made via the following types of components:
  - Terminals of a specific component (such as the main disconnect or overload relay)
  - UL 1059 Recognized Component (R/C) Terminal Block or Power Distribution Block.
  - UL 486 pressure wire connector (UL Listed lug)
  - Wire binding screw and terminal plate assembly
    - Typically a metal plate (.030”) for a 14 AWG wire or (.050”) for larger wire.
    - Screws must be at least two full threads into the plate.

Power Circuit Field Wiring – Section 28

Rockwell Automation

- The required size of the field wiring terminal shall be no less than 14 AWG.
- The field wiring terminals must be sized to accept a conductor sized at 125% of the full load current rating of the panel based upon Table 28.1.
- The terminals on the Listed circuit breaker/main disconnect may be used as is since this is evaluated under the device's own UL coverage.

Table 28.1
Ampacities of insulated conductors

Wire size		60°C (140°F)		75°C (167°F)	
AWG	(mm^2)	Copper	Aluminum	Copper	Aluminum
14	(2.1)	15	–	15	–
12	(3.3)	20	15	20	15
10	(5.3)	30	25	30	25
8	(8.4)	40	30	50	40
6	(13.3)	55	40	65	50
4	(21.2)	70	55	85	65
3	(26.7)	85	65	100	75
2	(33.6)	95	75	115	90
1	(42.4)	110	85	130	100
1/0	(53.5)	–	–	150	120
2/0	(67.4)	–	–	175	135
3/0	(85.0)	–	–	200	155
4/0	(107.2)	–	–	230	180
250 kcmil	(127)	–	–	255	205
300	(152)	–	–	285	230
350	(177)	–	–	310	250

Power Circuit Internal Wiring-Section 29

Rockwell Automation

- This section covers the internal wiring conductor requirements including: wire types, sizes, wiring methods, routing & separation.
- Internal wiring must be 90°C minimum and one of the following types:
  - UL 1063 Machine Tool Wire
  - UL 44 Thermoset Insulated Wire
  - UL 83 Thermoplastic Insulated Wire
  - UL R/C (AVLV2) Appliance Wiring Material (AWM)
  - Welding Cable
  - Busbar (1,000 A/sq. in.)

Table 28.1 only has 60°C & 75°C ratings which are used to size the wire. The 90°C insulation requirement is a safety factor. Typically, component terminals are not rated above 75°C.

Power Circuit Internal Wiring-Section 29

Rockwell Automation

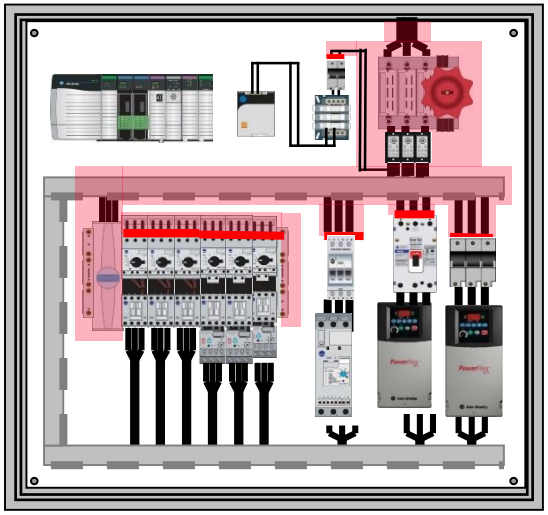
- All internal wiring terminations shall be mechanically secured (ie. solder joint, wire binding screw or pressure wire terminal)
- Internal wires shall be routed through smooth, well-rounded surfaces to minimize the abrasion of the insulation
- Wiring that is subject to movement or flexing shall use stranded conductors and be properly secured and protected
- Conductors used in different circuits shall be separated by a barrier or have insulation rated for the maximum voltage
- Internal wire shall be no less than 14 AWG and determined as follows:
  - Add full load currents of all external loads and motor FLA per Table 50.1 and determine the minimum size using Table 28.1
  - Busbar sizing is done in the same way

Power Circuits – Feeder and Branch

The Feeder Circuit contains all conductors and components between the incoming line of the ICP and the line side of the last BCPD (Branch Circuit Protective Device)

"Feeder Circuit"

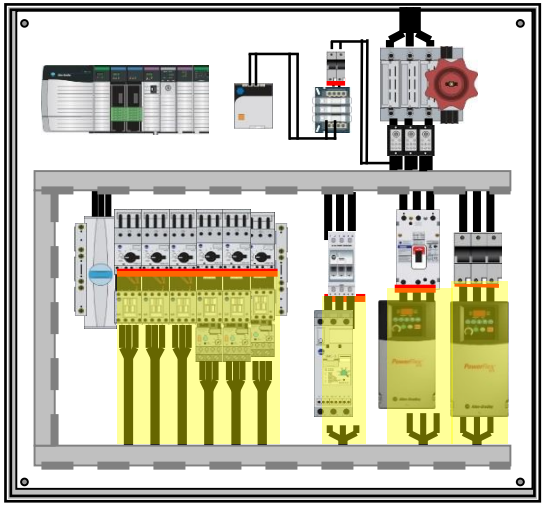
"BCPD"



The Branch Circuit contains all conductors and components between the load side of the BCPD and the load side of the motor controller

"Branch Circuit"

"BCPD"



Disconnect Switches – Section 30

Rockwell Automation

There must be a disconnect for each incoming supply circuit and must be one of the following:

- UL Listed (UL 98) disconnect switch
  - Sized at not less than 115% of controlled load
- UL Listed (UL 489) circuit breaker
  - Sized to carry not more than 80% of its nominal ampere rating, unless it is marked for continuous use at 100% of its rating
- UL Listed (UL 508) self-protected combination motor
  - Sized to carry 100% of the controlled load
- UL Listed (UL 508) manual motor controller
  - Can only be used on load side of the branch circuit protective device and must be marked as 'Suitable as motor disconnect'

UL 508A Enclosure door locking systems

Rockwell Automation

Pursuant to UL 508A, Part 2, “Industrial Machinery”, or NFPA79, any circuit breaking device for supply lines - in the enclosure or near it - must make it possible to lock enclosures with live parts with voltages
> 50 VAC or
60 VDC.

Both mechanical and electric locking mechanisms are acceptable.

If there are several doors, no door must open before the circuit breaker has isolated the enclosure from the mains.

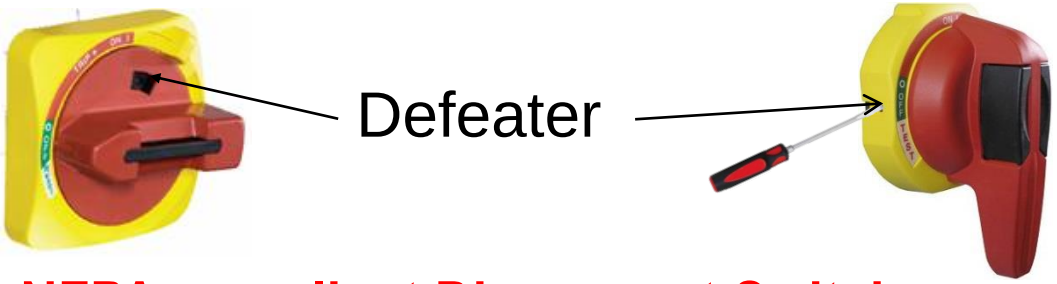
The locking mechanism must be reactivated only after all doors have been closed.

UL 508A Enclosure door locking systems

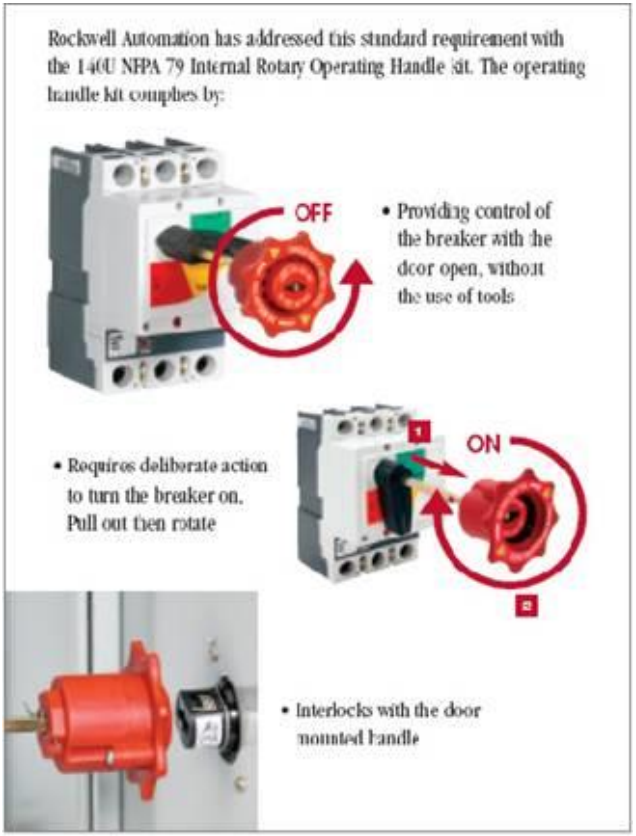
UL 508A Enclosure door locking systems

Rockwell Automation

- Qualified personnel may open the energized enclosure with appropriate methods and tools.
- If this is an option, live parts must be protected from direct contact. (within 50 mm)



- **NFPA compliant Disconnect Switch**
- When the door is open, turning the main disconnect on and off must be possible without tools.
- Turning the switch on must require deliberate action.



UL 508A Enclosure door locking systems

Rockwell Automation

The circuit breaker with locking mechanism must be positioned inside the enclosure or immediately adjacent to it. (Exception: plug and socket device)

If this is impossible or if a plug and socket device is being used, access to the enclosure must only be for qualified personnel with a key or tool unless the design prevents direct contact. (which is not necessarily the equivalent of ‘finger safe’ pursuant to IEC)

A safety notice according to ANSI Z535 is required

Branch Circuit Protection – Section 31

Rockwell Automation

Table 76.2
Various constructions of combination motor controllers
Table 76.2 revised April 15, 2010

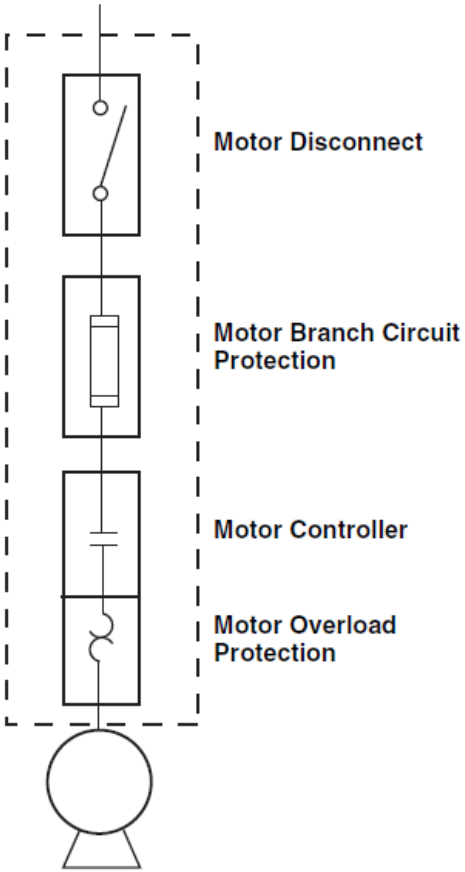
Construction Type	Construction Requirements, Paragraphs	Component[a]	Component Standard	Component Function			
				Disconnect	Branch Circuit Protection	Motor Control	Motor Overload
A	76.4 – 76.8	Manual Disconnect	UL 98 or UL 489	X			
		Fuse	UL 248 series		X		
		Magnetic or Solid State Motor Controller	UL 508			X	
		Overload Relay	UL 508				X
B	76.4 – 76.8	Manual Disconnect	UL 98 or UL 489	X			
		Motor Short-Circuit Protector	UL 508		X		
		Magnetic or Solid State Motor Controller	UL 508			X	
		Overload Relay	UL 508				X
C	76.4 – 76.8	Inverse-Time Circuit Breaker	UL 489	X	X		
		Magnetic or Solid State Motor Controller	UL 508			X	
		Overload Relay	UL 508				X
D	76.4 – 76.9	Instant-aneous-Trip Circuit Breaker	UL 489	X	X		
		Magnetic or Solid State Motor Controller	UL 508			X	
		Overload Relay	UL 508				X
E[b]	76.3.1 – 76.6, 76.8 – 76.13	Self-Protected Control Device	UL 508	X	X	X	X
F	76.3.1 – 76.9	Manual Self-Protected Combination Controller	UL 508	X	X		X
		Magnetic or Solid State Motor Controller	UL 508			X	

[a] Tests are conducted on the individual components per the applicable requirements from the UL Standards in the table.
[b] See 76.11.

Branch Circuit Protection – Section 31

Rockwell Automation

Required Functions of Combination Starters



UL Combination Starter Type	Device Used for Component Function			
	Disconnect	Branch Circuit Protection	Motor Controller	Motor OL Relay
A	UL 98 Manual Disconnect	UL 248 Fuses	UL 508 Magnetic or Solid State Controller	UL 508 Motor Overload Relay
B		UL 508 Motor Short Circuit Protector		
C	UL 489 Inverse Time Circuit Breaker			
D	UL 489 Instantaneous Trip Circuit Breaker			
E	UL 508 Self-Protected Combination Controller			
F	UL 508 Manual Self-Protected Combination Controller		UL 508 Magnetic or Solid State Controller	UL 508 Manual Self-Protected Combination Controller

Branch Circuit Protection – Section 31

Rockwell Automation

Branch circuit protective devices shall be one of the following:

- UL Listed (UL 489) Inverse-time circuit breaker.
- UL R/C (UL 489) Instantaneous-trip circuit breaker
  - Only when evaluated as part of a UL Type D combination motor controller.
- UL Listed (UL 248) Fuse.
- UL Listed (UL508) Self-protected combination motor controller (Type E/F).

Branch Circuit Protection – Section 31

Rockwell Automation

The following devices may not be used as branch circuit protective devices:

- UL R/C (UL 1077) supplementary protector (ie. Mini-breakers)
- UL Listed or R/C (UL 248 Series) miniature and micro fuses.
- UL Listed (UL 508) manual motor controller provided with a instantaneous trip function
- A panel rated at 1000 Amps or more shall additionally have Ground Fault Protection.

The use of Supplementary Protectors in branch circuits is a very common misapplication.

Branch Circuit Protection – Section 31

- Sizing Branch Circuit protection for single motor circuit
  - Determine motor FLA from Table 50.1 or 50.2.
  - Determine max. percentage of FLA based on device from Table 31.1
  - Multiply Motor FLA and max. percentage

Table 50.1
Full-load motor-running currents in amperes corresponding to various a-c horsepower ratings

Horse power	110 – 120 Volts		200 Volts		208 Volts		220 – 240 Volts[a]		380 – 415 Volts		440 – 480 Volts		550 – 600 Volts	
	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase
1/10	3.0	–	–	–	–	–	1.5	–	1.0	–	–	–	–	–
1/8	3.8	–	–	–	–	–	1.9	–	1.2	–	–	–	–	–
1/6	4.4	–	2.5	–	2.4	–	2.2	–	1.4	–	–	–	–	–
1/4	5.8	–	3.3	–	3.2	–	2.9	–	1.8	–	–	–	–	–
1/3	7.2	–	4.1	–	4.0	–	3.6	–	2.3	–	–	–	–	–
1/2	9.8	4.4	5.6	2.5	5.4	2.4	4.9	2.2	3.2	1.3	2.5	1.1	2.0	0.9
3/4	13.8	6.4	7.9	3.7	7.6	3.5	6.9	3.2	4.5	1.8	3.5	1.6	2.8	1.3
1	16.0	8.4	9.2	4.8	8.8	4.6	8.0	4.2	5.1	2.3	4.0	2.1	3.2	1.7
1-1/2	20.0	12.0	11.5	6.9	11.0	6.6	10.0	6.0	6.4	3.3	5.0	3.0	4.0	2.4
2	24.0	13.6	13.8	7.8	13.2	7.5	12.0	6.8	7.7	4.3	6.0	3.4	4.8	2.7
3	34.0	19.2	19.6	11.0	18.7	10.6	17.0	9.6	10.9	6.1	8.5	4.8	6.8	3.9
5	56.0	30.4	32.2	17.5	30.8	16.7	28.0	15.2	17.9	9.7	14.0	7.6	11.2	6.1
7-1/2	80.0	44.0	46.0	25.3	44.0	24.2	40.0	22.0	27.0	14.0	21.0	11.0	16.0	9.0
10	100.0	56.0	57.5	32.2	55.0	30.8	50.0	28.0	33.0	18.0	26.0	14.0	20.0	11.0
15	135.0	84.0	–	48.3	–	46.2	68.0	42.0	44.0	27.0	34.0	21.0	27.0	17.0
20	–	108.0	–	62.1	–	59.4	88.0	54.0	56.0	34.0	44.0	27.0	35.0	22.0
25	–	136.0	–	78.2	–	74.8	110.0	68.0	70.0	44.0	55.0	34.0	44.0	27.0
30	–	160.0	–	92	–	88	136.0	80.0	87.0	51.0	68.0	40.0	54.0	32.0

Table 31.1
Maximum rating of motor branch circuit device percent of full load amperes

Type of Branch Circuit Protective Device	Ampere Rating	Nominal rating of motor branch circuit protective device, percent of full load amperes	Notes
Nontime delay fuse	0 – 600	300	See 31.3.7, 31.3.8, 31.3.9(a)
Nontime delay fuse	Over 600	300	See 31.3.7, 31.3.8, 31.3.9(b)
Dual element fuse (time delay) except Class CC	All	175	See 31.3.7, 31.3.8, 31.3.9(c)
Class CC Dual element fuse (time delay)	0 – 30	300	See 31.3.7, 31.3.8, 31.3.9(a)
Inverse-time circuit breaker	0 – 100	250	See 31.3.7, 31.3.8, 31.3.9(d)
Inverse-time circuit breaker	Over 100	250	See 31.3.7, 31.3.8, 31.3.9(e)
Instantaneous-trip circuit breaker	All	800	See 31.3.4, 31.3.9(f)
Self-protected Combination Motor Controller	All	100	See 31.3.3
Manual Self-protected Combination Motor Controller	All	100	See 31.3.3

Branch Circuit Protection – Section 31

Rockwell Automation

- A group of loads can be protected by a single fuse or breaker
  - Max. size is 20A @ 125V or 15A @ 600V
  - Each motor load must not exceed 6A and branch protection is sized as follows:
    - Determine motor FLA from Table 50.1 or 50.2.
    - Determine max. percentage of FLA based on device from Table 31.1
    - Multiply Motor FLA and max. percentage for the largest motor and add the FLAs of all the other motors

Branch Circuit Protection – Section 31

- Branch circuit protection for variable-speed drives shall be as specified in the manufacturer's installation instructions
- When the instructions don't specify the type and size, it can be calculated based upon the drive's Output Current Rating

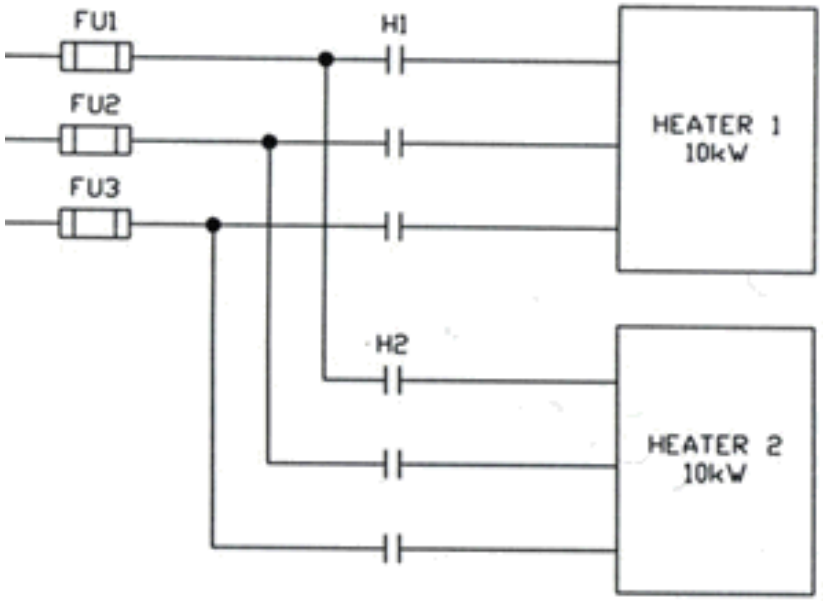
480 Volt AC and 650 Volt DC Input Protection Devices - Frames 1…7

Applied Rating (1)	Frame (2)	Cont. Output Amps	Drive Sized For Normal Duty			Drive Sized For Heavy Duty			Input Quantities		AC Input Protection Devices					
			Catalog Number	Output Overload Amps		Catalog Number	Output Overload Amps		Continuous AC Input		Dual Element Time Delay Fuse		Non-Time Delay Fuse		Circuit Breaker Max Size (5)	Motor Circuit Protector (6)
			(x = F or G)	1 min	3 sec	(x = F or G)	1 min	3 sec	kVA	Amps	Min (3)	Max (4)	Min (3)	Max (4)		
480 Volt AC Input																
1.0 Hp	1	2.1	20x…D2P1	2.3	3.2	20x…D2P1	2.3	3.2	1.3	1.6	2	3	2	3	15	3
2.0 Hp	1	3.4	20x…D3P4	3.7	5.1	20x…D3P4	3.7	5.1	2.2	2.6	6	6	6	6	15	7
3.0 Hp	1	5	20x…D5P0	5.5	7.5	20x…D5P0	5.5	7.5	3.2	3.9	6	6	6	6	20	7
5.0 Hp	1	8	20x…D8P0	8.8	12.0	20x…D8P0	8.8	12.0	5.7	6.9	10	15	10	15	30	15
7.5 Hp	1	11	20x…D011	12.1	16.5	20x…D011	12.1	16.5	7.9	9.5	15	20	15	20	40	15
10 Hp	1	14	20x…D014	15.4	21.0	20x…D022	16.5	21.0	10.4	12.5	20	25	20	25	50	20

Branch Circuit Protection – Section 31

Rockwell Automation

- There are two basic requirements regarding resistive type heaters:
  - Heating element loads cannot draw more than 48A.
  - Branch circuit protection cannot be rated more than 60A.



UL 508A Slash Ratings

A circuit breaker with a slash rating, such as 120/240V or 480Y/277, shall be permitted to be applied in a **solidly grounded** circuit where the nominal voltage of **any conductor to ground** does not exceed the lower of the two values of the circuit breaker's voltage rating and the nominal voltage **between any two conductors** does not exceed the higher value of the circuit breaker's voltage rating…"

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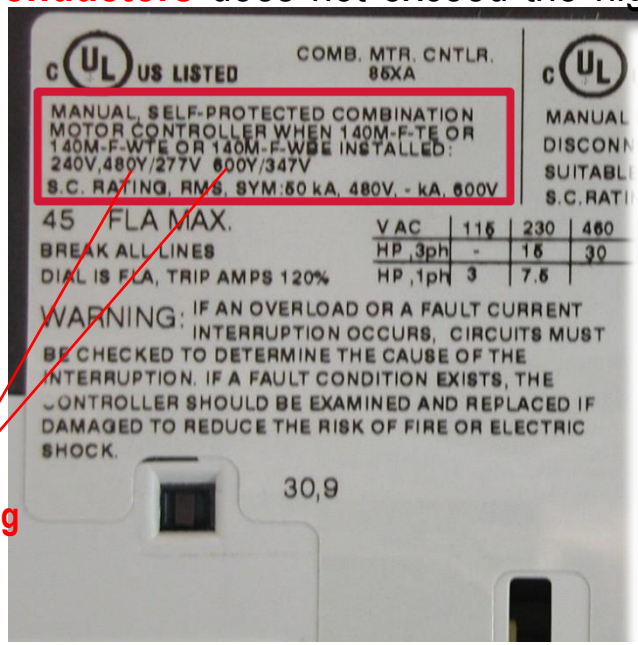
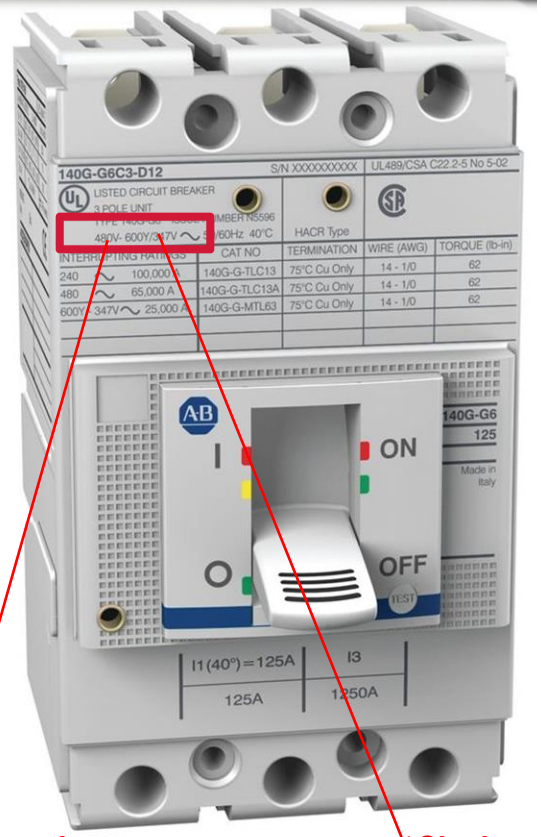


Slash rating



Non Slash rating

Slash rating

Feeder Circuit Protection – Section 32

Rockwell Automation

- There are two basic components allowed for Feeder protection
  - Inverse-time Circuit Breaker (UL 489) sized per the 80% rule
  - Branch Circuit Fuses (UL 248) with Disconnect (UL 98)
  - Manual Motor Controllers per UL508 are **NOT** allowed in a Feeder
- Feeder Overcurrent Protection is sized as follows:
  - It shall not exceed the rating of the largest Branch Protective Device plus the full-load currents of all other motors or loads in the group

OR

  - It shall not exceed Ampacity of feeder conductors or busbar

There are Load Switches Listed to UL 508 which have external operating handles and are often misapplied as disconnects. Only the two types listed above have the spacings and ratings to be properly applied in a Feeder Circuit.

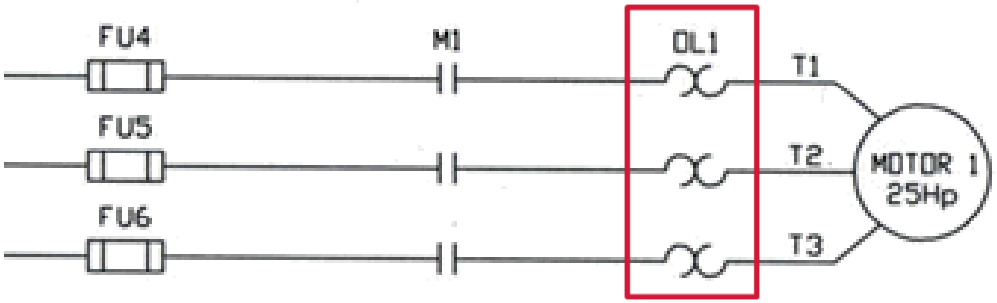
Load Controllers – Section 33

Rockwell Automation

- Motor Controllers must comply with UL 508 and be one of the following types:
  - Magnetic, Manual, Combination, Solid State or Definite Purpose or Reduced Voltage Starter
  - Variable Speed Drives must comply with UL 508C
- Sizing of a load controller is as follows:
  - Must have proper Voltage Rating
  - Ampere rating not less than the sum of all loads controlled with HP ratings converted to FLA using Table 50.1 & 50.2

Motor Overload Protection – Section 34

- Motor overload protection is required for every motor circuit which could include:
  - Separate overload relay: solid state or heater element type
  - Solid state motor controller with integrated overload protection
  - Self-protected motor controller with integrated overload.
  - Drives with integrated overload protection if Listed to UL 508C
  - Thermal device integrated into the motor
- Motor overload protection shall be sized at 115% of the motor FLA nameplate



Power Transformers – Section 35

- Power Transformers are different from ‘control’ transformers because their secondary supplies power to loads or combinations of loads
- Overcurrent protection must be branch rated fuses or circuit breakers and located: Primary Only (Table 35.1) or Primary & Secondary (Table 35.2)

Table 35.1
Sizing of primary winding only branch circuit protection

Power transformer primary current, amperes	Rating of branch circuit protection maximum percentage of primary current
9 or more	125[a]
2 – 8.99	167
less than 2	300

[a] Where the calculated size of the branch circuit protection does not correspond to a standard size fuse or nonadjustable inverse-time circuit breaker, the next larger size is able to be used. See 31.3.8 for standard sizes of branch circuit protection.

Table 35.2
Sizing of primary and secondary branch circuit protection of a power transformer

Primary winding		Secondary winding	
Rated amperes	Branch circuit protection, percent of rated amperes	Rated amperes	Branch circuit protection, percent of rated amperes
9 or more	250	9 or more	125[a]
2 – 8.99	250	less than 9	167
less than 2	300	–	–

[a] Where the calculated size of the branch circuit protection does not correspond to a standard size fuse or nonadjustable inverse-time circuit breaker, the next larger size is able to be used. See 31.3.8 for standard sizes of branch circuit protection.

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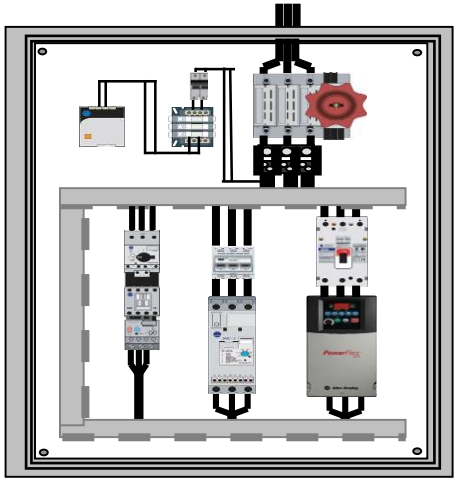
UL508A Industrial Control Panels – Control Circuits –



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Control Circuits – Overview of Sections

Rockwell Automation

- Section 37 – Field Wiring Terminals
- Section 38 – Internal Wiring
- Section 39 – Disconnecting Means
- Section 40 – Overcurrent Protection
- Section 41 – Sizing of Control Circuit Overcurrent Protection
- Section 42 – Overcurrent Protection (Isolated Secondary)
- Section 43 – Limited Energy Circuits
- Section 44 – Class 2 Circuits
- Section 45 – Switching Devices
- Section 46 – Loads
- Section 47 – Miscellaneous Devices
- Section 58 – Pneumatic Switching Devices

Control Circuit Terminals – Section 37

Rockwell Automation

- A Terminal must be provided for connection of each conductor (copper or aluminum) installed in the control panel.
- Terminals must be accessible and able to be connected without removing other components.
- The required size of the field wiring terminal shall be no less than 14 AWG and determined by the overcurrent protection ahead of the terminals.
  - Limited Energy & Class 2 Circuits are allowed to have terminals rated for smaller conductors than 14 AWG

Control Circuit Wiring – Section 38

Rockwell Automation

- Control Circuit conductors are allowed to be less than 14 AWG with a minimum temperature rating of 60°C.
- The size if internal wiring of a control circuit is determined by the ampere rating of the overcurrent protective device.
- The wire gauge can be sized using the Field Wiring Table 28.1 or Table 38.1 shown below.

Table 38.1
Ampacities of control circuit conductors

Ampacity, amperes	Conductor size	
	AWG	(mm^2)
10	16	(1.3)
7	18	(0.82)
5	20[b]	(0.52)
3	22[b]	(0.32)
2	24[b]	(0.20)
1	26[b]	(0.13)
0.8	28[a, b]	(0.08)
0.5	30[a, b]	(0.05)

[a] Where these conductors are contained in a jacketed multi-conductor cable assembly.
[b] These sizes of conductors are only for connection of control circuits for electronic programmable input/output and static control (having no moving parts).

Overcurrent Protection – Section 40/41

Rockwell Automation

- Control circuit overcurrent protection can be provided by:
  - Branch Circuit Fuses or Inverse-time Circuit Breakers
  - Miniature Type supplemental fuses (UL 248-14)
  - Supplementary protectors (ie. UL 1077 mini-breakers)
- Overcurrent protection is sized based upon the ampacity of the control circuit conductor and the source of the control circuit voltage
- Common Control Circuit protection is based upon Table 41.1 or 41.2 depending on whether or not there are wires that leave the panel

Table 41.1
Motor branch circuit protection of common control circuit without remote control devices

Control circuit wire size		Maximum protective device rating, amperes
AWG	(mm^2)	
22	(0.32)	12
20	(0.52)	20
18	(0.82)	25
16	(1.3)	40
14	(2.1)	100
12	(3.3)	120

Table 41.2
Motor branch circuit protection of common control circuit with remote control devices

Control circuit wire size		Maximum protective device rating, amperes
AWG	(mm^2)	
22	(0.32)	3
20	(0.52)	5
18	(0.82)	7
16	(1.3)	10
14	(2.1)	45
12	(3.3)	60

Control Transformers – Section 42

Rockwell Automation

- Control Transformers supplies power to control devices that direct the performance of a controller and NOT to power loads
- Overcurrent protection is often less than 15 Amp and can be either: Primary Only (Table 42.1) or Primary & Secondary (Table 42.2)

Table 42.1
Sizing of primary winding only overcurrent protection of a control transformer

Control transformer primary current, amperes	Rating of overcurrent protection, maximum percentage of primary current
9 or more	125[a]
2 – 8.99	167
less than 2	500

[a] Where the calculated size of the overcurrent protection, branch circuit or supplementary type, does not correspond to a standard size protective device, the next larger size is able to be used. See 31.3.8 for standard sizes of branch circuit protection.

Table 42.2
Sizing of primary and secondary overcurrent protection of a control transformer

Primary winding		Secondary winding	
Rated amperes	Overcurrent protection percent of rated amperes	Rated amperes	Overcurrent protection percent of rated amperes
9 or more	250	9 or more	125[a]
2 – 8.99	250	less than 9	167
less than 2	500	–	–

[a] Where the calculated size of the overcurrent protection, branch circuit or supplementary type, does not correspond to a standard size protective device, the next larger size is able to be used. See 31.3.8 for standard sizes of branch circuit protection.

Other Control Circuits – Section 42 - 44

Rockwell Automation

- Power Supplies used in a control circuit must be Listed to UL 1012 and can only be loaded at 50%
  - Exception: Power Supplies which meet the UL508 Temperature Test can be loaded to 100% rating
- Class 2 power supplies have fire and shock safety features to limit the output power to less than 100VA if there is a failure
  - Components and terminals in Class 2 circuits are not requested to be investigated

Class 2 Circuits are often misapplied due to the cost of power supplies. It is not acceptable to use a larger power supply and fuse into several smaller circuits.

Markings – Section 52

- This section details of all required panel markings and their locations.

Table 52.1
Locations of required markings

Paragraph	General description	Location categories (see notes)	
		Enclosed	Open
	General markings		
52.1	Nameplate stating: manufacturer, maximum voltage, total FLA, largest motor FLA, phase, frequency, field wiring diagram, short circuit current rating	a or b	f
52.2	External load ratings	a, b, or e	e or f
	Enclosure markings		
53.1	Environmental type	a or b	–
53.2	Conduit hubs for Type 2, 3R or 3RX enclosures	a, b, or e	–
53.3	Conduit hubs for Type 3, 3S, 3SX, 3X, 4, 4X, 5, or 12 enclosures	a, b, or e	–
53.4	Modular enclosure marking, specifying interconnections	a or b	–
53.5	Single conduit entry, non-metallic enclosure only	a, b, or e	–
53.6	Location of conduit entry	a or b	–
53.7	Instructions for field installed bonding means	a, b, or e	–
	Field wiring terminal markings		
54.1	Field wiring terminal identification	c	c
54.2 – 54.4, 54.11	Type of field wiring conductors, field wiring temperature rating (power circuit only), terminal tightening torque	b, c, or e	c, e, or f
54.5	Equipment grounding terminal identification	c	c
54.6	Class 1 markings	b, c, or e	c, e, or f
54.7	Class 2 markings	b, c, or e	c, e, or f
54.8	Routing of Class 1 and Class 2 conductors	b, c, or e	c, e, or f
54.9	Control circuit wire size [less than 14 AWG (2.1 mm^2)]	b, c, or e	c, e, or f
54.10	Connect secondary neutral to grounding electrode conductor	b, c, or e	c, e, or f
54.12	Slash voltage rating	a, b, or e	e or f
	Cautionary markings		
55.4	Multiple disconnect marking	a	d
55.5	Polymeric enclosure with multiple conduit entries	b	–
55.6	Instantaneous trip circuit breaker used as branch circuit protection for a combination motor controller	a, b, or c	c or d

Table 52.1 Continued

Paragraph	General description	Location categories (see notes)	
		Enclosed	Open
55.7	Self-protected combination motor controller, including manual type	a, b, or c	c or d
	Fuseholders		
56.1	Fuse replacement marking	b or c	c or d
	Switches		
57.1	Disconnect handle, "on" and "off"	c	–
57.2	Manual switch, not to operate under load	c	c
57.3	Reverse fed disconnecting means	a	d
	Overload Relay Heater Tables		
58.1	Overload relay heater element table	b or c	c or d
	Receptacles		
59.1	General use receptacle in power circuit	c	c
59.2	Multi-pin receptacle, identification of load connection	c	c
59.3	General use receptacle in control circuit	c	c
59.4	Receptacle not to operate under load	c	c
	Field provided components		
60.1, 60.2	Disconnect switch, branch circuit protection and/or overload relay to be provided by installer	e	e
60.3	Other devices to be provided by installer	e	e
	Schematic Wiring Diagrams		
61.1, 61.2	Complete schematic	e	e

NOTES

a) Marking shall be visible without opening the door or cover of the enclosure.

b) This marking is able to be provided on the door or cover of the enclosure or on the inside walls of the enclosure.

c) Marking shall be on or adjacent to the component in question. Fuse replacement markings are able to be on a chart displayed as specified in (b) when each fuseholder is marked with a distinctive designation, such as F1. For open panels, the chart is able to be supplied as described in (d).

d) Marking shall be shipped separately on a self-adhesive label with the device (this is intended to be placed on or in the ultimate enclosure).

e) Marking shall be on the field wiring diagram, prints, or instructions that are referenced on the panel nameplate and is to be shipped with the panel (either loosely, in the "print pocket," or adhered to the inside of the enclosure).

f) Marking shall be on the subpanel component mounting plate.

Missing or incorrect panel marking is a common UL citation.

Markings – Section 53 & 54

Rockwell Automation

- These sections provide more detail for specific marking types
- Enclosure: An enclosed panel must be marked with an appropriate Type Rating and instructions for conduit fittings.
- Field Wiring Terminals: Must be marked to indicate proper connect of supply and load corresponding to a wiring diagram.
  - Required type of field wiring conductor.
  - Temperature rating of field conductor.
  - Terminal tightening torque per Table 54.1
- Power Circuit Terminals: Must be marked with the appropriate wire temperature ratings determined from Table 28.1.
- The Equipment Ground Terminals: Must be specifically identified.
  - Green terminal screw or “Ground” or “GND” or symbol 

Markings – Section 55 thru 61

- Cautionary Markings: Legible and visible to the operator during normal operation typically located on a non-removable part of the panel
- Fuseholder Markings: Must be marked with the voltage and current rating of the replacement fuse
- Switch Markings: Disconnecting handles must be marked to indicate their "On/Off" positions
- Overload Relay: If there are replaceable heater elements, the a table or selection chart must be provided
- Receptacle: Must be marked with the ampere rating and intended use.
- Field Provided: Must be marked when separate branch protection or disconnect is required
- Schematic Wiring Diagram: A complete electrical schematic wiring diagram must be included. Any field installed components must be noted

Specific Use Panels – Section 62 thru 99

Rockwell Automation

- Enclosures – Panel builder fabricated Type 1 enclosures
- Industrial Machinery - Requirements align with NFPA 79
- Crane and Hoist Control - Additional panel requirements
- Service Equipment Use - Additional panel requirements
- Elevator Control - In addition to ASME A17.1 and A17.5
- Flame Control - Safety control and ignition transformer control
- Marine Use - Additional requirements for vessels over 65 ft. long.
- A/C and Refrigeration Equipment - Additional panel requirements.
- Fountain Control - Additional panel requirements
- Irrigation Equipment - Additional panel requirements

Industrial Machinery – Section 65 - 67

Rockwell Automation

- These sections provide additional panel requirements for Industrial Machinery which align with NFPA79
- Enclosure door must be interlocked with disconnecting means
- Maintenance lighting circuit must not exceed 115V @ 15 Amps
- Field power terminals must be sized by adding up the following loads:
  - 125% of all heater loads
  - 125% of the largest motor load & FLA of all other simultaneous loads
- Power circuit conductor colors: Black = AC Power, White = AC Ground
- Power circuit conductors sized similar to field power terminals above
- Disconnecting means must be provided for all incoming supplies
  - Class H fuses are not allowed
  - Readily accessible and operated independent of the door position

Industrial Machinery – Section 65 - 67

Rockwell Automation

- Main disconnect sized based on the sum of:
  - The largest branch circuit protective devices in the panel;
  - 125 percent of all heater loads;
  - 125 percent of the largest motor load; and
  - The full-load currents of all other simultaneously operating loads
- Control circuit wiring colors are as follows:

Black	Ungrounded AC at supply voltage
Red	Ungrounded AC less than the supply voltage
Blue	Ungrounded DC control circuits
Yellow or orange	Control remains energized when the main disconnect is off
White	Grounded AC control circuit conductor regardless of voltage
White w/Blue	Grounded DC control circuit conductor
White w/Yellow or orange	Power remains energized when the main disconnect is off.

Industrial Machinery – Section 65 - 67

Rockwell Automation

- Control circuit conductors shall not be smaller than 18 AWG.
- Emergency Stop button is required on panels that have other operators.
- Emergency Stop must be self latching, palm type button with Red/Yellow color scheme.
- Additional nameplate markings include the Short Circuit Current Rating.

The 'Industrial Machinery' control panel requirements referenced in UL 508A do align with NFPA 79.

Rockwell Automation

Definition of terms

Motor Controller (with or without protective function)

Turning a motor on and off

- manual (**Manual Motor Controller**)
- remote (contactor, Softstarter, FU)

Motor Starter, and/or Motor Controller with protective function

- **Non Combination Motor Starter** (Motor Controller)
  - No breaker, no short circuit protection, but overload protection
- **Combination Motor Starter** (Motor Controller)
  - Breaker, short circuit and overload protection

Rockwell Automation

Unevaluated Devices

Unevaluated Devices may not be used

- if non-electric and non-hydraulic (e.g. pneumatic)
- if run through **Class 2 transformers or power supplies**
- in **LVLE**-circuits
- in control circuits when protected with **US**-FI switches
  (e.g. push buttons, sensors, etc. but!! not power circuits)
- after UL acceptance

More about this in the Control Circuits chapter

Example of sizing procedure for ICP

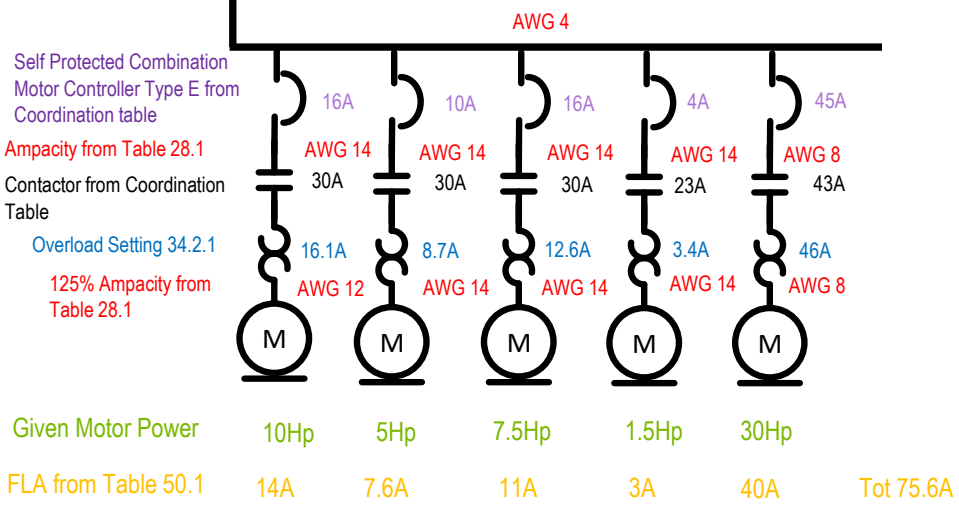
480V/60Hz

MCCB UL 489

<= 80.6A = 14+7.6+11+3+45

<= AWG 4

From 32.3.1 a) b)



Motor		Circuit Breaker		Contactor	Overload Relay	
3 ph [HP]	1500 rpm [A] 1)	Catalog Number	Magnetic Trip Current [A]	Catalog Number 2)	Catalog Number 3)	Thermal Setting [A]
---	---	140M-C2N-A40	5.2	100-C09...	193-EEAB	0.1 - 0.4
---	---	140M-C2N-B10	13	100-C09...	193-EEBB	0.2 - 1.0
1/2	1.1	140M-C2N-B25	33	100-C09...	193-EECB	1.0 - 5.0
3/4	1.6	140M-C2N-B25	33	100-C09...	193-EECB	1.0 - 5.0
1	2.1	140M-C2N-B25	33	100-C09...	193-EECB	1.0 - 5.0
1 1/2	3.0	140M-D8N-B40	52	100-C23...	193-EECB	1.0 - 5.0
2	3.4	140M-D8N-B40	52	100-C23...	193-EECB	1.0 - 5.1
3	4.8	140M-D8N-C10	130	100-C30...	193-EEDD	3.2 - 10
5	7.6	140M-D8N-C10	130	100-C30...	193-EEDD	3.2 - 10
7 1/2	11	140M-D8N-C16	208	100-C30...	193-EEDD	3.2 - 10
10	14	140M-D8N-C16	208	100-C30...	193-EEDD	3.2 - 10
15	21	140M-D8N-C25	325	100-C30...	193-EEED	5.4 - 25
20	27	140M-F8N-C32	416	100-C37...	193-EEFD	9.0 - 43
25	34	140M-F8N-C45	585	100-C37...	193-EEFD	9.0 - 43
30	40	140M-F8N-C45	585	100-C43...	193-EEFD	9.0 - 43

Table 28.1
Ampacities of insulated conductors

Wire size		60°C (140°F)		75°C (167°F)	
AWG	(mm²)	Copper	Aluminum	Copper	Aluminum
14	(2.1)	15	–	15	–
12	(3.3)	20	15	20	15
10	(5.3)	30	25	30	25
8	(8.4)	40	30	50	40
6	(13.3)	55	40	65	50
4	(21.2)	70	55	85	65
3	(26.7)	85	65	100	75
2	(33.6)	95	75	115	90
1	(42.4)	110	85	130	100
1/0	(53.5)	–	–	150	120
2/0	(67.4)	–	–	175	135
3/0	(85.0)	–	–	200	155
4/0	(107.2)	–	–	230	180

Table 50.1
Full-load motor-running currents in amperes corresponding to various a-c horsepower ratings

Horse power	110 – 120 Volts		200 Volts		208 Volts		220 – 240 Volts[a]		380 – 415 Volts		440 – 480 Volts		550 – 600 Volts	
	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase
1/10	3.0	–	–	–	–	–	1.5	–	1.0	–	–	–	–	–
1/8	3.8	–	–	–	–	–	1.9	–	1.2	–	–	–	–	–
1/6	4.4	–	2.5	–	2.4	–	2.2	–	1.4	–	–	–	–	–
1/4	5.8	–	3.3	–	3.2	–	2.9	–	1.8	–	–	–	–	–
1/3	7.2	–	4.1	–	4.0	–	3.6	–	2.3	–	–	–	–	–
1/2	9.8	4.4	5.6	2.5	5.4	2.4	4.9	2.2	3.2	1.3	2.5	1.1	2.0	0.9
3/4	13.8	6.4	7.9	3.7	7.6	3.5	6.9	3.2	4.5	1.8	3.5	1.6	2.8	1.3
1	16.0	8.4	9.2	4.8	8.8	4.6	8.0	4.2	5.1	2.3	4.0	2.1	3.2	1.7
1-1/2	20.0	12.0	11.5	6.9	11.0	6.6	10.0	6.0	6.4	3.3	5.0	3.0	4.0	2.4
2	24.0	13.6	13.8	7.8	13.2	7.5	12.0	6.8	7.7	4.3	6.0	3.4	4.8	2.7
3	34.0	19.2	19.6	11.0	18.7	10.6	17.0	9.6	10.9	6.1	8.5	4.8	6.8	3.9
5	56.0	30.4	32.2	17.5	30.8	16.7	28.0	15.2	17.9	9.7	14.0	7.6	11.2	6.1
7-1/2	80.0	44.0	46.0	25.3	44.0	24.2	40.0	22.0	27.0	14.0	21.0	11.0	16.0	9.0
10	100.0	56.0	57.5	32.2	55.0	30.8	50.0	28.0	33.0	18.0	26.0	14.0	20.0	11.0
15	135.0	84.0	–	48.3	–	46.2	68.0	42.0	44.0	27.0	34.0	21.0	27.0	17.0
20	–	108.0	–	62.1	–	59.4	88.0	54.0	56.0	34.0	44.0	27.0	35.0	22.0
25	–	136.0	–	78.2	–	74.8	110.0	68.0	70.0	44.0	55.0	34.0	44.0	27.0
30	–	160.0	–	92	–	88	136.0	80.0	87.0	51.0	68.0	40.0	54.0	32.0

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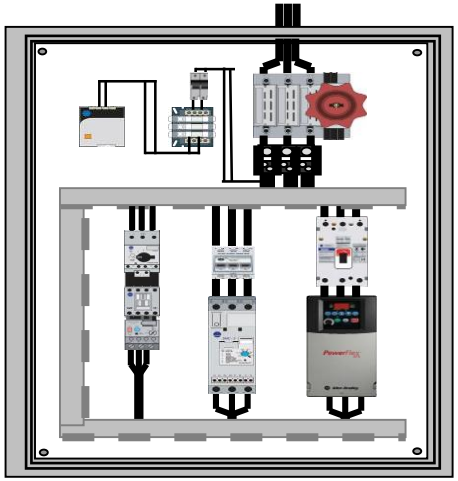
UL508A Industrial Control Panels – SCCR



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Short Circuit Current Rating (SCCR) – Supplement SB4

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- Supplement SB4 covers requirements for:
- Standard and High Fault short circuit current ratings for all Industrial Control Panels
- NEC Article 409 requires panels to be marked with an SCCR and references UL 508A, SB4 as an approved method
- The overall panel short circuit rating shall be the lowest short circuit rating of all power circuit components or the short circuit rating of the branch circuit device, whichever is lower.

To meet NEC Article 409, it is necessary to know the Available Fault Current for the incoming supply power to ensure the panel SCCR is adequate. Often panel builders aren't given this information, but it could be helpful when selecting the Feeder and Branch protective devices.

Short Circuit Current Rating (SCCR) – Supplement SB4

Rockwell Automation

To determine short circuit ratings, the following steps need to be followed:

1. Establish short circuit rating of each component in power circuit for each branch circuit. (SB4.2)
2. Modify short circuit rating based upon the use of current limiting components, if applicable. (SB4.3)
3. Determine overall short circuit rating for the panel. (SB4.4)
4. Add SCCR markings to panel nameplate (SB5.1):
   - "Short Circuit current: ____ kA rms symmetrical, ____V maximum"

Short Circuit Current Rating (SCCR) – Supplement SB4.2.1

Rockwell Automation

- All power circuit components, including disconnect switches, branch circuit protective devices, branch circuit fuse holders, load controllers, motor overload relays, terminal blocks, and bus bars, shall have a short circuit current rating expressed in Amperes or kiloAmperes (kA) and voltage
  - **Exception No. 1**: Power transformers, reactors, current transformers, dry-type capacitors, resistors, varistors, and voltmeters are not required to have a short circuit current rating
  - **Exception No. 2**: The "S" contactor of a wye-delta motor controller is not required to have a short-circuit current rating

Short Circuit Current Rating (SCCR) – Supplement SB4.2.2

Rockwell Automation

- The short circuit current rating of a component shall be established by one of the following methods:
  - The short circuit current rating marked on the component or on instructions provided with the component;
  - The short circuit current rating determined by the voltage rating of the component and the assumed short circuit current from Table SB4.1; or
  - The short circuit current rating for a load controller…that has been investigated in accordance with…UL 508, and described in the manufacturer's Procedure

Short Circuit Current Rating (SCCR) – Supplement Table SB4.1

Rockwell Automation

- Default short circuit current ratings when not marked or provided by the manufacturer.

Table SB4.1
Assumed maximum short circuit current rating for unmarked components

Component	Short circuit current rating, kA
Bus bars	10
Circuit breaker (including GFCI type)	5
Current meters	a
Current shunt	10
Fuseholder	10
Industrial control equipment:	
a. Auxiliary devices (overload relay)	5
b. Switches (other than mercury tube type)	5
c. Mercury tube switches	
Rated over 60 amperes or over 250 volts	5
Rated 250 volts or less, 60 amperes or less, and over 2 kVA	3.5
Rated 250 volts or less and 2 kVA or less	1
Motor controller, (including combination motor controllers, float and pressure operated motor controllers, power conversion equipment and solid state motor controllers), rated in horsepower (kW)[d]	
a. 0 – 50 (0 – 37.3)	5[c]
b. 51 – 200 (38 – 149)	10[c]
c. 201 – 400 (150 – 298)	18[c]
d. 401 – 600 (299 – 447)	30[c]
e. 601 – 900 (448 – 671)	42[c]
f. 901 – 1600 (672 – 1193)	85[c]
Meter socket base	10
Miniature or miscellaneous fuse	10[b]
Receptacle (GFCI type)	2
Receptacle (other than GFCI type)	10
Supplementary protector	0.2
Switch unit	5
Terminal block or power distribution block	10
Multi-point interconnection power cable assembly	5
Multiwire (power distribution) lug	10

[a] A short circuit current rating is not required when connected via a current transformer or current shunt. A directly connected current meter shall have a marked short circuit current rating.
[b] The use of a miniature fuse is limited to 125-volt circuits.
[c] Standard fault current rating for motor controller rated within specified horsepower range.
[d] Highest rated horsepower of motor controller.

Short Circuit Current Rating (SCCR) – Supplement SB4.2.3

Rockwell Automation

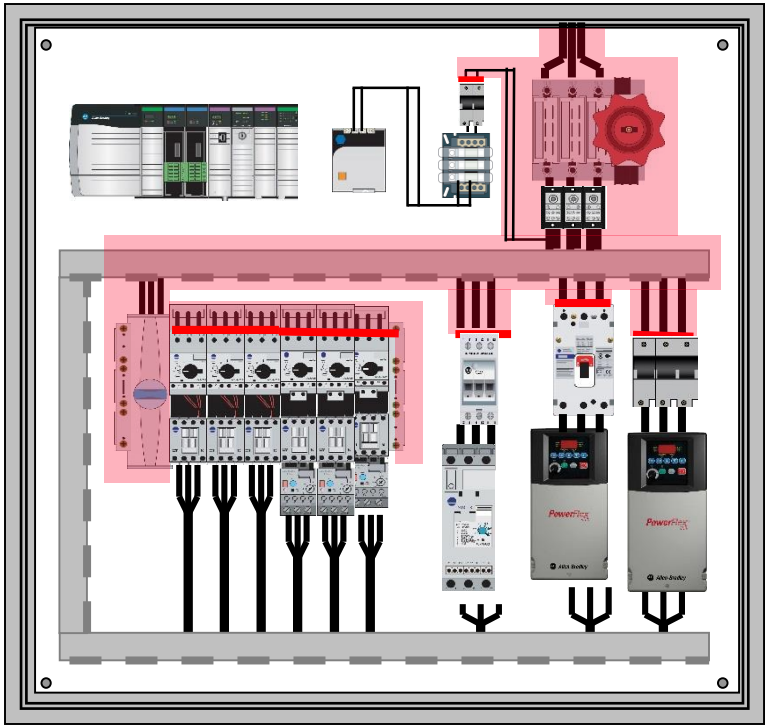
- A high fault short circuit current rating for a motor controller, an overload relay, or a combination motor controller, as specified in SB4.2.2 (a) or (c), shall only be used as the short circuit current rating of the component when the specified branch circuit protective device is provided
  - Hi fault short circuit current rating is an higher rating than the one provided for that specific component
  - Global SCCR

Short Circuit Current Rating (SCCR) – Supplement SB4.3

Rockwell Automation

- Feeder components that limit the short circuit current available.
  - **SB4.3.1** – Power transformer with an isolated secondary winding.
  - **SB4.3.2** – Circuit breaks UL Listed as “Current Limiting”.
  - **SB4.3.3** – Fuses: Class CC, G, J, L, RK1, RK5, or T.

<u>Feeder Circuit</u> – The conductors and circuitry on the supply side of the branch circuit protective device.



Short Circuit Current Rating (SCCR) – Supplement SB4.3.1

Rockwell Automation

- Power Transformer with an isolated secondary winding.
- The secondary available short circuit current of the power transformer is determined either by calculations or by using Tables SB4.3 or SB4.4
- Calculations
  - Single Phase Transformers:

    Full-Load Current (I_{FL}) = (kVA x 1000) / Voltage

    Short Circuit Current (I_{SC}) = (I_{FL}) / Impedance (Z)

  - Three Phase Transformers:

    Full-Load Current (I_{FL}) = (kVA x 1000) / (Voltage x 1.732)

    Short Circuit Current (I_{SC}) = (I_{FL}) / Impedance (Z)

- If the Impedance is not known, a default of Z = 2.1% can be used.

Short Circuit Current Rating (SCCR) – Supplement SB4.3.1

Rockwell Automation

- Power transformer available short circuit current: Tables SB4.3 or SB4.4

Table SB4.3
Single phase transformer secondary available short circuit currents (Amps)[a]

Column 1	Column 2							
Transformer	Minimum Transformer Secondary Voltage (V)							
Max kVA	120	120/240[b]	208	240	277	347	480	600
1	400 A	300 A	230 A	200 A	180 A	140 A	100 A	80 A
3	1,200 A	900 A	690 A	600 A	520 A	420 A	300 A	240 A
5	1,990 A	1,490 A	1,150 A	1,000 A	860 A	690 A	500 A	400 A
10	3,970 A	2,980 A	2,290 A	1,990 A	1,720 A	1,380 A	1,000 A	800 A
15	5,960 A	4,470 A	3,440 A	2,980 A	2,580 A	2,060 A	1,490 A	1,200 A
25	9,930 A	7,450 A	5,730 A	4,970 A	4,300 A	3,440 A	2,490 A	1,990 A
37.5	14,890 A	11,170 A	8,590 A	7,450 A	6,450 A	5,150 A	3,730 A	2,980 A
50	19,850 A	14,890 A	11,450 A	9,930 A	8,600 A	6,870 A	4,970 A	3,970 A
75	29,770 A	22,330 A	17,180 A	14,890 A	12,900 A	10,300 A	7,450 A	5,960 A

[a] Z assumed to be 2.1%.
[b] Short-circuit current shown is line-to-neutral.

Table SB4.4
Three phase transformer secondary available short circuit currents (Amps)[a]

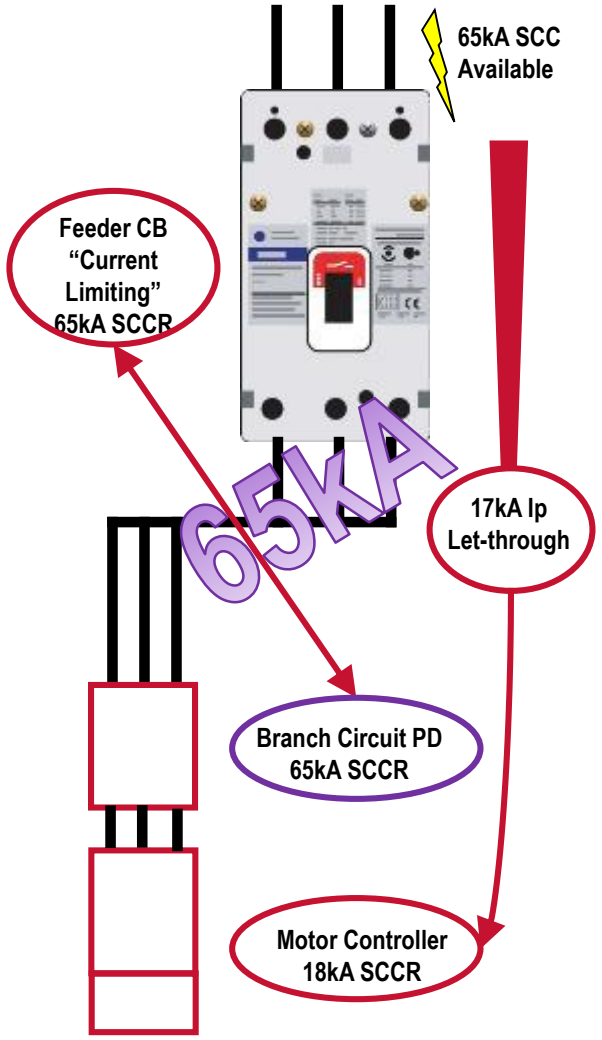
Column 1	Column 2						
Transformer	Minimum Transformer Secondary Voltage (V)						
Max kVA	208Y/120[b]	208	240	480Y/277[b]	480	600Y/347[b]	600
5	840 A	670 A	580 A	360 A	290 A	230 A	230 A
10	1,660 A	1,330 A	1,150 A	730 A	580 A	460 A	460 A
15	2,490 A	1,990 A	1,730 A	1,090 A	870 A	690 A	690 A
20	3,310 A	2,650 A	2,300 A	1,440 A	1,150 A	920 A	920 A
25	4,140 A	3,310 A	2,870 A	1,800 A	1,440 A	1,150 A	1,150 A
30	4,980 A	3,980 A	3,450 A	2,160 A	1,730 A	1,380 A	1,380 A
45	7,450 A	5,960 A	5,170 A	3,240 A	2,590 A	2,070 A	2,070 A
75	12,410 A	9,930 A	8,610 A	5,390 A	4,310 A	3,450 A	3,450 A
100	16,550 A	13,240 A	11,470 A	7,180 A	5,740 A	4,590 A	4,590 A

[a] Z assumed to be 2.1%.
[b] Short-circuit current shown is line-to-neutral.

Short Circuit Current Rating (SCCR) – Supplement SB4.3.2

Rockwell Automation

- For Branch Circuits supplied by a Listed CB marked "current limiting" in the Feeder Circuit, the SCCR on the line side of the CB will be one of the following:
  - a) The interrupting rating of the feeder circuit breaker when:
    1. all of the individual components in the branch circuit have a short circuit current rating not less than the peak let-through current of the circuit breaker, and
    2. the short circuit current rating of any combination motor controller on the load side is not less than the interrupting rating of the feeder circuit breaker
  - b) The smallest interrupting rating of any branch circuit protective device on the load side of the feeder circuit breaker, when the condition 1 it is not true
  - c) The smallest short circuit current rating of any branch circuit on the load side of the Feeder CB when a) and b) are not met
- SB4.3.3 for Fuses is similar to current limiting circuit breakers.

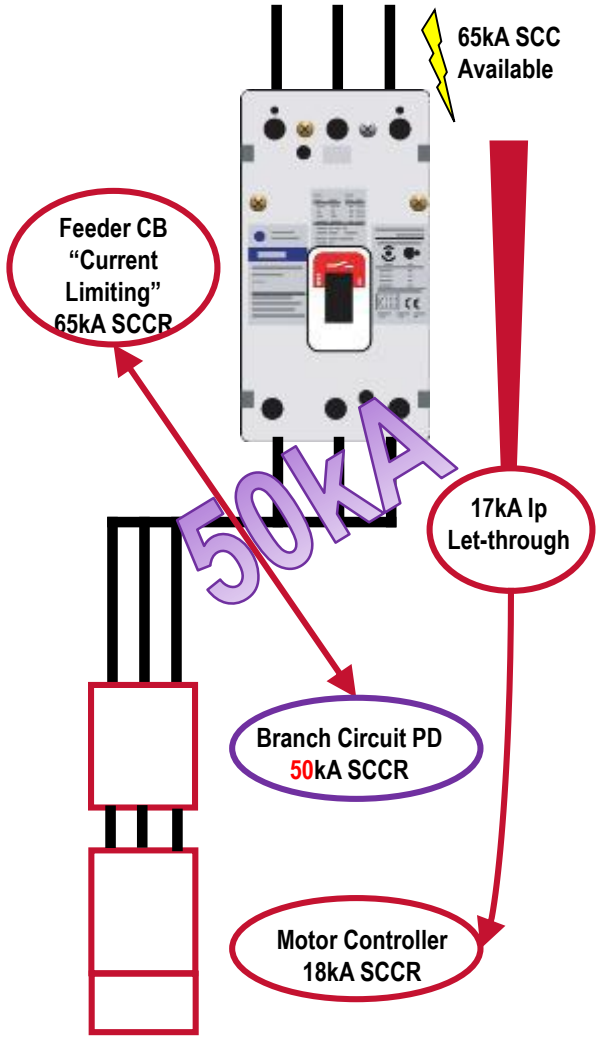


Short Circuit Current Rating (SCCR) – Supplement SB4.3.2

Rockwell Automation

- For Branch Circuits supplied by a Listed CB marked "current limiting" in the Feeder Circuit, the SCCR on the line side of the CB will be one of the following:
  - a) The interrupting rating of the feeder circuit breaker when:
    1. all of the individual components in the branch circuit have a short circuit current rating not less than the peak let-through current of the circuit breaker, and
    2. the short circuit current rating of any combination motor controller on the load side is not less than the interrupting rating of the feeder circuit breaker
  - b) The smallest interrupting rating of any branch circuit protective device on the load side of the feeder circuit breaker, when the condition 2 it is not true
  - c) The smallest short circuit current rating of any branch circuit on the load side of the Feeder CB when a) and b) are not met

- SB4.3.3 for Fuses is similar to current limiting circuit breakers.

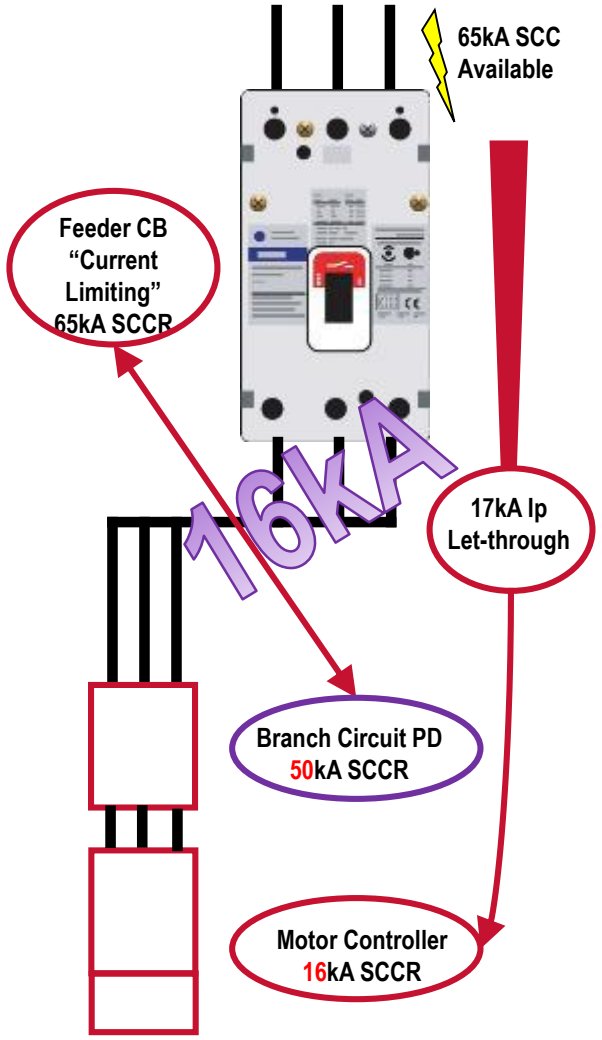


Short Circuit Current Rating (SCCR) – Supplement SB4.3.2

Rockwell Automation

- For Branch Circuits supplied by a Listed CB marked "current limiting" in the Feeder Circuit, the SCCR on the line side of the CB will be one of the following:
  - a) The interrupting rating of the feeder circuit breaker when:
    1. all of the individual components in the branch circuit have a short circuit current rating not less than the peak let-through current of the circuit breaker, and
    2. the short circuit current rating of any combination motor controller on the load side is not less than the interrupting rating of the feeder circuit breaker
  - b) The smallest interrupting rating of any branch circuit protective device on the load side of the feeder circuit breaker, when the condition 2 it is not true
  - c) The smallest short circuit current rating of any branch circuit on the load side of the Feeder CB when a) and b) are not met

- SB4.3.3 for Fuses is similar to current limiting circuit breakers.

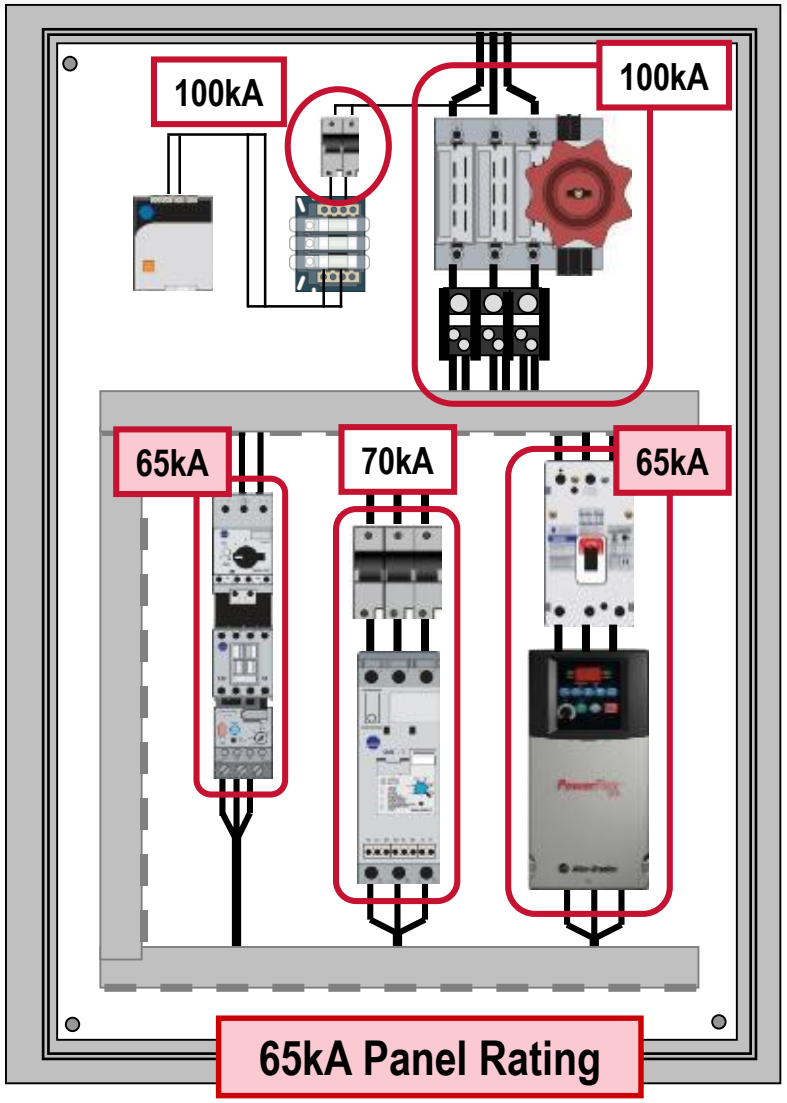


Short Circuit Current Rating (SCCR) – Supplement SB4.4

Rockwell Automation

- For each branch circuit provided with branch circuit protection within the industrial control panel, the smallest short-circuit current rating of all power circuit components on the load side of a branch circuit protective device **and** the control circuit over-current protection in SB3.2.1 shall be determined and compared with the short-circuit current rating of the branch circuit protective device. The smaller of the two ratings shall be assigned to the line side of the branch circuit protective device.

- In other words, use the lowest rating of a component or branch protective device to determine branch rating.



Example of sizing procedure for ICP

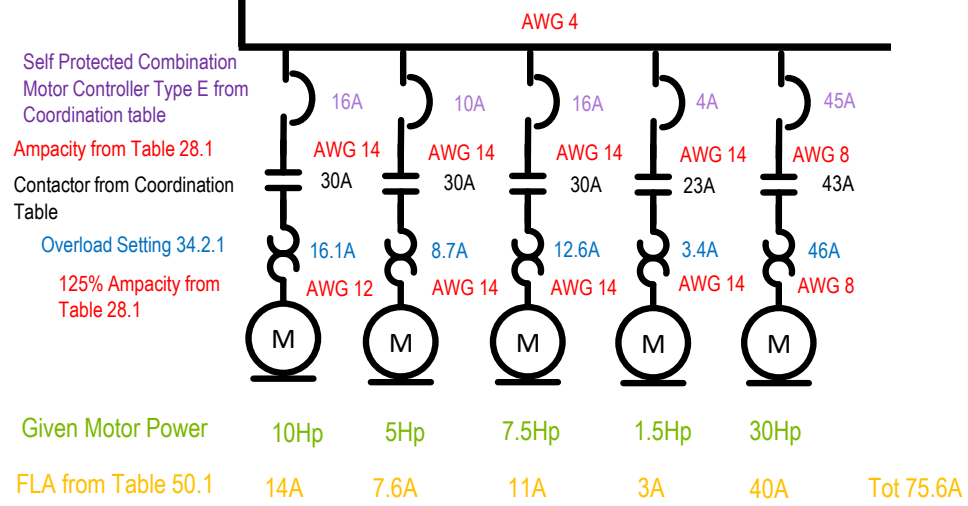
480V/60Hz

MCCB UL 489

<= 80.6A = 14+7.6+11+3+45

<= AWG 4

From 32.3.1 a) b)



Motor		Circuit Breaker		Contactor	Overload Relay	
3 ph [HP]	1500 rpm [A] 1)	Catalog Number	Magnetic Trip Current [A]	Catalog Number 2)	Catalog Number 3)	Thermal Setting [A]
---	---	140M-C2N-A40	5.2	100-C09...	193-EEAB	0.1 - 0.4
---	---	140M-C2N-B10	13	100-C09...	193-EEBB	0.2 - 1.0
1/2	1.1	140M-C2N-B25	33	100-C09...	193-EECB	1.0 - 5.0
3/4	1.6	140M-C2N-B25	33	100-C09...	193-EECB	1.0 - 5.0
1	2.1	140M-C2N-B25	33	100-C09...	193-EECB	1.0 - 5.0
1 1/2	3.0	140M-D8N-B40	52	100-C23...	193-EECB	1.0 - 5.0
2	3.4	140M-D8N-B40	52	100-C23...	193-EECB	1.0 - 5.1
3	4.8	140M-D8N-C10	130	100-C30...	193-EEDD	3.2 - 10
5	7.6	140M-D8N-C10	130	100-C30...	193-EEDD	3.2 - 10
7 1/2	11	140M-D8N-C16	208	100-C30...	193-EEDD	3.2 - 10
10	14	140M-D8N-C16	208	100-C30...	193-EEDD	3.2 - 10
15	21	140M-D8N-C25	325	100-C30...	193-EEED	5.4 - 25
20	27	140M-F8N-C32	416	100-C37...	193-EEFD	9.0 - 43
25	34	140M-F8N-C45	585	100-C37...	193-EEFD	9.0 - 43
30	40	140M-F8N-C45	585	100-C43...	193-EEFD	9.0 - 43

Table 28.1
Ampacities of insulated conductors

Wire size		60°C (140°F)		75°C (167°F)	
AWG	(mm²)	Copper	Aluminum	Copper	Aluminum
14	(2.1)	15	–	15	–
12	(3.3)	20	15	20	15
10	(5.3)	30	25	30	25
8	(8.4)	40	30	50	40
6	(13.3)	55	40	65	50
4	(21.2)	70	55	85	65
3	(26.7)	85	65	100	75
2	(33.6)	95	75	115	90
1	(42.4)	110	85	130	100
1/0	(53.5)	–	–	150	120
2/0	(67.4)	–	–	175	135
3/0	(85.0)	–	–	200	155
4/0	(107.2)	–	–	230	180

Table 50.1
Full-load motor-running currents in amperes corresponding to various a-c horsepower ratings

Horse power	110 – 120 Volts		200 Volts		208 Volts		220 – 240 Volts[a]		380 – 415 Volts		440 – 480 Volts		550 – 600 Volts	
	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase
1/10	3.0	–	–	–	–	–	1.5	–	1.0	–	–	–	–	–
1/8	3.8	–	–	–	–	–	1.9	–	1.2	–	–	–	–	–
1/6	4.4	–	2.5	–	2.4	–	2.2	–	1.4	–	–	–	–	–
1/4	5.8	–	3.3	–	3.2	–	2.9	–	1.8	–	–	–	–	–
1/3	7.2	–	4.1	–	4.0	–	3.6	–	2.3	–	–	–	–	–
1/2	9.8	4.4	5.6	2.5	5.4	2.4	4.9	2.2	3.2	1.3	2.5	1.1	2.0	0.9
3/4	13.8	6.4	7.9	3.7	7.6	3.5	6.9	3.2	4.5	1.8	3.5	1.6	2.8	1.3
1	16.0	8.4	9.2	4.8	8.8	4.6	8.0	4.2	5.1	2.3	4.0	2.1	3.2	1.7
1-1/2	20.0	12.0	11.5	6.9	11.0	6.6	10.0	6.0	6.4	3.3	5.0	3.0	4.0	2.4
2	24.0	13.6	13.8	7.8	13.2	7.5	12.0	6.8	7.7	4.3	6.0	3.4	4.8	2.7
3	34.0	19.2	19.6	11.0	18.7	10.6	17.0	9.6	10.9	6.1	8.5	4.8	6.8	3.9
5	56.0	30.4	32.2	17.5	30.8	16.7	28.0	15.2	17.9	9.7	14.0	7.6	11.2	6.1
7-1/2	80.0	44.0	46.0	25.3	44.0	24.2	40.0	22.0	27.0	14.0	21.0	11.0	16.0	9.0
10	100.0	56.0	57.5	32.2	55.0	30.8	50.0	28.0	33.0	18.0	26.0	14.0	20.0	11.0
15	135.0	84.0	–	48.3	–	46.2	68.0	42.0	44.0	27.0	34.0	21.0	27.0	17.0
20	–	108.0	–	62.1	–	59.4	88.0	54.0	56.0	34.0	44.0	27.0	35.0	22.0
25	–	136.0	–	78.2	–	74.8	110.0	68.0	70.0	44.0	55.0	34.0	44.0	27.0
30	–	160.0	–	92	–	88	136.0	80.0	87.0	51.0	68.0	40.0	54.0	32.0

UL 508A – Common non conformities

- Application of the wrong standards
- Selection of unsuitable products
  - Main disconnect is not approved under UL 98 or UL 489
  - UL 489 MCCB is used with 100% nominal current, but is not labeled accordingly
  - BCP is a Manual Motor Controlled Suitable as Motor Disconnect and it is not approved as Type E/F Self Protected Combination Motor Controller
  - Type E/F Motor-protective circuit breakers protect transformers and resistive loads
  - Circuit Breaking devices are used in the main circuit
- Overload and short circuit protection
- Group Motor Installation
- Enclosure and IP codes
- Labels, Documentation
- Electrical and mechanical construction

UL 508A Components

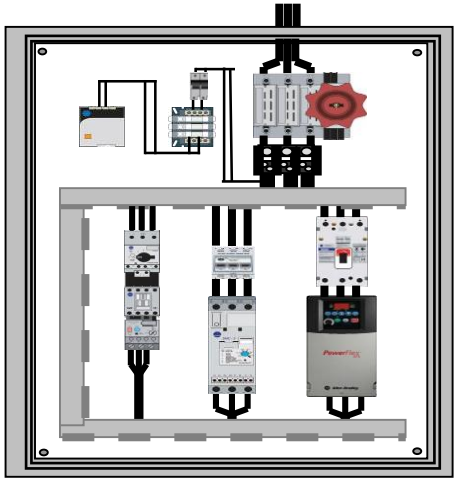
Rockwell Automation

Typical mistakes

- Main disconnect is not approved as main disconnect
- Motor-protective circuit breaker is not approved as Type E Controller (i.e. requires upstream fuse)
- Type E Motor-protective circuit breakers protect transformers and resistive loads
- Circuit Breaking devices are used in the main circuit
- Circuit Breaker is used with 100% nominal current, but is not labeled accordingly
- Not in keeping with enclosure rating
- Wiring error (current carrying capacity, cross section, etc.)
- Insufficient documentation

LISTEN. THINK. SOLVE.®

UL508A Industrial Control Panels – Rockwell Automation components



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Allen-Bradley • Rockwell Software

Rockwell Automation

UL 508A Components Disconnect

UL 98 Power circuit switch (also true for Molded Case Switches)

Arrangement / nominal current =

115% of the sum of all motor currents according to Table 50.1

(For FUs use the sum of all input currents)

+ 100% of the sum of all other loads

For non motor loads and fused disconnects use a fuse for 125% of the load current

194R,1494V fused or non-fused

UL 508A Components MCCB

Main disconnect or Circuit breaker

UL 489 Circuit Breaker (MCCB)

Arrangement / nominal current =

125% of all loads (load current = 80% of nominal current if 100% has not been explicitly specified)

140U-D

0.5A - 30A

140G-G to 140G-R

15A to 3000A

UL 508A Components BCP

Rockwell Automation

In the USA a distinction is made between:

- **Branch Circuit Protective Devices**
- **Supplementary Protectors (recognized, not listed)**

Branch Circuit Protective Devices are:

- **UL 248** Branch Circuit Fuse (Fuse Holder pursuant to **UL 512**)
- **UL 489** Listed Circuit Breaker
- For Motor outputs, Combination Controllers pursuant to **UL508**

CAUTION:

The kinds of circuit breakers common within the IEC are not BCPD and should only be used in a control circuit for device protection.

They are approved as Supplementary Protectors pursuant to UL 1077 and are recognized.

UL 508A Components BCP

UL 248 Branch Circuit Fuse (Fuse Holder pursuant to **UL 512**)

- Non time delay fuse
- Dual Element (time delay) fuse

Class J up to 600A

Class CC up to 30A

Overview Fuse Classes

- Class L – UL/CSA/ANCE 248-10
- Class H/K – UL/CSA/ANCE 248-6, 7 & 9
- **Class RK1 & RK5 – UL/CSA/ANCE 248-12**
- **Class J – UL/CSA/ANCE 248-8**
- Class T – UL/CSA/ANCE 248-15
- Class G – UL/CSA/ANCE 248-5
- **Class CC – UL/CSA/ANCE 248-4**

140F

1492-FB

56 Fuseholder Markings

56.1 A branch circuit fuseholder that accepts a fuse having a rating larger than the maximum specified rating and all control circuit fuseholders shall be marked with the voltage and current rating of the replacement fuse.

Rockwell Automation

UL 508 Motor or Load Controller

Contactor* (Direct Online,DOL-Starter)

Reversing contactor (Reversing Motor Controller)

- must be locked electrically **or** mechanically

Star delta starter (Y-Delta Motor Controller)

Motor-protective circuit breakers (Manual Motor Controller)

Starter (Combination and Non-Combination Starter)

Semiconductor contactor, Softstarter (SSD,Solid State Device)

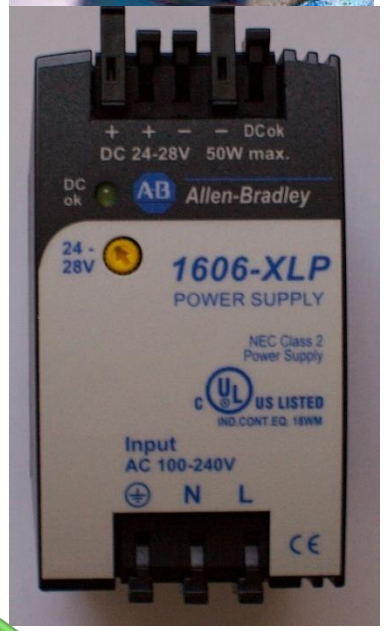
Frequency inverter pursuant to UL 508C (Variable Speed Drive)

* German “Hilfsschütze” are “Control Relays” in the US, so not really “Schütze” (contactors)

UL 508A Component Control Circuit

Rockwell Automation

Typical components in the control circuit



1492-REC15G GFCI Receptacle

UL 508A Component Control Circuit

Definition of terms

Class 1 Circuit

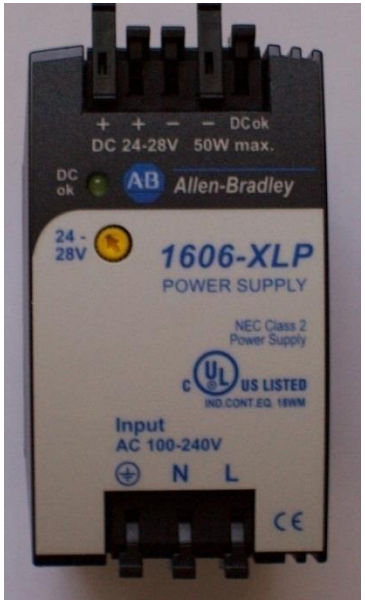
Control Circuit at a branch circuit protector with < 600V and unlimited power

Control Circuit on the load side of a load limiting device (transformer, power supply)

Class 2 Circuit

Control Circuit, limited to 100VA with an effective voltage of no more than 30V (transformer, power supply)

1497 Control Transformer



1606 Power Supplies

UL 508A Component Control Circuit

Rockwell Automation

Low-Voltage Limited Energy Circuit (LVLE)

Control Circuit with U max (DC or peak value) < 42.4 V (= 30V rms) with current limitation by means of fuses, power supplies, transformers with inner resistance or a combination of transformers with inner resistance and downstream impedance.

Devices without UL approval may be operated on a LVLE; if the device is labeled as “Class 2 Source Required” a Class 2 power supply is required.