

Low-voltage power distribution and control systems &gt; Automatic transfer switches &gt;

# Power frame type transfer switches

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*Powering Business Worldwide*

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## General Description

Eaton's power frame type transfer switches are constructed with low-voltage power switches and circuit breakers, offering the highest amperage capacity in the industry.

Designed for applications where total system coordination must be accomplished, they offer integral overcurrent protection with an electronic trip unit for a variety of standby power applications feeding critical and non-critical loads.

Standard and custom designs are available.

## Product Configuration

- ATS and bypass isolation ATS
- Automatic and non-automatic
- Open and closed transition
- 2-, 3- and 4-pole
- 200–5000 A
- Single- and three-phase
- Up to 600 Vac, 3- or 4-wire
- 50/60 Hz
- NEMA® 1, 3R, 3RX
- Behind-the-door and through-the-door
- Drawout or fixed mounting
- Service entrance rated

## Design Highlights

- Automatic controller
- UL® and CSA® Listed
- Short-circuit and short-time withstand closing ratings
- Dual drawout
- Electrical and manual operation
- Spring stored energy mechanism
- Quick make / quick break
- Manual transfer under load
- Multi-tap control power transformer
- Switched or solid neutral (fully rated)
- Electrical and mechanical interlocks
- Deadfront panel
- Freestanding enclosure
- Seismic certified
- Integral overcurrent protection with electronic trip (LSI, LSIG, LSIA)
- ARMS (Arcflash Reduction Maintenance System™)
- Service entrance marked for use at 100% of amperage rating and fully UL 1008 Listed
- Magnum™ DS low-voltage power switch/circuit breaker rear and front access

- Top/bottom cable entry

## Standard Features (ATS)

- ATC-900 controller
- Color LCD and keypad
- Mimic bus with LED indication
  - Source available
  - Source connected
  - Preferred source
- Source sensing
  - Undervoltage/overvoltage
  - Underfrequency/overfrequency
  - Phase sequence
  - Voltage unbalance/phase loss
  - Negative sequence detection
- Load sensing
  - Voltage decay
- Dual automatic plant exercisers
  - Load/no load engine test
  - Daily, 7-, 14-, 28-day
  - Calendar date
  - Runtime
- Programmable time delays
  - Engine start
  - Normal to emergency
  - Emergency to normal
  - Engine cool-down
  - Emergency engine fail
  - Pre/post transfer
  - Source disconnect/reconnect
  - Load disconnect
  - Source synchronization
- Source available relay outputs
- Auxiliary position contacts
- Engine start contacts (Form C)
- Programmable I/O
  - Control inputs (multipurpose)
  - Relay outputs (multipurpose)
- System diagnostics and help
- Serial communication (Modbus®)
- USB port
  - Power quality data and setpoint download/upload
  - Firmware field update
- Password protection
- Silver-plated bus
- Mechanical lug terminals
- Rear access



*Power Frame ATS (behind-the-door)*



*Power Frame Bypass Isolation ATS (Through-the-Door)*

### Optional Features (ATS)

- Operator controls
- Controller integral load metering
  - Current
  - Power (kW, kVA, kvar)
  - Power factor
- Temperature controlled heater
- Surge protection
- Power quality metering
- Ethernet communication
- Expanded programmable I/O
- 24 Vdc or 120 Vac controller supply power provision
- HMI remote annunciator controller
- Lift device and yoke
- Tin-plated bus
- Bus duct termination
- IR window
- Enclosure
  - Front access cabinet
  - Depth extension
  - Filters and gaskets
  - Custom paint colors
  - Stainless steel
- Protective relays
- Synchroscope
- Compression lug terminals
- Source cable termination swap (top/bottom)

### Assembly Ratings

- Continuous current (amperes):  
200, 300, 400, 600, 800, 1000,  
1200, 1600, 2000, 2500, 3000,  
3200, 4000, 5000
- System voltage (AC): 120, 208, 220,  
240, 380, 415, 480, 600
- Operating frequency (hertz): 50, 60
- UL1008 withstand closing current  
(when protected by fuse):  
200 kA short-circuit <sup>①</sup> (600 V)
- UL 1008 withstand closing current  
(when protected by circuit breaker):
  - 100 kA short-circuit <sup>②</sup> (0.05 sec/600 V)
  - 85 kA short-time <sup>③</sup> (0.5 sec/600 V)
- Certifications:
  - UL1008 Listed
  - CSA 22.2, No. 178 Listed
  - Seismic – OSHPD, IBC, CBC, UBC  
zone 4
  - NEMA 1, 3R

<sup>①</sup> 3200 A and below

<sup>②</sup> UL 891/UL1066 at 5000 A

<sup>③</sup> UL 891/UL1066 at 4000 and 5000 A

### Enclosure Structure

#### Standard Finish

Gray finish (ANSI 61) is applied to interior and exterior surfaces using an automated electrostatic powder coat system that includes spray de-grease and clean, spray rinse, iron phosphate spray coating spray rinse, non-chemical seal, oven drying, electrostatic powder spray paint coating and oven cure.

#### Frame

A rugged frame, constructed of 12-gauge steel, provides structure rigidity.

#### Door

The enclosure front door, constructed of 14-gauge steel, includes a handle with padlock provision and is attached to the frame with heavy-duty hinges. Device panels and automatic controller are mounted within the front door. When the door is open, service personnel have access to the power switches/circuit breakers, terminal blocks, control wiring, electrical components and other accessories. Door swing (direction can be reversed upon request) is limited to 90 degrees and an optional door-stop is available to hold it open. If necessary, door removal can be accomplished by lifting the hinge pins. An optional rear door can be provided.

#### Covers

Side and rear bolted covers, constructed of 14-gauge steel, are attached to the frame and split into upper and lower panels to facilitate ease of handling during removal and installation. Covers can be removed to gain access to cable terminations, wiring and devices during installation or maintenance.



*Removing the Upper Side Cover,  
Lifting Brackets can be Seen at the Top*

#### Deadfront

A removable steel deadfront, with handles, is mounted flush with each of the power switch/circuit breakers providing a physical barrier.

#### Lifting Brackets

Located at the apex of each structure, lifting brackets can easily be extended upward and locked in place for lifting the transfer switch enclosure assembly during installation.

#### Mounting Brackets

The transfer switch includes side and rear mounting brackets that are attached to the frame at each corner post for shipment and installation.

### NEMA Enclosure Types

Power frame type transfer switch enclosures are available as either NEMA 1 or NEMA 3R.

Standard construction is steel with a gray finish (ANSI 61) applied to all interior and exterior surfaces. Alternatively, 304 or 316 grade stainless steel, with a mill or painted finish, can be provided for corrosive environments. For indoor or outdoor environments, vented enclosure panels can be fitted with replaceable air filters.

For NEMA 1, enclosures can be further defined as either “behind-the-door” or “through-the-door” indicating where the face of the power frame switch/circuit breaker resides in relation to the front door.

With a “through-the-door” type, an operator can interact directly with the power frame switch/circuit breaker without having to open the front door. A “behind-the-door” type requires the operator to open the door.



*NEMA 1—Through-the-Door*

### Open Frame Type

For integration into a new or existing distribution line-up, an open frame transfer switch provides two power frame switch/circuit breakers fixed on a robust steel chassis with two side mounting flanges.

An automatic controller, device panel, control power transformer panel and neutral assembly (wye systems) are provided loose from the chassis for separate mounting. An optional 96-inch wire harness extension is available when integrating into larger spaces.

All source and load connections are made directly to the silver-plated copper bus.



**Power Frame Transfer Switch—Open Frame**

### Power Bus

Silver-plated bus is provided as the standard configuration for power frame transfer switches and meets the needs of most installation sites.

For applications with special chemical environments, tin-plated bus can be provided to mitigate against the growth of silver filaments (whiskers).

Hydrogen sulfide is a colorless, poisonous, flammable gas that can often be found in wastewater treatment facilities because it results from the bacterial breakdown of organic matter in the absence of oxygen.

When silver is exposed to hydrogen sulfide, whiskers can form, which has the potential to create a dangerous situation for electrical equipment. Tin-plated bus can also whisker, but the length is usually shorter (compared to silver) and limited to a few millimeters thus minimizing risk.

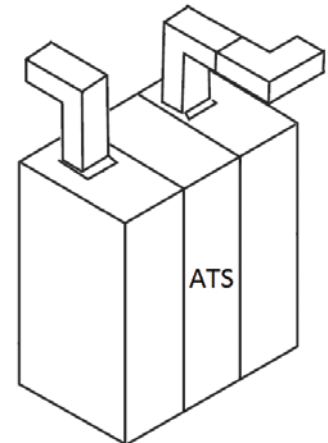


**Silver Whisker Growth**

### Power Connections

UL listed screw-type mechanical lug terminals (CU/AL) are the standard connection method for power cables. Lugs include an anti-rotation feature and are mounted directly on the power bus (source and load). Alternatively, provisions can be provided for connection via two-hole compression lug terminals or direct bus termination.

For applications requiring a busway connection, provisions can be made in the enclosure roof to accept a standard flange (3- or 4-wire). For multiple busway connections, one or more side cabinets can be added, and/or the enclosure depth can be increased. A busway flange drawing, with dimensional and orientation information, must be provided to the factory.



**Busway Flange Termination  
at Side Cabinet Roof**



## Cable Ingress and Access

Power frame type transfer switches are designed to accommodate cable entry at the top and/or bottom of the enclosure.

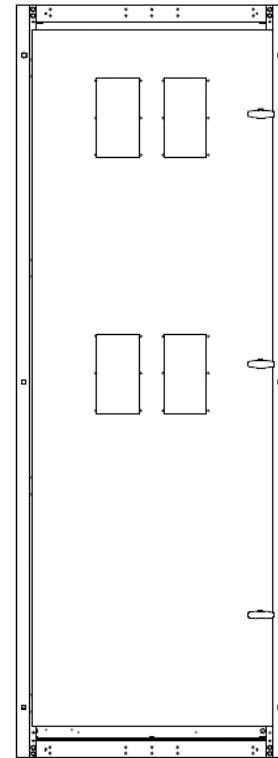
Internally, the normal power terminations are located closer to the top of the enclosure and emergency power terminations are closer to the bottom. Load power connections are located in the center. For installation flexibility a "source swap" option is available that flips the location of the normal and emergency terminations.

NEMA 1 and 3R enclosure types have removable bolted panels located at the rear providing easy access for cable termination.

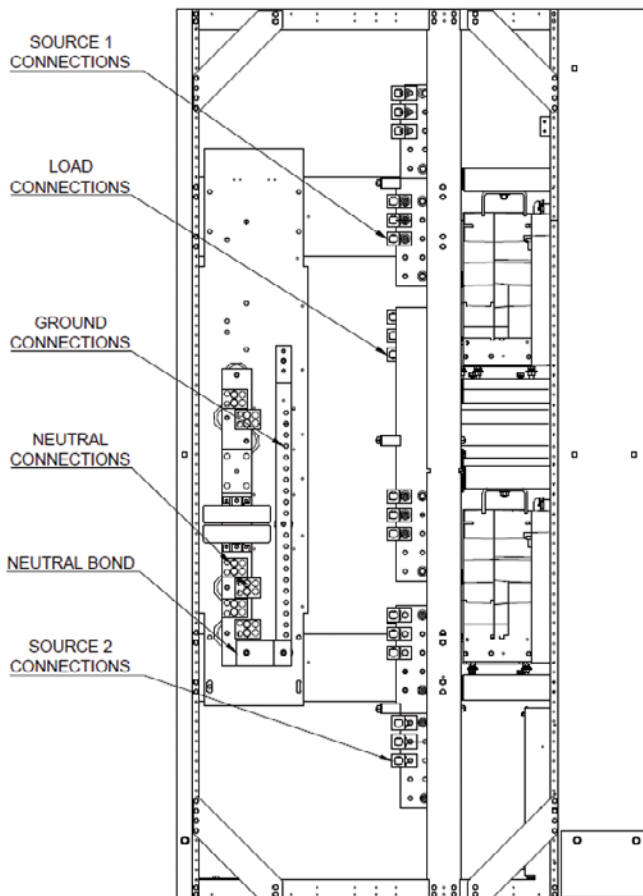
For applications requiring front access, an optional side cabinet can be added to the left or right side of the ATS.

Higher amperage assemblies (4000 and 5000 A) typically include an additional wireway or side cabinet to accommodate an increased number of cables. In this configuration, both rear and front access is often required. A mix of cable and direct bus connect is possible. The wireway can be located to the left or right of the ATS.

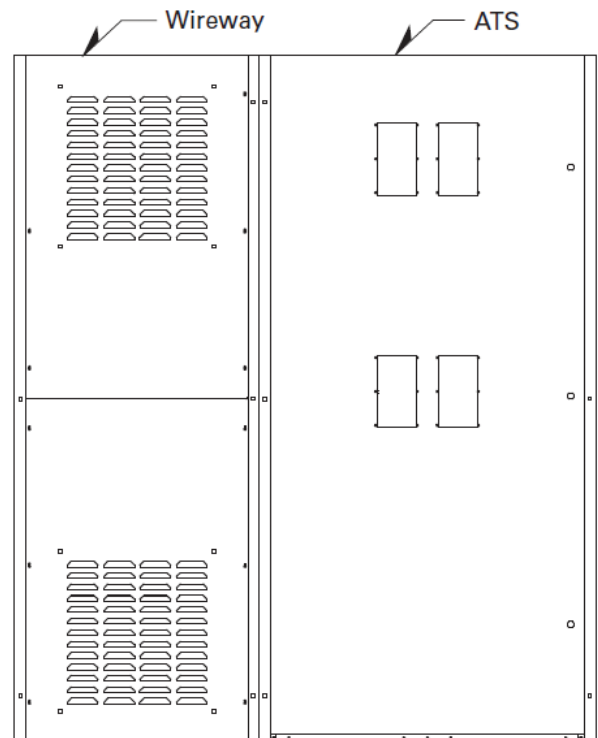
For a bypass isolation transfer switch, an additional structure (not shown) containing the bypass switch would adjoin the ATS.



**NEMA 1 ATS—Front View**



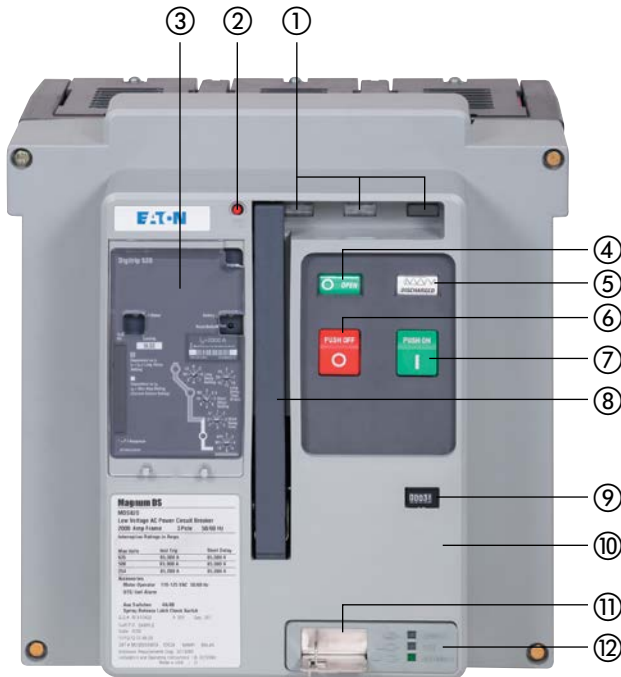
**NEMA 1 ATS—Left Side View (Panels Removed)**



**NEMA 1 ATS with Wireway—Front View**

## Magnum DS Power Switch/Circuit Breaker

At the heart of the power frame transfer switch design is the UL1066 Listed Magnum DS low-voltage power switch/circuit breaker. When configured with an electronic trip unit (Digitrip RMS, 520MC, 1150), a power circuit breaker is provided. When absent of a trip unit, a power switch is provided. A power switch does not include any type of trip functionality.



**Magnum DS Power Circuit Breaker (With Trip Unit)**



**Magnum DS Power Switch (No Trip Unit)**

### Front Cover Details

Controls and indicators are functionally grouped on the faceplate to optimize the user interface, visibility and ease of use.

- Accessory viewing windows for:
  - Shunt Trip Attachment (ST)
  - Spring Release Device (SR)
  - Optional (undervoltage release device or second ST)
- Red mechanical trip flag pop-out indicator (circuit breaker only)
- Digitrip RMS trip unit protected by a clear cover and secured by thumb screw knobs with wire-tie provisions for security
- Contact status indicators:
  - OPEN (Green)
  - CLOSED (Red)
- Spring status indicators:
  - Charged (Yellow)
  - Discharged (White)
- OFF pushbutton (red): to open main contacts
- ON pushbutton (green): to close main contacts
- Manual charging handle: to charge spring stored energy mechanism
- Mechanical operations counter (optional)
- Kirk-key lock (optional— not shown)
- Padlockable levering device shutter (drawout only)
- Color-coded position indicator (drawout only):
  - CONNECT (Red)
  - TEST (Yellow)
  - DISCONNECT (Green)

### Rigid Frame Housing

Magnum switches/circuit breakers use a rigid frame housing construction of durable engineered thermoset composite resins.

- Strong and lightweight material with strength to weight ratio twice that of steel. Proven able to withstand high dynamic and thermal stresses
- Excellent dielectric characteristics, resisting arc tracking

### Three-Piece Construction

The 3-piece construction (rear housing, front housing and cover) provides support while isolating and insulating power conductors.

- A 2-piece case encloses current paths and arc chambers. Chambers act to channel arc gases up and out during interruption
- The operating mechanism and accessories sit on the front of the case. Only the insulating front cover needs to be removed to access mechanism and/or accessories
- The operating mechanism achieves a longer life as a result of reduced frame deflection during operation along with stiff component mounting

### Two-Step Stored Energy Mechanism

Magnum switches/circuit breakers are equipped with a true 2-step stored energy mechanism.

- Closing springs can be charged manually or electrically
- 5 to 7 downward strokes on the charging handle completes charging process
- Mechanism provides for a complete OPEN – CLOSE – OPEN cycle

### Unsurpassed Performance

The performance characteristics of the Magnum DS switch/breaker are attributed in many ways to a C-loop current path design and movement. Contact fingers perform both the main and arcing contact functions on different parts of the same finger. A complete movable contact assembly is a combination of a number of single contact fingers. The exact number of contact fingers required depends upon the frame size and interrupting rating of the breaker. Braided connectors (flexible shunts) are used to attach each contact finger. The result is an efficient and uniquely functional main contact system with the following advantages:

- Eliminate bolted joints reducing hot spots
- Reduced mounting space for primary contacts
- Smaller and lighter operating mechanism for longer life
- Higher interrupting and short time (withstand) ratings
- 5-cycle or less closing
- Improved contact material
- Contact wear indicator for each primary contact structure
- Individually removable arc chambers insulate/isolate each pole
- Able to withstand high dynamic and thermal stresses

### Value Added Features

Magnum provides numerous other internal and external features that further enhance the reliability, maintenance and safety. A number of additional common features are highlighted below.

- Arcflash Reduction Maintenance System on Digitrip 520MC and 1150, to lower personnel risk and PPE levels in the arcflash boundary
- Mechanical and electrical anti-pump features
- Easily removable arc chutes for inspection
- Common accessories for all frame sizes (electrical and mechanical)
- Conveniently located finger proof secondary contacts

### Mounting Configurations

Power frame transfer switches can be configured with fixed or drawout Magnum switches/circuit breakers.

#### Fixed

Fixed mounted configurations bolt directly to the main bus via pre-drilled primary terminal pads. They are simple and economic because there are no drawout components.

### Drawout

A drawout configuration is used in combination with a cassette that provides primary and secondary connections. Finger clusters located at the rear slide onto the main bus stabs.



Movable extension rails allow the unconnected power switch/breaker to be easily levered and drawn out from the cassette using a standard 3/8-inch drive extension, without having to de-energize the transfer switch. Once drawn out, the lever shutter can be padlocked, and maintenance or inspection can be performed.



*Drawout Magnum DS Switch/Circuit Breaker*



*Levering Device Shutter and Position Indication*



*Power Pole Main Contacts  
with Arc Chute Removed*

### Lift Devices

Lift trucks/hoists and yokes are available for removing fixed or drawout power switch/breakers from the transfer switch.



### Plug-in Accessories

Each power switch/circuit breaker in a transfer switch includes shunt trip, spring release and auxiliary switch accessories for electrical operation of the main contacts. The 120 Vac control signal is derived from the normal or emergency power source.

Alternatively, transfer switch designs using ST and SR accessories actuated by a DC voltage derived from a test source circuit (internal 120 Vac or external battery source) are available upon request.

#### Shunt Trip (ST)

The ST acts to electrically open the main contacts when its trip coil is energized by a control voltage signal applied through the secondary contacts, by the automatic controller or a control switch.

#### Spring Release (SR)

The SR acts to electrically close the main contacts when its close coil is energized by a control voltage signal applied through the secondary contacts, by the automatic controller or a control switch.

#### Auxiliary Switch

Each auxiliary switch provides 2A (normally open) and 2B (normally closed) contacts wired to the breaker secondary contacts. Contacts not dedicated for use by the transfer switch system logic are available for customer use.

### Other Accessories

#### Padlockable Pushbutton Covers

Molded plastic or metal frame hinged covers can be mounted over the OPEN (green) and CLOSE (red) pushbuttons. With the covers closed and padlocked, they prevent access to the pushbuttons.



*Clear Plastic Pushbutton Covers  
with Padlock Provision*

#### OFF Key Lock

Allows the power switch/breaker to be locked in the OPEN position with the key removed, preventing the main contacts from being closed. It is primarily intended for use on fixed mounted configurations that cannot be drawn out and padlocked.



*OFF Key Lock and Counter (Fixed Magnum DS)*

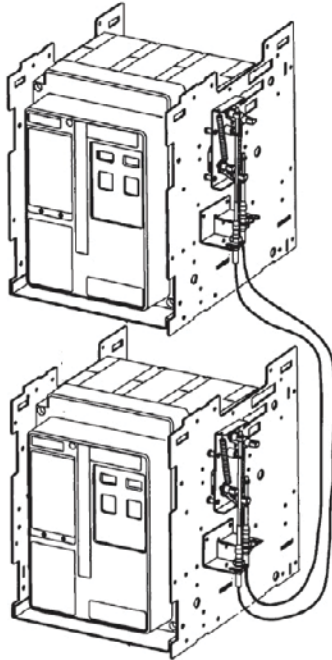
#### Operations Counter

A mechanical device used to provide a record of the number of circuit operations. It is mounted in the lower right portion of the front cover.



## Mechanical Interlock

For open transition transfer switches, each power switch/breaker (fixed or drawout configuration), is equipped with a mechanical interlock preventing simultaneous closure of both sets of main contacts.



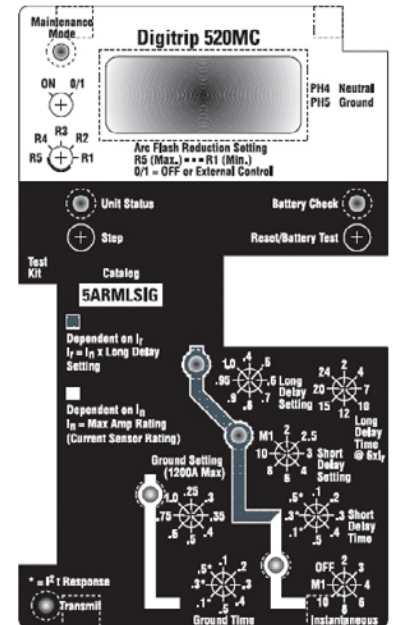
**Normal and Emergency Power Switch/Circuit Breaker Pair with Mechanical Interlock**

## Digitrip RMS Trip Units

Magnum circuit breakers can be configured with any one of four Digitrip electronic trip unit models (520MC and 1150). Each trip unit is microprocessor-based and a true rms sensing device. The different models within the family provide for increasing levels of protection and feature options for coordination, information, diagnostics and communications.

All Digitrip RMS models offer a wide array of common features.

- Current sensors
- Rating plug
- Intuitive operator interface
- Interchangeable models
- Self-powered device
- Status LED
- Cause of trip LED
- Security cover



**Table 25.3-1. Digitrip Functionality—Summary of Key Features**

Functions	520MC ①	1150+ ①
LSIG protection	Yes	Yes
Disable (I)	Yes	Yes
GF protection	Yes	Yes
GF alarm	No	Yes
Display	No ②	Yes ③
Programmable	No	Yes
Metering	No ④	Yes
Power and energy values	No	Yes
Power quality	No	Yes
Communication	No	Yes
ARMS	Yes	Yes

① Available control voltages are 24/48 Vdc, 125 Vdc, 120 Vac and 240 Vac.

② One-line (four characters per line) LCD display.

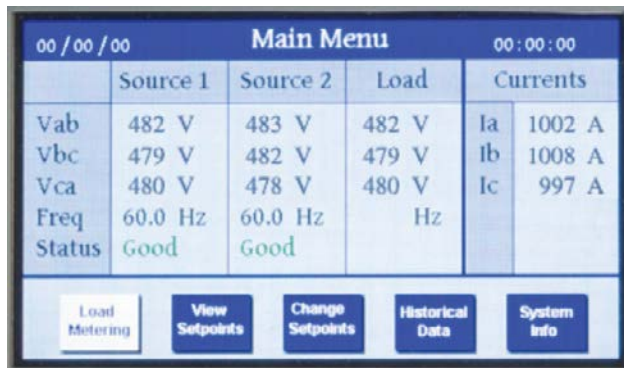
③ Three-line (eight characters per line) LED display.

④ Phase, neutral, ground and high load current only.

## ATC-900 Automatic Controller

Eaton's ATC-900 brings intelligence, adaptability, enhanced supervisory and programming capabilities to Eaton's entire transfer switch product family.

The simple yet powerful user interface includes many intuitive features. The color display and mimic bus with LED indication provide enhanced operator visibility of transfer switch status and metering data. Front arrow keys allow for quick screen navigation, removal of codes and abbreviations avoid potential confusion, and refined data screens provide for ease of viewing and programming.



Main Menu					
	Source 1	Source 2	Load	Currents	
Vab	482 V	483 V	482 V	Ia	1002 A
Vbc	479 V	482 V	479 V	Ib	1008 A
Vca	480 V	478 V	480 V	Ic	997 A
Freq	60.0 Hz	60.0 Hz	Hz		
Status	Good	Good			

Navigation buttons: Load Metering, View Setpoints, Change Setpoints, Historical Data, System Info

ATC-900 Main Menu Screen

## Primary Features

- Monitor voltage and frequency of normal source, emergency source, and load
- Self-acting load transfer between power sources
- Display of real-time and historical information
- Programmable setpoints
- User-configurable control inputs and relay outputs
- Dual engine start/shutdown signaling
- Dual programmable plant exercisers
- Integral load metering
- Detailed and time-stamped event log and history
- Advanced diagnostics and troubleshooting with pre-/post-event data capture
- Download of setpoints, event log and metering data via USB flash drive
- Upload of setpoints and firmware updates via USB flash drive
- Industry standard serial communication
- Symmetrical component calculation
- Record test data to comply with The Joint Commission, NFPA 99 and NEC (700, 701, 708) requirements
- Generator start contacts (Form C) provide means to comply with 695.14(F) and 700.10(D)(3) of the NEC (2017 and 2020)
- ATS Health and Maintenance Watch™

### LED mimic diagram

Color-coded LEDs provide status indication. Source 1 Available (white) and Connected (green), Source 2 Available (amber) and Connected (red), Preferred Source (green).

### Display and main menu

Provides status at a glance. Source 1, Source 2, and Load status and metering data are displayed. Additional screens are easily accessed using navigation keys.

### Arrow key navigation

Right and left arrow keys are used to navigate menu options and up and down arrow keys are used to scroll screens and change setpoint values.

### USB port

Download/upload setpoints, events, statistics, meter data, and firmware.



### Unit status

LED (green) blinks, indicating that the ATC-900 is operating normally. If the LED is not lit or is on continuously, then a problem condition is indicated.

### Help

Displays controller firmware version and user tips.

### Lamp test

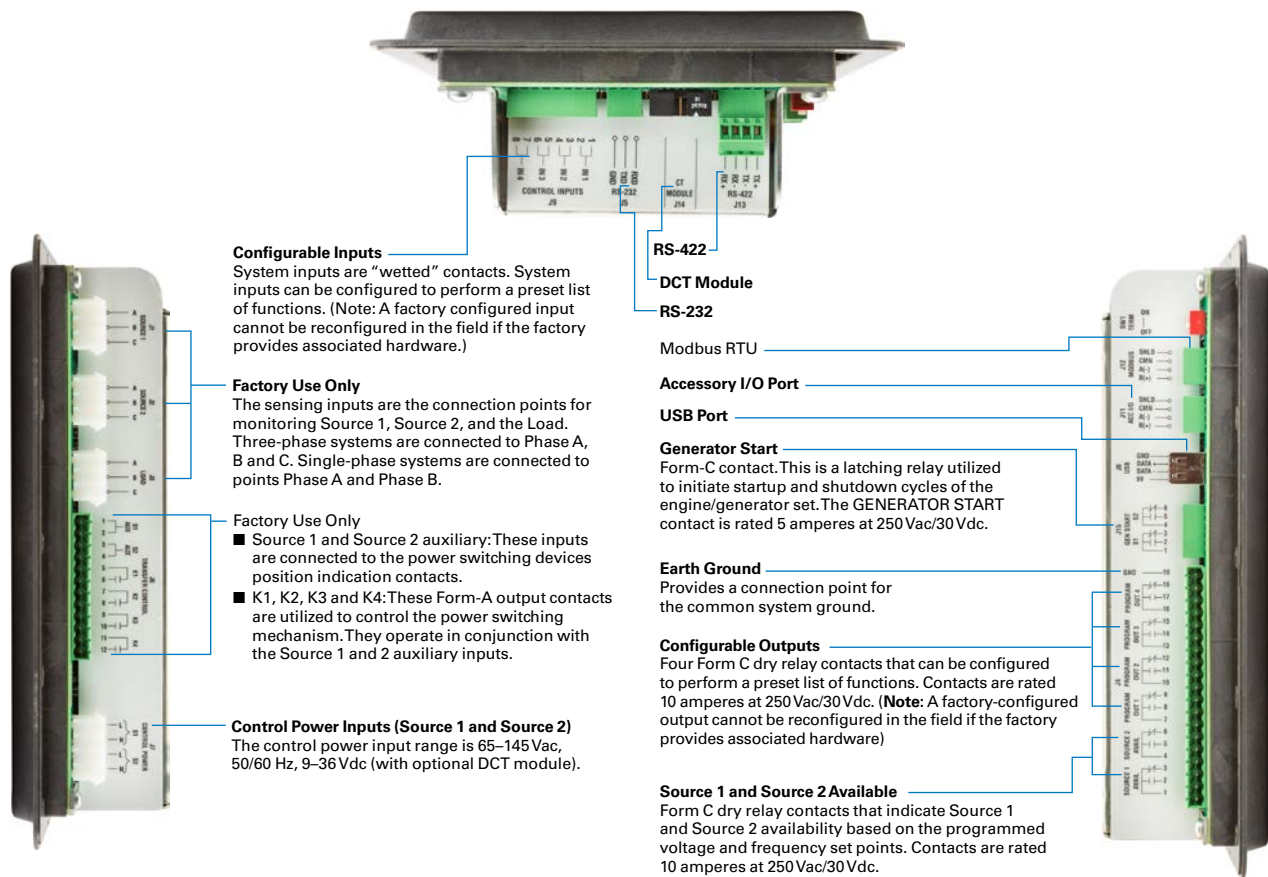
Pressing the Lamp Test pushbutton lights all LEDs and then displays ATC-900 information.

### Engine test

Performs an engine test using the programmed engine run and cool-down times. This is a password-protected feature.

### Bypass time delays

Pressing the Enter and Help pushbuttons simultaneously reduces the active programmed time delay to zero.



## Accessory Modules

The ATC-900 utilizes supporting hardware accessory modules to expand its functionality.

## Integral Metering and DC Supply Voltage

An optional DCT module mounts directly to the rear of the ATC-900 and supports the connection of three current transformers via shorting block termination to provide integral power metering (amps, kW, kVA, kvar, PF) complementing standard ATC-900 voltage and frequency monitoring.

24 Vdc can be supplied externally to keep the ATC-900 continuously powered and communicating when the normal and emergency sources are not available.



Load Metering					
Vab	482 V	Ia	1002 A	kW	789
Vbc	479 V	Ib	1008 A	kVAR	261
Vca	480 V	Ic	997 A	kVA	831
Freq	60.0 Hz			PF	.95

## Programmable Inputs/Outputs

The ATC-900 standard offering of four programmable inputs and four programmable outputs is expandable by adding I/O modules.

Each I/O module provides an additional four inputs (wetted, 24 Vdc at 10 mA) and four outputs (Form C rated 10 A at 250 Vac/30 Vdc). A maximum of four I/O modules can be daisy-chained for a total of 20 inputs and 20 outputs.



Setpoints - Programmable Inputs	
Input 1	Go To Emergency
Input 2	Emergency Inhibit
Input 3	Preferred Source
Input 4	Bypass Timers
Accessory I/O Modules 0	



### Programmable Input Functions

- Monitor mode
- Bypass timer
- Lockout
- Manual retransfer
- Enable manual retransfer
- Secondary control
- Remote engine test
- Preferred source selection
- Go to emergency
- Emergency inhibit/load shed
- ATS on bypass
- Go to neutral position
- Closed transition disable
- Disabled

### Programmable Output Functions

- Source 1 available
- Source 2 available
- Source 1 connected
- Source 2 connected
- ATS not in automatic mode
- General alarm
- ATS in test status
- Engine test aborted
- Engine cool-down in process
- Engine 1 start status
- Engine 2 start status
- Emergency inhibit on
- ATS on bypass
- Load sequence
- Selective load shed
- Load bank control
- Pre/post transfer
- Pre-transfer
- Post-transfer
- User remote control
- Health
- Waiting for source sync
- Disabled

### Fixed Output Functions

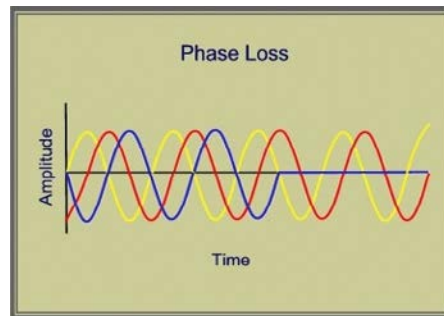
- Source 1 available
- Source 2 available
- Engine start 1
- Engine start 2

### Symmetrical Components

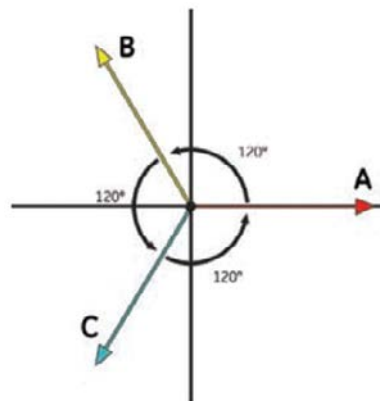
The ATC-900 calculates both positive and negative sequence components for voltage and current to determine when abnormal conditions exist that might otherwise go undetected.

An example is a single-phase loss (e.g., open feeder fuse) at the normal source, which would typically cause a transfer to the alternate source.

Once the normal source is unloaded, a condition can develop whereby the single-phase loss is masked due to an induced or “phantom” voltage. If undetected, this could result in a retransfer back to the normal source. Once the normal source is loaded again, the cycle can repeat itself, resulting in continuous power interruptions until the phase loss condition is corrected.



Through the calculation of symmetrical components, the ATC-900 is capable of detecting this abnormal condition and preventing transfer cycling. To protect mechanical loads from potential damage, the ATC-900 can disconnect the load from the normal source (immediately or after a time delay) until the alternate source becomes available.



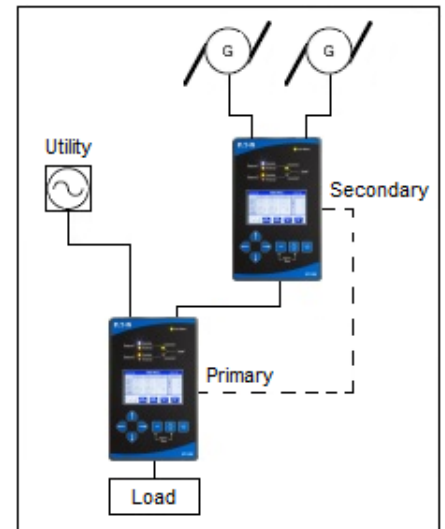
**ATC-900 Uses Negative Sequence Components to Detect Abnormal Conditions**

### Three Source Arrangement with Primary/Secondary Control

The primary/secondary functionality provides the ability to configure two independent automatic transfer switches in a three-source arrangement consisting of a utility and two generator sources (permanent or portable).

In this configuration, the engine start signal from the primary ATS is wired directly to a programmed control input at the secondary ATS. The engine start 1 and engine start 2 signals at the secondary ATS are wired to the generators. The ATC-900 at the secondary ATS requires a DCT module (fed by an external 24Vdc supply) to keep the controller powered.

In the event of a utility power failure, the primary ATS engine start relay closes signaling the secondary ATS to start either a preferred generator (if designated) or both generators. Generator start, and stop is managed by the secondary ATS. Upon restoration of utility power, the primary ATS engine start relay will open, signaling the secondary ATS to begin generator shutdown.



**Primary/Secondary Configuration with ATC-900**



### Load Management

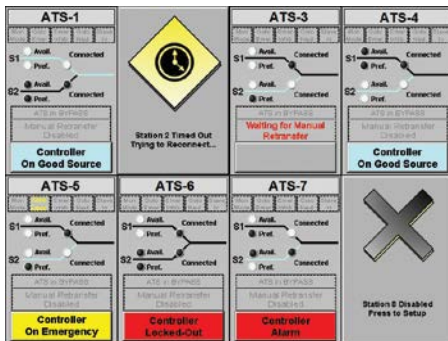
The ATC-900 includes several features, enhancing a user's ability to manage load.

- **Integral load metering:** Monitor load power utilization and compare to baseline measurements
- **Selective load shed:** Drop and pickup non-essential loads when programmed kW threshold levels are reached
- **Emergency inhibit/load shed:** Inhibit or disconnect the load connection to emergency source
- **Pre-/post-transfer:** Control select loads during the transfer process
- **Load bank control:** Disengage a load bank connection from the emergency source upon loss of the normal source
- **Normal source disconnect/reconnect:** When an abnormal power condition is present at the normal source, disconnect the load to prevent potential damage
- **Emergency source disconnect/reconnect:** When an abnormal power condition is present at the emergency source, disconnect the load to prevent potential damage

## HMi Remote Annunciator Controller

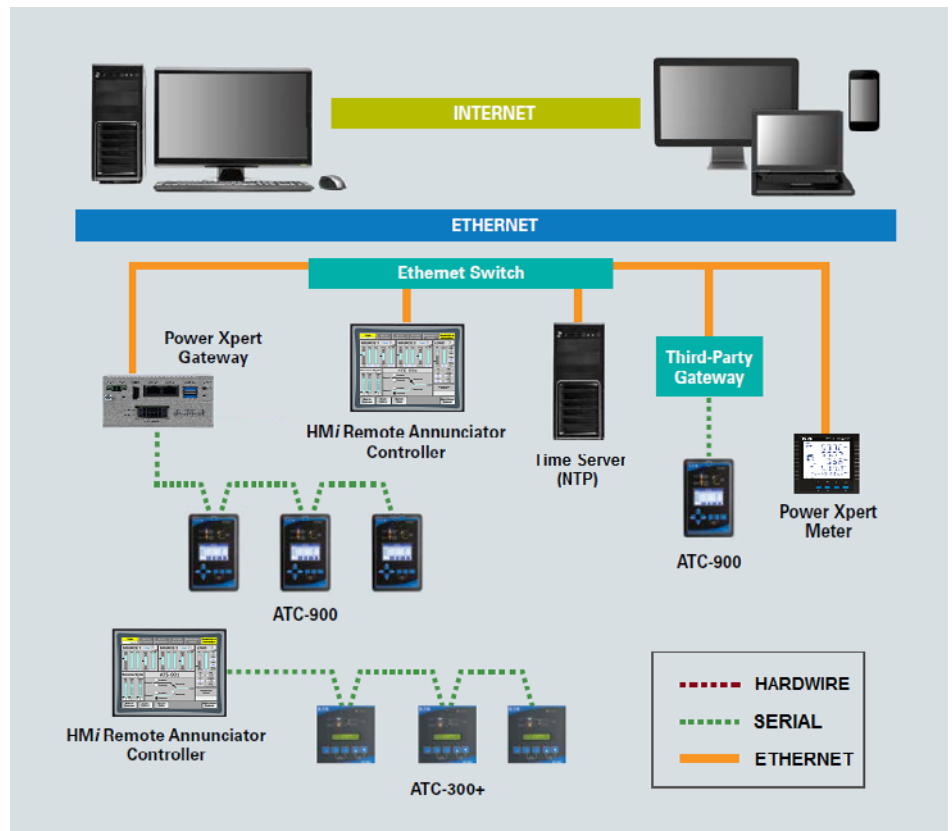
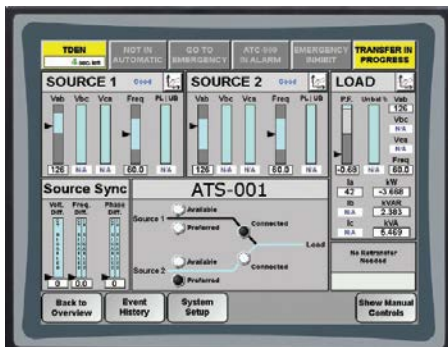
Tightening arc flash regulations and requirements for personal protective equipment are driving more and more end users toward the use of remote monitoring and control devices.

Eaton's HMi Remote Annunciator Controller offers a simple and cost-effective means of monitoring and controlling up to eight automatic transfer switches via serial or Ethernet communication.



Using one intuitive touch screen interface, users can:

- Monitor source vitals and health
- Analyze metering and trend data of sources and load
- View and program transfer switch controller set points, control inputs and relay outputs
- Start and stop a generator engine test
- Initiate a transfer to the alternate source
- Bypass a time delay countdown
- Initiate a manual retransfer
- View and silence alarms
- Perform basic troubleshooting
- Monitor source synchronization during in-phase or closed transition
- View event history
- View the status of up to eight transfer switches on a single overview screen



System Architecture

## Communication

Eaton transfer switch controllers include native support for serial communication and a Modbus register map is available for interfacing with a building management or power management system. When Ethernet communication is desired, there are several modular options available. Modules are typically DIN rail mounted within the enclosure assembly but can be shipped loose.

The Power Xpert PXG 1000 is a full-featured gateway and includes an embedded web server. Eaton technical document TD152035EN can be referenced for details.



The ELC-CAENET module is a basic serial to Ethernet adapter and supports a variety of protocols. Eaton document MN05002003E can be referenced for details.



## Advanced Metering

Power Xpert Power and Energy Meters allow owners and operators to interface with their equipment at varying levels of sophistication.

To learn more about Power Xpert Metering products that can be integrated into an Eaton transfer switch, please reference publication BR140001EN or visit [www.eaton.com/meters](http://www.eaton.com/meters).

## Surge Protection

Surge protection devices can easily be integrated within a transfer switch at the normal (utility) and/or the emergency (generator) power source connection(s).

The purpose of an SPD is to protect electrical and electronic equipment, such as the automatic controller, from damage and degradation due to short duration, high-energy transients. IEEE C62.41.2 describes a number of transient waveforms, with a duration in microseconds or milliseconds, that might be found in an electrical system.

While SPDs do an excellent job of mitigating voltage transients, they are not designed to provide continuous sinusoidal voltage regulation. When an SPD is subjected to a sustained overvoltage, there is a very real danger of the SPD being permanently damaged.

While power obtained from an electric utility typically has very good voltage regulation, a standby or emergency generator may not due to generator undersizing or use of a low-cost voltage regulator.

When specifying an SPD for use on the emergency (generator) side of a transfer switch, the following is an abbreviated list of recommendations. A more detailed discussion can be found in Eaton application paper AP01001003E.

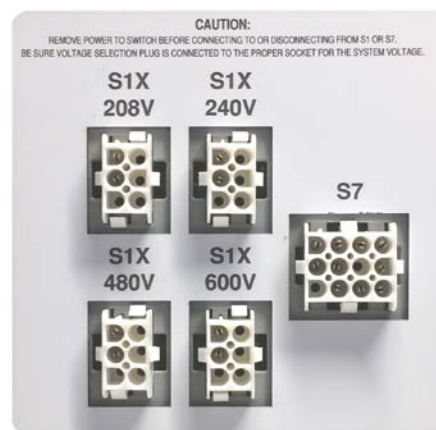
- Utilize a SPD with a delta (3-wire + ground) voltage code for three-phase electrical equipment to improve reliability of the emergency power system.
- Specify a SPD with a surge current capacity rating (kA) per the location categories outlined in the latest IEEE C62.41.1 standard. By example, a service entrance transfer switch is considered category C.
- Specify a minimum nominal discharge current rating of 20 kA.

SPDs are typically equipped with an audible alarm and a Form C relay contact for remote annunciation of status. Some models offer an optional surge counter with nonvolatile storage and reset button.

## Control Power Transformer

Transfer switches can easily be field configured for operation with different system voltages via a multi-tap control power transformer (CPT) with keyed quick-disconnect plugs.

Supported three-phase system voltages are 208, 240, 480, 600 Vac (domestic type) and 220, 230, 380, 415 Vac (international type). Either CPT type is available as 60 Hz or 50/60 Hz rated.



Multi-Tap Control Power Transformer  
(Domestic)

## Thermographic Imaging

Routine inspection of energized conductor terminations, in electrical distribution equipment, is commonly performed to ensure system reliability and uptime.

Over time, bus joints and cable terminations are often subject to recurring thermal expansion and contraction, which can eventually cause loosened connections resulting in excessive heat. If left unchecked, these "hotspots" can ultimately create an electrical hazard for personnel and/or lead to equipment failure.

One method for periodically verifying the integrity of conductor terminations is to conduct a thermographic scan using an infrared (IR) camera. Line-of-sight is needed between the IR camera and the target termination(s) being scanned, which often requires the equipment enclosure to be fitted with an IR window(s).

IR windows come in various shapes and sizes to accommodate differing target distances and IR camera equipment. A protective cover is typically provided to guard against impact. Based on application needs, power frame transfer switches can optionally be fitted with one or more IR windows as specified by the engineer.



IR Windows

In scenarios where the use of an IR camera is not plausible because of physical limitations, safety concerns or the inability to frequently perform inspections, alternative thermal surveillance technologies can be considered.

Thermal sensors (wired or wireless) are now available commercially and can be positioned within electrical equipment to provide unmanned, 24/7 monitoring of bus and cable connections. Although the idea of real-time monitoring is appealing, replacing a failed thermal sensor could prove challenging, especially in critical operation facilities.

## Synchroscope

A synchroscope is a device that monitors and visually indicates electrical synchronization between two power sources. When integrated into a closed transition automatic transfer switch, it tracks the phase angle and frequency difference between a generator and utility source. As the phase angle and frequency differ, so does the synchroscope indication.

When the generator is running “faster” (higher frequency compared to utility), the synchroscope indication rotates clockwise. When the generator is running “slower” (lower frequency compared to utility), the synchroscope indication rotates counterclockwise. As the magnitude of the frequency difference increases, the speed of indication rotation increases. A change in generator frequency is directly related to the speed of the prime mover (e.g., diesel engine). The “position” of synchroscope indication (LED lit at 3 o'clock position) provides the phase angle difference between the two sources.

The position, direction and speed of indication can be used by an operator to make governor adjustments at the prime mover in an effort to synchronize the generator and utility sources.

In some cases, an automatic transfer controller (ATC-900) can provide synchroscope functionality possibly eliminating the need for a separate synchroscope device.



**Synchroscope with LED Indication Windows**

## Protective Relays

Closed transition applications can often require the use of protective relays to meet local utility interconnection requirements that are in place to ensure human safety, minimize possible damage to equipment or property, and sustain electrical power system operation.

### Reverse Power Relay

Generally, utility companies will require that the amount of time an alternative power source (e.g., generator) is paralleled with the utility grid be limited to 100 milliseconds. In transfer switch equipment, this is accomplished by the automatic transfer switch logic controller with a discrete parallel limit time relay serving as a failsafe backup. As an additional means of backup, a reverse power relay (IEEE device 32) with a maximum time delay (e.g., 1 second), can be required by the utility company to sense current flowing from the alternative power source to the utility grid. This relay can be used to trip the alternative power source off-line and prevent a prolonged paralleling condition that can damage the alternate power source (motoring).

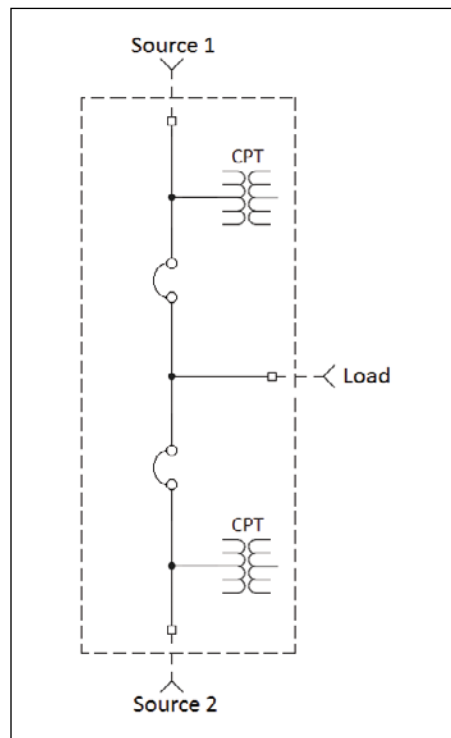
### Lockout Relay

To ensure that a de-energized electrical system (due to a fault condition) is not reenergized by automatic control action, a lockout relay (IEEE device 86) can be required by the utility company to ensure human inspection and/or repair of equipment before the system can be safely placed back into service. In transfer switch equipment, the lockout relay will “lockout or disable” the automatic control logic and prevent reclosure of the tripped power switch/circuit breaker until the relay is manually reset.

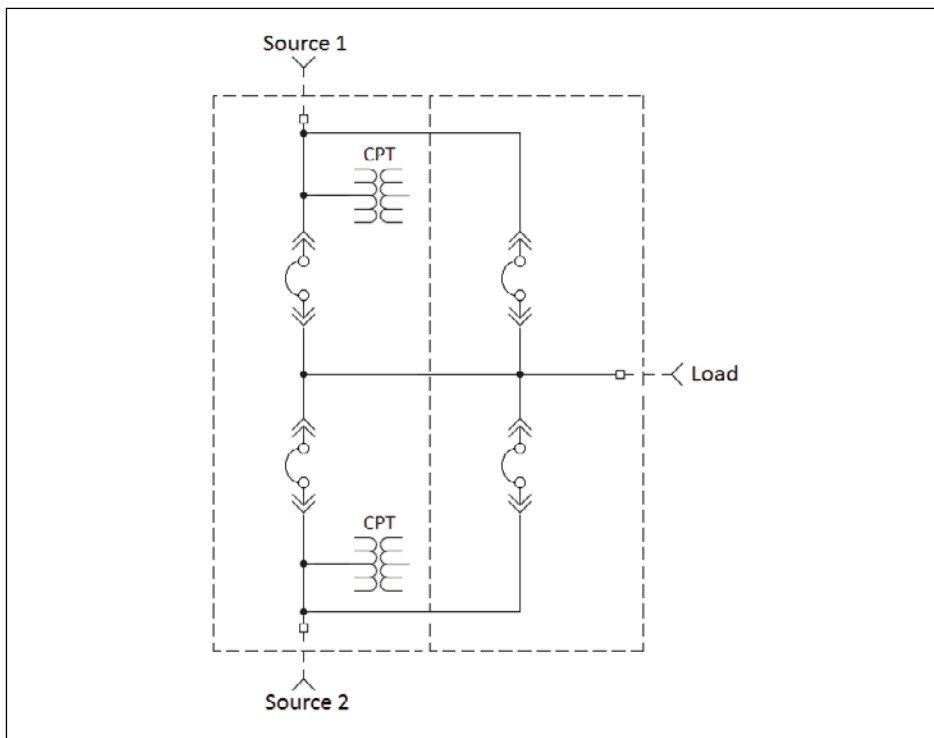
Both types of relay devices can easily be integrated into a closed transition transfer switch design upon request.



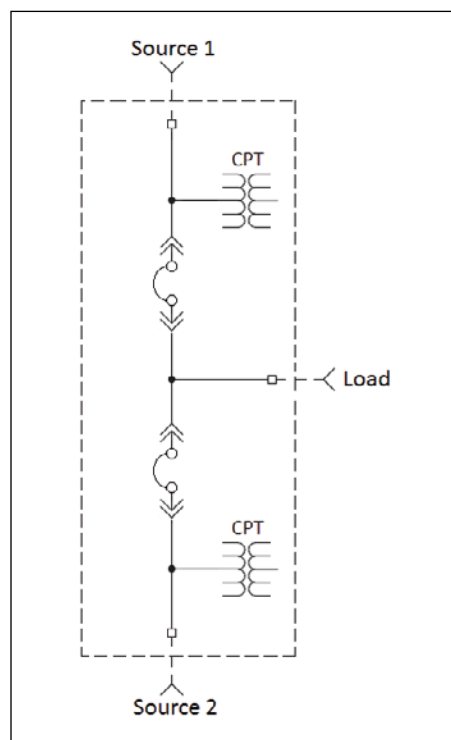
## Standard Layouts



**Figure 25.3-1. Power Frame Transfer Switch—Fixed**



**Figure 25.3-3. Power Frame Bypass Isolation Transfer Switch—Drawout**



**Figure 25.3-2. Power Frame Transfer Switch—Drawout**

## Standard Dimensions and Weights

### Power Frame Automatic Transfer Switch

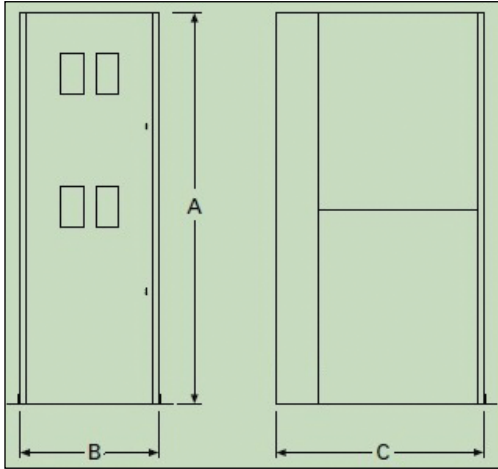


Figure 25.3-4. NEMA 1 (up to 3200 A)

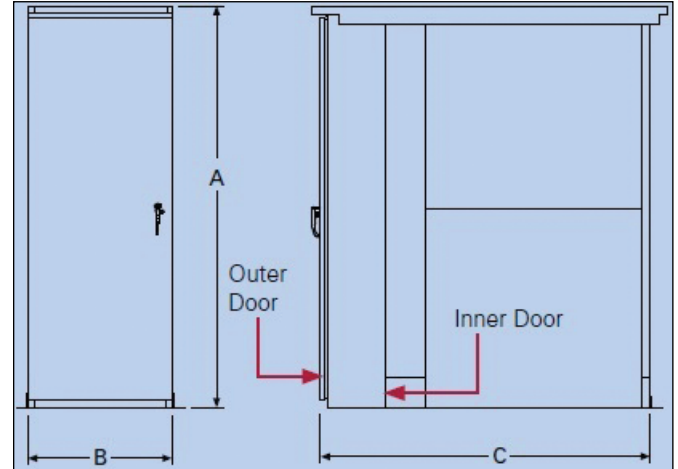


Figure 25.3-5. NEMA 3R (up to 3200 A)

Table 25.3-2. Standard Dimensions and Weights (up to 3200 A)

Ampere Rating	Number of Poles	A Height Inches (mm)	B Width ① Inches (mm)	NEMA 1				NEMA 3R			
				Fixed Mount		Drawout		Fixed Mount		Drawout	
				C Depth ① Inches (mm)	Shipping Weight Lb (kg)	C Depth ① Inches (mm)	Shipping Weight Lb (kg)	C Depth ① Inches (mm)	Shipping Weight Lb (kg)	C Depth ① Inches (mm)	Shipping Weight Lb (kg)
200–2000	2	90.00 (2286.0)	32.00 (812.8)	48.00 (1219.2)	1050 (476)	60.00 (1524.0)	1600 (726)	63.00 (1600.2)	1600 (726)	75.00 (1905.0)	2100 (953)
	3	90.00 (2286.0)	32.00 (812.8)	48.00 (1219.2)	1050 (476)	60.00 (1524.0)	1600 (726)	63.00 (1600.2)	1600 (726)	75.00 (1905.0)	2100 (953)
	4	90.00 (2286.0)	32.00 (812.8)	48.00 (1219.2)	1250 (567)	60.00 (1524.0)	1900 (862)	63.00 (1600.2)	1800 (817)	75.00 (1905.0)	2400 (1089)
2500–3200	2	90.00 (2286.0)	44.00 (1117.6)	48.00 (1219.2)	1900 (862)	60.00 (1524.0)	2500 (1134)	63.00 (1600.2)	2400 (1089)	75.00 (1905.0)	3000 (1361)
	3	90.00 (2286.0)	44.00 (1117.6)	48.00 (1219.2)	1900 (862)	60.00 (1524.0)	2500 (1134)	63.00 (1600.2)	2400 (1089)	75.00 (1905.0)	3000 (1361)
	4	90.00 (2286.0)	44.00 (1117.6)	48.00 (1219.2)	2000 (907)	60.00 (1524.0)	2800 (1270)	63.00 (1600.2)	2500 (1135)	75.00 (1905.0)	3300 (1498)

① Seismic mounting brace adds an additional 3 inches (76.2 mm) to each side—front left and front right side and 3 inches (75.6 mm) additional to rear side.

② Dimensions and weights shown are approximate and subject to change. Reference product outline drawings for the latest information.

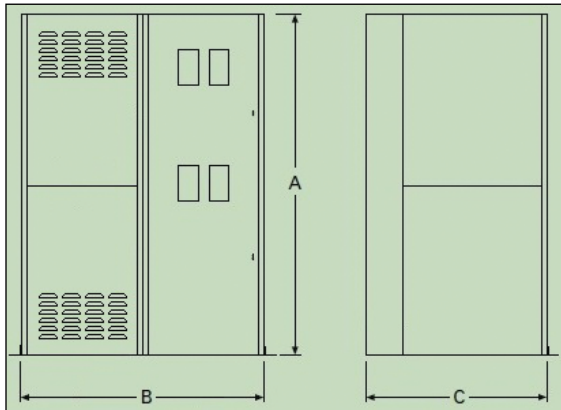


Figure 25.3-6. NEMA 1 (4000–5000 A)

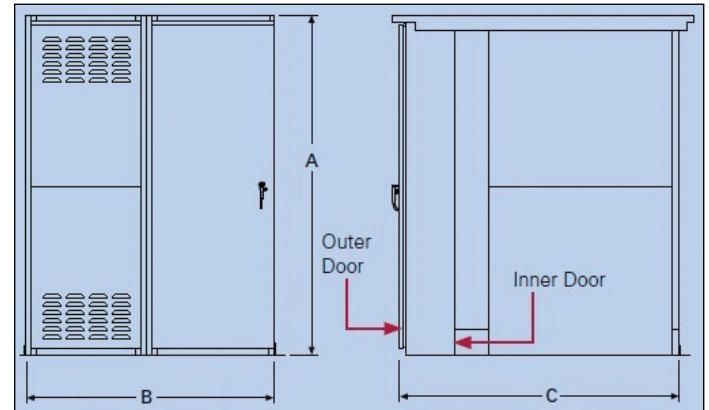


Figure 25.3-7. NEMA 3R (4000–5000 A)

**Table 25.3-3. Standard Dimensions and Weights (4000–5000 A)**

Ampere Rating	Number of Poles	A Height Inches (mm)	B Width ① Inches (mm)	NEMA 1 Drawout		NEMA 3R Drawout	
				C Depth ① Inches (mm)	Shipping Weight Lb (kg)	C Depth ① Inches (mm)	Shipping Weight Lb (kg)
4000	2 or 3	90.00 (2286.0)	86.00 (2184.4)	68.00 (1727.2)	4400 (1998)	80.81 (2052.6)	5400 (2542)
	4	90.00 (2286.0)	86.00 (2184.4)	68.00 (1727.2)	5100 (2315)	80.81 (2052.6)	6100 (2769)
5000	2 or 3	90.00 (2286.0)	86.00 (2184.4)	68.00 (1727.2)	4900 (2225)	80.81 (2052.6)	5900 (2679)
	4	90.00 (2286.0)	86.00 (2184.4)	68.00 (1727.2)	5600 (2542)	80.81 (2052.6)	7100 (3223)

① Seismic mounting brace adds an additional 3 inches (76.2 mm) to each side—front left and front right side and 3 inches (76.2 mm) additional to rear side.

② Dimensions and weights shown are approximate and subject to change. Reference product outline drawings for the latest information.

### Bypass Isolation Power Frame Automatic Transfer Switch

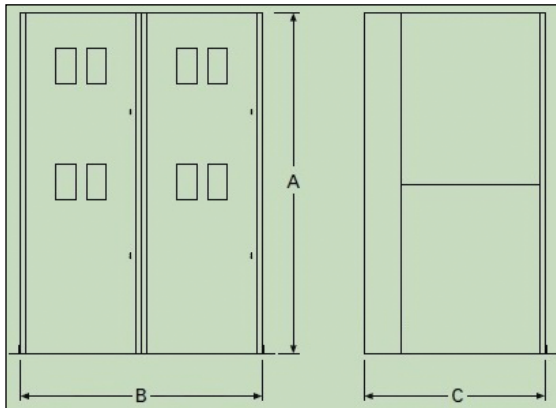


Figure 25.3-8. NEMA 1 (up to 3200 A)

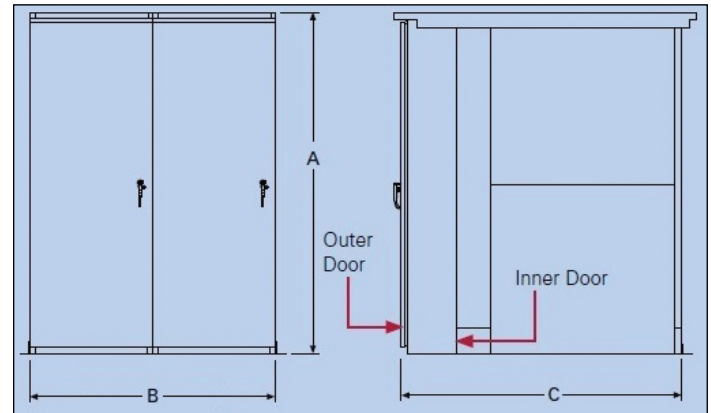


Figure 25.3-9. NEMA 3R (up to 3200 A)

**Table 25.3-4. Standard Dimensions and Weights (up to 3200 A)**

Ampere Rating	Number of Poles	A Height Inches (mm)	B Width Inches (mm)	NEMA 1 Drawout		NEMA 3R Drawout	
				C Depth Inches (mm)	Shipping Weight Lb (kg)	C Depth Inches (mm)	Shipping Weight Lb (kg)
200–2000	2	90.00 (2286.0)	64.00 (1625.6)	60.00 (1524.0)	3100 (1407)	75.00 (1905.0)	4100 (1861)
	3	90.00 (2286.0)	64.00 (1625.6)	60.00 (1524.0)	3100 (1407)	75.00 (1905.0)	4100 (1861)
	4	90.00 (2286.0)	64.00 (1625.6)	60.00 (1524.0)	3700 (1680)	75.00 (1905.0)	4700 (2134)
2500–3200	2	90.00 (2286.0)	64.00 (1625.6)	60.00 (1524.0)	4700 (2134)	75.00 (1905.0)	5700 (2588)
	3	90.00 (2286.0)	64.00 (1625.6)	60.00 (1524.0)	4700 (2134)	75.00 (1905.0)	5700 (2588)
	4	90.00 (2286.0)	64.00 (1625.6)	60.00 (1524.0)	5400 (2452)	75.00 (1905.0)	6500 (2951)

**Note:** Seismic mounting brace adds an additional 3 inches (76.2 mm) to each side—front left and front right side and 3 inches (76.2 mm) additional to rear side. Dimensions and weights shown are approximate and subject to change. Reference product outline drawings for the latest information.

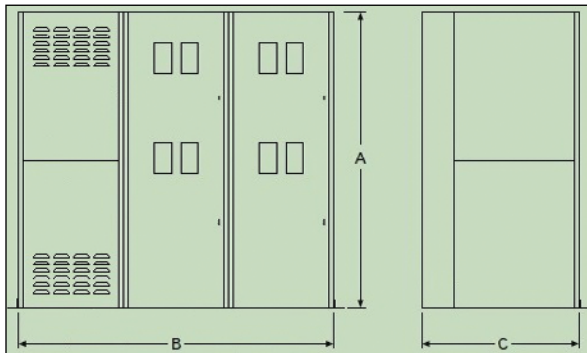


Figure 25.3-10. NEMA 1 (4000–5000 A)

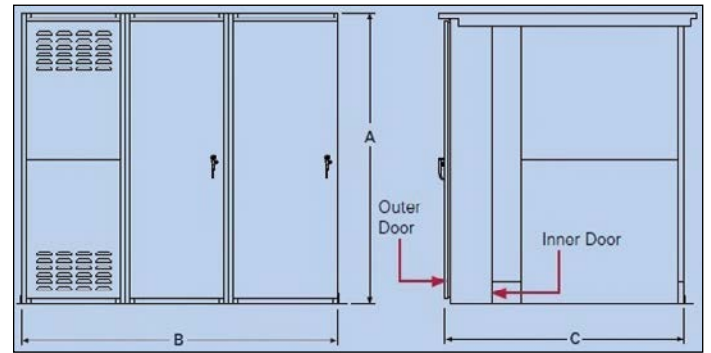


Figure 25.3-11. NEMA 3R (4000–5000 A)

**Table 25.3-5. Standard Dimensions and Weights (4000–5000 A)**

Ampere Rating	Number of Poles	A Height Inches (mm)	B Width Inches (mm)	NEMA 1 Drawout		NEMA 3R Drawout	
				C Depth Inches (mm)	Shipping Weight Lb (kg)	C Depth Inches (mm)	Shipping Weight Lb (kg)
4000	2 or 3	90.00 (2286.0)	137.00 (3479.8)	60.00 (1524.0)	6900 (3133)	75.00 (1905.0)	7900 (3587)
	4	90.00 (2286.0)	137.00 (3479.8)	60.00 (1524.0)	7600 (3450)	75.00 (1905.0)	8600 (3904)
5000	2 or 3	90.00 (2286.0)	137.00 (3479.8)	60.00 (1524.0)	7900 (3587)	75.00 (1905.0)	8900 (4041)
	4	90.00 (2286.0)	137.00 (3479.8)	60.00 (1524.0)	8600 (3904)	75.00 (1905.0)	9600 (4358)

**Note:** Seismic mounting brace adds an additional 3 inches (76.2 mm) to each side—front left and front right side and 3 inches (76.2 mm) additional to rear side. Dimensions and weights shown are approximate and subject to change. Reference product outline drawings for the latest information.



## Usual Environmental Conditions

### Ambient Temperature

- Operation: -20 °C to +40 °C (-4 °F to +104 °F)
- Storage: -30 °C to +80 °C (-22 °F to +176 °F)

### Relative Humidity

- Operation: up to 90% (noncondensing)
- Altitude: Product voltage and current ratings are applicable up to a maximum altitude of 2000 meters (6562 feet) above sea level

## Unusual Environmental Conditions

Special attention should be given to applications subject to the following conditions:

1. **Excessive dust or flyings**  
It is generally recommended that the transfer switch be installed in a clean, dry room with filtered and/or pressurized clean air. Air filters and gasketing material can be added to ventilated enclosures upon request.
2. **Excessive moisture**  
Depending upon conditions, an internal thermostat-controlled heater may be indicated to mitigate condensation. Additionally, stainless-steel enclosure designs are available.
3. **Excessive altitude**  
When a transfer switch installation exceeds 2000 meters (6562 ft) in altitude, voltage and current ratings are subject to the following derating factors based on ANSI C37.20.1

**Table 25.3-6. Altitude Derating**

Meters	Feet	Voltage	Current
2000	6562	1.0	1.0
2134	7000	0.989	0.998
2286	7500	0.976	0.995
2438	8000	0.963	0.993
2591	8500	0.950	0.990
2743	9000	0.933	0.987
2896	9500	0.917	0.983
3048	10,000	0.900	0.980
3200	10,500	0.883	0.977
3353	11,000	0.867	0.973
3505	11,500	0.850	0.970
3658	12,000	0.833	0.967
3810	12,500	0.817	0.963
3962	13,000	0.800	0.960

**Note:** Values for intermediate altitudes may be derived by linear interpolation.

### 4. Excessive high or low temperatures

For ambient temperatures exceeding 40 °C, and based on a standard temperature rise of 65 °C, the continuous current rating of the transfer switch is subject to the following thermal derating based on ANSI C37.20.1:

$$I_a = I_r \sqrt{\frac{105^\circ\text{C} - \text{Special Ambient, } ^\circ\text{C}}{65^\circ\text{C}}}$$

where:

$I_a$  is the derated continuous current (Amps) at the special ambient temperature

$I_r$  is the rated continuous current (Amps), on the basis of 40 °C ambient temperature

### 5. Damaging or hazardous vapors

For installations in corrosive environments where standard silver-plated bus is subject to “whiskering” in the presence of hydrogen sulfide (e.g., wastewater treatment facilities), tin-plated bus can be provided to mitigate whisker length to a few millimeters.

## Heat Loss

Estimated heat loss of the transfer switch (fixed and drawout mount) is based on operation at 100% of the continuous current rating.

**Table 25.3-7. Estimated Heat Loss**

Current Rating (Amperes)	Fixed Mount (Watts)	Drawout Mount (Watts)
200	20	22
300	23	27
400	26	34
600	36	54
800	50	83
1000	68	119
1200	91	163
1600	147	276
2000	220	421
2500	228	543
3000	320	774
3200	362	878
4000	421	824
5000	438	1068

## Transfer Switches



**Automatic Transfer Switch Family**

### General Description

Eaton's low-voltage automatic transfer switch assemblies provide a reliable means of transferring essential load connections between primary and alternate sources of electrical power.

Data centers, hospitals, factories and a wide range of other facility types that require continuous or near continuous uptime typically utilize an emergency (alternate) power source, such as a generator or a backup utility feed, when their normal (primary) power source becomes unavailable.

When the normal power source fails, the transfer switch quickly and safely transitions the load connections to the emergency power source, allowing critical loads to continue running with minimal or no interruption. All electrical power consumed by the circuit, equipment or system connected to the transfer switch output is defined as the load.

A typical transfer sequence includes these steps:

1. The normal utility power source fails.
2. When power from the generator or backup utility feed is stable and within prescribed voltage and frequency tolerances, the transfer switch shifts the load to the emergency power source. Depending on a facility's needs and preferences, the transfer process is self-acting or manually initiated.

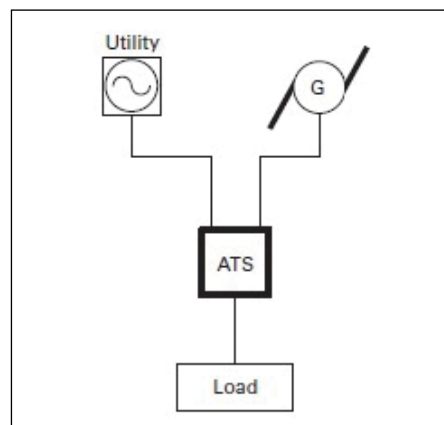
3. When utility power is restored, the transfer switch returns the load from the emergency power source to the normal power source. The retransfer process is self-acting or manually initiated.

### Arrangements

#### Two Power Sources

##### Utility—Generator

The standard transfer switch use case includes an electric utility service and an engine-generator set (generator) providing the normal and emergency power sources. This system arrangement is typically referred to as an emergency standby generator system. The single generator shown may be several engine-generator sets operating in parallel.

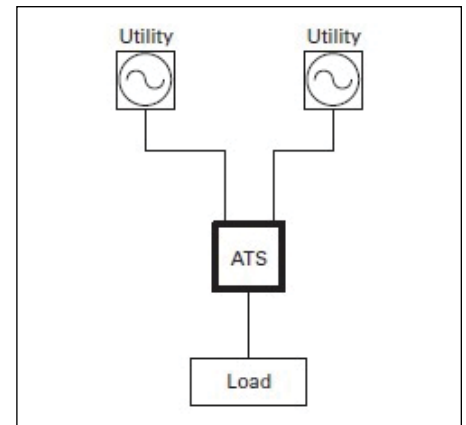


**Figure 25.3-12. Utility—Generator**

##### Utility—Utility

This use case employs two utility sources providing some level of redundancy in the distribution system and allows for quick restoration of service to the load if an upstream equipment failure occurs.

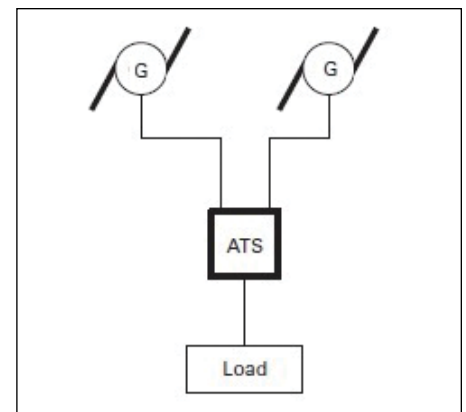
The two sources can be independent of each other, requiring the public utility company to provide dual electric services, or they can originate from a single electric service that is distributed through redundant paths within the facility.



**Figure 25.3-13. Utility—Utility**

##### Generator—Generator

Transfer switches are sometimes applied between two generator sets for prime power use, often at remote installations. In such cases, the generator may be required to provide continuous power 24/7. As a means to equally share run-time, source power is periodically alternated between the generator sets.



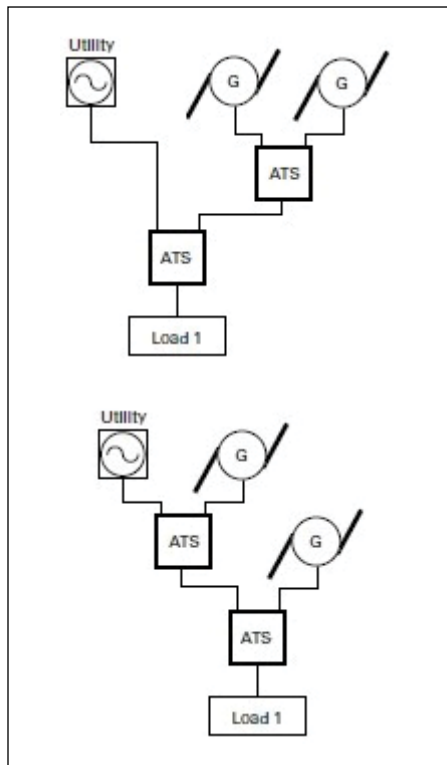
**Figure 25.3-14. Generator—Generator**

### Three Power Sources

#### Utility—Generator—Generator

Critical facilities with an emergency standby generator system will often include provisions for a second generator connection to serve as a redundant emergency backup that can be used during periods of inclement weather or when scheduled maintenance is being performed on the first generator.

In some cases, the first generator is permanently installed on-site whereas the second generator will be a portable roll-up type that is deployed when needed. Two variations of this arrangement are shown. When configured as shown in the first example, the generator start circuits must be managed to prevent unnecessary running when the utility source is available.

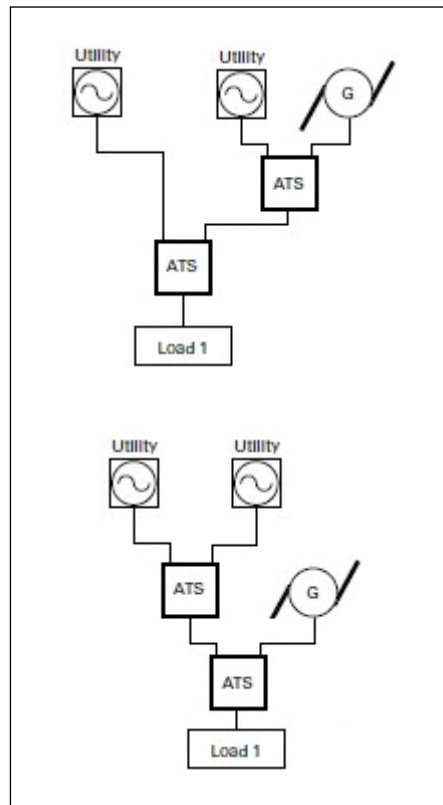


**Figure 25.3-15. Utility—Generator—Generator**

### Three Power Sources

#### Utility—Utility—Generator

This use case expands on the redundancy provided by dual utility arrangement and includes an emergency standby generator source. The generator can be dedicated for use by a single transfer switch or shared among multiple transfer switches employing a priority control scheme. Two variations of this arrangement are shown.



**Figure 25.3-16. Utility—Utility—Generator**

### Transition Types

Transfer switches can transition loads between normal and emergency power sources in two basic ways: open or closed.

The specific functions performed by a given load and the importance of those functions to safety or security play an important role in determining which kind of transition is required.

#### Open Transition

An open transition is a “break before make” transfer. That is, the transfer switch breaks its connection to one power source before making a connection to the other. For some period of time between disconnection and connection, neither the normal power source nor the emergency source is providing electricity to downstream loads.

There are two kinds of open transition: open delayed and open in-phase.

#### Open Delayed Transition

For an open delayed transition, the transfer switch pauses in-between disconnecting the load from one power source and connecting it to the other power source. The delay typically lasts either a pre-set amount of time (fixed or programmed time delay) or however long it takes the load voltage to decay below a pre-specified level (programmed threshold). The load voltage decay approach is more precise.

#### Open In-Phase Transition

With open in-phase transition, an automatic controller uses built-in intelligence to execute an open transition at the precise moment it expects the normal and emergency power sources to be synchronized in phase, voltage and frequency.

In-phase transitions are typically completed in 150 milliseconds or less to ensure that inrush current is equal to or less than the normal starting current of any inductive load(s).

If synchronization doesn’t occur within this time span, the transfer switch may have the ability to default automatically to a delayed transition that serves as a failsafe.

### Closed Transition

A closed transition is a “make before break” transfer, in that the transfer switch makes a connection to a second power source before breaking its connection with the first power source. As there’s no gap between disconnection and connection, downstream loads receive continuous power throughout the transfer process.

Switches configured for closed transition transfer power automatically as soon as both power sources are closely synchronized in phase, voltage and frequency. The overlap period during which both sources are simultaneously connected, or “paralleled,” usually lasts no more than 100 milliseconds to comply with local utility interconnect requirements.

### Modes of Operation

Power transfers involve two processes: initiation and operation. Initiation is what starts the transfer. Operation is what completes it. Most transfer switches can support multiple operation modes through the addition of configurable options.

#### Manual Mode

In manual mode, both initiation and operation are performed manually, typically by pushing a button or moving a handle. Initiation occurs locally.

#### Non-Automatic Mode

In non-automatic mode, the operator manually initiates a transfer by pressing a button or rotating a switch that causes an internal electromechanical device to electrically operate the switching mechanism. Initiation can occur locally or remotely.

#### Automatic Mode

In automatic mode, the transfer switch controller is self-acting and completely manages both initiation and operation. Initiation is triggered when the automatic controller senses an unavailability or loss of source power followed by operation of the switching mechanism.

### Switching Mechanism

The switching mechanism is the part of a transfer switch that is physically responsible for carrying the rated electrical current and shifting the load connection from one power source to another.



**Power Frame Switching Mechanisms are Available up to 5000 A and Utilize Stored Energy Technology**

Low-voltage switching mechanism technology comes in two basic varieties, commonly referred to as “contactor type” and “circuit breaker type”. Circuit breaker switching mechanisms can be further divided into two sub-types: molded case and power frame.

#### Contactor Type

This is the most common and typically most economical switching mechanism type. Contactors are constructed as an electrically controlled, double-throw switch where a single operator opens one set of power contacts while closing a second set. In an open transition design, a mechanical interlock is often employed to prevent simultaneous closure of both contact sets. In a closed transition design, the mechanical interlock is absent. Unlike a circuit breaker, a contactor is not designed to provide overcurrent protection or interrupt short-circuit fault current.

Contactor switching mechanisms are fast and flexible, but don’t offer overcurrent protection.

#### Molded Case Type

Routinely used for closing and interrupting a circuit between separable contacts under both normal and abnormal conditions, molded case switches feature simple designs and are capable of supporting either a mechanically operated, over-center toggle or a motor operator. They are typically assembled in an enclosed housing constructed of insulating material.

When configured for use in a transfer switch, a pair of molded case switches are operated via a common, interlocking mechanical linkage.

The linkage can be driven manually or automatically. When overcurrent protection is needed, molded case circuit breakers equipped with a thermal-magnetic or electronic trip element are used.

Molded case switching mechanisms provide a compact, cost-effective and service entrance-rated solution, as they eliminate the need for additional upstream protective devices. Each molded case mechanism individually complies with industry standard UL® 489, which covers low-voltage molded case switches and circuit breakers.

Molded case switching mechanisms are ideal for applications that require integral overcurrent protection.

#### Power Frame Type

Power frame switches are larger, faster and more powerful than molded case switches, and are capable of handling up to 5000 A.

A two-step stored energy technology is utilized that permits manual and electrical operation under load.

When an application requires integral overcurrent protection, power circuit breakers are configured with an electronic trip unit that facilitates selective coordination.

Power frame switching mechanisms are a good fit for applications vulnerable to large fault currents.

Each power frame switch or circuit breaker individually complies with industry standard UL 1066, which covers low-voltage power circuit breakers.

**Note:** For more detail, reference Eaton Publication WP140001EN.



## Mounting

### Drawout

The use of drawout construction permits the switching mechanism to be levered into three different positions (connected, disconnected, withdrawn) within a cassette or cell structure facilitating safety, testing and serviceability. Drawout is typically achieved using rail slides or rollers.

When in the disconnected position, the switching mechanism is isolated from the main power bus or cabling. Some designs may allow the switching mechanism to be manually or electrically (via control power) exercised to satisfy preventive maintenance requirements. Placing the switching mechanism in the disconnected position can also be used during a lockout/tagout procedure.

Removing the switching mechanism from the transfer switch allows for bench testing or replacement.

Drawout construction is often employed in bypass isolation type transfer switches used in mission-critical applications.

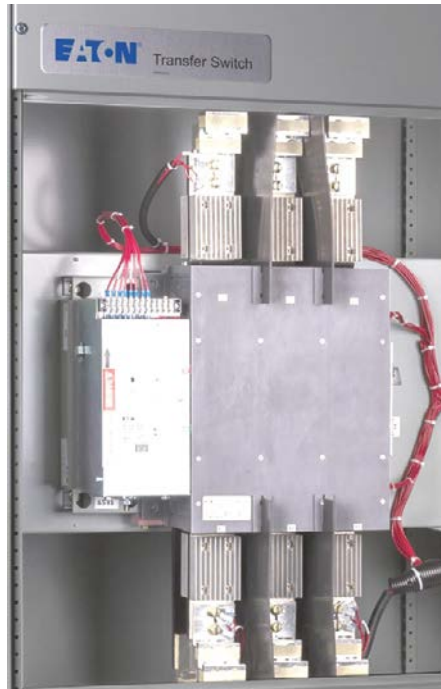


**Drawout Mounting**

### Fixed

Switching mechanisms with a fixed mounting configuration are simple and economical because there are no drawout system components.

The switching mechanism bolts directly to the main power bus or cable conductors and may result in a reduced enclosure depth when compared to drawout.

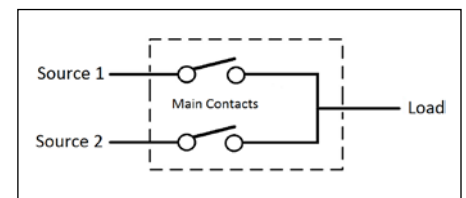


**Fixed Mounting**

## Power Poles

Every transfer switch includes a specific number of power poles. 2- and 3-pole designs are commonly employed in locations fed by single-phase power whereas 3- and 4-pole designs are utilized in places supplied with three-phase power.

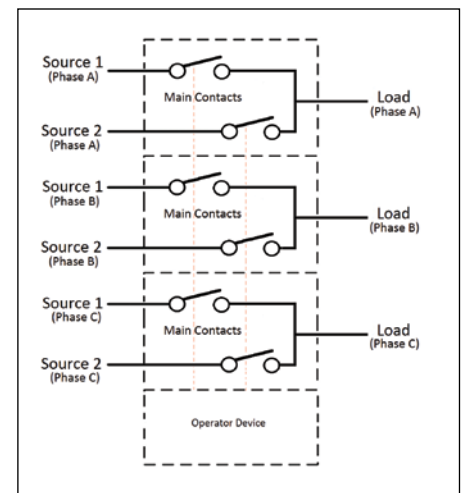
Each power pole is constructed with two sets of main contacts (momentary and stationary components) that are interconnected to form a three-terminal, single-pole switch. This arrangement allows the load terminal to be connected with one or both power source terminals.



**Figure 25.3-17. Power Pole**

Power poles are used to switch individual phase conductors of the power source and where required, the neutral conductor.

When multiple power poles are combined with an operator device(s), a switching mechanism is formed.



**Figure 25.3-18. Switching Mechanism**

For simplicity, multiple power poles are eliminated from the common transfer switch symbol used in one-line drawings.

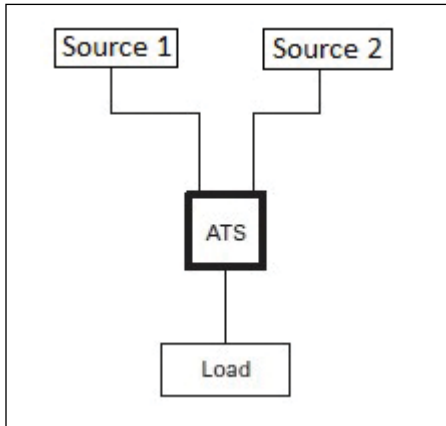


Figure 25.3-19. Transfer Switch Schematic Drawing

In open transition transfer switches, the main contacts are mechanically interlocked preventing both sets from being closed at the same time. This action prevents the inadvertent electrical paralleling of the two power sources that can differ in voltage, frequency and phase.

Closed transition designs do not include a mechanical interlock and will permit simultaneous paralleling of the power sources when they are electrically synchronized, however, an electrical interlock is used to limit the paralleling time (typically 100 ms) to comply with public utility interconnect specifications.

Power poles also include features to mitigate arcing and erosion of the main contacts such as arcing contacts, arc runners and arc chutes.

### Arc Chutes

Switching mechanisms include arc chutes, housed within an arc chamber constructed of high-dielectric high-strength material, that are mounted over each set of main contacts. Arc chutes are constructed of metal plates designed to extinguish an electrical arc and protect the main contacts.



Arc Chutes

### Operator Device

The operator device drives the power pole main contacts open or closed. Depending on the switching mechanism type, this is accomplished using an electric solenoid, electric motor or a spring stored energy mechanism.

Some operator device designs allow the source 1 main contacts to be driven independently of the source 2 main contacts. This permits the load to remain disconnected from either of the power sources for a programmed time delay or until the residual load voltage decays below a programmed threshold. When the load is disconnected in this manner, the transfer switch is said to be in a center-off or “neutral-position”.

Contact type switching mechanisms that provide a “neutral-position” are referred to as 3-position, otherwise, they are termed 2-position. All molded case and power frame type switching mechanisms provide a “neutral-position”.

Applications (e.g., inductive loads) specifying open-delayed transition will require a transfer switch with a “neutral-position”.

### Switched Neutral

For three-phase power applications requiring that the neutral conductor be switched, transfer switches can be configured with a fully rated fourth pole that performs identical to the individual phase (A, B, C) power poles. For single-phase applications, a fully rated third pole can be configured.

A switched neutral is commonly used when the transfer switch is fed by separately derived power sources. The benefits of using a switched neutral include the following:

- Inhibits circulating ground current from flowing between power sources on the neutral conductor that can cause nuisance tripping of the ground fault relay at the de-energized or unconnected source
- Prevents de-sensitizing the ground fault relay at the energized or connected source
- Eliminates the need for complex ground fault sense wiring

**Note:** For more detail, reference Eaton White Paper IA08700002E.

For closed transition transfer switches, the switched neutral pole operates as “make-before-break” and simultaneous closure or overlapping of the neutral contacts is limited to 100 ms.

For open transition transfer switches, the switched neutral pole operates in a “break-before-make” fashion and eliminates potential problems that can occur with a three-pole solid neutral or three-pole overlapping neutral (not offered by Eaton) configuration.

The likelihood of a ground fault occurring during the time period that neutral contacts are simultaneously closed or overlapped is just as likely as any other time but perhaps slightly more. When transferring between power sources, dynamic changes are introduced into the system such as moving contacts, vibration and energizing previously de-energized conductors that may push and pull equipment and cables in different directions.

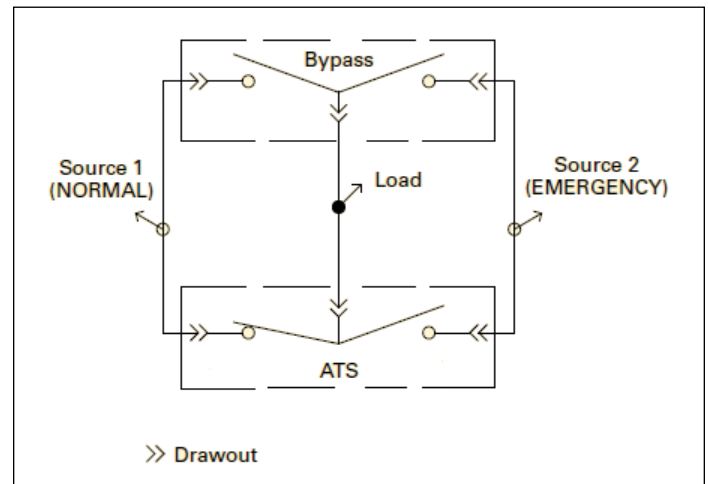
Configuration	Advantages	Disadvantages
Three-pole	Lower cost	Nuisance tripping of ground fault (GF) relay on de-energized or unconnected source. De-sensitizing the ground fault relay at the energized or connected source. Added complexity to implement ground fault relay circuit to prevent nuisance tripping of ground fault relay at de-energized or unconnected source.
Four-pole (switched neutral)	No circulating ground current (eliminates nuisance tripping of ground fault relay at de-energized or unconnected source and desensitizing ground fault relay at energized or connected source).	Higher cost
Three-pole (overlapping neutral)	May be less expensive than four-pole if overlapping neutral is not fully rated.	During the time when both neutrals are connected, the same disadvantages as a three-pole switch exists.

### Bypass Isolation Automatic Transfer Switches

For simplified maintenance and improved uptime, bypass isolation automatic transfer switches provide dual switching functionality and redundancy for critical applications. The primary switching mechanism (automatic transfer switch) handles the day-to-day distribution of electrical power to the load, while the secondary switching mechanism (bypass switch) serves as a backup or redundant device. During repair or maintenance procedures, service personnel can bypass power around the automatic transfer switch through the bypass to ensure that critical loads remain powered without interruption.

In some bypass isolation transfer switch designs, the bypass switch is fully automatic and self-acting providing increased redundancy. When in the automatic bypass mode of operation, the control logic continues to monitor the normal power source and will automatically initiate a transfer to the alternate source should the normal source fail.

A bypass isolation transfer switch is frequently selected for use in healthcare, as well as in other critical applications, because it allows the automatic transfer switch (ATS), and in some cases the bypass switch, to be drawn out and isolated from the power source(s) to facilitate regular maintenance, inspection and testing as prescribed by code (NFPA 110).

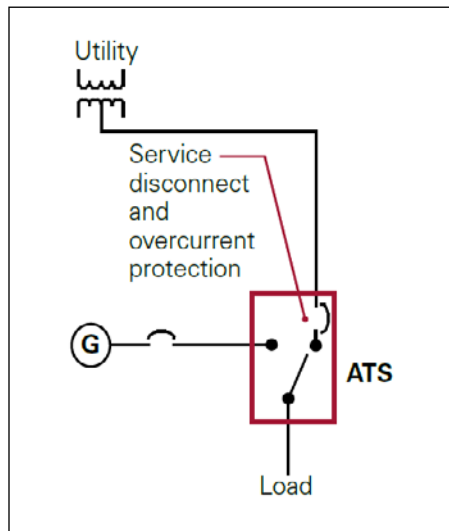


**Figure 25.3-20. Bypass Isolation ATS Schematic Drawing**

### Service Entrance Transfer Switches

Facilities with a single utility connection and a single emergency power source will often have an automatic transfer switch located at the service entrance to ensure that critical loads can quickly and safely shift to emergency power (generator) if utility power is interrupted. Non-critical loads are often inhibited or shed from connection to the emergency power source to avoid capacity overload.

Service entrance rated transfer switches include integral overcurrent protection and a disconnect means allowing them to be installed directly at the point of service entrance which eliminates the need for separate upstream device(s), including additional power connections. As required they can also include ground fault protection.



**Figure 25.3-21. Service Entrance Transfer Switch with Integral Overcurrent Protection Saves Space and Cost**

### Arc Flash Reduction

When required by the National Electrical Code (NEC), integral overcurrent protection can be configured with technology to reduce clearing time, such as an Arcflash Reduction Maintenance System (ARMS), resulting in lower incident energy at all downstream work locations.

A circuit breaker equipped with ARMS can improve worker safety by providing a simple and reliable method to reduce fault clearing time. For applications where the highest continuous current trip setting of the overcurrent device in a circuit breaker is rated (or can be adjusted to) 1200 A or higher, a method to reduce clearing time is required per NEC 240.87.

When the ARMS maintenance mode is enabled, an integral analog trip circuit provides an accelerated instantaneous trip. To facilitate maximum arc flash reduction while avoiding nuisance tripping, the ARMS pickup level is adjustable.

Service entrance transfer switch construction can vary in the marketplace and care should be taken by the consulting engineer to consider when the transfer equipment needs to be “fully UL1008 Listed” and marked for use at 100% of rated current.

The phrase “fully UL 1008 listed” is used to describe the entire transfer switch enclosure assembly—including the integral circuit breaker and power bus—which has passed rigorous temperature rise performance testing required by the UL 1008 standard for transfer switch equipment.

**Table 25.3-8. Incident Energy Level Decreases with ARMS**

Service Entrance Transfer Switch Rating (A)	Available Fault Current (kA)	Arcing Fault Current (kA)	Without ARMS		With ARMS	
			Maximum Clearing Time (sec)	Incident Energy (cal/cm <sup>2</sup> )	Maximum Clearing Time (sec)	Incident Energy (cal/cm <sup>2</sup> )
4000	64	32	0.5	58.4	0.04	4.7
3000	51	26.4	0.5	47.3	0.04	3.8
2000	39	21	0.5	37	0.04	3.0
1600	28	15.8	0.5	27.2	0.04	2.2
1200	19	11.3	0.5	19	0.04	1.5

**Note:** Overcurrent protection device modeled is Eaton Magnum DS circuit breaker (520MC or 1150+ trip). When Eaton MCCB (310+ trip) is used as the protection device, maximum clearing time (ARMS) is 0.03 sec. Arcing fault current and incident energy values derived using SKM System Analysis software Incident energy is calculated immediately downstream of transfer switch load.



## UL 1008 Standard

The industry safety standard governing the construction and performance criteria for transfer switch equipment, having a maximum voltage rating of 1000 volts, is UL 1008.

To ensure a minimum level of reliability, the standard requires that all transfer switch equipment, listed to apply the UL 1008 mark, meet rigorous performance testing—regardless of the design type.

### Performance Tests

#### Undervoltage

A voltage sensing relay coil shall be capable of withstanding 95% of rated pull-in voltage without damage.

#### Overvoltage

An electromagnet coil shall be capable of withstanding 110% of rated voltage without damage.

#### Overload

The transfer switch must operate for a number of operation cycles, with a non-unity power factor, at a multiple of its rated current.

#### Dielectric

The transfer switch shall be capable of withstanding 1000 Vac, plus twice its maximum rated voltage, without breakdown.

#### Temperature Rise

While operating at 100% of its rated current, the transfer switch temperature shall not exceed a maximum value, sustain material damage or pose a fire risk.

#### Endurance

The transfer switch must operate for thousands of operation cycles without fail.

### Withstand and Closing

With the transfer switch closed into a test circuit, it must “withstand” a short-circuit current, at a specific voltage, for a specified time period or until a specific overcurrent protective device opens. The same transfer switch sample must then “close-into” a test circuit, with a short-circuit current applied, for a specified time period or until a specific overcurrent protective device opens. At the conclusion of each test, a set of operational, physical and electrical criteria must be met.

An optional short-time variant of the test can be performed at the request of the manufacturer but is not required to obtain a UL 1008 mark.

### Withstand Closing Current Ratings

When applying a transfer switch for use in a power distribution system, consideration must be given to the withstand closing current rating (WCR) to ensure system integrity and reliability.

The UL1008 standard permits transfer switches to be marked with one or more short-circuit and/or short-time WCRs specific to an overcurrent protection (OCP) device type. Transfer switches with multiple ratings provide greater application flexibility.

The WCR represents a transfer switch's capability to ride-out a fault condition until the overcurrent protective device (a circuit breaker or fuse that is integral to the transfer switch assembly or is located externally upstream) opens and clears the fault. The WCR, applicable up to a maximum voltage, is given in thousands of amperes and must be equal to or greater than the available fault current calculated at the location of the transfer switch in the electrical circuit. In some instances, a WCR may be further qualified by a maximum time duration.

### Short-Circuit Withstand Closing Rating

Applied in electrical circuits where the overcurrent protection (OCP) device, a fuse or circuit breaker, is equipped with an instantaneous trip response capable of clearing a fault quickly without intentional delay.

Various transfer switch short-circuit WCR examples are as follows:

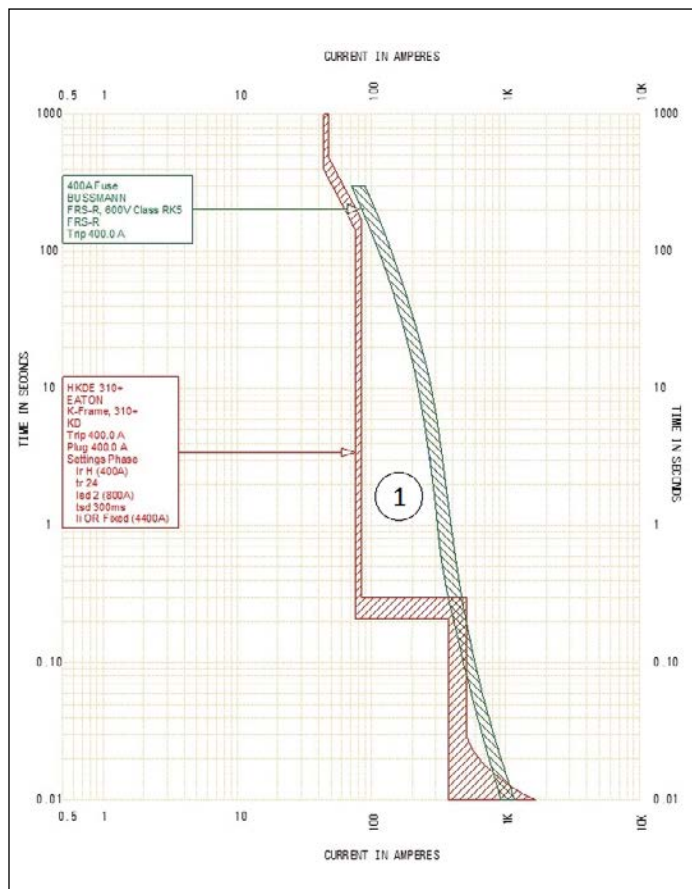
- When the overcurrent protection device is an external circuit breaker, of **any** type, a “time-based” short-circuit WCR can be applied. An important caveat is that the maximum clearing time of the circuit breaker's instantaneous trip response must be equal to or less than the maximum time duration of the marked short-circuit WCR.
- When the overcurrent protection device is an external circuit breaker, of a **specific** type that appears on a manufacturer's list, a “specific circuit breaker” short-circuit WCR can be applied and offers a higher current rating compared to a time-based rating.
- When the overcurrent protection device is a fuse, of a **specific** type or classification, a “fuse” short-circuit WCR can be applied and offers the highest current rating.
- When the overcurrent protection (OCP) device is integral to the transfer switch assembly, an “integral OCP” short-circuit WCR can be applied. A typical use is a service entrance transfer switch that is fed directly from the utility.

A transfer switch short-circuit withstand closing current rating (WCR) is frequently utilized in circuits where the overcurrent protective device is a UL 489 circuit breaker. A common example is a molded case circuit breaker installed in UL 891 switchboard, serving as a feeder to a transfer switch.

When applying a transfer switch short-circuit WCR, it's important to note that UL 489 Listed circuit breakers include a magnetic, built-in instantaneous override that can't be defeated or disabled. For molded case breakers, the override is fixed at approximately 10–12 times the nominal trip or frame rating. For insulated case breakers, the override is fixed at approximately 13–18 times the nominal trip or frame rating.

For many years, fuses and thermal-magnetic circuit breakers (UL 489) have successfully been used to provide overcurrent protection for short-circuit rated transfer switches. Today, circuit breakers are more commonly configured with an electronic trip unit having a short-time element (LS, LSI, LSG, LSG) allowing the short-time pick-up/delay to be adjusted.

When a circuit breaker's short-time element adjustments are set to maximum, the protection provided can be similar to that of a fuse or thermal-magnetic circuit breaker. However, adjusting the settings to something less than maximum can provide shorter clearing times and increased protection at lower level faults when compared to a fuse (**Figure 25.3-22**) or a thermal-magnetic circuit breaker. As a result, UL 489 breakers equipped with a short-time element have the ability to provide "better protection" compared to a fuse or a circuit breaker without a short-time element.



**Figure 25.3-22.** Time-current characteristic curve showing that a UL 489 circuit breaker with LSI trip (red curve) can clear the same level of fault current more quickly (region 1) than a fuse (green curve)

### Short-Time Withstand Closing Rating

Typically applied in critical electrical circuits where the overcurrent protection device is a circuit breaker, equipped with an adjustable electronic trip capable of providing intentional delay, that allows for selective coordination within the distribution system. In many cases, the instantaneous response of the circuit breaker is disabled.

When a transfer switch carries an optional short-time WCR, it will always be qualified by a maximum time duration. Values typically range between 0.1 and 0.5 seconds correlating with a circuit breaker's short-time response. To ensure proper protection, the circuit breaker short-time settings must be coordinated with the maximum time duration of the marked short-time WCR.

Short-time WCRs are frequently utilized in circuits where the overcurrent protective device is a UL 1066 circuit breaker, such as UL 1558 switchgear.

Transfer switches with a short-time WCR and maximum time duration of 0.5 seconds offer the greatest flexibility to the specifying engineer when designing a selectively coordinated system.

### Life Expectancy

Transfer switches are periodically exercised upon a loss of normal power or when conducting routine testing. Many designs include control logic with a plant exerciser capable of initiating a test automatically based on a programmed schedule (weekly, biweekly, monthly).

Assuming a transfer switch is exercised once a week through scheduled testing or a power outage condition, an approximation of life expectancy can be made based on UL 1008 endurance test criteria that is conducted with and without rated current.

**Table 25.3-9. UL 1008 Endurance Testing**

Transfer Switch Rating (Amperes)	Number of Operation Cycles		Total
	With Current	Without Current	
0–300	6000	—	6000
301–400	4000	—	4000
401–800	2000	1000	3000
801–1600	1500	1500	3000
1601 and above	1000	2000	3000

**Table 25.3-10. Estimated Transfer Switch Life Expectancy**

Transfer Switch Rating (Amperes)	52 Transfer/Retransfer Operations per Year		
	With Current (Years)	Without Current (Years)	Total (Years)
0–300	115	—	115
301–400	76	—	76
401–800	38	19	57
801–1600	28.5	28.5	57
1601 and above	19	38	57

## **NFPA 70 System Installation Types**

Transfer switches are employed in a variety of special conditions that typically fall into one of four categories defined by the National Electrical Code (NFPA 70): emergency systems, legally required systems, critical operations power systems and optional standby systems.

### **Emergency systems**

Emergency systems supply, automatically distribute and control electricity used by systems essential to life safety during fires and other disasters. They include fire detectors, alarms, emergency lights, elevators, fire pumps, public safety communication systems and ventilation systems, and are commonly found in hotels, theaters, sports arenas and hospitals.

Emergency systems are regulated by a municipal, state, federal or other government agency. Transfer from the normal power source to the emergency source must complete within 10 seconds and meet the requirements of Article 700 of the National Electrical Code (NFPA 70). In addition, overcurrent devices must be selectively coordinated with all supply-side overcurrent protective devices.

### **Legally Required Systems**

Legally required systems automatically supply power to a selected set of regulated loads not classified as emergency systems when normal power is unavailable. They serve critical heating, refrigeration, communication, ventilation, smoke removal, sewage disposal, and lighting functions that could create hazards or hamper rescue or fire-fighting operations if denied electrical power.

As with emergency systems, legally required systems are regulated by municipal, state, federal and other governmental agencies. Transfer from the normal power source to the emergency source must complete within 60 seconds and meet the requirements of Article 701 of the National Electrical Code (NFPA 70). Overcurrent devices must be selectively coordinated with all supply-side overcurrent protective devices.

### **Critical Operations Power Systems (COPS)**

COPS supply, distribute and control electricity in designated critical areas when a normal power source fails. They include HVAC, fire alarm, security, communication, signaling and other services in facilities that a government agency has deemed important to national security, the economy, or public health and safety.

All COPS must meet the requirements of Article 708 of the National Electrical Code (NFPA 70), and their overcurrent devices must be selectively coordinated with all supply-side overcurrent protective devices.

### **Optional Standby Systems**

Optional standby systems supply power to loads with no direct bearing on health or life safety and are not required to function automatically during power failures. They are typically found in commercial buildings, farms and even residences, and must meet the requirements of Article 702 of the National Electrical Code (NFPA 70).

### **Special Occupancies**

In addition to the special conditions previously discussed, transfer switches are utilized in the critical, life safety and equipment branches of an essential electrical system located within a healthcare facility and subject to Article 517 of the National Electrical Code (NFPA 70).

### **Other Standards**

Other relevant industry standards for transfer switches are NFPA 99 (Health Care Facilities Code) and NFPA 110 (Emergency and Standby Power Systems).

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