Equipment Type

Figure 7. Typical Enclosed Automatic Transfer Switch.

Automatic

Figure 7. Automatic transfer switches include controls that continuously monitor the condition of both sources, comparing the quality of the two sources to the set-points for conditions including any or all of the following: voltage, frequency, phase rotation, phase loss. If any of the sensed conditions fall out of specifications within the time set for any intentional time delays, transfer is initiated to the alternate source if the alternate source conditions are within proper operating conditions. Thus, transfer is automatic and unaided by an operator. This type of transfer switch provides for the most reliable power and is imperative for unattended operation.

Figure 8. Enclosure Interior of Automatic Transfer Switch.

Figure 8 and Figure 9. Many automatic switches also include provisions for manual transfer. Some switches limit the manual transfer to no load and require

Automatic (cont'd)

the load be disconnected (or the transfer switch to be isolated) prior to load transfer. Some switches even require the switch be disconnected from all power sources for manual transfer operation.

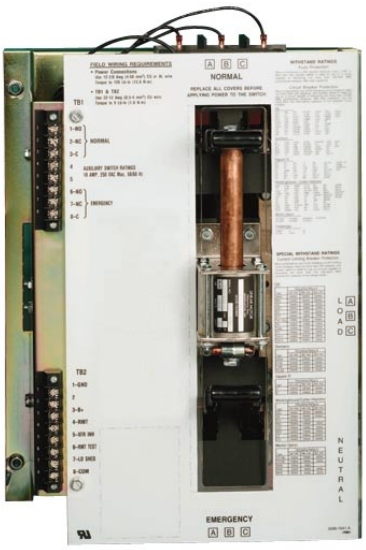

Figure 9. Power Switching Device in an Automatic Transfer Switch.

Nonautomatic

Nonautomatic switches must be actuated manually by an operator and are intended for applications where operators are present. They are also commonly applied to facilities that are not required to be on line by code in very short time periods and where the facility operation does not pose immediate life safety or health hazards upon loss of power. These are often applied in facilities that do not include a permanently installed generator, but rather, at facilities where a mobile generator is dispatched during extended utility outages.

These switches are available with either electric or manual operators. Electrically operated switches generally have operator pushbuttons mounted on the switch enclosure. However, the operator pushbutton controls can be located remotely such as in a facility monitoring station, convenient to personnel responsible for facility operations. Switches with manual operating handles require personnel to go to wherever the switch is located to transfer loads. Some manually operable switches may not be designed with load break capability. These require transfer at no load after the loads are disconnected by other means. To achieve full load manual operating capability, the switch must employ a fast acting switching mechanism that is spring loaded and operates at speeds independent of how fast the operator moves the manual operating handle.

Open Transition

Transfer switch equipment may be either open transition or closed transition. Open transition equipment transfers the connected load between power sources with a momentary interruption in power, when both sources are available, as the switch contacts open from one source and close to the other source. This momentary power interruption is called Contact Transfer Time; and without intentional delay during transition, has a duration of 6 cycles or less depending on the size of the equipment. A mechanical interlock is provided to prevent interconnection of the two power sources.

Closed Transition

Figure 10. Typical Closed Transition Transfer Switch.

Figure 10. With both sources available, closed transition transfer equipment parallels the power sources either momentarily or for an adjustable duration sufficient to ramp load onto and off of the generator set. Closed transition transfer equipment can either actively synchronize both power sources before paralleling them, or passively check for synchronism before allowing paralleling. Closed transition equipment operates in open transition when one of the sources has failed, and closed transition when both sources are present. Closed transition operation prevents the momentary interruption in power when both sources are present, such as exercise, test, and retransfer. Closed transition transfer equipment does not substitute for an uninterruptible power supply where one is required by the load equipment.

Bypass Isolation

Figure 11. Typical Bypass/Isolation Transfer Switch.

Figure 11. Bypass–Isolation automatic transfer switch equipment is configured with a manual bypass transfer switch in parallel with an automatic transfer switch.

Bypass Isolation (cont'd)

The parallel connections between the bypass switch and the transfer switch are made with isolating contacts such that the automatic transfer switch can be drawn out for testing, service and repair. While the transfer switch is isolated, power is fed to the load through the bypass switch. The bypass–Isolation automatic transfer equipment available from Cummins is the non–load break type. There is no power interruption to the load when the equipment operates to bypass. Also available from other manufacturers is load break isolation–bypass equipment, which isolates the load from both power sources before bypassing the ATS. The bypass–isolation equipment available from Cummins is a two–source bypass. The bypass switch can be operated to either source (if power is available). Also available from other manufacturers is single–source bypass where the bypass switch can be switched to only one source, typically the normal source.

Equipment Ratings

Continuous Current

Generally, the continuous current rating must be selected in accordance with the total connected load requirements , sized essentially in the same manner as the circuit conductors. Most transfer switches are capable of carrying 100% rated current at an ambient temperature of 40ºC. However, transfer switches incorporating integral overcurrent protective devices may be limited to a continuous load current not to exceed 80% of the switch rating. The manufacturer's specification sheets indicate whether the device is 80% or 100% rated.

Most switches that incorporate a switched fourth neutral pole utilize a neutral pole rated the same as the phase poles but the manufacturers literature should be referenced to confirm. It is recommended that fully rated neutrals be used in applications containing nonlinear loads, where the load induced harmonics create substantial neutral current. The ampacity of the switch must meet or exceed that of the connected conductors. Certain applications may require the switch to be sized larger including:

- Situations where feeder conductors are oversized to limit voltage drop and the minimum rated switch cannot except the larger cable. The field wiring lugs have a limited cable size range.
- Where heavy concentrations of nonlinear load are present, and the harmonics combined with single phase load unbalance are likely to cause high levels of neutral current, it may be desirable to have the neutral circuit sized larger than the phase circuits.
- Fire pump applications require any normal source overcurrent devices be sized to carry the fire pump locked rotor current indefinitely. This may require overcurrent devices larger than allowed for transfer switch upstream protection, forcing the switch to be oversized.
- Where available fault current exceeds the capability of the switch, a larger switch may be required to achieve the required withstand capability.

Most Cummins transfer switch continuous current ratings are Underwriter's Laboratories "Total System Transfer" ratings. The transfer switch is suitable for use with any combination of motors, electric discharge lamps, tungsten filament lamps, and electric heat equipment. This rating is intended for general use

Continuous Current (cont'd)

where the sum of full load ampere ratings does not exceed the rating of the transfer switch, and the tungsten lamp load does not exceed 30% of the total. Included in the "Total System Transfer" rating is test verification of the ability to switch, interrupt and close onto currents of six times the transfer switch rating at low power factor. Therefore, the rating permits use with a single squirrel–cage induction motor, with a full load current up to the rating of the transfer switch.

Voltage

Transfer switch equipment is available for a wide range of operating voltages at both 50 and 60 Hz. All types of switches are available for low voltage (600 VAC and below) applications. Transfer switch types required for higher voltages (medium and high voltage) are limited to those using mechanisms comprised of high voltage contactors and breakers.

The voltage chosen for the transfer switch will match the system voltage for the application, however, withstand and closing ratings for the switch may vary with its voltage rating. This rating difference can affect the type of protection equipment required upstream of the transfer switch.

Switching Duty

Transfer switches have unique load switching requirements from most other load switching equipment. Transfer switches must be capable of switching loads with many different electrical characteristics between two available power sources that can be operating at different frequency and at opposite polarity. When transferring loads between two energized power sources (when re–transferring to the preferred source or when testing the system), the switch must be capable of load break transfer when the two sources are up to 180 degrees out of phase. During load transfer, the load current must be interrupted by open transition type switches. During interruption, arcing occurs across the open contacts. This arc must be completely extinguished before the opposite source contacts are closed to prevent source–to–source faults. Of course the situation is most severe when the two sources are completely out–of–phase and twice rated voltage exists across open contacts.

The problem is further exaggerated due to the characteristics of the loads being transferred. Some loads like tungsten lights, motors and transformers draw many times rated current when initially connected to a power source. Inductive loads, like motors, maintain terminal voltage for some time after being disconnected from a power source. Transfer switching mechanisms must be designed to accommodate these conditions.

The basic contact structure may consist of both main current carrying contacts and separate arcing contacts, both contained within an arc chute assembly. The arcing contacts are configured to be the last contacts to open and the first to close during transfer in order to perform the arc extinguishing function during opening, preventing erosion of the main current carrying contacts. The arc chutes are designed to be a part of the arc current carrying path and serve to lengthen the path gradually during opening, cooling and extinguishing the arc prior to contacts closing to the opposite source.

Phase

Transfer switch equipment is generally available with three phase poles and a solid neutral connection block; or with four poles, three phase poles and a neutral pole. Four–pole transfer switch equipment is typically used in electrical distribution systems as required to assure accurate sensing of ground fault protection systems.

Short Circuit

Withstand and Closing Ratings – An important consideration in the application of transfer switch equipment is its ability to withstand and close into fault currents. This is an important factor in achieving the highest power reliability to the loads. Often times, faults are temporary in nature. These faults are initiated by wires touching, contaminants or debris falling into electrical gear, internal arcing faults in motor insulation systems, etc. Quite often, these temporary faults are arcing faults and, if the source of power is intentionally interrupted (by some overcurrent device), the faulted circuit can be successfully re–energized by re–applying power. In a properly designed distribution system, if a temporary fault occurs on the load side of a transfer switch, either a load side branch breaker will clear the fault and the remaining loads continue to operate or a breaker upstream of the switch operates and the source is lost. When the source is lost, the transfer switch should detect loss of power and initiate transfer to the alternate source in an attempt to restore power. If the fault was temporary and cleared during the initial fault (debris blown clear, for example), power may be reapplied to the load. If, however, the fault is permanent, the switch must be capable of closing into the fault and withstanding the fault current until a protective device on the alternate source interrupts the fault.

Two types of mechanical transfer switch equipment have been defined by the IEC Standard 947, and are recognized by National Electrical Code 110–9 and 110–10. Type PC (contactor type) transfer switch equipment is designed to withstand and close into short circuit current until an external upstream overcurrent protective device opens and clears the fault. Type CB (circuit breaker type) transfer switch equipment includes integral overcurrent devices that are intended to interrupt fault level current. All transfer switch equipment, both classes, have short circuit ratings that are Withstand and Closing Ratings (WCR), which are expressed in RMS symmetrical amperes at a maximum system voltage. The asymmetrical current capability is based on X/R ratios used for short circuit testing. See Short Circuit Protection and Application below. The WCR is established by testing only. Calculations of short circuit ratings have no validity for application.

Solid state switches typically have considerably lower fault current capability than mechanical switches, particularly when protected by circuit breakers. Solid state switches are generally equipped with fast acting current limiting fuses that interrupt the fault current before damaging the solid state elements of the switch.

The suitability of transfer switch equipment for application in circuits with high available fault current is tested to the requirements of UL Standard 1008. A contactor type transfer switch must be able to withstand the mechanical and thermal stresses caused by short circuit currents, remain closed until the upstream overcurrent device has cleared, and then be capable of transferring the load to the opposite source. (A short time delay is standard in the control to override the voltage drop caused by a fault and to allow the transfer switch contacts to remain closed.) A circuit breaker type transfer switch is allowed to open or interrupt the short circuit current, and then transfer the load to the opposite source.

If a fault occurs on the load side of the transfer switch and is cleared by an overcurrent protective device, the transfer switch will transfer to the opposite source, if and when available. It cannot be assumed that the fault condition will have cleared before the opposite source restores power. Therefore, UL1008 also re-

Short Circuit (cont'd)

quires demonstration by test that the transfer switch is capable of closing into a short circuit fault with the same available fault current as the withstand test. Thus the UL rating is a Withstand and Closing Rating, not a withstand rating only. Because arcing across the contacts as they close makes the closing test considerably more severe than the withstand test where contacts remain closed under pressure, the closing test capability usually determines the WCR. Some manufacturers publish a withstand rating only without including closing ability. These ratings should not be compared on an equal basis to a WCR as published by Cummins and as required by UL 1008.

Cummins transfer switches are tested and rated with specific upstream overcurrent protection devices. Short circuit tests using both current–limiting fuses and molded case circuit breakers as the upstream overcurrent protection establish the WCRs with specific overcurrent devices. Accordingly, Cummins transfer switch equipment has two sets of overcurrent device specific WCRs, one rating with molded case circuit breakers, and one rating with current limiting fuses. In compliance with UL 1008, the circuit breaker WCR lists the circuit breaker manufacturer's name(s) and type designation(s), and maximum circuit breaker rating. The fuse WCR specifies the UL fuse class and the maximum continuous current rating of the fuse. These ratings and the allowable overcurrent device information are required markings on the transfer switch equipment. Inspection authorities can easily verify that appropriate overcurrent devices are installed upstream of the transfer switch equipment.

UL 1008 also permits short circuit tests without specific upstream overcurrent devices where the test current is maintained for 3 or 1.5 cycles depending on the rating of the transfer switch. Using overcurrent devices marked specifically on the transfer switch equipment is not required when the transfer switch is applied within this WCR, usually referred to as the "3–cycle" rating. However, just the same as with specific device ratings, the upstream overcurrent device must be either a current–limiting fuse, or a molded case circuit breaker with an instantaneous response and without an adjustable short–time delay. Power frame breakers are not permissible, nor are circuit breakers with an adjustable short–time delay function, including molded case and insulated case breakers. A 3–cycle WCR will typically be lower than a specific overcurrent device WCR for the same transfer switch.

Cummins recommends application of the transfer switch equipment using one of the two specific overcurrent device WCRs, because the coordination between the specific overcurrent device and the transfer switch equipment has been verified by UL as a condition of the listing. The inspection authority need only check that the upstream overcurrent device is included in the marking on the transfer switch. If the transfer switch equipment is applied based on a 3–cycle WCR, the inspection authority can only verify that the WCR is adequate based on the installed upstream overcurrent device interrupting rating. It then becomes the responsibility of the system designer to select, specify, and verify the field installation of an overcurrent device that will clear the available fault current in less than 1.5 or 3 cycles; and that the device has no adjustable short time delay function included.

Short Time Withstand and Closing Rating – Some transfer switches also carry a long time WCR, typically lower than the short time WCR. These ratings are generally limited to circuit breaker type switches applied near the normal utility

Short Circuit (cont'd)

point of supply. The long time withstand ratings are needed to allow the switch to remain connected during short circuits for sufficient time to allow downstream overcurrent devices closest to the fault to clear the fault.

Interrupting – Transfer switches have unique load switching requirements from most other load switching equipment. Transfer switches must be capable of switching loads with many different electrical characteristics between two available power sources that can be operating at different frequency and at opposite polarity.

Circuit breaker style transfer switches contain integral overcurrent protection. These switches also must carry an interrupting rating sufficiently high to allow them to safely interrupt load side faults at the required available fault current level.

