Transfer Mechanism Basics

White Paper 71
Revision 1

Transfer Mechanism Basics

Description and Operation

The central component of every power transfer switch is its switching mechanism. In ASCO switches, essential components include electrical contacts, solenoid-driven operators, and features that mitigate electrical arcing and its effects. Switch features and operation are described in the following narrative.

MAIN CONTACT DESIGN AND OPERATION

Transfer switches connect load circuits to either Normal or Emergency sources of electrical power, as shown in Figure 1. Within this equipment, a transfer mechanism dedicates electrical contacts to each switched conductor. When connected, current passes through mating momentary and stationary contacts to the load.

Notably, the momentary contacts are equipped with a flexible arm. When closing, deflection of this arm applies pressure to the contacts. This ensures that the surface of each contact is firmly pressed together to minimize contact resistance and any associated temperature rise. When contacts must carry large loads (typically 600 Amps or more), the contacts may be constructed of multiple spring-loaded segments, which provides the necessary contact deflection. Segmenting contacts results in multiple current pathways, which minimizes extent of pitting and reduces resistance and heating.

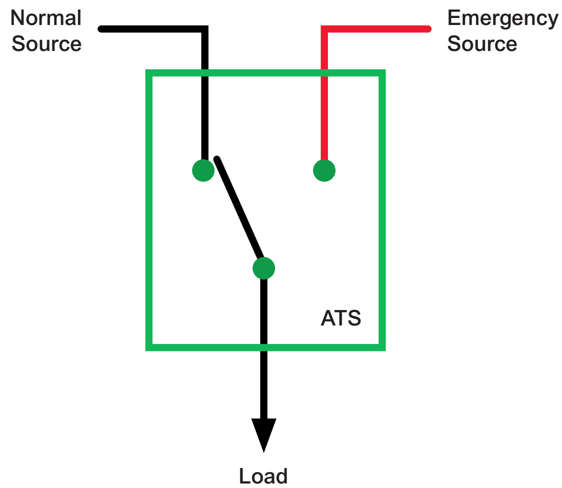

Figure 1: Transfer switches transfer loads between two power sources.

As contacts begin to close, they may experience some amount of arcing, as shown in Figure 2. As contact closure is completed, either the moveable contact deflection or the spring on the stationary contacts ensures that the mating surfaces are fully pressed together to conduct the full amount of current. As the contacts begin to open, arcing begins again. This arc is drawn across the increasing air gap until it can no longer be sustained. The cycle ends with contact in the fully open position.

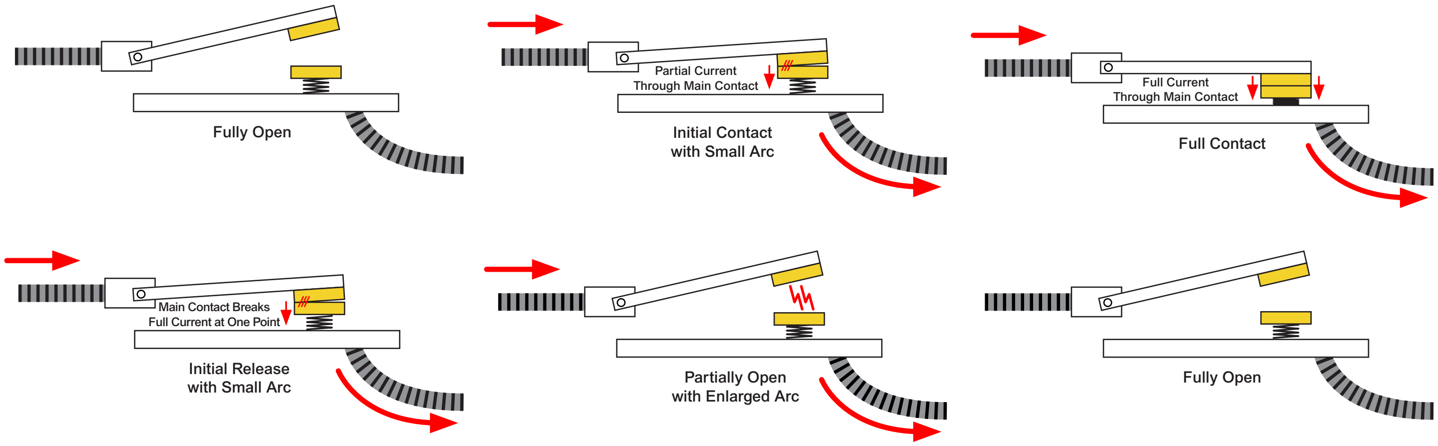

Figure 2: Transfer Cycle

In reviewing Figure 2, note that arcing occurs twice during each transfer cycle. The first arc occurs when the contact surfaces approach closure and begin to conduct current. The second event occurs when the fully-connected contacts separate. Arcing causes pitting to occur on the contact surfaces, as shown in Figure 3 below. Over time, repeated switching cycles increase the extent of pitting, which decreases the surface area of the contact, resulting in increased resistance and heating. For this reason, technicians must check contact resistance and temperature when inspecting and servicing transfer switches.

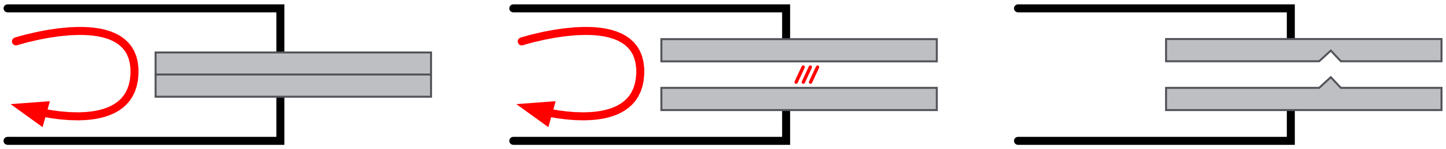

Figure 3: Arcing causes pitting of contact surfaces.

SOLENOID AND OPERATING MECHANISM

The contacts are actuated by an operating mechanism, to which a rotating weight is affixed. The weight is mechanically linked to an electric solenoid. Applying current causes the solenoid to pull the linkage, causing the weight to turn the shaft and move the contacts. Momentum continues to rotate the weight and the attached shaft to its opposite position after the solenoid is electrically disconnected, where it is mechanically held. This operation comports with Section 7.1.6 of *UL1008 – Standard for Transfer Switch Equipment*, which reads:

> *7.1.6 The operating mechanism of the normal and emergency contacts of an automatic transfer switch for use in emergency systems shall be electrically operated. Other than as noted in 7.1.7, the normal and emergency contacts of an automatic transfer switch intended for use in emergency systems shall be mechanically held in a closed position.*[1]

This arrangement also conforms with a similar requirement in Article 701.5(C) of the 2017 National Electrical Code®.[2] Figure 4 shows the operating sequence for a single transfer.

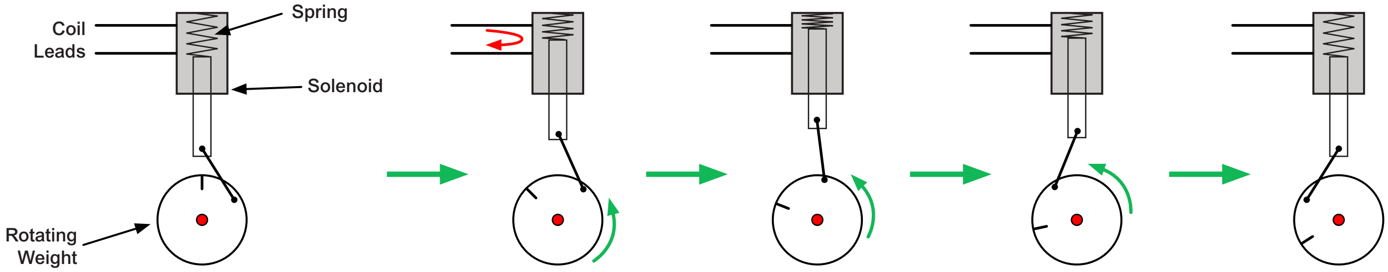

Figure 4: Mechanism Rotation Sequence

[1] Underwriters Laboratories, Inc., UL 1008 – Standard for Safety – Transfer Switch Equipment, Eighth Edition, 2014.

[2] National Fire Protection Association, NFPA 70 - National Electrical Code®, Fourteenth Edition, 2017. Quincy, Massachusetts, 2016.

Open transition transfer switches typically use a transfer mechanism with a single operator. The solenoid operator and the contacts for a single operator mechanism work together as shown in Figure 5 below. Delayed Transition and Closed Transition switches use dual-solenoid dual-operator mechanisms that allow for center-off and overlapping operation, respectively.

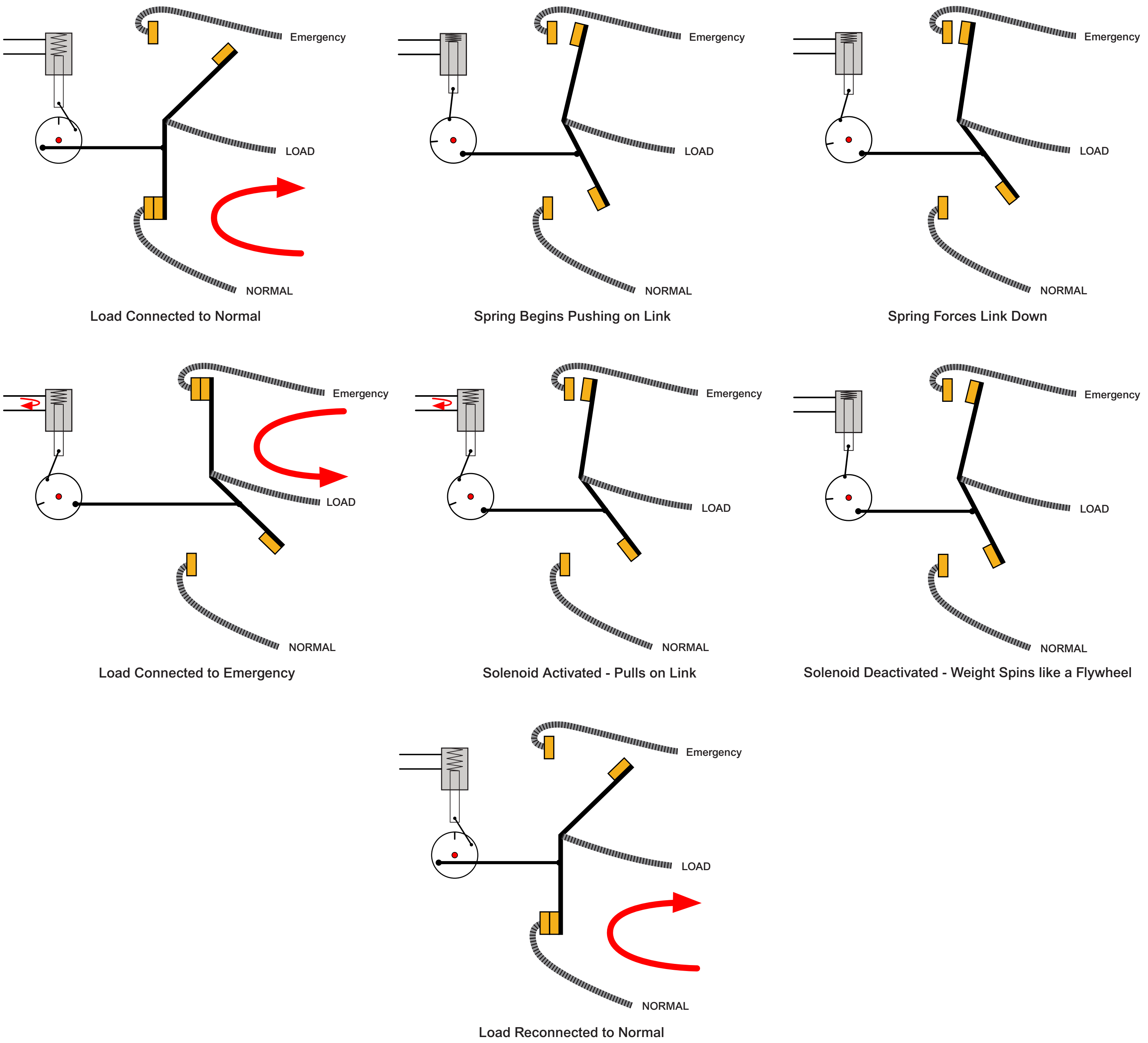

Figure 5: Switch Mechanism Operation

ARC MANAGEMENT

Arcing occurs between contact surfaces during each switching cycle. Transfers switches are designed to execute thousands of cycles during their service life. Consequently, arcing effects must be mitigated to ensure proper contact function and longevity. Two methods for reducing arcing effects include (1) adding sacrificial *Arcing Contacts* to provide an alternate pathway for arc currents, and (2) placing *Arc Chutes* near contacts to redirect and extinguish arcs. These features are described in the following sections.

Arcing Contacts

Arcing contacts are a second set of mating electrical contacts that extend from main contacts. When loads are transferred, the arcing contacts close just before, and open just after, the main contacts. As the main contacts close or open, all current flows through the closed arcing contacts, where any associated arcing then occurs. Pitting and erosion thus occur on the surfaces of the arcing contacts, which can be replaced when necessary. Their use limits arcing and its associated impacts on the main contacts. Main and arcing contacts are shown in Figure 6.

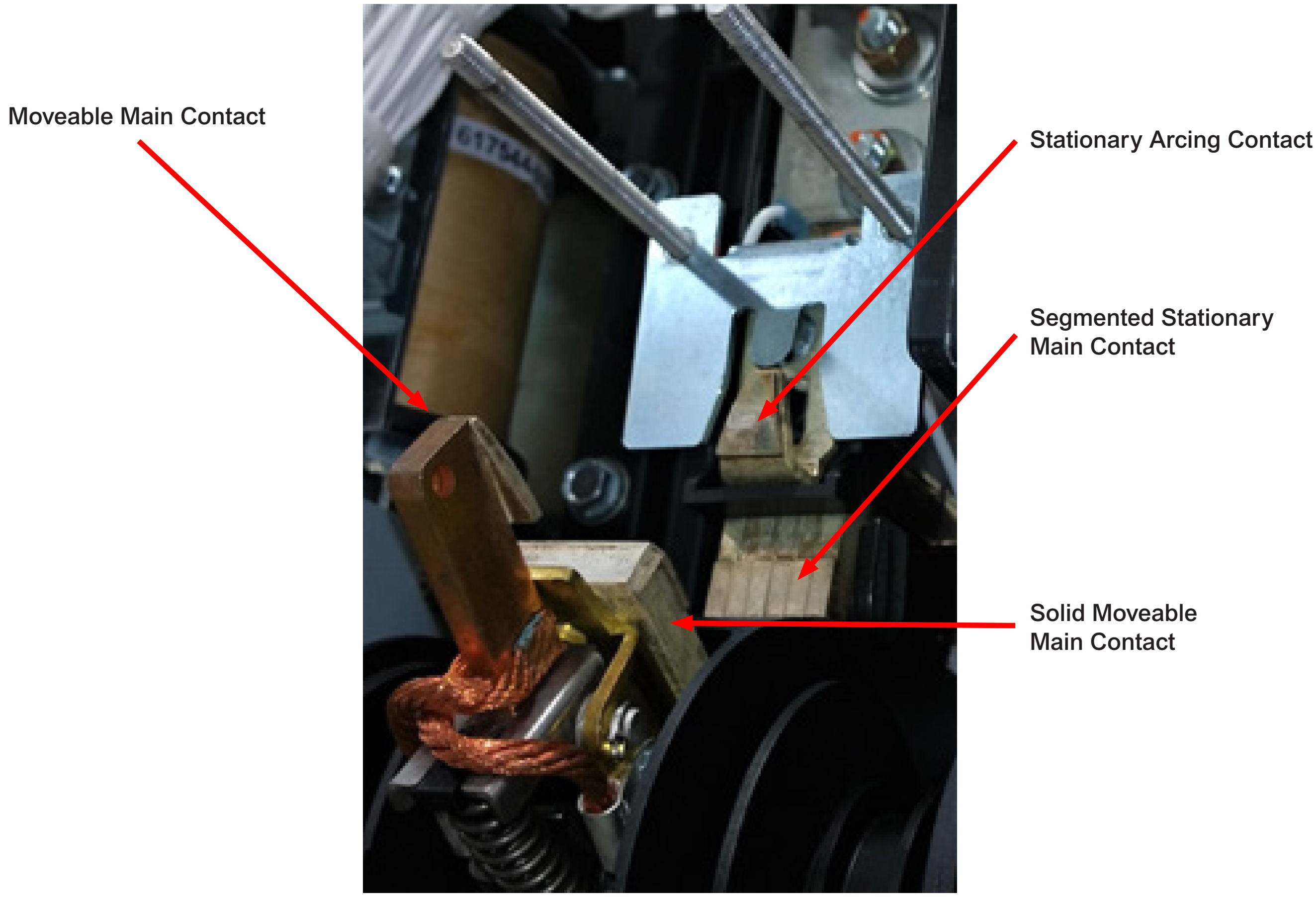

Figure 6: Arrangement of Main and Arcing Contacts

Arc Chutes

Arc chutes are assemblies of steel plates that are installed near contacts on all UL1008-listed transfer switches. These plates draw the arc away from contacts. Arc chutes also break the arc into discontinuous segments to aid in cooling and dissipation of the arc, when the associated energy is released as heat. Figure 7 illustrates their effect. Figure 8 shows an arc chute assembly. Figure 9 shows the spatial relationship between arc chutes and contacts in an ASCO mechanism.

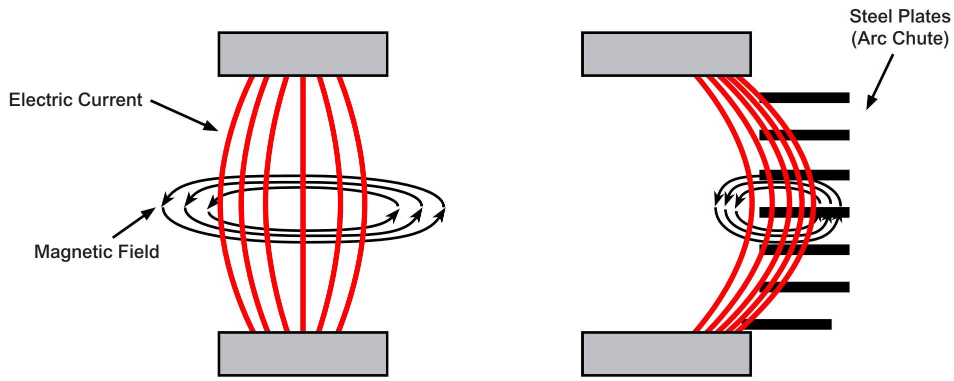

Figure 7: Arc chutes draw arcs away from contacts.

Figure 8: An arc chute assembly

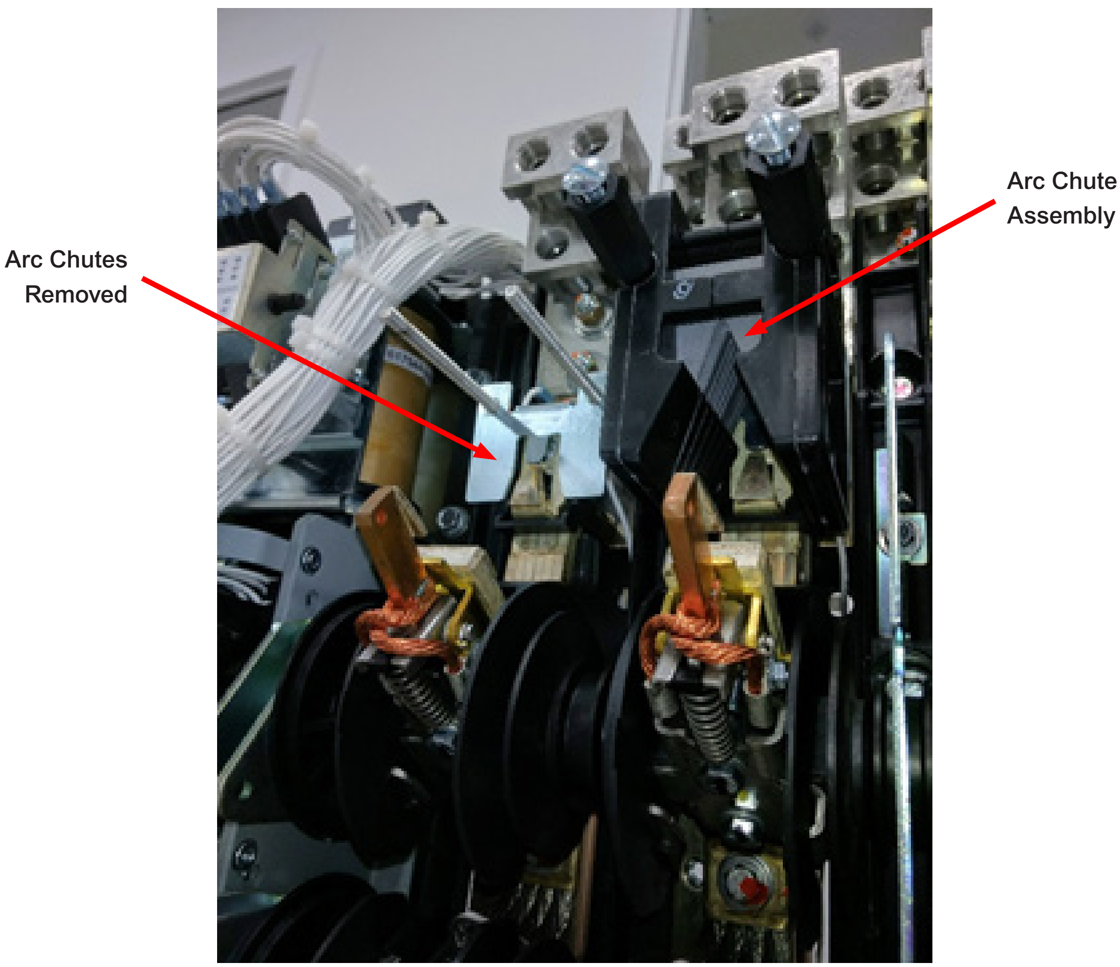

Figure 9: Contact Assemblies with and without Arc Chutes

Putting It All Together

Transfer switch mechanisms area available in a range of ampacities and features that can be selected for specific applications. Key components of transfer switch mechanisms are labelled in Figure 10 and described in the following table.

Solenoid Operator	Uses electrical power to drive the transfer mechanism
Main Contact Shafts	Rotate to move contacts in position
Main Contact - Momentary	Transfer power when engaged
Main Contact - Stationary	
Arcing Contact - Momentary	Circumvent arcing current before main contacts close and after main contacts open
Arcing Contact - Stationary	
Pole Cover	Protect switch against inadvertent contact with people and objects and prevent inter-pole arcing
Connection Terminal	Terminals for connecting power sources and loads to a transfer switch

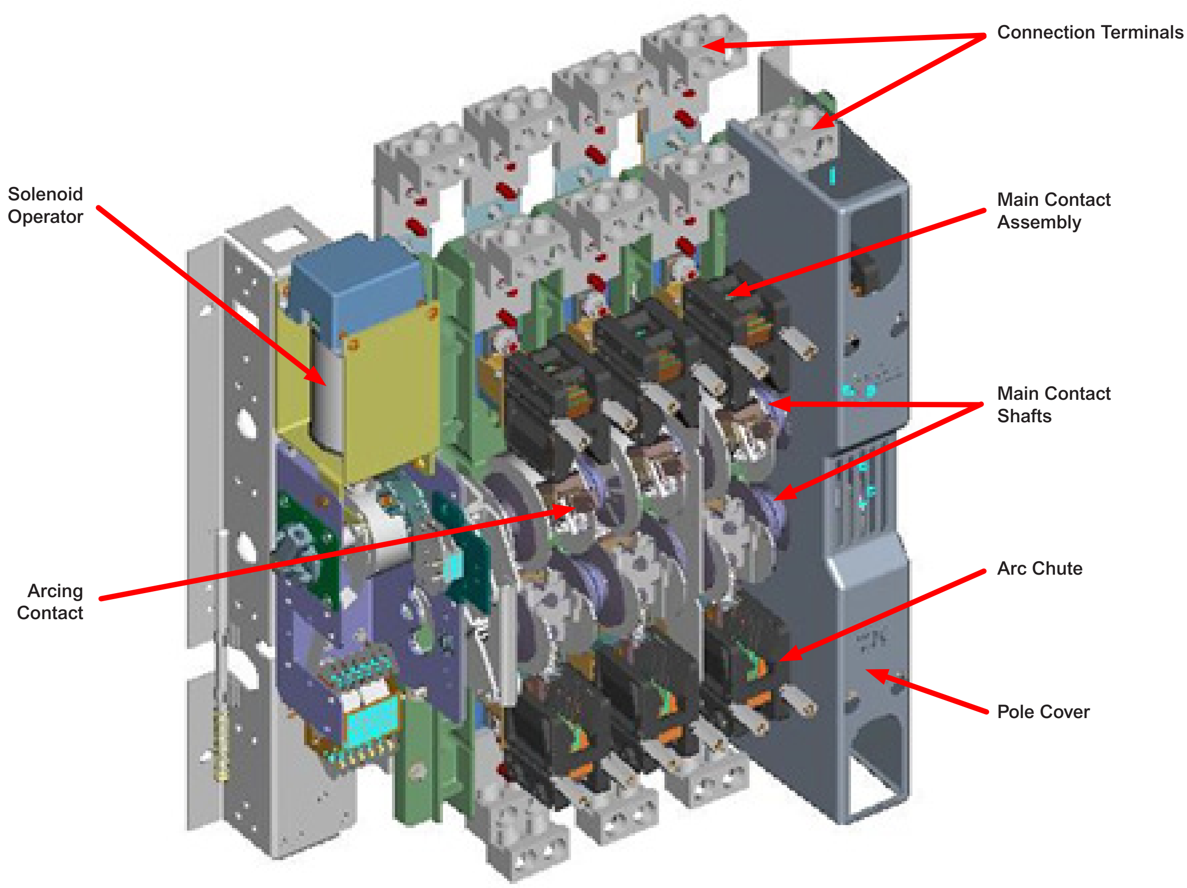

Figure 10: Key Components of a Transfer Switch Mechanism

The image in Figure 10 shows a transfer mechanism from an ASCO H-frame switch. ASCO H-frame switches have rated ampacities of 600 to 1,200 Amps. This four-pole unit switches three phase conductors and a neutral conductor. (To learn more about switched neutrals, read our White Paper entitled Switching the Neutral Conductor.) Its dual-operator design offers *Open Transition* or “break-before-make” switching. (To learn more about transfer switching modes, read Part 1 and Part 2 of our White Paper entitled *Transition Modes for Automatic Transfer Switches.*)

SUMMARY

Key components of transfer switch mechanisms include a solenoid that powers the operator mechanism(s) and its connected rotating shafts and weights. They also include the main and arcing electrical contacts and arc chutes. Open transition switches typically use a single operator and solenoid. Delayed Transition and Closed Transition switches use two-solenoid two-operator mechanisms.

A complete transfer switching cycle provides two opportunities for arcing to occur across contacts. This first occurs when contacts approach closure. The second occurs as contacts open. These arcs can pit contact surfaces, which increases resistance and produces heat.

Two methods for mitigating arcing include the use of arcing contacts and the use of arc chutes. Arcing contacts divert arcing currents to sacrificial contacts to preserve the condition of main contacts. Arc chutes breakup arcs to facilitate their dissipation. These measures mitigate arcing effects to promote equipment longevity.

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ASCO Power Technologies - Global Headquarters
160 Park Avenue
Florham Park, NJ 07932
Tel: 800 800 ASCO

whitepapers.ascopower.com
customercare@ascopower.com