



PDHonline Course E192 (4 PDH)

Loadbreaking and the Bazooms Curve

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LOADBREAKING AND THE BAZOOMS CURVE

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Course Content

1. Loadbreak Connector System Construction

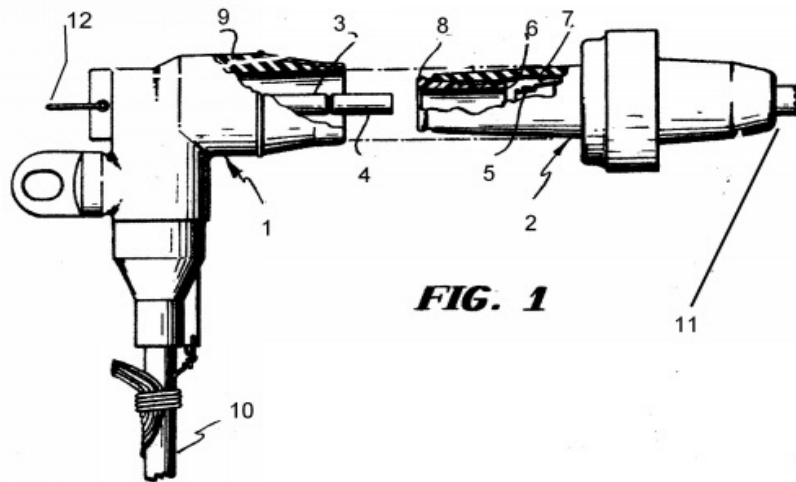


Fig. 1 depicts a sketch of the loadbreak connector system. The numbered components are as follows:

1. **THE ELBOW ASSEMBLY.** The elbow assembly is composed of a molded elastomeric insulation, which forms the configuration of the elbow itself. The insulation is jacketed or covered with a semi-conductive elastomeric layer which is connected to the ground plane. The length of the elbow will vary with the manufacturer, but it is about 8 to 10 inches or greater based on voltage ratings.
2. **THE BUSHING ASSEMBLY.** The bushing assembly is composed of a metal body, with an outer insulation that mates with the elbow assembly. The opposite connection end of the bushing can be varied depending on its application. The length of this assembly varies with the manufacturer, but it is about 5-1/2 to 7 inches or greater based on the voltage ratings of the connector system.
3. **THE PROBE.** The probe is the conductor/contact for the elbow to bushing and elbow to line conductor (10). It is a cylindrical rod, generally copper, that is threaded on one end

- to accept a connector which connects to the line conductor. The other end is designed to accept the arc follower (4) and completes the probe assembly.
4. **THE ARC FOLLOWER.** The arc follower is composed of a special material (generally thermoset or thermoplastic) which will emit an arc quenching and electrically insulating gas when struck by a high temperature electrical arc. It is cylindrical and the same diameter as the probe (3).
 5. **THE BUSHING CONTACT.** The bushing contact is a “tulip” type tubular contact, secured mechanically and electrically to the body (7) of the bushing. Longitudinal slots are cut on one end to form flexible contact leads that will accept entry of the arc follower and the probe when the elbow is inserted into the bushing. When the conducting portion of the probe meets the bushing contact, electrical connection from the elbow to the bushing is made.
 6. **THE ARC SNUFFER.** This component is also composed of an arc quenching, electrically insulating material. It is essentially cylindrical and tubular in shape but specially contoured at the open end to form a locking ring. The body of the arc snuffer is designed to mechanically connect to the body of the bushing. It forms a guide for the probe assembly when the elbow is inserted into the bushing.
 7. **THE BUSHING BODY.** This is the metallic housing of the bushing and houses the components that are part of the bushing assembly. Insulating material is molded around this part to provide the shape, interface and insulation for the bushing.
 8. **LOCKING RING.** The locking ring is an integral part of the arc snuffer (6). This portion of the arc snuffer will interface with a receptacle within the elbow to secure the elbow and bushing together when the elbow is completely inserted into the bushing.
 9. **ELBOW GROUND SHIELD.** The outer jacket of the elbow and some outer surfaces of the bushing are composed of electrically semi-conductive coverings on the insulation portion of the body. The coverings are generally composed of elastomeric material especially formulated for low electrical conductivity and connected to the ground plane.
 10. This represents the distribution conductor inserted into the elbow. This conductor normally incorporates a surrounding conductor as a ground plane. When the surrounding conductor is large enough, it can also serve as a ground return. The ground is connected to the outer jacket of the elbow (9).
 11. This end of the bushing can be configured in different ways. It can have a specific configuration to fit into the transformer, achieve electrical connection and provide an insulating interface. It can also be configured within an insulating bus to provide a bypass or power tap points when bypassing the transformer or the rest of the circuit.
 12. **PULLING EYE.** This part can be composed of an integrally molded elastomeric ring on the elbow itself or an attached metallic ring. It provides an attachment to connect to a “hot stick” (live line) pole which is about 8 foot long. The hot stick has a mechanical device at one end to hook into the eye and secure the elbow to permit manual insertion and removal of the elbow from the bushing.

Note: This depiction of the loadbreak connector system represents one of the very original

configurations. Configurations and inner constructions have varied widely in the past years. Many more complex devices exist, particularly within the bushing.

2. Standards, Operation, Performance

The generally accepted standard for this product is ANSI/IEEE Std 386. It is accepted by both ANSI and IEEE. The standards are directed to construction, operation, sealing, ampacity and insulation requirements. The only construction requirements of interest to this paper refer to interchangeability of the elbow/bushing with different manufacturers. An entire section is devoted to dimensional restrictions in order to insure each complying manufacturer's bushings are compatible with other manufacturers' elbows and vice versa. The same is true with testing. To claim interchangeability, one must be able to test combinations of bushings and elbows. We will not discuss insulation, sealing and ampacity requirements, but will only concentrate on the operation and performance of the loadbreaking and fault close functions.

Original voltage ratings for loadbreaking (load switching) were for the commonly known 15 kV systems. The actual voltages in this system measure 14.4 kV phase to phase and 8.3 kV phase to ground (8.3 kV/14.4 kV RMS). As developments progressed, 25 kV systems were included with actual voltages of 15.2 kV/26.3 kV. Some work was done for the 35 kV systems; however, the 15 kV and 25 kV systems are most widely used. Requirements are for ten samples to be tested at the manufacturer's designated rated voltage for at least ten successive successful make/break operations at 200 amperes RMS on each individual elbow/bushing combination. This test requires a circuit with an impedance value to produce a lagging power factor of 70% to 80% (current lag). Then using the designated voltage rating of the connectors, each previously tested sample is subjected to connect at 10,000 amperes RMS (fault close). No specific circuit is required as long as the current value is met. The duration of the fault current must be at least 10 cycles (0.17 seconds). This connection must be safely accomplished with no external ground current, and all parts must remain within the connector assembly. The connector assembly need not be reusable. At least one of the samples must be closed at an instant when the voltage is 80% or more of its peak value.

The operations are to be performed manually. The standards specify operation using a "live line" tool, commonly known as a hot stick. Monitoring of the test data is done by oscillograph traces or the equivalent. Voltages, currents and ground currents are observed. No ground current is allowed during operation. Method of mounting and spacing of connectors, ambient temperatures and other physical conditions are specified. Operators are generally clothed in the type of gear worn by linemen (boots, helmet, heavy jacketing, goggles, etc.) in accordance with the safety rules of the job.

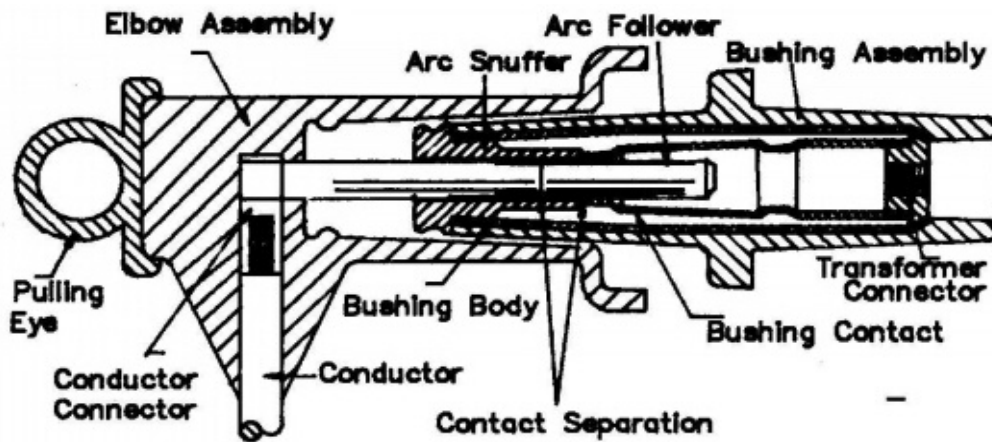


FIGURE 2

Fig. 2 depicts a cutaway representation of a sample elbow/bushing at a position where the contacts are separated. The elbow is movable; the bushing is stationary. The bushing is mounted in a transformer well at the threaded receptacle on the right side. The threaded portion electrically connects the bushing to the transformer stud, and the well intimately accepts the elastomeric insulation to effect a tight, corona-proof mating. Obviously, if the elbow is moving to the right, it is preparing to make contact. If it is moving to the left, it has broken contact and is preparing to exit the bushing. Of important note is the area shown as contact separation. This will be referred to frequently in our analysis. It refers to the point where the copper probe and the insulated arc follower are joined and the end of the bushing contact which is the point where bushing contact is initially made on loadmake or finally broken on loadbreak.

Note that a bevel exists on the end of the arc follower. This enables the operator to sense contact of the probe assembly on the bushing contact. Normal operation on loadmake is accomplished by the operator first securing the elbow to a suitable hot stick, then carefully installing the elbow into the bushing until the bevel on the arc follower is just seated on the end of the bushing contact. This can be felt by the operator. At this point, contact separation is large enough to insure the voltage will not arc from the bushing to the elbow. Then the operator assumes a firm stance, firmly grasps the hot stick and rapidly fully inserts the elbow. On loadbreak, the operator assumes a firm stance and firm grip, then rapidly completely removes the elbow from the bushing.

3. Problem Analysis and the Bazooms Curve

Early connector systems that were vented to the inside of the transformer performed well. A limit of 10 loadbreaks was imposed by the manufacturers due to the accumulation of contaminants on the arc follower and the arc snuffer. However, when the unvented, closed volume connectors were tested, problems occurred at loadbreaking and fault close. On occasion,

arcs to ground were experienced from the bushing to the elbow when disconnection was made. Also after the elbow/bushing experienced 10 loadbreaks, failures were often experienced on fault close (connection to 10,000 amperes).

In order to find the causes of what appeared to be random failures, it was necessary to instrument the events taking place during the switching operations in real time. High speed motion pictures were taken during fault close operations and revealed that unexpectedly high pressures were developed at the instant of fault close. Successful closures did not exhibit such pressures. Instrumentation was then introduced to determine the real time position of the probe and bushing connector during fault close. While the actual circuit current and voltage were available from laboratory instrumentation, positioning was difficult to instrument. The hot stick was being held by hand and the positioning and proximity of the probe and bushing contact could not be easily detected, particularly in an environment where as much as 10,000 amperes ground current could be expected. In the likely event the current would arc to the instrumentation, it would have fed back to the control room and caused considerable problems. It was then decided to mount the hot stick in a fixture and instrument the hot stick with a positioning sensor. The sensor varied a voltage proportional to its location. A position trace was incorporated with a voltage and current trace in coordination with real time. Also, it was realized that, by comparing the slope of the position trace with time, we could determine the velocity of the probe at the time of connection.

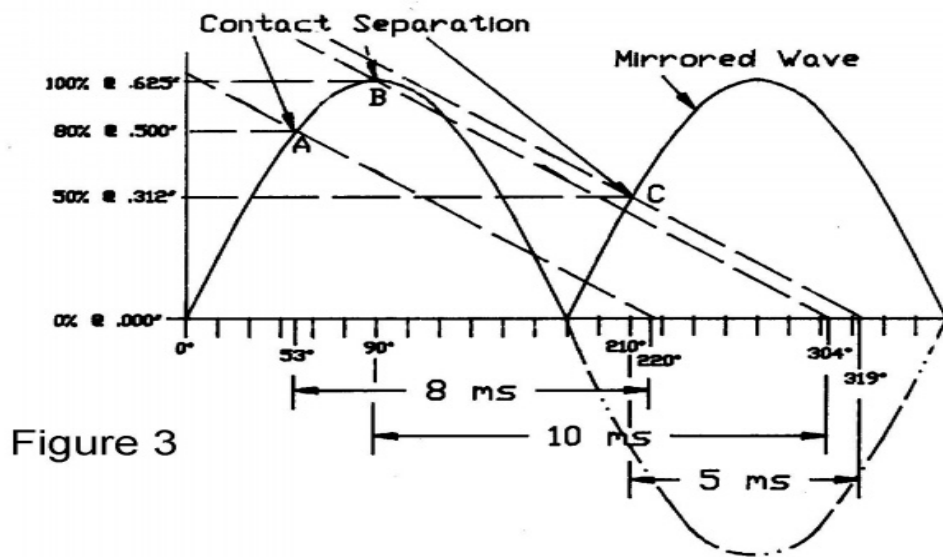


Figure 3

Fig. 3 is a drawn sample illustrating the trace details for a fault close operation. Both curves are not drawn at specific voltages, only a percentage of the maximum voltage. Fig. 3 is based on a voltage of 8.3 kV RMS, or a peak of 11.8 kV. Because we are illustrating an analysis technique, this type of analysis can be applied to fit different voltages by adjusting the parameters. The parameters must be assigned by actual experimentation inasmuch as they will vary with product use and operator.

In order to simplify our analysis, the negative portion of the voltage wave form (represented by the dot-dash line) was reflected and drawn as a positive wave form. While it is understood that, depending on electrode shape, arcing can occur at different polarities, the shape of electrodes on the elbow/bushing combination are similar and can be considered quite similar with arc characteristics. By reflecting the negative wave form as a positive wave, the position and contact separation of the elbow/bushing electrodes are more readily analyzed. When the idea was presented, however, for reasons that may appear to be obvious, the idea was dubbed “the Bazooms Curve.”

It was realized that velocity of insertion is an important parameter for fault close in order to limit arcing time. Measurement for this parameter could be easily evaluated by observing the slope of the position trace developed by the position sensor. Operators of varying size and physical abilities were tested in an effort to assign a realistic velocity for analysis. It was determined the velocity at contact separation close to the arcing point achieved a constant speed. On experimentation, it appeared that about 60 inches per second was a realistic value. Then the task of determining arcing distance was tested. Samples were tested by imposing a 60 cycle AC voltage of 8.3 kV RMS (11.8 kV peak) on the elbow/bushing, using a power supply with a low amperage capacity. The elbow was slowly inserted into the bushing until arcing was initiated. Samples previously used in the 10 loadbreaks and also new samples were tested. As expected, a considerably greater distance for arc initiation was observed for the seasoned samples. After loadbreaking, the effects of arcing on the arc follower and arc snuffer left residue which was carbonized and became somewhat conductive. The arc distance varied with each seasoned sample, but a realistic value of 0.625 inches was determined to be practical at a peak voltage of 11.8 kV.

The determinations were subsequently supported by actual fault close tests done in a power laboratory. It was also determined, after actual power testing, that seasoned elbow/bushing combinations that initiated arcing at 80% or higher voltage peak at fault close were more likely to fail with existing designs. Referring to Fig. 3, the lines representing the slopes of the contact position (contact separation) are shown intersecting the sine wave representing voltage. Once the contact slope intersects the voltage wave, arcing is initiated. We must appreciate the energy, resultant temperature and force that is created in the small fraction of an inch across the contacts. The instant arcing is initiated, a full 10,000 amperes RMS flows through this area with an arc that has literally made the ionized air separating the contacts a virtual electrical conductor.

Standards dictate that the fault currents must be maintained for 10 cycles. This amounts to 0.17 seconds (170 ms). This is the duration required for the distribution circuit breakers to

interrupt a fault of this type. Arcing within the bushing can be extinguished in only 4 ways. First, a solid contact must be made with the probe and bushing contact and hold the fault current until the breaker interrupts the current. Second, the current must reach a current zero, and the gap remaining between contacts cannot allow a restrike of the arc. Third, the contacts must be separated a great enough distance to prevent the arc from bridging the air gap. Fourth, all arcing continues until the breaker interrupts the current (10 cycles). The only safe fault close operation is the first. The current may reach zero during the fault close; however, the arc will immediately strike again (restrike) because the contacts will now be close together and the ionized air will actually provide a conductive path. Separation of the contacts will only produce more powerful arcing because the ionized air will still bridge the contact with a conductive path. If the arc is allowed to continue for 10 cycles, total damage of powerful arcs to ground will result. It again must be appreciated, that the energy of a 10,000 ampere is far too great to be extinguished or prevented with the gasses emitted from the arc follower and arc snuffer.

Fig. 3 shows 3 contact separation paths, A, B and C. All 3 are drawn at a slope of 60 inches per second. Again, it is pointed out that each operator achieves different velocities of insertion. However, it is reasonable to assume that this velocity is one that can be achieved by trained personnel, with most personnel achieving higher velocities. By observing Fig. 3, it can be readily appreciated that higher velocities (steeper slopes) achieve shorter periods of time to make contact and further decrease arcing. Path A shows a curve intersecting the voltage wave at 80% of peak. This is a separation of about 1/2 inch. At this position and velocity, contact will be made at 0.008 seconds (8 ms), which will be the duration of the arc. Path B shows a curve intersecting at 100% of the voltage wave at a separation of 5/8 inch. This curve shows contact made in 0.01 seconds (10 ms), with the arc sustained for a much longer period of time. Path C shows a curve intersecting at 50% of the wave with an arc duration of 0.005 seconds (5 ms). By comparing this analysis of actual fault close tests and results, it was determined that the critical arcing point was 80% or higher. Actually, because the current is in phase with the voltage in this circuit, an approximation of energy can be made by measuring the area beneath the curve for duration of arcing. The total area under the 80% curve measures about 10% greater than the 100% curve. If the arcing voltage is based on a relatively equal voltage due to the arc plasma generated, the energy within the arc is actually slightly more at 80%.

High lab fees, cost of manpower, travel and product samples constitute a large expense. Testing a new design required a plan to conserve these expenses. Very few problems were observed in load switching. Fault close became the most crucial part of a successful design. Further, fault close tests require that all samples be previously switched at least 10 times, and 10 successive samples are required to be successfully fault closed, with at least one at 80% more of the wave form. The objective was to be able to predictably fault close at that point to limit the samples required for design and qualification. A fixture was designed to hold a suitable hot stick in a position compatible to the normal position of an operator. The stick was not secured but loosely positioned except for a clamp that prevented forward motion for insertion. The clamp was then mechanically connected to an electrical solenoid, which was triggered to open by a circuit referencing the voltage wave form of the fault close power circuit. A simple silicon

controlled rectifier (SCR) was used to do this. The operator then moved the stick for insertion in a normal manner. The clamp would release within thousandths of a second to effect fault close at a proper point of the wave form. Because each operator varied with velocity of insertion and each sample varied with arcing point, it was not possible to fix the trigger circuitry to release the hot stick at the same point each time. Instead, the setting had to be adjusted for each operator and sample. Thus, the concept of what was termed a “mini-shot” was created. Each sample for fault close was positioned in the fixture. The power circuit was set at the prescribed voltage, but only to provide about 1 ampere of current. The clamp was set at any random release setting. The operator then “fault closed” in a normal manner at 1 ampere. The traces from the operation were then examined to determine the point where arcing initiated. Because only 1 ampere was being conducted through the contacts, no damage to the connector or change in its condition was effected. The trigger circuit was adjusted to release the clamp at the proper setting. Then the power circuit was reset to deliver 10,000 amperes with the clamp timing setting. Once the procedure was established, only 1 “mini-shot” was required to establish the particular setting for the particular operator and sample. At least 80% of the time, fault close was made within 80 to 100% of the peak of the voltage wave form. This approach alone reduced our samples, time and expenses considerably.

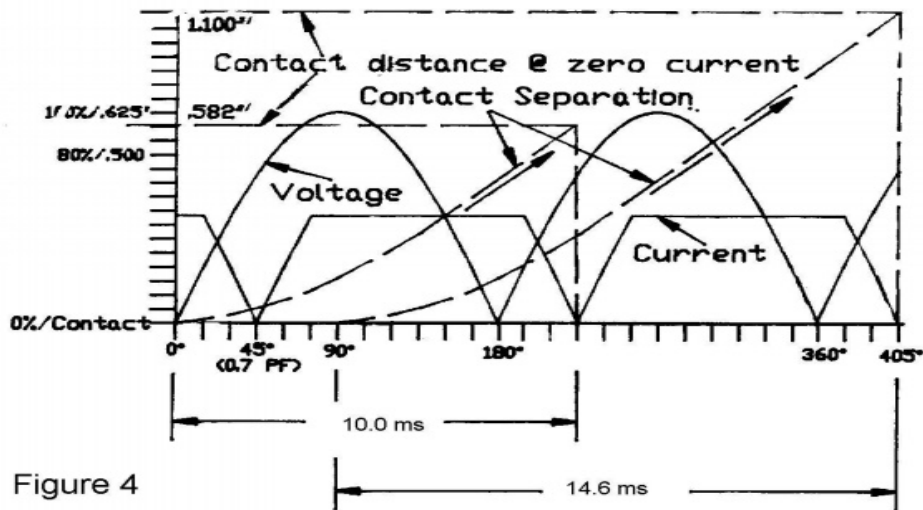


Figure 4

Fig. 4 is a set of curves representing loadbreak or disconnection of 200 amperes RMS from the circuit. Loadmake or connection would be represented in a somewhat similar fashion to the curves of Fig. 3 except that the amperage curve would not be in the same phase to the voltage immediately after arcing or connection. Because the energy of the arc at 10,000 amperes is about 2,500 times more than that at 200 amperes, virtually no problems were experienced when connecting 200 amperes. However, on occasion an arc to ground occurred on a load

disconnection. Because it happened so quickly, it was difficult to determine whether the arc to ground occurred before or after the elbow exited the bushing. Fig. 4 reveals some interesting information.

The standard specifies that the test circuit for normal current switching includes a total power factor of 70 to 80% lagging. This means that the current must lag the voltage by about 37 to 45 degrees. Fig. 4 reflects a lag of 45 degrees as worst case. Power Factor at loadmake or connection is not as critical because the arc is terminated when the probe and bushing contact meet, but at loadbreak, the arc is extinguished only at “current zero.” When disconnecting thousands of volts, it is very difficult to actually quench an arc only with gasses. At lower voltages, this is easily done, but at voltages that we are dealing with, we must depend on the arc extinguishing when current no longer flows through it (current zero). At the lower amperages (200 amperes), the gasses produced by the arc striking the arc quenching material, are adequate to prevent a restrike providing the connections are not close enough for voltage breakdown. With this circuit, at the instant current zero extinguishes the arc, however, the voltage across the contacts is leading the current and increases to a value of about 80% of the peak. Depending on contact separation distance, restrike of the arc is inevitable. Fig. 4 shows 2 contact separation paths. Note that the paths differ from those of Fig. 3 in that they are curved at the outset. This reflects the starting velocity at zero and gradually accelerating to about 60 inches per second. Again, while these values vary with the operator, they can be considered as representative. The path on the left assumes separation of the contacts has begun at the 0 degree point of the voltage wave form. Because a current zero occurs at 45 degrees on the voltage wave, contact separation at current zero is well within the arcing voltage distance, and arcing will continue.

The next current zero occurs at 225 degrees. At this point, contact separation is about 0.6 inches and the separation distance is greater than that required for restrike. While there are ionized gasses present, the effects of the arc quenching gasses emitted from the arc follower and arc snuffer are sufficient to prevent restrike with currents as low as 200 amperes. However, the path on the right reveals an interesting observation. If separation of the contacts begins at the 90 degree point of the voltage wave form, the first current zero occurs at about 225 degrees, with contact separation within the arcing voltage distance, and arcing will continue. The next current zero occurs at 405 degrees (or 45 degrees in the next wave form). While contact separation is more than enough to prevent restrike, the arc follower is beginning to exit the bushing arc snuffer while it is still arcing, exposing ionized gasses to the environment outside of the connector. Such a condition can occasionally strike an arc to ground, particularly if the “hot” side is at a probe of the elbow. This condition becomes more critical if the elbow is withdrawn at greater velocities than shown. In this case, the slope of the position trace will be even steeper, and the probe will exit the bushing at even greater separation, almost guaranteeing that arcing is still taking place. This presented a very plausible explanation for some of the arcs to ground on elbow withdrawal.

4. Definition of Problem and Solutions

After a review of the problem symptoms, it became obvious that catastrophic fault close failures were a direct result of pressures built up within the bushing. Vented connectors seemed

to be able to successfully close. Using high speed photography, unvented connectors that failed fault close were shown to build pressures so high that they actually blew up the elbows as if they were balloons. Also, the photography showed that on occasion the elbow was inserted into the bushing to a point, rapidly pushed back and then finally inserted. This occurred within thousandths of a second, not long enough to allow the power circuit breaker to clear the power and not noticed by the operator. Examination of failed parts revealed that considerable damage was done to the connectors, including melted metal and totally burned contacts. Connectors experiencing successful fault close did display some damage but in all cases the connection was made. Thus when the pressures in the bushing and on the elbow delayed contact, continued arcing further exacerbated the condition and prevented arc shutoff until the circuit breaker opened. Apparently, with fault closures at less than 80% of the voltage wave, the pressures developed were not great enough to prevent successful contact. This can be attributed to less actual amperage and to less arcing time before contact. Once contact was successfully made, the contacts in the elbow/bushing connector were adequate to hold the amperage until the breaker cleared the circuit.

Two different approaches were taken to resolve the problem. One approach was to reduce the pressures developed inside the bushing within short milliseconds of the arc initiation. Examination of the connectors after fault close (and also loadbreak) revealed small deposits of the arc quenching material within the bushing body. This was evidence that the quenching material became gasified and then condensed when it cooled on the bushing surfaces. There was also evidence that a great deal of pressure was developed when the arc quenching material rapidly expanded from a solid to a gas and was trapped within the bushing/elbow connector. The design solution incorporated a body with slightly more volume and contained a wound copper screen, capable of rapid heat absorption, placed in the expanded portion of the body. The shape of the body expanded from the contact area and reduced the effect of the shock wave created by the arc. The wave, high temperatures and gasified arc quenching material then impinged upon the screen and immediately condensed, thereby rapidly preventing further pressure buildup. (Refer to U.S. Patent #3,813,639; Shurter and DeLuca, May 1974.) This design was successfully tested to ANSI/IEEE Std. 386 and marketed.

Another approach was to effect mechanical means to hasten contact upon initial arcing at fault close. The bushing contact was movable and not secured into the body of the bushing. It also was part of a piston assembly. Upon arc initiation during fault close, the pressures developed were directed to the piston incorporating the bushing connector. This rapidly propelled the contact to the probe assembly effecting rapid connection and arc cessation. The piston mechanism only separated on fault close, not on loadmake. Many other variations were developed and patented. (Refer to patents 3,917,374, 3,982,812, 4,068,913 and others.) These concepts passed tests and are most commonly marketed today.

A third design was patented, however was never developed for testing. It permanently secured the bushing contact and incorporated a sliding tube which acted to block the arcing and prevent exposure of the contaminated follower to the snuffer until just prior to contact (Refer to U.S. Patent 5,266,041; DeLuca, Nov. 1993). This feature functioned on all operations, fault

close, loadmaking and loadbreaking.

Loadbreak performance was addressed by examining the modes of failure. Fig. 4 revealed that it is possible to carry an arc outside the bushing on loadbreak. Because standards required a grounded conductive jacket around the insulation of the elbow, the original elbows maintained the jacket to the end that interfaced with the bushing. This was in direct proximity to any ionized gasses coming out of the bushing upon elbow separation from the bushing. The insulation design was modified to leave the conductive jacket extended to the end or lip of the elbow but covered the outer jacket with an insulated jacket. This provided ground shielding and also protected the lip of the elbow from arc strikes during loadbreak.

The concept of removal of the elbow at too great a velocity was later supported with another development intended to solve the fault close problem. A spring actuated hot stick was developed to be used for fault close operation and could also be used for loadbreak. The mechanical actuator was able to insert the elbow into the bushing at velocities well above 100 inches per second, however also removed the elbow at high velocity. Upon loadbreak, some arcs to ground were detected even with insulated elbow lips. The ionized gasses found paths to adjacent grounded areas.

5. Applications

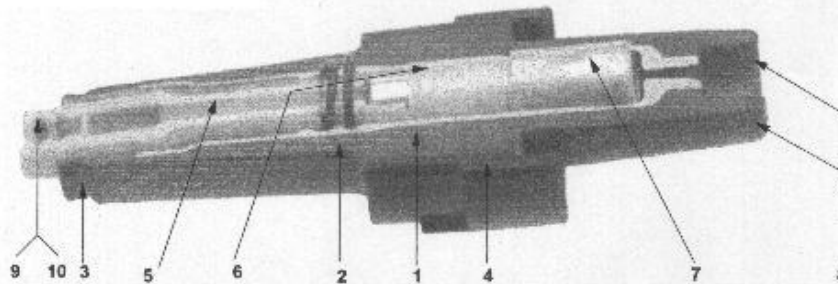
Originally, loadbreak connectors were used in primary underground voltage distribution. As previously described, they are used in radial circuits in order to isolate faulted underground circuits allowing customers to be served power while the faulted circuit was being repaired. In addition, they also used the bushing as a bus system rather than simply mounting it within the transformer. This bus system was installed in a distribution cabinet where distribution of various circuits could be made. The convenience of switching the connector using an ordinary hot stick lent a great deal to the operation. After the connector system was well tested and proven, it was used in selected high rise buildings. One of the first buildings to utilize this type of connector system was the Sears Tower in Chicago. Instead of distributing heavy secondary conductor up the total height of the building, transformers were located on selected floors of the building. The transformers used primary voltage and distributed the secondary within that floor and adjacent floors. This relieved the requirement for having secondary conductors extend over 100 stories high. Uses are applied for large factories or buildings where distribution of primary conductor at a lesser weight, could be more easily made to distant parts of the buildings or floors. Today, this is also being used within the confines of shopping centers where power must be distributed over large areas and only fed in two or three areas from the utilities. Architects, constructors and engineers will be able to discover even more applications for this very versatile and unique connector system.

Appended are catalogue pages illustrating the latest concept in loadbreak connector systems. These connects are rated for 15.2 kV phase to ground and 26.3 kV phase to phase (25 kV systems). The products are supplied by Hubbell Power Systems, Aiken, South Carolina 29801.



25 kV LOADBREAK BUSHING INSERT

Photo reprinted with permission from Hubbell Power Systems, Inc.



ALL COPPER DESIGN

The Hubbell Loadbreak Bushing Insert represents the state-of-the-industry design in an all-copper construction. It is designed for installation on transformers or other equipment having a bushing well that meets the requirements of IEEE Standard 386, Fig. 3.

PRODUCT FEATURES

1. EPDM Insulation - peroxide cured process. Provides superior stress-relaxation characteristics, assuring long life under high ambient temperature.

2. Interface - conforms to IEEE Standard 386, Fig. 7. When a suitable elbow is installed, provides proper creep distance and watertight fit.

3. Locking groove - conforms to IEEE Standard 386, Fig. 7. Mates with elbow locking ring.

4. Molded shield - conductive, abrasion-resistant 1/8-inch thick shield of peroxide cured EPDM. Three molded tabs provide convenient points for external grounding of the shield.

5. Loadbreak assembly - includes ARC MATE™ ablative material that produces gas when exposed to the loadbreak loadmake switching arc.

6. Pinch-finger contacts - part of the loadbreak assembly, which has an all-copper current path.

7. Piston assembly - patented concept. Piston movement assists operator under fault-close conditions.

8. Interface - conforms to IEEE Standard 386, Fig. 3, bushing well interface.

9. Valve Holder - patented feature containing a gas trap, "O" ring and detent "O" ring. Aids in reliable switching performance, particularly in the presence of adjacent grounds.

10. Detent - "O" ring provides a precontact detent. Provides proper spacing between the elbow probe and pinch-finger female contacts when used with an elbow probe that conforms to IEEE Standard 386, Fig. 7.

SELECTION AND ORDERING*

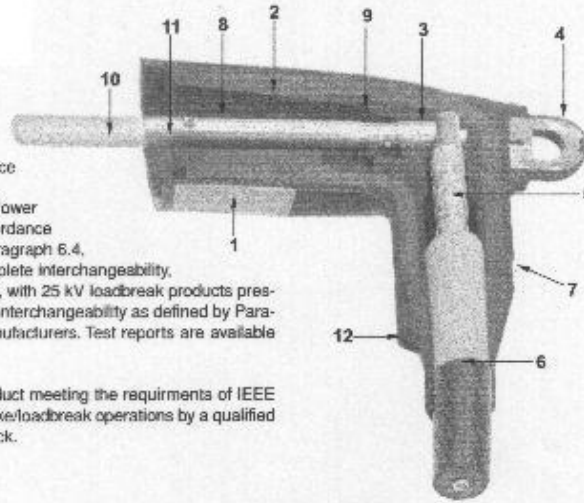
9U02BAB001	Bushing Insert
9U04BEB001	Feed-thru Insert
9U01BAJ6 — —	Bushing Insert and Elbow with Capacitance Tap (Long - Bimetal Connector)
9U01BBJ6 — —	Bushing Insert and Elbow without Capacitance Tap (Long - Bimetal Connector)

*For the last two digits of Catalog Number, refer to Selection Table shown on page C2-4.



25 kV LOADBREAK ELBOW Series 600

Photo reprinted by permission of
Hubbell Power Systems, Inc.



The Hubbell 25 kV 600 Series Loadbreak Elbow Connector has been tested in accordance with the requirements of IEEE Standard 386, "Separable Insulated Connector Systems for Power Distribution Systems above 600 Volts." In accordance with provisions of the Standard, outlined in Paragraph 6.4, interchangeability testing has established complete interchangeability, as defined by Paragraph 6.4.1 of the Standard, with 25 kV loadbreak products presently manufactured by ELASTIMOLD® and limited interchangeability as defined by Paragraph 6.4.2 of the Standard with all other manufacturers. Test reports are available upon request.

The Elbow, when mated a with loadbreak product meeting the requirements of IEEE Standard 386, is suitable for energized loadmake/loadbreak operations by a qualified lineman using a shotgun-type (Chance) hot stick.

PRODUCT FEATURES

1. Molded external shield — conductive, abrasion resistant 1/8-inch thick shield of peroxide cured EPDM.

2. EPDM Insulation — cured with peroxide process provides superior stress relaxation characteristics and assures long life under high ambient temperatures. Compatible with polyethylene, crosslink polyethylene, and EPR insulations.

3. Molded conductive insert — guards against high electrical stress from corners of crimped connector.

4. Hot-stick operating eye — reinforced with stainless steel ring. Withstands 500-pound pull and 10 foot-pound torque. Permits energized loadmake/loadbreak operation with hot-stick tool.

5. Compression connector — meets requirements of ANSI C119.4/ NEMA CC3 for Class A connectors.

6. Cable entrance — has conductive rubber stress relief area which contacts extruded cable insulation shield. Elbow model selected to assure interference fit along cable insulation surface providing proper creep distance and water-tight fit.

7. White-black-white band — identifies elbow (and mating bushing insert) as having phase-to-ground and phase-to-phase voltage rating. Both the black and white bands are individually removable.

8. Interface — allows interference-fit seal when installed on mating components designed to IEEE Standard 386 interface. Provides proper creep distance and watertight fit, yet permits unplugging of elbow after years of service.

9. Locking ring — is a part of IEEE Standard 386 requirements. Provides positive

gripping. Initial pull-off force to unseat from mating groove in bushing Insert produces fast break necessary for loadbreak switching.

10. Probe — mates with pinch-finger contacts in bushing insert or other switch point. Inner end has threads with pilot to aid installation in crimped connector without thread stripping. Outer end is made of ArcMate™ ablatives material that produces gas when exposed to loadbreak arc, permitting reliable interruption, even with close ground spacing.

11. Detent groove — mates with detent "O" ring in bushing insert valve holder.

12. Grounding tab — designed so that a single #14 awg copper wire can be inserted in the hole. Use of a separate wire is recommended. Do not use a single strand from the concentric neutral.