

Types E, 4E, and L single-phase recloser series-trip solenoid hydraulic control mechanism

The basic mechanism of series-trip solenoid-operated, hydraulically controlled reclosers has been proven reliable through many years of field service. Series tripping provides simple, reliable operation since the tripping energy is taken directly from the fault itself. During tripping, the mechanism stores energy for reclosing. Hydraulic control permits accurate coordination with other protective equipment.

Interruption takes place in oil. The contact structure provides two breaks in series. The Type L recloser has a cross-blast interrupter; Types E and 4E reclosers have self-regenerating interrupters.

Series-trip solenoid

Fault currents are sensed by a series-connected solenoid coil carrying rated line current. When a fault occurs, the movement of the solenoid plunger initiates tripping. The plunger, normally held at rest by closing springs, is drawn into the coil by the magnetic force produced by the fault current. Downward travel of the plunger overcomes springs in the operating mechanism, opening the recloser contacts. The same motion charges the closing springs in preparation for a reclosing operation.

When the contacts open, current flow is interrupted, deenergizing the solenoid coil. This allows the solenoid plunger to return to its original position under the force of the springs that were loaded on its downward stroke, permitting the closing springs to close the recloser contacts.

Since contact closing speed is controlled by the springs, it is independent of the magnitude of the fault current. The time to initiate a contact opening is related directly to the speed of the solenoid plunger which, in turn, is proportional to the level of fault current passing through the solenoid coil. During a delayed trip operation, the hydraulic control mechanism modifies the speed of the solenoid plunger, but is still directly related to the level of fault current.

When the recloser operates to lockout, the hydraulic mechanism releases a charged lockout spring and mechanism, preventing the plunger from resetting and the contacts from reclosing.

The series-trip coil is capable of withstanding the magnetic forces generated by maximum-rated fault currents and is effectively shunted by a bypass gap for surge protection.

Hydraulic control mechanism

Types E, 4E, and L reclosers incorporate a hydraulic control system which provides selectivity in timing, enabling flexibility in application and coordination with other protective equipment.

All timing is governed by the hydraulic mechanism which:

- Controls timing before contact opening
- Establishes time delay before contacts reclose
- Counts the number of trip operations
- Locks out the recloser when the preset number of operations has been completed

Recloser time-current characteristics are established for each solenoid coil rating available (Figure 1). The A characteristic is the fast curve (no intentional time delay). The others (B, C, and D) are the time-delay curves, one of which may be specified when ordering the recloser. Curve identification is built into the catalog number.

For time-current characteristics of Type L recloser, see Reference Data R280-91-3; for the Type E recloser, see Reference Data R280-91-10; for the Type 4E recloser, see Reference Data R280-91-8.



Powering Business Worldwide

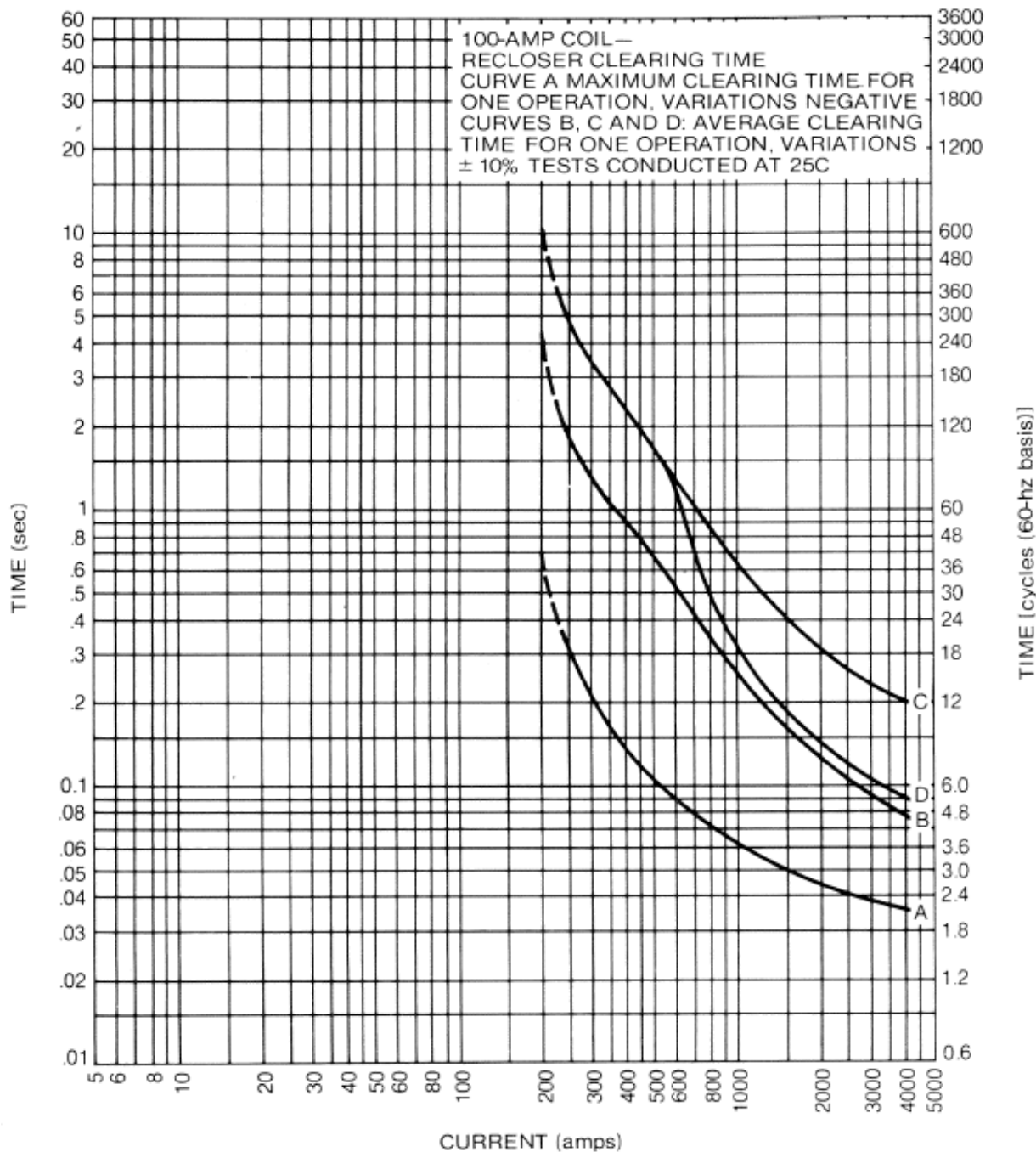


Figure 1. Typical time-current characteristics for Type 4E reclosers. Full-scale curves for all coil ratings are available in Reference Data R280-91-8.

Fast and delayed tripping

Current above minimum trip flowing through the solenoid coil causes the solenoid plunger to be pulled down, forcing oil out of the plunger chamber. The flow of the displaced oil determines the timing before contact opening. Reference Figure 2.

Initial fast tripping is obtained by allowing the free flow of oil from the plunger cylinder as the plunger is pulled down. The displaced oil raises the slide valve and flows unimpeded through the escape port between the slide valve cylinder and the trip piston cylinder. Time-current characteristics follow the A curve.

A pump piston, part of a separate hydraulic circuit, moves down as the solenoid plunger moves up on its return stroke. The piston's downward stroke pumps a measured charge of oil under the trip piston. This charge is retained by a ball-check valve.

As subsequent operations advance the trip piston up, it blocks off the escape port. Oil flow from the plunger cylinder is then limited by the timing orifice, impeding downward travel of the solenoid plunger. This provides time-delayed tripping; the time-current characteristic is determined by the size of the timing orifice. Time-current curves B, C, and D are thus developed, permitting close coordination with fuses and other protective equipment.

When delayed operations are caused by low-current faults, oil escapes only through the timing orifice in the timing plate. If the magnitude of the fault is higher, the pressure developed is sufficient to open the spring-loaded control valve, and oil flows through both orifices. The combination produces the desired inverse-time shape of the curve.

As the solenoid plunger begins its return travel following the final trip operation in the preset sequence, the trip piston raises to where it releases the lockout toggle, preventing reclosing. Contacts are held in the open position until manually reset.

The trip piston resettles by oil bleeding past the trip piston. Resetting time is approximately one minute per operation. The recloser can then be reset for a new sequence of operation. Should a fault clear before lockout, the bleeding action permits the trip piston to resettle at about the same rate.

Reclosing Time

Reclosing time is controlled by an orifice in the slide valve. When the recloser contacts are in the open position, the closing springs are exerting force to return the solenoid plunger back up to its normal position. The resulting reduced pressure in the plunger cylinder draws the slide valve down and blocks the escape port between the slide-valve cylinder and the trip-piston cylinder. Oil flow into the plunger cylinder is limited to the slide-valve orifice. This restricted flow results in reclosing time of one and one-half seconds. Reference Figure 3.

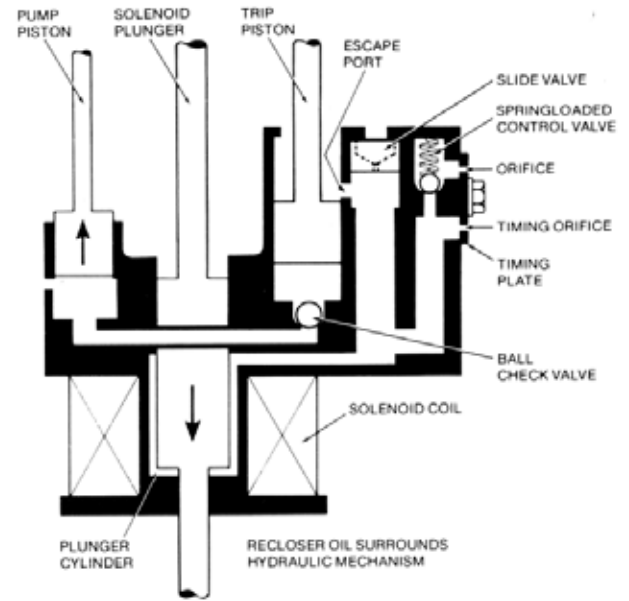


Figure 2. During fast tripping, oil flows freely from the plunger cylinder as the plunger is pulled down. On delayed operations, the trip piston blocks the escape port, so the timing orifice is the only opening through which oil can flow.

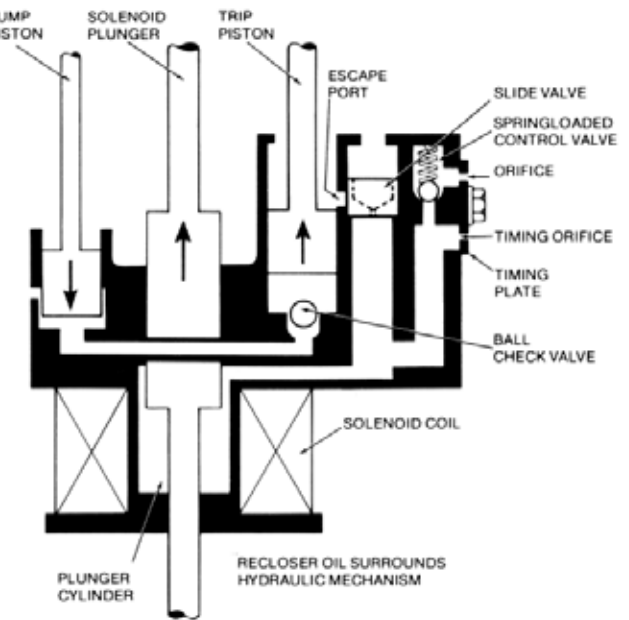


Figure 3. During reclosing, oil flow into the plunger cylinder is limited to the slide-valve orifice, resulting in reclosing times of about 1-1/2 seconds.

Hydraulic control settings

Several timing characteristics and sequences can be programmed for a maximum of four operations. When a recloser is programmed for both fast and delayed operations, the fast operations occur first in the sequence and are according to the A curve time-current characteristic. Delayed B, C, or D time-current curves are determined by the position of the timing plate (Figure 4).

The most commonly used operating sequence is two fast operations followed by two delayed operations. Other sequences including fewer operations to lockout are also available and are obtained by substituting hydraulic parts. The operating sequence, including the number of fast and delayed operations, is built into the catalog number.

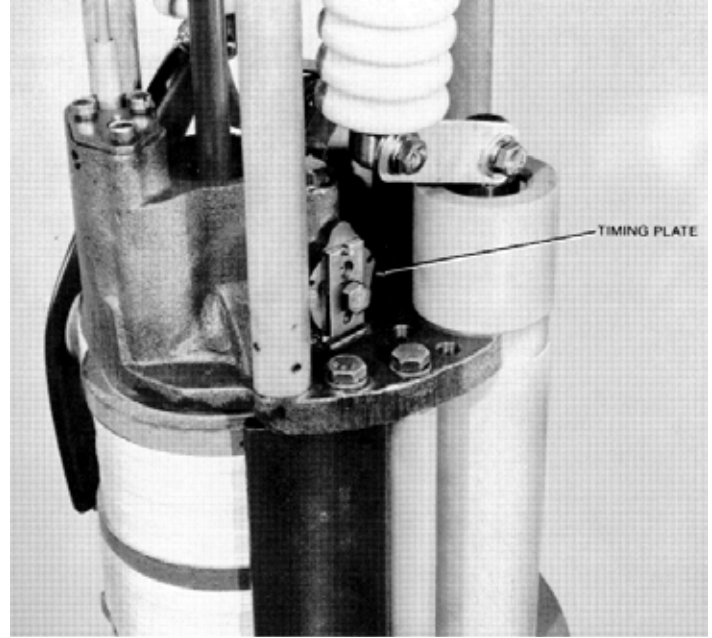


Figure 4. The Type 4E recloser timing plate determines B, C, or D time-current characteristic. (Type L is similar).

Eaton
1000 Eaton Boulevard
Cleveland, OH 44122
United States
Eaton.com

Eaton's Cooper Power Systems Division
2300 Badger Drive
Waukesha, WI 53188
United States
Eaton.com/cooperpowerseries

© 2015 Eaton
All Rights Reserved
Printed in USA
Publication No. TD280020EN