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OVERLOAD CURRENT PROTECTION OF MERCURY-ARC RECTIFIERS

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/A Digest/

The basic requirements for the protection of mercury-arc rectifiers from excess currents are rapid action, selectivity, and maximum sensitivity. High-speed protection is necessary in view of the sharp loss in vacuum due to the time lag which occurs when the arc-backs in the rectifier are cut off.

A positive solution of the problem of high-speed protection simultaneously satisfies the requirement of selectivity, when damage occurs in the high-voltage alternating current circuits. Consequently, the nature of the protective action against this type of damage will not be discussed here. The requirement of maximum sensitivity is stipulated by the fact that relatively weak currents may arise in the primary winding of the transformer when the arc-backs originate.

In view of frequent occurences of arc-backs, protection for this form of abnormal condition must be very reliable to prevent deterioration of the internal condition of the rectifier. Such deterioration may result from delayed protective action or strong actuating current in overload relays.

Existing Methods for Achieving Protection

As protection against excess currents, caused either by breakdowns in the transformer or by arc-backs, two-phase overload protection has generally been used, operating with time delay or instantaneously (cut-off). For manual control with circuit breakers, direct-acting overload relays built into the breaker drive mechanism were frequently used.

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The actuating current of the cut-off relay must be greater than the magnetizing current kick which may arise when the transformer is switched on. In practice this current has four to ten times the value of the nominal current. Therefore, a protective scheme in which the actuating current is large enough to permit switching on the transformer, with specified values for the magnetizing current kicks, is inadequate from the standpoint of protection requirements against arc-backs in the rectifier, where the value of the breakdown current in the primary winding of the transformer may, in the initial stages, be lower than the specified values for the magnetizing current in some cases.

Furthermore, good results cannot be obtained from a time-delay protective device which can operate at lower actuating currents (due to the rapid decrease in the magnetizing current kick) since instantaneous action of the protective device is the basic requirement for counteracting arc-backs.

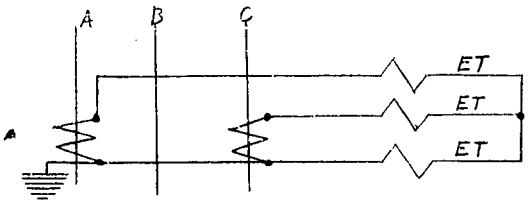
The protection given by the two relays in two-phase protective schemes may be inadequate due to unbalance in the breakdown phase currents. Therefore, three-phase protection should be used in such cases. This does not require three-current transformers; all that is needed is the inclusion of a third relay operated by the sum of the currents of two phases. The effect is the same as that of including three relays operated by the phase current of three current transformers.

Protective Devices Operating on Direct Current

The circuit diagram below shows a proposed scheme for overload current protection which is largely free of the defects mentioned above. Protective time delay is used only when the transformer is switched on. Normally, the protective device operates without time delay, which makes it possible to select the actuating current of the overload relays corresponding to the minimum value of the breakdown current during arc-backs at the anodes.

Direct Current Scheme of Protection for Mercury-Arc Rectifiers

Circuits for Current Transformers



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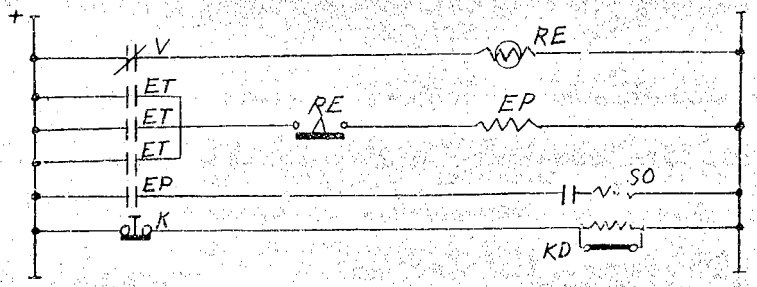
Operating Circuits of the Protective Device



ET-Instantaneous overload relay
EP-Intermediate relay
SO-Cut-out solenoid for circuit breaker
V-Block contact for circuit breaker
K-Push button
KP-Holding coil of VAB automatic equipment
RE-Type RE-102 electromagnetic relay with damper

For Type RMNV 500 x 6 (12) rectifiers, grid-protection devices using thyratrons are supplied by the plant. So far as is known to the author, at present, there is no operational verification on the use of this device But if it proves reliable in practice, and grid protection satisfies the given requirements, the role of overload protection in the sense of protection from arc-backs will become less important, since proper grid protection, according to the "Rules for the Operation of Industrial Installations," must function in at least 75 percent of the cases of arc-backs. In addition, there are grounds for anticipating, when grid protection is used, that the installation will not be switched off as a result of overload protection because of the great sensitivity of the thyratrons and the great speed with which negative potential is applied to the rectifier grids.

Protective Devices Operating on Alternating Current

When there are no independent sources of operating current, the proposed protection scheme can be operated on alternating current.

In this case, the basic protection of the transformer against interphase short circuits in the windings and at the outlet leads is effected by means of direct-action relays which cut out the transformer without time lag. The actuating current of these relays is selected according to the maximum value of the transformer current magnetization kick which is determined experimentally.

For protection from arc-backs, a separate relay system is provided which, when operated on direct current, serves as protection against all types of breakdowns.

The operating circuits for arc-back protection are fed from the alternating current supply lines through selenium rectifiers connected in a Graetz fullwave circuit. The output voltage of a Type VS-6 selenium rectifier, when supplied with 220-volt alternating current, is 160 volts with a load of 2 amperes. This operating voltage is quite permissible for rapid closing of the intermediate relay and the cut-off solenoid, which have coils with a nominal voltage of 110 volts. The blocking relay with a nominal coil voltage of 220 volts also operated reliably, its core being pulled in down to 70 volts.

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Connecting selenium rectifiers directly to the 220-volt phase voltage of the alternate current network is undesirable as there would then be a permanent ground on the operating circuit. An intermediate transformer should therefore be provided, excluding metallic contact between alternate current and operating circuits. A single rectifying circuit of suitable power can be used to feed the operating circuits of several units.

Although the busbar voltage of a 6-10 kilovolt substation may fall during arc-backs in a mercury rectifier, it is practically impossible for the alternate current operated protection to fail, since a voltage margin was provided for in the circuit, as described above. Therefore, the protection is adequate in such cases.

The holding coil of the TAZ automatic equipment can also be fed from the selenium rectifiers, while the cut-off circuit of the closing solenoid of this equipment can be fed from the rectified voltage circuit of the mercury-arc rectifier.

Opening of the automatic device due to short circuits in the alternate current network, accompanied by heavy voltage drops, are very rare when the holding coil is fed as described, and in practice this does not effect the reliability of supplying electricity to the direct current consumer.

Conclusions

1. Relay protection of mercury-arc rectifiers can, as a rule, be operated on alternating current. Direct current should be used when storage batteries, installed for purposes not connected with the mercury-arc rectifiers, are available.

2. Whether alternate current or direct current is used, maximum sensitivity to arc-backs in the rectifier is required. This involves the use of three-phase overload protection with a time interlock to allow for the magnetization current kick when the transformer is switched on.

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