MISCELLANEOUS ELECTRICAL VOLUMES II

FIST VOLUMES 3-18 THROUGH 3-28

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UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF RECLAMATION

MISCELLANEOUS ELECTRICAL VOLUMES II

CONTENTS

BUREAU OF RECLAMATION

FACILITIES INSTRUCTIONS, STANDARDS, & TECHNIQUES

Volume 3-18

REPLACING GLAZE BURNED INSULATORS

Replacing Glaze Burned Insulators

It is recommended that damaged or suspected damaged transmission line and station insulators be immediately replaced to reduce the probability of in service failures and subsequent outages.

Very few insulators are punctured in service, since a surface flashover usually occurs before puncture. When puncture does occur, it is usually the result of small cracks in porcelain started by cement growth or mechanical or thermal shock. Since a puncture usually occurs under the head of the insulator, there may be no visual evidence of the damage. The only reliable method of detecting the puncture is electrical test. The Doble test method has proven quite reliable.

Large arc burns on transmission and bus insulators indicate that the insulators have been subjected to electrical and thermal stress, which could cause complete failure at a later time. A number of transmission line suspension insulators, which had been damaged by flash burns, were tested by the Doble method, and it was found that they did not meet acceptable standards for good insulators.

In view of the comparatively low cost of line and bus insulators and the uncertainty of retaining burned insulators in service, all insulators with extensive glaze burns should be replaced without delay.

Line and bus insulators with chips or broken skirts have been subjected to mechanical stress which may result in future failure. Because of the relatively low cost of such insulators, all insulators with evidence of mechanical damage should be removed from service and junked.

Minor glaze burns probably have little effect on the reliability of insulators. However, it is recommended that insulators with such burns be replaced, when convenient, in order to eliminate all doubt. A record should be kept of the location and extent of all flashovers.

High-voltage equipment bushings, which do not depend on the bulk porcelain for insulation strength, can be retained in service with small chips or glaze burns provided no more than one skirt is damaged, and there is no evidence of cracks in the main porcelain shell. Such damaged areas, are usually cleaned and painted with glyptal. Since a glyptal finish tends to crack after a prolonged exposure to the elements, epoxy materials have been used for this purpose, or as an adhesive to replace a piece which has broken off.

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CORRECTION FOR FAULTY OPERATION OF MERCURY SWITCHES

Correction for Faulty Operation of Mercury Switches

For approximately the first two years of operation of the Trinity Plants, problems were experienced with the units tripping off or locking out due to false operation of the mercury switches. This trouble was first experienced by the Lewiston Construction Office personnel before these plants were transferred to operation and maintenance status.

Investigation of this repetitive problem disclosed that operation of these mercury switches (thrust bearing oil level-, turbine bearing oil level, thrust and lower guide bearing oil temperature switches, and occasionally others) was initiated by vibration. This vibration was greatest as the units were synchronized on the line and as the units passed through rough loading ranges. The troubles initiated by rough synchronizing were corrected by proper adjustment of the automatic synchronizer.

It was found that the mercury switches were mounted practically flat and heavy vibration caused the mercury to splash, momentarily closing the contacts. Anti-vibration type mercury switches were purchased by the Lewiston Office for the thrust bearing oil high and low level interlocks on each generator as these were the switches that had caused the greatest number of false operations. The anti-vibration mercury switches have been very satisfactory after minor adjustment on the slope of the mercury tube.

False operation of the remaining mercury switches has been corrected by relocating some of the switches to locations where they are subject to less vibration and by adjusting the mounting to increase the slope of the mercury tube to prevent the mercury from splashing. Therefore, it has not been necessary to replace any of the remaining mercury switches with the anti-vibration type.

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GENERAL GUIDE FOR CHECKOUT OF NEW ELECTRICAL FACILITIES

General Guide for Checkout of New Electrical Facilities

The following list is to be used as a general guide for O&M checkout of new facilities, and should be followed to the extent practical prior to placing the facilities in commercial operation.

1. Schematic diagrams are to be checked for errors. Special consideration must be given to schematic diagrams for differential relaying current circuits and for ground relay polarizing circuits since errors are most frequently found in these circuits.

2. All detail wiring diagrams should be checked against the schematic wiring diagrams.

3. Check control wiring against the detail wiring diagrams. A complete detailed O&M check of all control board wiring is not required if such a check was made by the construction inspectors. However, in all cases a complete detailed O&M check of all alternating current protective relaying and metering current and potential circuit wiring is required regardless of checks by others.

4. Check the polarity of all current transformers, and check the ratio where practicable. The polarity of ground relay polarizing current transformers in the tertiary windings of autotransformers should be checked using the method presented in the copy of an article at the end of this section from the February 8, 1965, issue of Electrical World magazine.

5. Test and adjust all revenue and non-revenue metering equipment and all kilowatt-hour telemetering facilities.

6. Test and set all protective relays, and test all switchboard instruments.

7. Check and calibrate all analog and digital telemetering.

8. Test and adjust all supervisory control and associated selective telemetering equipment.

9. Test and adjust all communications circuits regardless of type and use.

10. Doble test all power transformers, circuit breakers, instrument transformers, lightning arresters, coupling capacitors, bushings, etc. These initial test results will be used as reference points for evaluation of future tests.

11. Make physical oil and dissolved gas-in-oil tests (where applicable) for oil filled equipment. These tests results will also be used as references for judging results of future tests.

12. Check all gages and alarms for proper operation.

13. If a factory erecting engineer was employed during installation of a circuit breaker and records are available, no O&M check of the breaker is required. If no erection engineer was employed, a complete O&M check of breaker adjustments, timing tests and contact resistance tests should be made. Timing tests must be made after installation of a circuit breaker in any event.

14. Check all high voltage switches for proper operation and adjustment

15. Make complete functional tests of all controls and equipment. Tests should be made to determine that each element of each relay and other protective devices trip the proper circuit breakers; all manual controls, including supervisory, function properly; all reclosing, transfer trip, and blocking schemes operate properly, etc.

16. After energizing, test and adjust capacitor potential devices.

17. Check phasing and phase rotation and check synchronizing circuits.

18. Take current, voltage and phase angle readings in directional overcurrent, distance, and differential relay circuits. In overcurrent-type bus differential relaying schemes where the current through the relay is zero under normal conditions,

one set of current transformers should be shorted, the external leads disconnected, and measurements made for proper unbalanced current in the relay coils. This test should be made with loads on all circuits connected to the bus to verify that all current transformers are connected properly and none left shorted.

19. Inspect all nameplates for control board panels, meters, instruments, relays, control switches, high-voltage switches, fuses, etc., to be certain that they are correct and in accordance with the latest standards. If any nameplates are missing or are incorrect, adequate temporary labels must be provided before the equipment is released for operation. Any temporary or special operating instructions shall be furnished by the use of the "special condition" procedure outlined in FIST Volume 1-1, Power System Clearance Procedure, or by permanent instruction plates, whichever procedure is appropriate.

20. Conduct staged fault tests. Such tests will be made on the transmission lines terminating in a station. Staged faults are not required inside station differential zones, but oscillograph elements should be connected in the appropriate differential current circuits to check for balance and current transformer saturation for through faults. Normally, one phase-to-ground fault and a phase-to-phase fault on the other two phases should be made on each line.

ELECTRIC UTILITY METHODS REPORT

Lv Dc Checks Current-Polarized Directional Grd Relays

W. A. Wolfe, System Protection Engineer,
Kansas Gas & Electric Co., Wichita, Kansas

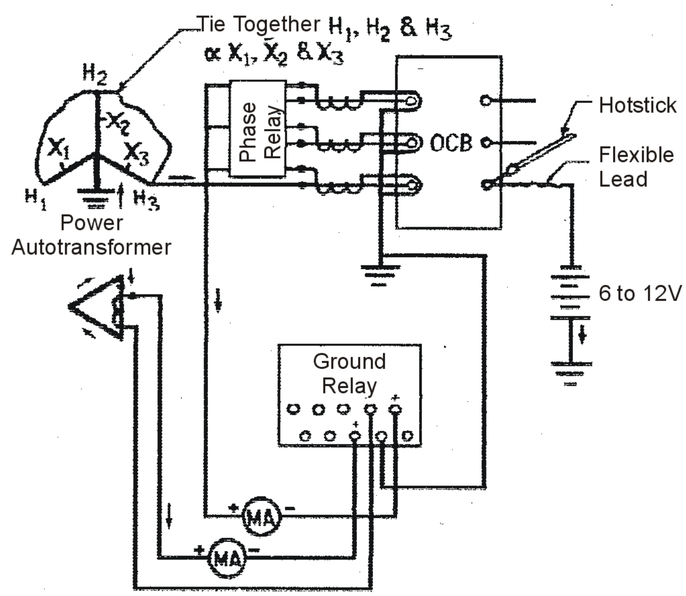
Connections required in the test are shown in the illustration. From the manufacturer's instruction book and prior testing, the relative polarity of the relay coil terminals will be known. With the milliam-meters connected as shown with respect to the known polarity of the relays, closing of the circuit will cause both milliammeters to connected in the same direction; when the circuit is opened they will deflect in the opposite direction. In the case of relays protecting large transformers, several seconds must be allowed for the iron to magnetize before the circuit is opened to get a deflection.

In most cases three terminals of the wye-connected winding must be tied together to gel sufficient meter deflection. Use of a hot stick, rather than a knife switch or similar low-voltage device, is recommended to make anti break the circuit because considerable voltage and a rather long arc are generated when the circuit is broken. With careful attention It/ making the lest connections, it is possible also Itl check the line and polarizing circuits separately if the circuit from the transformer to the OCB, as shown, cannot be completed conveniently.

Correctness of connections for current polarized directional ground relays may be checked easily with a low-voltage, dc-test method devised al Kansas gas & Electric Co. It replaces the procedure of carefully tracing wires and connecting the relay, then hoping for the best.

The new method also is simpler than the elaborate and clumsy approach, sometimes used for circulating primary current of proper magnitude to operate the relays. The method does not, however, eliminate the need for care in connecting the relays; rather, it offers a satisfactory method of proving out the connections to these relays.

The method requires several No 6 dry cells or an automobile battery of 6 or 12 v, a means of opening and closing the circuit and one or two dc milliammeters. One or more of the milliammeter scales on the common multi-meter (volt-ohm-milliammeter) test instrument are ideal for the latter.



SIMPLE METHOD requires one or two dc milliameters, plus a dc supply source to prove connections to relays

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GENERAL ELECTRIC COMPANY RELAYS

General Electric Company Relays

General Electric Company Type Rpm Relays

At one of our facilities, false tripping has been attributed to overtravel in a General Electric Type RPM timer relay. The cam assembly overtraveled while resetting, and this allowed the TU2 contact to close. This happened just as the fault was reestablished and allowed the backup distance relay to trip without delay.

Some newer RPM relays are provided with a cam to maintain the TU2 contacts closed, after its time delay, until the RPM is deenergized. When a long-time delay is required, the back edge of the cam is near the TU2 contacts at the reset position; and any overtravel during resetting can cause the cam to bump the TU2 contacts closed.

The photographs below show a type RPM relay with the setting of its TU2 near its maximum. Figure 1 shows the position of the cam at reset. Figure 2 shows the cam's position with the relay energized. Figure 3 shows TU2 contact closed due to overtravel during reset.

At locations were this is found to be a problem, a small portion of the cam's surface can be removed from the back edge. Only that portion of the cam that is causing the problem should be removed, since a shorter time delay setting may be required in the future.

All type RPM relays should be checked to see that this problem does not exist during the next scheduled routine test.

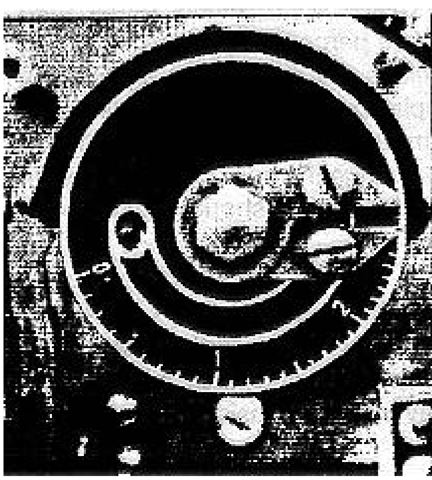

Figure 1

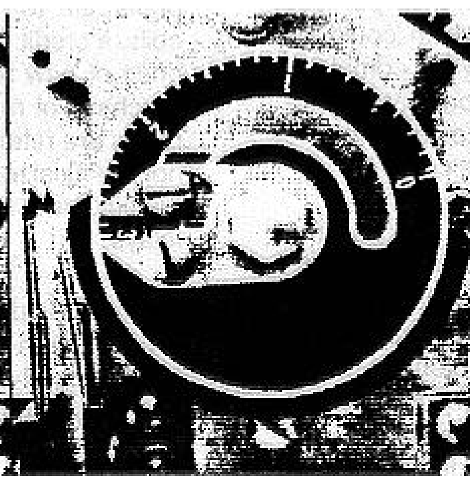

Figure 2

Figure 3

Potential Problems With General Electric Type HFA, HGA, HKA, and HMA Relays

The following information was received in a letter dated October 15, 1973, from the General Electric Company, Installation and Service Engineering Department, Denver, Colorado.

In 1954, a program was initiated to improve the mechanical and electrical properties of paper-based spools used for General Electric Type HFA, HGA, HKA, and HMA relay coils. Heat-stabilized nylon was selected for the spool material because its temperature characteristics made it well suited for Class A coils, and the material provided the desired improvement in electrical and mechanical properties. Manufacturing of HMA relays with the nylon spools started in 1955. After 3 years of successful experience, the change to nylon spools was implemented in HFA, HGA, and HKA relays in 1958.

In the mid-60's, a few failures of HMA coils utilizing the nylon spools for d-c applications were reported. As a result of these failures, an investigation was undertaken to determine the cause of the failures. It was found from this investigation that the heat stabilizing element of the nylon coil spool contained halogen ions which could be released over a period of time. When combined with moisture, the halogen ions form hydrochloric acid and copper salts which could cause the eventual open circuit failure of the coils.

The most significant contributing factor in the reported failures is high humidity. Other contributing factors are the small wire size used in HMA relays and in d-c relays, and the release of halogen ions is accelerated by d-c potential. Relay coils which are continuously energized are not subject to this phenomenon because the coil temperature is maintained considerably above ambient, thus minimizing the probability of moisture getting into the coil.

After the spool material was changed to nylon in 1955-1958, a new material, Lexan, became available. Lexan has the desired chemical, mechanical, and electrical characteristics for use in spools. The change to the use of Lexan for spools was started in 1964 and completed in 1968. The first relay change was the HMA followed by the HGA, and HFA. Black was chosen for the color of the Lexan spools to make them distinguishable from the nylon. Since the initial reports of open circuited HMA coils, the failures of auxiliary relays have been very limited. However, recently one customer reported an accumulation of open circuit failures of a significant number of HGA relays with nylon spools which were used in X-Y closing circuits of breakers. As a result of this recent report and in keeping with our procedure of informing you of potential problems, were are bringing this matter to your attention, even though the overall rate of failure continues to be extremely low.

The relays covered by this letter have been in service a number of years; however, in recognition of the potential for shorter than normal life, replacement relay coils will be furnished at 60 percent of the normal price of the coils. If it is preferable to replace entire relays rather than coils, a credit of 40 percent of the normal selling price of new relays will be allowed against the purchase of replacement relays at the time old relays are returned to Philadelphia. Note that is not practical to change the coils of HMA relays in the field; any replacements should be complete relays.

If you have applications of HFA, HGA, HKA, and HMA relays in areas of high humidity, intermittent operation, d-c power, and with white nylon spools, you may wish to consider replacing the coils or relays.

Further instructions regarding replacement relays or coils can be obtained from the General Electric Company.

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GENERAL ELECTRIC TYPE EJ-01 AND TYPE EF-1 FUSE PROBLEMS

GENERAL ELECTRIC TYPE EJ-01 AND TYPE EF-1 FUSE PROBLEMS

General Electric Type EJ-0-1 Sand-filled Glass PT Fuses

(This information is from a Bonneville Power Administration Substation Maintenance Information Sheet Dated June 30, 1971)

The purpose of this chapter is to alert personnel to a potential problem that may develop because of impact closing of the subject fuses.

A discrepancy in revenue metering led to the inspection of the associated fuse bank. One of the fuses was not making contact with the harp, and the resulting arc had eroded the silver from the fuse surface. The increased contact resistance in the fuse clip affected the accuracy of the revenue metering.

The harps on this type of fuse mount can be permanently sprung open by a forcible closing of the fuse with a hot stick in the manner normally used to close a hook-operated disconnect switch. The result of such closing will spread the harp to the point of poor or no contact with the possibility of the fuse dropping back open if the lower fuse contact is not tight enough to hold the fuse in the upright position.

The harp is a poor design utilizing a short leaf-type spring made of phosphor-bronze material to exert fuse-clip pressure on the cartridge-type fuse ferrule. This spring - as springs go - is relatively dead soft and takes a permanent set if bent too far. Because of the height of the mountings and the limber hot sticks, it may be difficult to close the fuses by pushing and may require a jab to close. The fuse clip will not stand anything but a gentle close as the hot stick inertia will bottom the fuse and spread the clip.

If trouble is experienced with this GE-type fuse mount, consideration should be given to replacing it with a more suitable fuse mount.

Failure Of General Electric Type Ef-1, 115-kV, A30E Ampere Fuse

A General Electric fuse Type EF-1, 115-kV, A30E failed in the early 1960's at a Reclamation substation. Lightning arced over in the station and two fuses were found blown. One fuse was in Phase A and the other was in Phase C. The fuses were replaced and the station energized. About a half hour later, the Phase B fuse began burning and arcing. This fuse was replaced and the station energized.

Inspection of the removed Phase B fuse disclosed that the ejecting spring in the bottom of the fuse which gives part of the ejecting force to the conducting rod was broken into three pieces. The spring showed considerable rusting and broke in two places at spots that were severely rusted. It is apparent that the rusting deterioration of the spring took place over a period of time. The fuse holder or tube was filled with a considerable amount of accumulated material that resembled sticky dirt or sand. This material did have some corrosive effect on the connecting rod that is supposed to eject when the fuse link fails due to high current. It is believed the main cause of the failure of the conducting rod to eject was the broken spring. The sticky material which accumulated in the holder or tube could have provided enough friction to prevent the conducting rod from falling out due to gravity; but, because of the light weight of the conducting rod, no definite conclusion can be made on this point.

The actual fuse link length in these fuses is approximately 4 inches. Separation on fuse failure is by ejection of the conducting rod. Failure of the conducting rod to eject results in a separation or open circuit distance of 4 inches. With reenergizing of the circuit a current path can easily be established over this short distance at 115-kV. A fuse conducting rod that fails to eject provides no protection whatsoever.

The fuse is fitted with a disc over the bottom of the tube that is supposed to keep out dirt and presumably moisture, yet be fragile enough to allow ejecting of the conducting rod when the fuse link melts. However, in service these discs generally do not stay in place. They drop off within a relatively short time in most cases.

It is recommended that fuses with similar operating mechanisms be thoroughly inspected on an annual basis with particular attention given to operability of fuse ejection features.

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INSTRUMENT TRANSFORMER SECONDARY GROUNDING

Instrument Transformer Secondary Grounding

ANSI C57.13.3 - Guide for the Grounding of Instrument Transformer Secondary Circuits and Cases, contains the following important grounding requirements:

1. The instrument transformer secondary circuit should be connected to the station ground at only one point. This holds true regardless of the number of instrument transformer secondary windings connected to the circuit. The reasons for grounding at a single point are as follows:

a. The flow of fault current through the ground mat can cause potential differences at different points in the ground mat. If the instrument transformer secondary circuit is grounded at more than one location, these potential differences can result in the flow of current through the relay, instrument, and meter coils resulting in instrument inaccuracies and possible relay misoperation. Also, high neutral conductor currents resulting from multiple ground connections can cause thermal damage to the neutral conductor.

b. The use of a single grounding point facilitates the temporary removal and re-establishment of the ground connection when desired in order to test for insulation deterioration or accidental grounds in the instrument transformer secondary circuit.

2. The point of grounding in the instrument transformer secondary circuit should be at the control board or the first point of application. Grounding at the point of application, rather than at the transformer, is preferred for the following reasons:

a. Instrument transformers, their enclosures, and connections are more capable of withstanding the effects of voltage rise than control board components.

b. The increased use of sensitive solid-state devices in instrument transformer secondary circuits requires that voltage levels in the control boards be limited.

c. It provides the maximum protection for personnel at the point where they are most apt to be exposed to circuit overvoltages, the control board.

We are aware that instrument transformer secondary grounding is not in accordance with the above recommendations at some Reclamation facilities. In some cases the arrangement of the secondary windings or devices in the circuit makes it necessary to ground at some point other than the control board in order to obtain correct equipment performance; however, all other instrument transformer secondary circuits that do not conform with the recommended grounding practices should, when feasible, be modified to be in compliance. Please contact D-8440, Denver, Office, if you need assistance in this process.

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OVERLOAD PROTECTION OF THREE-PHASE MOTORS

Overload Protection of Three-phase Motors

Since the early 1960's, most Reclamation power installations have been designed and constructed utilizing 3-phase overload protection for all 3-phase motors powering auxiliary equipment. Prior to 1960, most 3-phase auxiliary equipment was provided with 2-phase overload protection only.

The accompanying article, reprinted for this volume by permission from plant Engineering Magazine. explains why 3-phase protection is now required by the National Electrical Code. In addition, the article provides a reliable method of determining whether current unbalance in a 3-phase motor is due to unbalanced line voltage or is caused by problems in the motor itself.

While the older 2-phase overload protection is probably adequate for most existing installations, 3-phase protection should be provided for important existing auxiliary equipment (particularly where there has been a history of motor burnout) and whenever existing equipment is being modernized.

The case for three protectors-

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Overload Protection of Three-Phase Motors

By HARRY A. WRIGHT, P.E., Consulting Engineer
Elm Grove, Wis.

THE 1971 EDITION of the National Electrical Code requires that an overload protective device be installed in each phase of a 3-phase motor feeder. In the superseded 1968 edition, protection was mandatory in only two legs of a 3-phase motor feeder---provided that the motor was not installed in an isolated, inaccessible, or unattended location.

The new Code does away with the exception which permitted protection in only two phases for accessible motors, and 3-phase overload protection is now required in all cases for 3-phase motors, an overwhelming majority of industrial electrical motors are in- stalled in areas where the old "minimum of two overload elements" provision applied, and most 3-phase motors in service today have protection in only two legs. However an understanding of why the Code change was necessary bears out the wisdom of providing protection in each phase, and the advisability of retrofitting older motor branch circuits to incorporate 3-phase overload protection.

Requirement of protection in each phase of a 3-phase motor is, essentially, a means of minimizing motor burnouts that are caused by unbalanced line voltages or single-phasing. Here's what NEMA Standard MG 1-1433 has to say about the effect of voltage unbalance on polyphase motors:

> "The effect of unbalanced voltages on polyphase induction motors is equivalent to the introduction of 'negative sequence voltage' having a rotation opposite to that occurring with balanced voltages. This negative sequence voltage produces in the air gap a flux rotating against the rotation of the rotor, tending to produce high current. A small negative sequence voltage may produce in the windings currents considerably in excess of those present under balanced voltage conditions.
>
> "The voltage unbalance (or negative sequence voltage) in percent may be defined as follows: Per cent voltage unbalance =

$$\frac{\text{Max. voltage deviation from Avg. voltage x 100}}{\text{Average voltage}}$$

Example: With voltages of 220, 215, and 210, the average is 215, the maximum deviation from the average is 5, and the percent unbalance is

$$\frac{5}{215} \text{ x 100, or 2.3 per cent.}$$

> "A relatively small unbalance in voltage will cause considerable increase in temperature rise in the phase with the highest current, the percentage increase in temperature rise will be approximately two times the square of the percentage voltage unbalance. The increase in losses and, consequently, the increase in average heating of the whole winding will be slightly lower than the winding with the highest current.
>
> "To illustrate the severity of this condition, an approximate 3.5 percent voltage unbalance will cause an approximate 25 per cent increase in temperature rise.
>
> "The locked rotor current will be unbalanced to the same degree that the voltages are unbalanced but the locked rotor kva will increase only slightly.
>
> "The currents at normal operating speed with the unbalanced voltages will be greatly unbalanced in the order of approximately 6 to 10 times the voltage unbalance. This introduces a complex problem in selecting the proper overload protective devices, particularly since devices selected for one set of unbalanced conditions may be inadequate for a different set of unbalanced voltages, increasing the size of the overload device is not the solution inasmuch as protection against heating from overload and single phase operation is lost."

Voltage unbalance is difficult to detect with a common, industrial-type voltmeter of about two percent accuracy. However, since it is the current (I^2R} that causes heating, the phase currents of the motor can be readily measured with a clamp-on ammeter. A current reading of all three phases should be taken, if currents are balanced, it is practical to presume that the voltages are balanced. If currents are unbalanced, it can be assumed that voltages are unbalanced, or that there is an improper connection inside the motor.

A simple test will determine whether current unbalance is the result of voltage unbalance, or caused by problems in the motor itself, Fig. 1. Line leads and motor terminal leads are identified, and a current check is taken of each line lead. Motor terminals are then rotated in such a manner that direction of motor rotation is preserved. Another, current reading is taken of each line. if the high-reading line remains the same as on the first check, then the problem is one of voltage unbalance. If the high-reading is observed on another line, then the problem is internal to the motor or is in its connections.

If it is determined that the problem is one of voltage unbalance, the next step is to find out what caused the unbalanced condition. These are some of the causes:

1. Unequal loading per phase on the transformer serving the motor;
2. Single phasing, such as would be cansed by a blown fuse on the primary of the transformer serving the motor;
3. Unequal transformer tap settings;

4. Unequal transformer impedances (impedances can range from 1.6 to 6 per cent};
5. Capacitor banks with fuse blown or with unequal capacity per phase;
6. Voltage regulators out of step or calibration:
7. Transformer bank connected in configuration that inherently provides poor regulation, such as open delta or T-T connection.

Of these, the most common items are 1 and 2. Item 2 (open phase) can be quite difficult to detect if a high percentage of the load connected to the transformer secondary is rotating equipment, in such cases, the open phase may remain at approximately full potential.

Motor insulation tests (documented in AlEE Specification 510 and IEEE 117) show that 10 per cent increase in insulation temperature over design temperature cuts motor insulation life in half. And, as pointed out in NEMA Standard MG 1-14.33, voltage unbalance of only 3.5 per cent will cause an increase in temperature rise of about 25 per cent.

Examination of the winding of a motor that has failed because of voltage unbalance will reveal a failure pattern typical of single-phasing--a condition diagnosed as the cause of many motor winding failures. If investigation reveals that single-phasing did not occur, the failure is often attributed to a faulty motor.

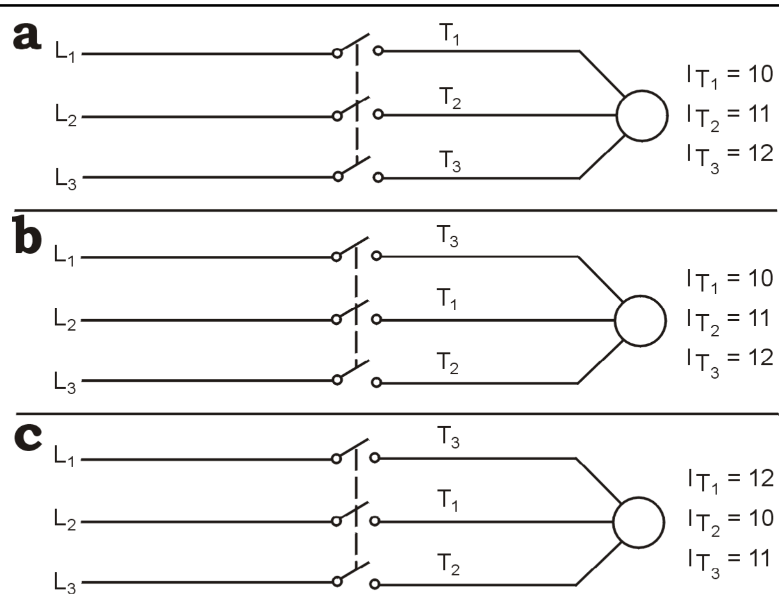
One electric utility reports that among its customers there were 300 confirmed cases of motor burnouts caused by single phasing or voltage unbalance within a one-year period. Because large industrial plants seldom report motor failures to the utility company, it follows that the reports of failure came from operators of commercial buildings and small plants which do not have their own electric department. Such users usually have a large proportion of single-phase load--such as lighting--in proportion to the balanced 3-phase load drawn by 3-phase motors. Uneven loading is quite likely in such operations. It is probable that the majority of the motors failing in a single-phasing type pattern actually failed because of voltage unbalance.

Even when voltage unbalance is suspected as tile cause of a high motor mortality rate, it is difficult to detect because of its erraticism, in such cases, a 3-phase recording ammeter can be a valuable tool in determining if unbalance is, in fact, the problem.

In the past, two overload protectors were usually considered adequate for most motor applications. Three-phase protection was usually provided only in the following types of situations:

1. Motor is in isolated, inaccessible, or unattended location.
2. Motor drives critical equipment.
3. Wye-delta or delta-wye transformer supplies the motor.
4. Transformer connections are unknown.
5. Motors are operated in parallel with other motors, which might cause circulating currents or permit sustained operation under single-phasing conditions.
6. Local electrical codes require three overload protective elements.

'"With the new National Electrical Code, 3-phase protection will be provided on all new motor installations, and eventually, motor starters with only two protectors will become rare. it is, therefore, advisable to review existing motor circuits in terms of retrofitting them with an additional protector. Its cost is only a fraction of total cost of the motor and control. End



Simple test determine whether current unbalance or motor problem is cause of voltage unbalance. In (a), line current-readings are taken of each phase. In (b) and (c) motor terminal connections have been rotated in a manner that motor direction of rotation remains unchanged. In (b), the same readings prevail as were read for the test connection in (a), indicating that the problem is caused by unbalanced line voltages. In (c), the highest-reading phase has shifted, indicating that the problem is in the motor connections or the motor.

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DOBLE TESTING OF COUPLING CAPACITORS

Doble Testing Of Coupling Capacitors

(Test procedure of TVA modified for Reclamation use)

Experience has proven that coupling capacitors will explode when they become defective. Because of the possibility of injury to personnel and poor carrier performance when coupling capacitors become defective, the testing of coupling capacitors is a necessity. This chapter is provided to serve as a guide in making coupling capacitor tests by a Doble power factor test set.

Figure 1 shows a typical coupling capacitor installation. Note that an installation generally consists of the porcelain-clad capacitor unit(s) and a base housing carrier-current and/or potential-device networks. If field test results are to be compared with nameplate or earlier field data, test procedures must be consistent. Also, knowledge of the carrier and potential-device networks is necessary in order that they be properly grounded or disconnected to eliminate any effect they might have on the measurement.

The test procedure outlined under Figure 1 is designed to produce the data required for individual units with a minimum of disconnection, while enhancing safety and reducing the effects of electrostatic interference.

Test data should be recorded on the Doble "Miscellaneous Equipment" form. The report form should include complete information regarding the capacitor manufacturer, type, rating, serial number, and nameplate data (capacitance and power factor). Experience and manufacturer recommendations indicate that power factor should be of the order of 0.25 percent (less than 0.5 percent) and capacitance should be within plus or minus 1 to 2 percent of the nameplate value.

Initial tests should include Doble tests and bridge tests of capacitance and dissipation factor. Routine tests should include bridge tests of capacitance and dissipation factor. Doble tests are not normally required on a frequent basis due to the difficulty in obtaining line outages and the low failure rate of the units. Testing them "as available," when other Doble test are being made, or whenever there is some doubt about their condition, should be adequate; however, the interval between tests should not exceed 2 years. Wherever electrical fields exist that cause interference with the Doble testing procedure, an ICD (Interference Cancellation Device) should be used.

References: 1961 Doble Client Conference Minutes, Sec. 9-201.
1968 Doble Client Conference Minutes, Sec. 9-204.

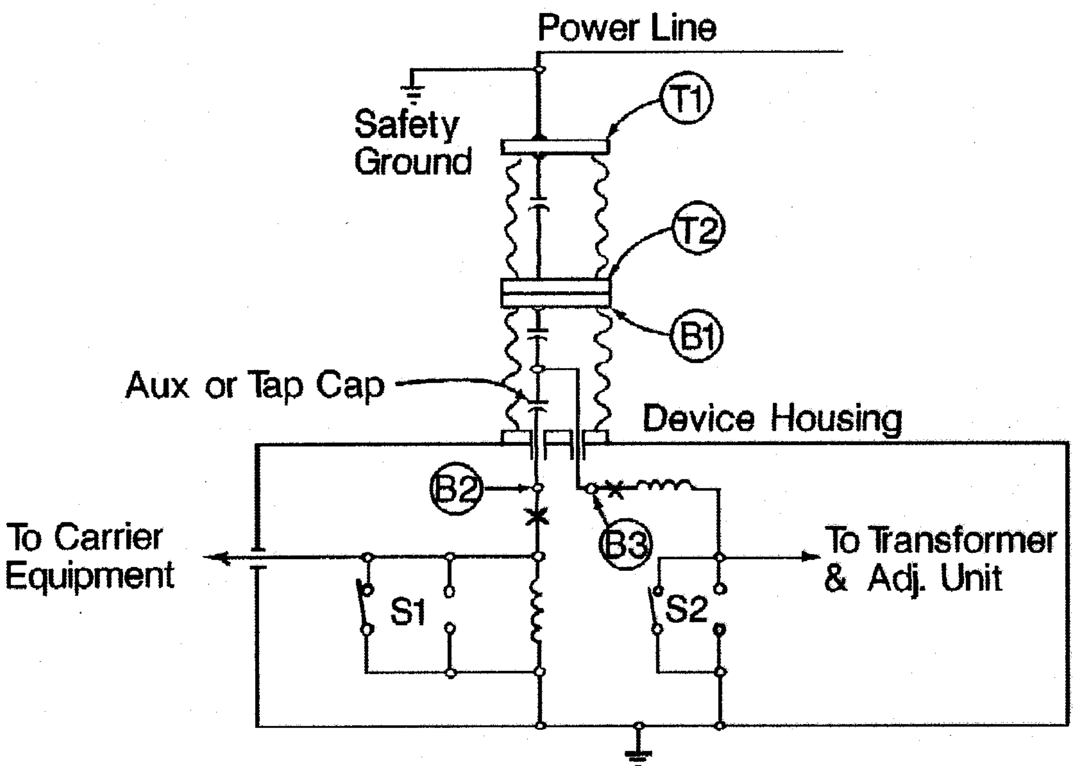

Figure 1

1. Deenergize Power Line.

2. Without disconnecting Power Line, ground T_1 using safety ground.

3. Close ground Switches S_1 and S_2 on the side of the device housing.

4. Disconnect B_2 and B_3 at Points "X" Inside the device housing. B_2 and B_3 may be found connected together, or B_3 may be floating if the capacitor is used only with carrier equipment. B_2 will be found grounded if the capacitor is used only with a potential device.

5. Test as follows:

To Measure	Energize	Ground	Guard	UST
$C(T_2\text{-}T_1)$	$B_1 = T_2$	T_1	B_3**	-
$C(B_1\text{-}B_3)$	$B_1 = T_2$	T_1	-	B_3
$C(B_1\text{-}B_2)$	$B_1 = T_2$	T_1	-	B_2
$C(B_3\text{-}B_2)$	B_3*	T_1	-	B_2

*Test voltage not to exceed rating of Tap or Auxiliary Capacitor.
**To make certain that all the current in the parallel circuit will be subtracted from the meter reading, vary the procedure slightly in that after applying the safety ground and closing the ground switches, disconnect the capacitor from the power line and test $C(T_2\text{-}T_1)$ by energizing T_2 and UST T_1.

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FAILURES OF PEDESTAL-TYPE (PIN AND CAP) INSULATORS

Failures of Pedestal-type (Pin and Cap) Insulators

The problem of failure of pedestal-type insulators first appeared on a 34.5-kV bus at a Reclamation substation in 1962. Since that time, similar failures have occurred on 12.47-kV, 34.5-kV, 41.8-kV, and 69-kV bus Installations at many other locations.

These failures, which are apparently due to cement growth causing the cap to separate from the porcelain, occur most often where the pedestal-type insulators are mounted in a horizontal position, either as bus supports or as supports for hook-stick-operated disconnect switches.

The only satisfactory solution to this problem has been to replace all pedestal-type insulators with post-type insulators, which not only have a much higher cantilever strength but also do not seem to be affected by cement growth.

During the late 1960's and early 1970's several projects carried out extensive insulator replacement programs involving 12.47-kV, 34.5-kV, 41.8-kV, and 69-kV bus installations. All of the replaced pedestal-type insulators were supplied under one specification when the power system was first constructed.

While the problem appears to be associated with moisture freeze-thaw cycling in the northern areas, we believe the problem may also exist at Reclamation facilities throughout southern portions of the United States. We therefore recommend that each project review its record of insulator failures and carefully examine pedestal insulators, particularly those mounted horizontally and used for hook-stick-operated switch supports. If the problem of defective insulators exists, a program should be developed for replacement with post-type insulators.

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SPARE PARTS FOR WESTINGHOUSE OUTDOOR SWITCHES

Spare Parts for Westinghouse Outdoor Switches

The Switchgear Division of the Westinghouse Electric Corporation withdrew from the outdoor disconnect switch business in August, 1974 and ceased production of all switch renewal parts. In 1975, Westinghouse made arrangements with an independent firm to supply renewal parts for the following switches:

Types V, V2, V3, V5, RL, RL-1, RL-2, HDB, CB, and LCO

Any inquiries regarding renewal parts for the above Westinghouse switches should be directed to:

Cleveland/Price Enterprises
12340 Linshan Drive
North Huntingdon, Pennsylvania 15642
Telephone (412) 864-4177

Your inquiry should contain the following information to assure a prompt response:

Switch Type
Voltage Rating
Westinghouse Shop Order Number
Part Description
Part Number
Quantity Desired

Cleveland/Price Enterprises will provide a direct quotation without the need to involve your local Westinghouse Electric Corporation salesperson.

Cleveland/Price Enterprises are in possession of all the necessary drawings, tooling and engineering experience to provide quality switch parts. They have indicated the parts would be available for a minimum of 3 years.

Renewal parts inquiries for Switch Types VRT, VRD, SRT, SRD, HRD, and HRS should be directed to your nearest I-T-E Imperial Corporation sales office.

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INSTALLATION OF CONNECTORS ON PMG WIRING

Installation of Connectors on PMG Wiring

The PMG (permanent magnet generator) must frequently be removed from the main generator exciter for maintenance or testing. The following suggestion was submitted by a Reclamation electrician to facilitate removal and reinstallation of the PMG.

Quick disconnect of PMG leads may be accomplished by the use of cannon or amphenol plugs. Selection of receptacles is dependent on the voltage and current ratings and the number of circuits. Also of consideration is that since the PMG is to be removed, the female receptacle should be on the PMG and the male should be attached by a panel mounting to the exciter. An example would be: for 500 VAC and 22 ampere rating with 26 contacts; amphenol No's MS3100A-28-12P, 3106A-28-12S, and 3057-16 could be used.

The receptacle connections should be made up prior to installation. A bracket for the panel mounting male receptacle may also be required. The PMG should be in place for the installation so that proper length of cable is used. Care must be exercised when drilling is done for the mounting bracket, that none of the filings drop into the exciter.

The new connectors eliminate the need for disconnecting and connecting individual leads to the terminal block, the need for taping PMG main leads and the possibility of reversing wiring during replacement of the PMG. However, since new connections are added, the pin and socket contacts should be inspected periodically for dust or corrosion build up which may weaken the electrical characteristics.

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