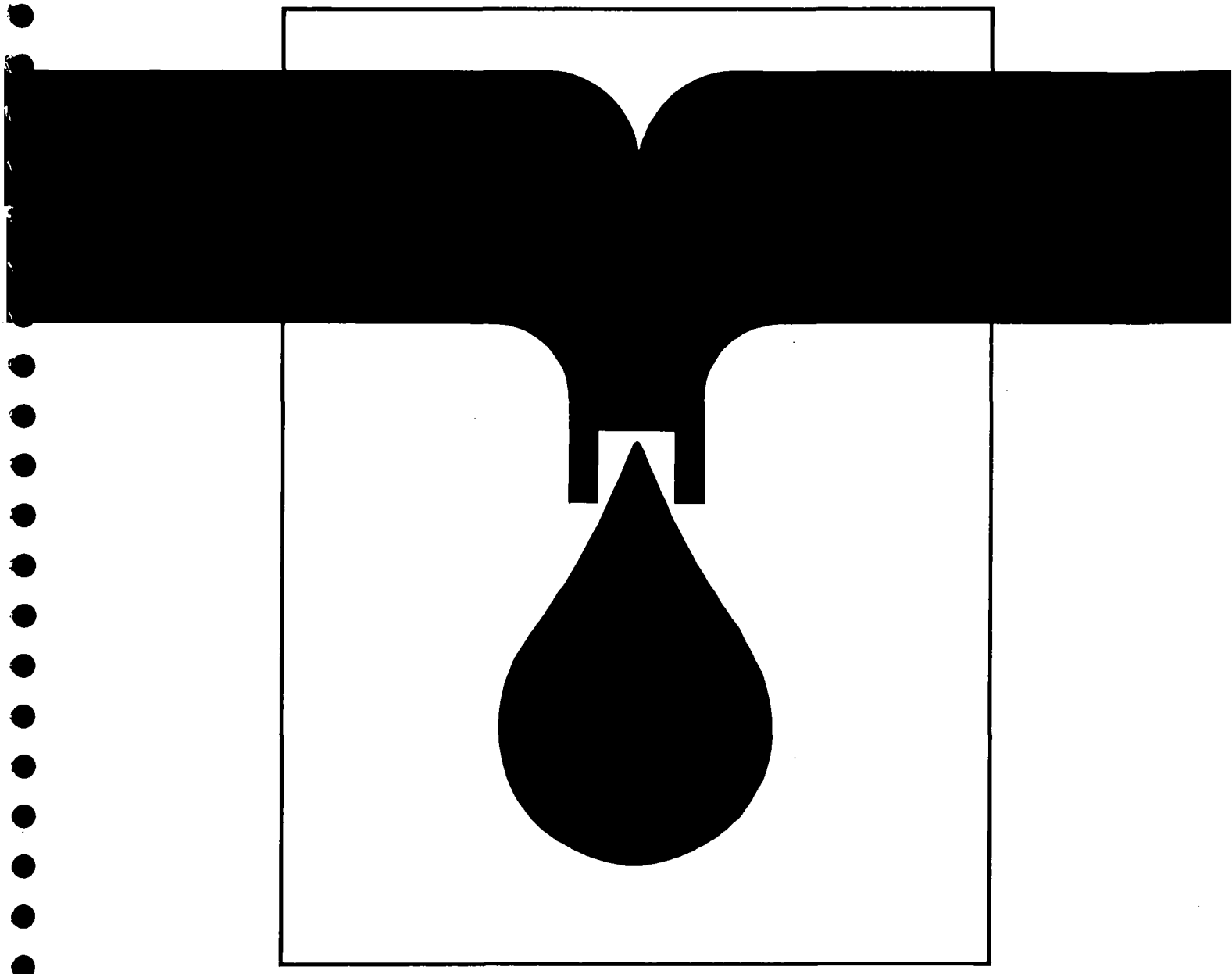
TRAINING MODULES
FOR
WATERWORKS PERSONNEL



Special Skills

3.3 i

Servicing and maintaining electrical equipment

Foreword

Even the greatest optimists are no longer sure that the goals of the UN "International Drinking Water Supply and Sanitation Decade", set in 1977 in Mar del Plata, can be achieved by 1990. High population growth in the Third World combined with stagnating financial and personnel resources have led to modifications to the strategies in cooperation with developing countries. A reorientation process has commenced which can be characterized by the following catchwords:

- use of appropriate, simple and – if possible – low-cost technologies,
- lowering of excessively high water-supply and disposal standards,
- priority to optimal operation and maintenance, rather than new investments,
- emphasis on institution-building and human resources development.

Our training modules are an effort to translate the last two strategies into practice. Experience has shown that a standardized training system for waterworks personnel in developing countries does not meet our partners' varying individual needs. But to prepare specific documents for each new project or compile them anew from existing materials on hand cannot be justified from the economic viewpoint. We have therefore opted for a flexible system of training modules which can be combined to suit the situation and needs of the target group in each case, and thus put existing personnel in a position to optimally maintain and operate the plant.

The modules will primarily be used as guidelines and basic training aids by GTZ staff and GTZ consultants in institution-building and operation and maintenance projects. In the medium term, however, they could be used by local instructors, trainers, plant managers and operating personnel in their daily work, as check lists and working instructions.

45 modules are presently available, each covering subject-specific knowledge and skills required in individual areas of waterworks operations, preventive maintenance and repair. Different combinations of modules will be required for classroom work, exercises, and practical application, to suit in each case the type of project, size of plant and the previous qualifications and practical experience of potential users.

Practical day-to-day use will of course generate hints on how to supplement or modify the texts. In other words: this edition is by no means a finalized version. We hope to receive your critical comments on the modules so that they can be optimized over the course of time.

Our grateful thanks are due to

Prof. Dr.-Ing. H. P. Haug
and
Ing.-Grad. H. Hack

for their committed coordination work and also to the following co-authors for preparing the modules:

Dipl.-Ing. Beyene Wolde Gabriel
Ing.-Grad. K. H. Engel
Ing.-Grad. H. Hack
Ing.-Grad. H. Hauser
Dipl.-Ing. H. R. Jolowicz
K. Ph. Müller-Oswald
Ing.-Grad. B. Rollmann
Dipl.-Ing. K. Schnabel
Dr. W. Schneider

It is my sincere wish that these training modules will be put to successful use and will thus support world-wide efforts in improving water supply and raising living standards.

Dr. Ing. Klaus Erbel
Head of Division
Hydraulic Engineering,
Water Resources Development

Eschborn, May 1987

Title: Servicing and Maintaining Electrical Equipment

Table of contents:

1 Electrical Equipment Servicing.

1.1 Introduction.

Electric power and control equipment upon which water supply and sewage treatment systems depend for continuity of service are no exception to the rule that periodic inspections and qualified maintenance are important in helping to keep these facilities running at maximum efficiency. Motor control devices may operate thousands of times a day, whereas protective devices may not be required to operate for years.

It is therefore important that motor control components be inspected regularly, so that worn devices can be replaced and repairs be made before a breakdown occurs. Protective devices on the other hand which are not subject to wear and tear as motor control devices must be checked on a regular basis to insure proper operation when called upon to operate.

Unfortunately, since most of the protective devices do not operate, except in the event of trouble, they do not receive the same attention given to other electrical equipment. The consequence of such neglect can be devastating. Many instances of extensive damage to equipment and personnel due to malfunctions of protective equipment have been recorded.

The are many and varied factors which create electrical equipment problems. Dirt, moisture, contamination, vibrations and failure to perform maintenance at prescribed intervals are the main causes of electrical problems.

All equipment manufacturers furnish recommendations for servicing and properly maintaining their equipment. These recommendations should be followed closely at all times. The recommendations contained in this module are intended to supplement those of the equipment manufacturer and serve as a guide in cases where the manufacturers recommendations are not obtainable.

There are three essentials to a successful maintenance operation-

- The preparation of a productive maintenance program consisting of a list of the items to be checked at each inspection.

- To keep an adequate supply of renewal and repair parts together with a set of required test instruments at hand. The equipment-

manufacturer furnishes such lists of recommended spare parts and test instruments upon request.

- If at all possible, spare parts should be of the same make and type as the ones furnished with the original equipment. This can save much time and trouble in the field.

2 Suggested Maintenance Inspection Schedule.

This schedule is based on average conditions. The actual frequency should be adjusted for each application as experience dictates.

Electrical equipment needs exercise. If an electrical switching device remains idle, either in the open or closed position for a period of six months or more, it should be opened and closed several times, preferably under load.

An insulation test should be made annually unless operating conditions make it advisable to shorten this period.

2.1 Motor Control Equipment - Monthly Inspections.

What to inspect:	What to inspect for:
Magnet-operated devices. contactors, relays, solenoids, brakes.	1 - Control circuit voltage.
	2 - Collection of dirt or gum.
	3 - Excess heating of parts - evidenced by discoloration of metal parts, charred insulation or odor.
	4 - Freedom of moving parts (no binding or sticking).
	5 - Corrosion of metal parts.
	6 - Remaining wear allowance on contacts.
	7 - Excess slam on pick-up.
	8 - Proper contact pressure.
	9 - Loose connections.
	10 - Conditions of flexible shuts.
	11 - Condition of arc chutes or barriers.
	12 - Worn or broken mechanical parts.
	13 - Excessive arcing in opening circuit.
	14 - Condition and level of oil (if oil immersed), check for sludge.

15 - Condition of gaskets (for oil immersed, dust-tight or watertight units).
16 - Excessive noise in ac magnets.
17 - Evidence of dripping water falling on equipment.
18 - Operation, including proper functioning of timing devices, sequencing etc.
19 - Condition of wheels and linings (on brakes).

Thermally operated devices. overload relays, temperature relays, thermostats.

1 - Same as items 2,3,4,5,8,9,10,12,13 and 17 above
2 - Condition of heating element.
3 - Condition of control circuit contacts.
4 - See that contact closes when latching mechanism trips.

Motor operated devices. motor operated timers, valves, rheostats brakes.

1 - Same as items 1,2,3,4,5,8,9,10,12,13,14,15 and 17 of motor operated devices.
2 - Operation, including proper operation of timing devices, sequencing etc.
3 - Excessive vibration or noise in operation.
4 - Wear or roughness in sliding contacts.
5 - Condition of gearing, lubricate where recommended.

2.2 Motor Control Equipment - Semi-annual Inspections.

What to inspect: What to inspect for:

Static Accessories. resistors, rectifiers, transformers, fuses, wiring and cables.

1 - Same as items 2,3,5 and 9 of motor operated devices.

Mechanically operated devices. switches, push-buttons, selectors, starters, limit-switches, float

1 - Same as items 2,3,4,5,6,8,9,10,11,12,13,14,15 and 17 of motor operated devices.
2 - Condition of control circuit contacts.
3 - Wear or roughness of sliding contacts.
4 - Lubricate contacts where recommended.

flow and pressure switches.

Flexible shuts.	1 - Corrosion. 2 - Damage from wear. 3 - Flex or twist slightly to make sure that they are in good condition.
Interlocks.	1 - Make sure they are adjusted as described in the manufacturers instruction book.
Push-buttons overload relays contacts.	1 - Make sure they function freely enough to provide protection if an emergency arises.
Gaskets.	1 - Corrosion. 2 - Torn or damaged, so that they do not make tight joints.

2.3 Distribution Switchgear and Protective Equipment - Annual Inspections.

What to inspect:	What to inspect for:
Switchgear.	1 - Collection of dirt or gum. 2 - Excess heating of parts - evidenced by discoloration of metal parts, charred insulation or odor. 3 - Loose connections. 4 - Evidence of dripping water falling on equipment. 5 - Tightness of splice bolts of buswork. 6 - Cleanliness and lubrication of drawout mechanisms. 7 - Operation of safety shutters and interlocks. 8 - Alignment and contacting of primary disconnecting devices. 9 - Corrosion of metal parts.
Air circuit breakers.	1 - Damaged insulating parts. 2 - Contact alignment. 3 - Condition of flexible shuts. 4 - Condition of arc chutes or barriers.

5 - Worn or broken mechanical parts.
6 - Condition of operating mechanism, cams, latches and roller surfaces (excessive wear).
7 - Lubrication of operating mechanism.
8 - Control circuit voltage.
9 - Collection of dirt or gum.
10 - Excess heating of parts.
11 - Corrosion of metal parts.
12 - Contact pressure.
13 - Excessive arcing in opening circuit.
14 - Operation, including proper functioning of tripping devices and remote operators, if any.

Molded case circuit breakers. These circuit breakers require very little routine maintenance unless they were subjected to operation conditions near or above their rating. Moulded case circuit breakers are lubricated at the factory and do not require additonal lubrication in the field.

Only tests to insure proper functioning are required as follows:
1 - Check deterioration of contact surfaces.
2 - Check for surface contamination on the inside of the circuit breaker.
3 - Loose connections.
4 - Damaged exterior housing.

Fuses, thermal relays. 1 - Same as static accessories, item 2.2 and thermally operated devices item 2.1.

3 How to Service Electrical Equiment.

How ro remove dust, dirt and grease.

If heavy dust or grease has accumulated on any part of the control, it should be removed with a heavy brush or wooden scraper. Dry dust and dirt should be blown off, using dry commpressed air if available. This is important, as dust may not only prevent the control devices from operating normally, but also may contain conductive particles which will ultimately form a path between points of different potentials, resulting in a short circuit. Dust on the surface of interlocks may prevent a circuit from being completed, even when the contacts are in the closed position. Grease oil or sticky dirt is removed by applying a cleaning fluid, such as carbon tetrachloride. Do not soak the parts, particularly the coils with the cleaner, but use just enough to loosen the grease so that it can be wiped off. For cleaning small parts, a small paint brush, dipped into the cleaning solution, is good for getting into corners and crevices.

How to care for fuse clips and ferrules.

While most fuse clips and fuse ferrules are plated to resist corrosion, it is well to occasionally remove the fuse from the clip and polish the contact surface. This does not apply to silver plated clips or ferrules. In replacing the fuses, make sure that they fit snugly into the clips.

How to care for silver contacts.

Many contactors, as well as small relays, utilize fine silver contacts, which oxidize more slowly than copper contacts. When silver oxide is formed on the contact, the oxide is self reducing. Therefore, it is not necessary nor recommended that fine-silver contacts be filed to remove the oxide. It does not take much filing to destroy the contacts usefulness completely.

How to care for copper contacts.

A contactor has several bolted or spring closed contacts. If excessive heating is apparent, the most likely point of high resistance is where the moving parts make contact with the stationary parts of the contact assembly. It is very easy to inspect these contacts on a monthly basis, and if the temperature is unduly high, to give them a few strokes with a file. Copper contacts oxidize rapidly at elevated temperatures, and slowly at room temperatures. The copper oxide which is formed has a very high resistance. A few strokes with a file will remove the oxide and reduce the resistance to a low value again. It is usually unnecessary to file copper contacts if the device is operated fairly often. The slight abration produced by the ordinary closing operation is sufficient to keep the oxide cleaned off.

A fairly common erroneous impression is that contacts which have been roughened by service should be kept smoothed so that they will carry the load. A roughened contact will carry current just as well as a smooth contact. Of course if a large projection should appear on a contact, because of unusual arcing, it should be removed. However, a contact that has been roughened by ordinary arcing need not be serviced. If a copper contact becomes overheated, this condition indicates that oxide has developed, and the oxides should be removed.

Contact surfaces should not be lubricated because the burning of the lubricant on circuit interruption increases the heating of the contact and shortens its life.

As the contact wears, pressure is maintained by a wiping spring which presses the movable contact against the stationary contact when the contact is closed. This spring should be checked at regular intervals, since contact heating may draw the temper of the spring and reduce the pressure of the contacts. The correct contact pressure is usually indicated on the manufactures instruction sheets.

If this information is not available it should be obtained from the manufacturer. Also the spring pressure of one pole can be compared with the contact pressure of the other poles of the same contactor. The spring pressure on all the poles should be approximately the same, and if one is considerably lower than the others, the spring should be replaced.

How to care for magnetic coils.

The coils of ac contactors are designed to operate satisfactorily over a range of 85 to 110 per cent of rated voltage, and dc contactors from 80 to 110 per cent. The temperature rise of standard coils should not exceed 85°C by resistance. This is a permissible temperature rise for use in ambients up to 40°C. With a rise of 85°C by resistance, the rise measured by thermometer on the coil surface will be about 65°C, depending upon the design of the coil.

How to handle coils.

Never use the leads on coils as carrying handles. Although the leads are strong enough to support the weight of the coil, this practice may cause a complete or partial fracture or the lead wire or joint, resulting in either an open-circuited coil or one that may open circuit shortly after being installed.

How coils work.

The current at ac shunt coils is at minimum value when the armature seals properly with the frame. Any excessive gap in the magnetic circuit lowers the resistance of the coil, and this will allow the coil to draw more current. If the magnet is accidentally blocked open, or if the voltage is so low that the magnet cannot close, the current is likely to be several times greater than the minimum gap current; and if this condition occurs, the coil will be damaged in a short time.

How to store coils.

DC shunt soils are particularly subject to failure causes bs absorbtion of moisture from the air. When a d c coil absorbs only a very slight amount of moisture, the next

time the coil is energized electrolytic action may be initiated between coil and guard, which will quickly cause an open circuit. Therefore, it is extremely important to store coils in a dry place and to keep the air reasonably dry where control is installed. For special high-humidity conditions (as in the tropics), coils that have been given special treatment are available.

How to dry coils.

If coils have become wet, they should be thoroughly baked as soon as possible in an oven at a temperature of 110°C to 125°C. This should also be done if coils have been soaked in carbon tetrachloride to remove grease or oil.

How to varnish coils.

If it is necessary to varnish coils, only an approved insulating paint or varnish should be used. Some paints or varnishes contain thinners that will rapidly attack coil and wire insulations. Apply paint while the coils are still warm from baking.

How to assemble coils.

When coils are assembled on the magnet frame, make sure to fasten them securely because when the coils are energized, a mechanical force develops which will tend to cause them to slip back and forth on the frame. This could in time cause excessive wear on the coil insulation or spool.

Assembling thermal overload relay heaters.

Many thermal overload relays are designed and furnished with interchangable heater elements. If it becomes necessary to change such a heater because the size of the connected motor was changed, notice carefully how the heater is mounted on the relay. When remounting the new heater be sure it is placed in the same position. If incorrectly installed the heater may touch the thermostatic strip making the relay inoperative.

It should be remembered, that thermal overload relays do not protect the motor against damage due to faults (grounds)

internal or external nor against burnouts in case of a bearing failure which allows the rotor to rub on the stator, nor can they protect themselves or the motor against short circuit conditions. This has to be done by fuses or circuit breakers of proper rating.

How to check contact alignment.

Close the contactor or breaker with a piece of tissue paper and carbon paper between the contacts and examine impression.

How to check deterioration of contact surfaces.

To determine the stage of deterioration of the contacts, a millivolt test should be conducted across the circuit breaker or starter contacts. Excessive millivolt drops can be an indication of eroded or loose connections. It is recommended that the test be made at a nominal dc voltage at 50 to 100 amps for larger contacts and at or below rating for smaller contacts.

How to check internal surface contamination of circuit breakers.

Internal surface contamination of enclosed circuit breakers, especially of the moulded case type, can best be dertermined by using a "Megger" insulation tester. The testing voltage recommended is at least 50 percent above breaker rating, however, a minimum of 500 volts is permissible for low voltage moulded case breakers.

4 Illustrations.

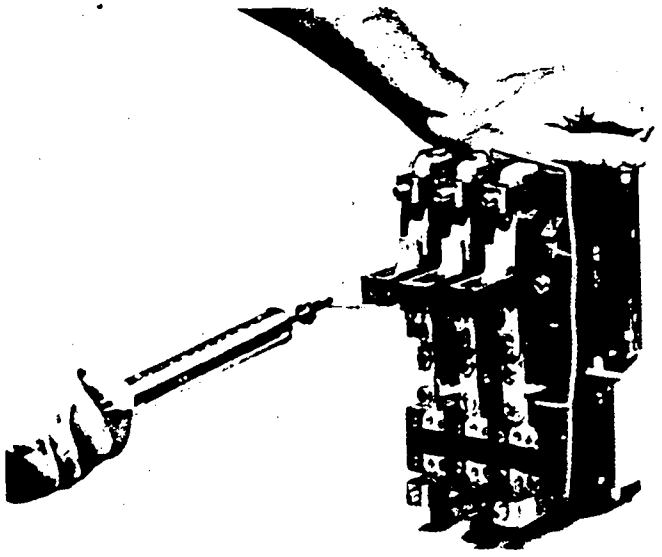
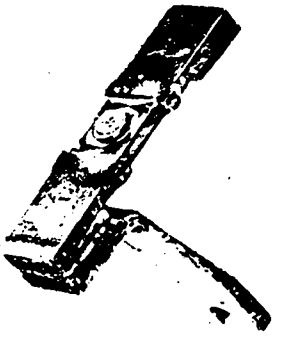
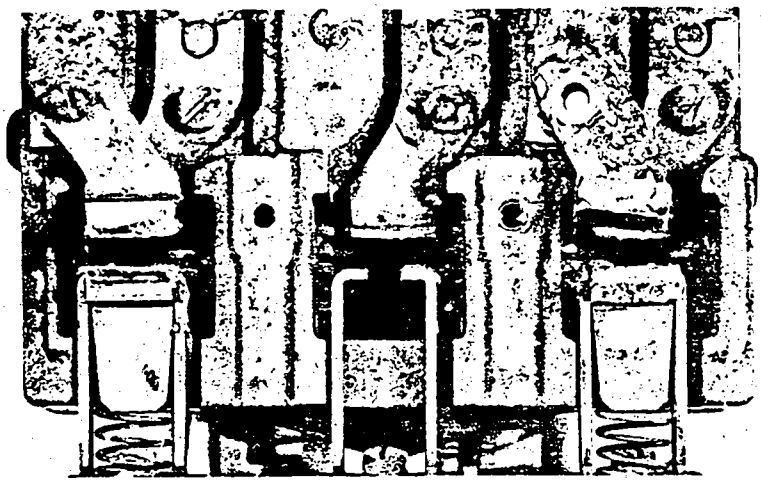


Fig.1 Checking contact pressure. Checking contact pressure by using a spring balance. Pull is to be perpendicular to contact surface.

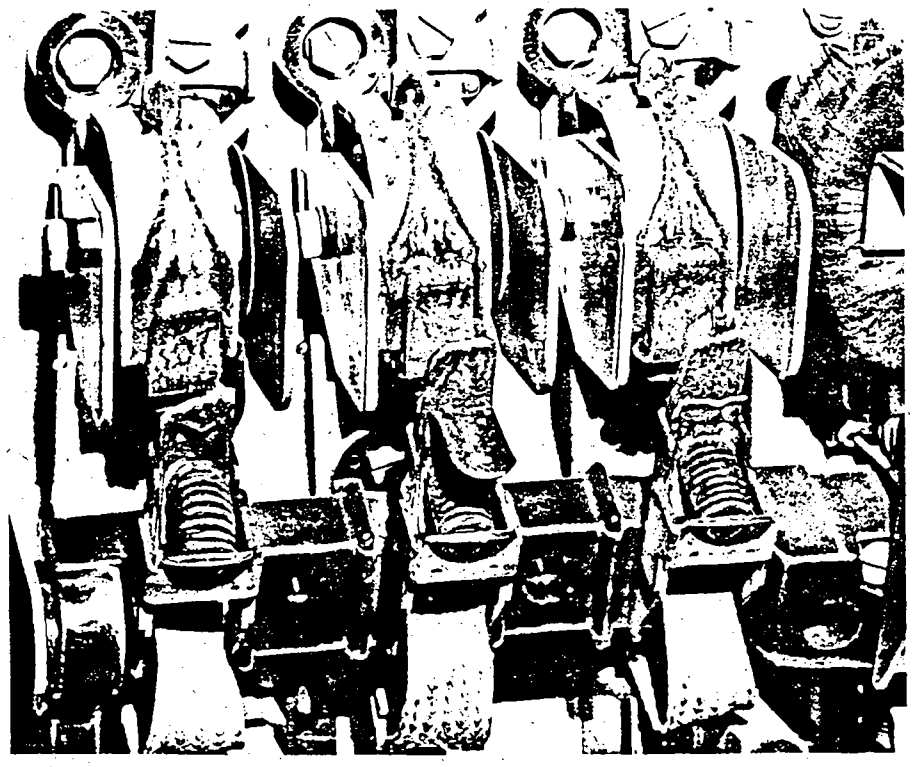
Fig.2 - Checking contact surfaces. Normal service will sometimes make contacts look like this. When inspection is made, the surface of contacts having this appearance should be left alone. Do not file them.



When contacts close they will have good contact and alignment.



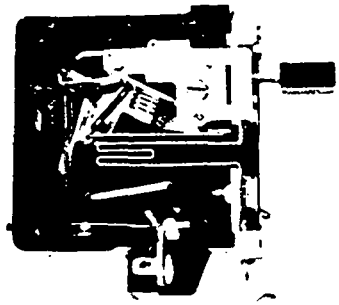
Never allow contacts to stay in service until they do not work.
Note damage to other parts of the control which could have been avoided.



When contacts have this apperance they should be replaced. Wear of other parts of the control causes poor alignment. When replacing contacts, make sure poor alignment is corrected.

Fig.3 - Contacter assemblies.

Fig.4 - Coil.
Careless handling of coils bends the connections and often makes a coil worthless, although the coil may be new.



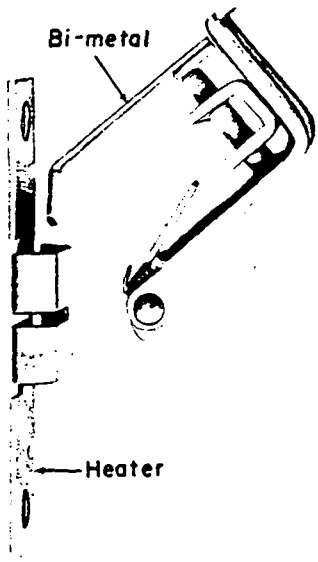


Fig.5 - Thermal overload relay.
If it is necessary to remove a relay heater, notice carefully how it is mounted on the relay; and when remounting it, be sure it is placed in the same position as it was originally. If incorrectly installed the heater may, by touching the thermostatic strip, make the relay inoperative. The screws holding the heater in place should be tight; otherwise, heating, which will affect the calibration of the relay, will develop.

If the relay trips frequently, first compare the rating of the heater with that recommended in the heater label. If the heater rating is correct, measure the current taken by the motor. If the current is higher than that shown on the motor nameplate (plus the service factor), the relay is doing a protective service and the mechanical load should be inspected to determine the cause of the overload. If the line voltage is low, it will cause the current to be high, and will trip. Low voltage may be caused by inadequate power leads running to the controller from the power supply.

Illustrations shown in this module by courtesy of:

Fig.1	The Westinghouse Electric Corp	Pittsbough, Penn. USA
Fig.2,3, 4,5.	The General Electric Co	Schenectady, NY USA

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH
Dag-Hammarskjöld-Weg 1 + 2 · D 6236 Eschborn 1 · Telefon (06196) 79-0 · Telex 407501-0 gtz d

The government-owned GTZ operates in the field of Technical Cooperation. Some 4,500 German experts are working together with partners from some 100 countries in Africa, Asia and Latin America in projects covering practically every sector of agriculture, forestry, economic development, social services and institutional and physical infrastructure. – The GTZ is commissioned to do this work by the Government of the Federal Republic of Germany and by other national and international organizations.

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- management of all financial obligations to the partnercountry.

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TRAINING MODULES FOR WATERWORKS PERSONNEL

List of training modules:

Basic Knowledge

0.1 Basic and applied arithmetic
0.2 Basic concepts of physics
0.3 Basic concepts of water chemistry
0.4 Basic principles of water transport
1.1 The function and technical composition of a watersupply system
1.2 Organisation and administration of waterworks

Special Knowledge

2.1 Engineering, building and auxiliary materials
2.2 Hygienic standards of drinking water
2.3a Maintenance and repair of diesel engines and petrol engines
2.3b Maintenance and repair of electric motors
2.3c Maintenance and repair of simple driven systems
2.3d Design, functioning, operation, maintenance and repair of power transmission mechanisms
2.3e Maintenance and repair of pumps
2.3f Maintenance and repair of blowers and compressors
2.3g Design, functioning, operation, maintenance and repair of pipe fittings
2.3h Design, functioning, operation, maintenance and repair of hoisting gear
2.3i Maintenance and repair of electrical motor controls and protective equipment
2.4 Process control and instrumentation
2.5 Principal components of water-treatment systems (definition and description)
2.6 Pipe laying procedures and testing of water mains
2.7 General operation of water main systems
2.8 Construction of water supply units
2.9 Maintenance of water supply units Principles and general procedures
2.10 Industrial safety and accident prevention
2.11 Simple surveying and technical drawing

Special Skills

3.1 Basic skills in workshop technology
3.2 Performance of simple water analysis
3.3a Design and working principles of diesel engines and petrol engines
3.3b Design and working principles of electric motors
3.3c –
3.3d Design and working principle of power transmission mechanisms
3.3e Installation, operation, maintenance and repair of pumps
3.3f Handling, maintenance and repair of blowers and compressors
3.3g Handling, maintenance and repair of pipe fittings
3.3h Handling, maintenance and repair of hoisting gear
3.3i Servicing and maintaining electrical equipment
3.4 Servicing and maintaining process controls and instrumentation
3.5 Water-treatment systems: construction and operation of principal components: Part I - Part II
3.6 Pipe-laying procedures and testing of water mains
3.7 Inspection, maintenance and repair of water mains
3.8a Construction in concrete and masonry
3.8b Installation of appurtenances
3.9 Maintenance of water supply units Inspection and action guide
3.10 –
3.11 Simple surveying and drawing work

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH

P. O Box 5180
Dag-Hammarskjöld-Weg 1+ 2
D 6236 Eschborn/Ts. 1
Telephone (0 61 96) 79-0
Telex 4 07 501-0 gtz d
Fax-No. (0 61 96) 79-1115