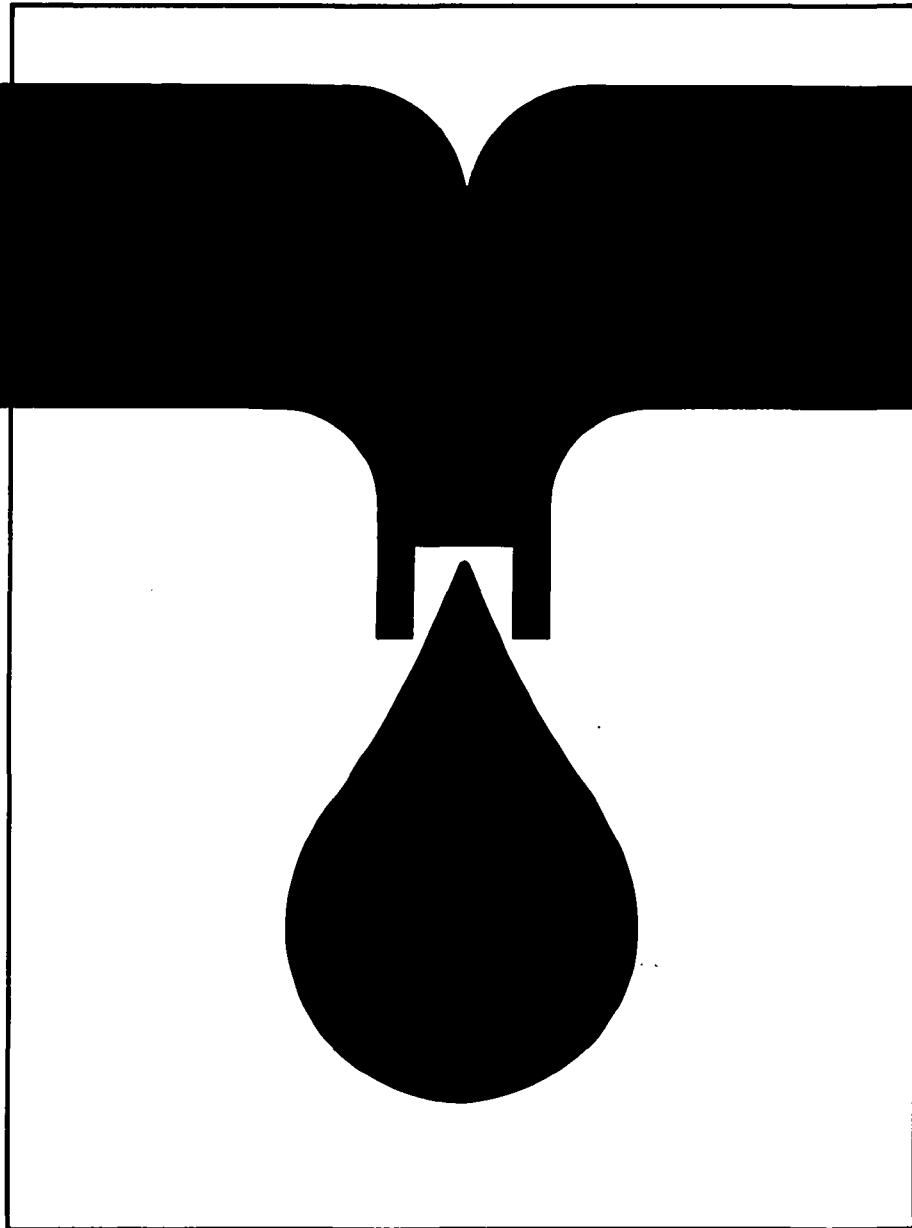




TRAINING MODULES FOR WATERWORKS PERSONNEL



Special Knowledge

2.9

Maintenance of water supply units
Principles and general procedures

STAMPED AREA

262.0-8132 ll

8132

262.0 87TR (2)

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: MAINTENANCE OF WATER SUPPLY UNITS
PRINCIPLES AND GENERAL PROCEDURES

Table of contents:	Page
1. Introduction	2
1.1 The problem	
1.2 The solution	
2. Operation and Maintenance	3
2.1 Operation	
2.2 Maintenance	
2.3 Curative maintenance	
3. Inspections	5
3.1 Scope of inspections	
3.2 Extent of inspections	
3.3 Types of inspections	
4. Inspections made before putting the unit into operation for the first time	7
5. Periodic inspections made normally without interrupting the operation	8
6. Periodic inspections made by interrupting the operation	9
7. Remedial Actions	10
8. Records	10
8.1 Records of the system and extensions	
8.2 Records of maintenance	
8.3 Recording of information	
8.4 Keeping of records	
8.5 Special and annual reports	
9. Maintenance Programmes	12
9.1 Components of a maintenance programme	
9.2 Inventory	
9.3 Tasks	
9.4 Schedules	

MAINTENANCE OF WATER SUPPLY UNITS
PRINCIPLES AND GENERAL PROCEDURES1. Introduction

The problems of planning, design, and construction of water supply systems are usually slight when compared with the problems of operation and maintenance of the systems, after they have been constructed.

The situation is aggravated by the glamour attached to new construction and the greater importance given to expenditures for new construction in contrast to expenditures which are necessary for operation and maintenance.

Once the units have been constructed, it is necessary to ensure that they have lasting reliability and will continue to function as intended.

The basic requirements for this are that the units have been constructed properly and that they are kept in a state of good maintenance.

1.1 The Problem

Cracks in masonry or concrete, leaky covers, damaged or defective pipes, vents, screens, etc., facilitate the entry of ground water and/or surface water and small animals which will contaminate the water and cause health hazards. Water will be lost as a result of cracks, leaky pipes, untight pipe passages through walls, etc., and joints. Metal parts rust. Corrosion leads to loss of water and contamination. Sediment can cause blockages, and affects the yields of wells and springs.

Valves not functioning properly will impede operation and cause loss and contamination of water. Clogged intakes, sand traps and screens do not only affect the proper functioning of the units and equipment, but they can also lead to contamination of the water and damages to equipment.

The watertight backfill can be damaged by excavations or by deep cracks in the soil; thereby allowing surface water to enter into the system and to cause health hazards.

In the long-run the safety of the structure itself can be endangered because of cracks in itself and/or the adjacent ground and as a result of ground water and/or surface water entering through the cracks.

Inadequate operation and maintenance leads to breakdowns involving water loses and interruptions. Water supply interruptions and water loses do not only affect the consumers, but they will also reduce the revenue. Reduction in revenue means less funds for operation and maintenance. This in turn results in inadequate operation and maintenance thereby completing and repeating the cycle of the vicious circle. If money has been borrowed for the construction of the water supply system loan repayment will be in areas; aggravating the situation.

1.2 The Solution

The solution is the execution of a maintenance programme which works.

Maintenance of a water supply unit is based on three considerations:

1. structural;
2. operational; and
3. hygienic.

Maintenance work must be carried out in time in order to prevent or at least minimize the possibilities of structural damages, interruption of service, contamination of the water and increases in the cost of repairs.

2. Operation and Maintenance

A water supply system is designed and constructed for the purpose of providing an uninterrupted supply of adequate and safe water.

Proper design and construction will ensure that the unit or system will function as intended provided it is operated and maintained properly.

After the construction is completed the system is handed over to people who are responsible for running it. Their work includes operation and maintenance which attempts to ensure that the various components of the system do function as intended and render the desired service.

2.1 Operation.

Operation refers to the performance of activities and use of resources for making a structure, a machine, an equipment, or a system of production do the work it is intended to do. To operate satisfactorily the system and its parts must be in a condition to do their intended work when given the necessary complementary inputs of labour, energy and raw materials. (Operation is not discussed in this part of the module.)

2.2 Maintenance

All types of structures, machinery, or equipment, units, or systems of production tend not to do the work that they are intended to do; or not to function at all, unless special efforts are made to maintain them and restore their capacity.

Maintenance means making periodic inspections which are necessary to determine the extent of this negative tendency, carrying out appropriate remedial measures, and keeping records of the observed deficiencies and the works carried out.

The word maintenance is normally used to describe one of two distinct types of activities: preventive maintenance. The other type is corrective (curative) maintenance.

Preventive maintenance is that which is conducted to minimise malfunctioning, failures or breakdowns; corrective maintenance is that which is carried out after the damage or breakdown has occurred. A preventive maintenance programme cannot hope to prevent all failures or breakdowns, thus some corrective maintenance will have to be carried out from time to time. A successful preventive maintenance programme will result in less frequent failures and shorter interruptions of service.

The discussion on preventive maintenance in this Module concerns itself with the technical aspects of water supply units including those described in Modules 2.8 and 3.8.

2.3 Curative Maintenance

Cases of emergency are examples of curative (corrective) maintenance and have to be dealt with as they occur.

The main cause of breakdown or malfunctioning of the unit may or may not be obvious at once. In any case the most obvious measures shall have to be taken immediately followed by systematic inspections in order to make a reliable job. At such inspections representatives of authorities who are concerned with the safety and stability of the structure, the operation of the unit, and the quality of the water, should be present if possible.

3. Inspections

Inspection consists of checking the physical conditions of a structure and its surroundings.

Inspections are made in order to find out what is missing, gone wrong, or about to go wrong, and to decide on the remedial actions that have to be taken.

3.1 Scope of Inspections

The inspections shall be made in order to assess the conditions of the units and determine the steps to be taken to remedy the deficiencies. Thereby, equal emphasis should be placed on the

- structural,
- operational, and
- hygienic

aspects.

The conditions will show whether and to what extent the deficiencies adversely affect

- the safety and stability of the structure;
- the proper operation of the unit; and
- the quality of the water.

3.2 Extent of Inspections

A record should be made of the observed deficiencies.

Water samples should be taken. Notes should be made on the accumulation of sediments, the presence of small animals and the origins of small animals.

The inspection must look out for

- rock pockets (porous, mortar deficient portions of hardened concrete consisting primarily of coarse aggregate and open voids; caused by leakage from formwork, or separation during placement of concrete or insufficient consolidation, or both);
- cracks;
- insufficient bond of screeds and plaster;
- cavities under screeds and plaster;
- roots (these are an indication for cracks and harmful connection with the exterior);
- roofs and covers which are not watertight;
- porous parts;
- holes;
- insufficient cover of the reinforcement steel;
- corroded pipes, ladders or climbing irons;
- defective inlet, outlet, overflow, and wash-out pipes;
- defective measuring facilities; and
- blocked vents.

3.3 Types of Inspections

Inspections can be classified according to the times when they are made. It is necessary to distinguish between three types of inspections.

1. Inspections made before putting the unit into operation for the first time;
2. Periodic inspections made normally without interrupting the operation; and
3. Periodic inspections made by interrupting the operations as necessary.

4. Inspections made before putting the unit into operation for the first time

It should be pointed out that even a newly constructed water supply system has to be checked before it is commissioned in order to ensure that it is properly constructed and that it works as intended. This first type of inspection is usually a part of the construction phase.

The more painstaking the construction work, and the more thorough the first inspection and the ensuing corrective work the less will be the trouble in the life of the structure as far as the structural condition is concerned.

4.1 Inspections

This first and most important inspection is the inspection which is made after the "completion" of the construction work and before the unit is put into operation for the first time. This inspection and the remedial work which follows it are the basis for a sound structure which will function provided it is properly maintained and operated in the future.

The team which was involved in the construction should not make the inspection by itself. The most appropriate members of the inspection team ought to be persons who would be responsible for the operation and maintenance of the unit or system.

The team which was involved in the construction would itself have made an inspection of the work and carried out improvement works as necessary before announcing that it is ready to hand over the unit which has been completed.

The structures will be inspected by a team whose members represent at least the group which is responsible for the construction on the one hand and the future operation and maintenance on the other hand.

In order to facilitate the work the inspection should follow a systematic pattern using a check list.

A record is made of the inspection and agreement reached regarding the works (if any) which have to be carried out before the unit is put into operation.

The second inspection will verify whether all works agreed upon during the first inspection have been carried out properly.



4.2 Tests

Tests are made to check the performance of the completed unit.

Water retaining structures including passages of all pipework and fittings which are built-in have to be tested for watertightness.

A record is made of the tests and their results.

4.3 Disinfection and putting into operation

After the successful completion of the works and the satisfactory results of the tests the units will be cleaned thoroughly and disinfected. Then the units are put into operation.

5. Periodic inspections made normally without interrupting the operation

Structures can be damaged as a result of acts of nature and/or human beings. Damages caused by human beings can be due to ignorance, carelessness, or abuse.

The physical conditions of the units have to be checked frequently. The frequency depends on local conditions. The type and location of the unit and the available manpower are some of the major factors which govern this frequency.

This is the essential part of preventive maintenance. Inspection of each unit by at regular intervals is necessary for the detection of structural defects and other faults which may develop from time to time either from fair wear and tear or through external conditions such as ground subsidence or abnormal weather. The roadways, pathways, fences and any buildings should also be inspected regularly with the aim of noting defects for repair. Paintwork, particularly of steel water tanks should be well maintained throughout the waterworks.

For some of the visual inspections it is not necessary to interrupt the operation. The aim of the inspection is to find any changes or developments in the structure and the surroundings which would adversely affect the safety or stability of the structure, the operation of the unit, and the quality of the water.

Basically the inspection concerning the physical conditions is similar to the inspection which is made before the unit was put into operation for the first time. The main difference is that the inspection and the ensuing remedy for the correction of the defects are now the sole responsibility of the maintenance team. However, in cases where major repairs or reconstruction works are necessary a construction team or group can be assigned to carry out the work.

Components of units such as valves, vents, overflow pipes, etc., can be inspected without interfering with the operation of the unit in question.

6. Periodic inspections made by interrupting the operations

The periodic inspections may sometimes also require the interruption of the service. They are concerned with the inspection of the interior of all water-retaining structures. The interruptions have to be made because the chambers shall have to be emptied in order to carry out the inspections and the ensuing necessary works.

Such an inspection will be made once a year, once in two or three years depending on the size of the system, the nature of the unit and the source and quality of the water.

Such maintenance should be made at times when the water consumption is low. Local conditions and experience will indicate the most suitable month of the year or even the day(s) of the week in that month. Even then preparatory work is necessary. All tools and equipment as well as materials and labour should be organised before the chambers are emptied and the maintenance works (= inspection + remedial action + records) started.

When the necessary maintenance does not require a long time, the impact of the interruption of service (if any) will not be too hard on the consumers. In any case the consumers ought to be informed in advance. They shall then be able to reserve some water and to programme their domestic activities. This also minimizes any inconvenience due to repairs which might take time in excess of the average.

7. Remedial Measures

Remedial activities of maintenance include

1. Repair, replacement, etc., of parts which are damaged, worn or become obsolete;
2. Removal of unwanted external and internal waste build-up;
3. Application of protective paint;
4. Cleaning;
5. Disinfection; and
6. Public relations and education.

The details of the remedial measures should be laid down in writing. Examples are given in Module 3.9. Some persons may be able to carry out the job without such written guidelines. What should be strived at is the cultivation of positive habits both during the training and the actual performance of duties. Only thus it will be possible to ensure that the maintenance work is carried out in a systematic manner.

8. Records

Records are required to provide information on which future actions can be based.

8.1 Records of the System and Extensions

These would include records (such as as-built drawings) of the various units of the waterworks. Instances are not uncommon, where the position of some valve or pipe is known only by one or two persons, usually the oldest employees. Such situations must be corrected.

Each water supply plant should have an up-to-date layout plan of the waterworks or units on which the line of every pipe and the location of every valve are clearly marked. Each valve on the plan should be numbered and the number painted on or near the actual valve. Such a plan is particularly useful whenever there is a change of attendant or in cases of emergency.

Any extension work is done to the system it should be recorded, preferably with a sketch. These records, if kept in a systematic manner, will provide ease of reference to any portion of the system. Alterations to all works should be recorded also.

8.2 Records of Maintenance

Records of maintenance are very important. They should clearly describe the deficiencies and the remedial measures that have been carried out. Whenever possible, the written descriptions ought to be supplemented with clear sketches.

All happenings affecting the works; actual works carried out, routine or unusual, (occasioned by accidents, breakdowns or other conditions), should be recorded as they occur. Copies of log sheets should be forwarded to the head office.

At least a simple log book or log sheet should be kept at even the smallest works. Any troubles that occur and the date when they are put right should be recorded also. Any sign of wear or damage should be noted in a diary and reported so that spare parts may be obtained on time. Records should also be kept of repairs that are required. The maintenance jobs that must be done at infrequent intervals should be marked in a diary in advance so that they are not forgotten.

From these records isolated and frequent troubles can be pinpointed, an efficient schedule for personnel planned, and estimates for operation and maintenance made with reasonable accuracy.

Further maintenance records will facilitate evaluation and monitoring as well as planned maintenance including the improvement of maintenance schedules.

The information is also invaluable for the improvement of future design and construction.

8.3 Recording of Information

Any modification, change or improvement in the system, unit, etc., is to be incorporated in the records as it occurs. Information should be recorded as soon as it is obtained and should not be allowed to accumulate. Such accumulation will deter a start. And when a start is made at last, it will prevent a good progress; as there will always be something which is more important or more urgent. Experience shows that recording of accumulated data is doomed to contain mistakes.

8.4 Keeping of Records

The manner of keeping records is important, too. Information should be retrieved easily and quickly from the records when it is required. A system which can only be worked by one or a few individuals has little value. There may be some water supply systems working without proper records but their effectiveness is limited, and they will have problems when emergency situations develop.

8.5 Special and Annual Reports

An annual report summarizes the records for each water supply system. It helps to assess future maintenance requirements, warns of possible extensions that may be required.

It is also most important to prepare certain special reports which are then distributed to those concerned.

9. Maintenance Programmes

It should be appreciated that it will not be possible to design and implement a maintenance programme which will satisfy all conditions everywhere. An individual schedule must be worked out for each individual system taking into consideration the local conditions. It should be remembered that such a schedule is dynamic and ought to be modified and improved all the time. The reports and records on the system and its maintenance will greatly help in the elaboration of the details for the modification and improvement of the



maintenance schedule. A systematic maintenance programme based on records and realistic schedules and provided with the necessary logistics will ensure a reliable service with less frequent breakdowns and shorter interruptions.

9.1 Components of a Maintenance Programme

In order to be effective a maintenance programme must have sound

- administrative;
- financial; and
- technical

components.

The discussion in this Module deals with the technical aspects only. It should be pointed out, however, that the technical measures cannot be fully realized without the necessary administrative and financial support.

9.2 Inventory

In preparing a maintenance schedule for the first time one should start with a survey of the water supply systems and make an inventory of all the components and units of the systems. Details of each unit should be recorded separately on suitable simple forms which could eventually provide a complete history of the unit and thus of the system of which it is a part. In case there are no previous records, the second thing to do will be to complete the records as appropriate where possible.

9.3 Tasks

After the completion of the inventory, the tasks to be carried out and their frequency shall be determined taking into account local conditions and experience. Presentation should at best be in tabular form.

9.4 Schedules

The work schedule which may be tabulated should show the work to be done at the prescribed frequency at every location. The individual items can be given reference numbers and the frequencies figures or signs to show whether the tasks are weekly, monthly, quarterly, six monthly, yearly, etc., in order to make the tabulated summaries handy.



Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH

Dag-Hammarskjöld-Weg 1 + 2 · D 6236 Eschborn 1 · Telefon (0 61 96) 79-0 · Telex 4 07 501-0 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.

GTZ activities encompass:

- appraisal, technical planning, control and supervision of technical cooperation projects commissioned by the Government of the Federal Republic of Germany or by other authorities
- advisory services to other agencies implementing development projects
- the recruitment, selection, briefing and assignment of expert personnel and assuring their welfare and technical backstopping during their period of assignment
- provision of materials and equipment for projects, planning work, selection, purchasing and shipment to the developing countries
- management of all financial obligations to the partnercountry.

The series "**Sonderpublikationen der GTZ**" includes more than 190 publications. A list detailing the subjects covered can be obtained from the GTZ-Unit 02: Press and Public Relations, or from the TZ-Verlagsgesellschaft mbH, Postfach 36, D 6101 Roßdorf 1, Federal Republic of Germany.

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 (06196) 79-0
Telex 407501-0 gtz d
Fax No. (06196) 79-1115