DIRECTORATE OF WATER SUPPLY
DIRECTORATE GENERAL CIPTA KARYA
MINISTRY OF PUBLIC WORKS
REPUBLIC OF INDONESIA

DIRECTORATE GENERAL
INTERNATIONAL COOPERATION
MINISTRY OF FOREIGN AFFAIRS
KINGDOM OF THE NETHERLANDS

MDP PRODUCTION TEAM

TRAINING MATERIALS FOR WATER ENTERPRISES

VOLUME 5A

		GUIDE FOR USERS OF TRAINING MATERIALS
●		TRAINING MODULES
		GENERAL
		ORGANISATIONAL
		Basic knowledge / skills
		Processes/procedures
		Equipment/materials
	●	TECHNICAL
		Basic knowledge/skills
	●	Processes/procedures
		withdrawal
		treatment
		distribution
		consumption
		Equipment/materials
		TAPE / SLIDE PROGRAMMES

MDP PRODUCTION TEAM
DHV - IWACO - TGI

DIRECTORATE OF WATER SUPPLY
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DEPARTMENT OF PUBLIC WORKS
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DIRECTORATE GENERAL
FOR INTERNATIONAL COOPERATION
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GOVERNMENT OF THE NETHERLANDS

MDP PRODUCTION TEAM

TRAINING MATERIALS FOR WATER ENTERPRISES

VOLUME 5A
TRAINING MODULES
TECHNICAL (processes/procedures)

DHV CONSULTING ENGINEERS
IWACO B.V.
T.G. INTERNATIONAL

JAKARTA
APRIL 1985

P R E F A C E

This volume is part of the Final Report of the MDP Production Team which produced Training Materials for Water Enterprises as part of a project under the bilateral cooperation programme between the Government of the Republic of Indonesia and the Government of the Kingdom of the Netherlands.

This Final Report contains the following volumes:

Volume 1	Guide for users of training materials	
Volume 2A	Training Modules,	GENERAL + ORGANIZATIONAL (basic knowledge/skills)
Volume 2B	Training Modules,	GENERAL + ORGANIZATIONAL (basic knowledge/skills)
Volume 3	Training Modules,	ORGANIZATIONAL (processes/procedures; equipment/materials)
Volume 4	Training Modules,	TECHNICAL (basic knowledge/skills)
Volume 5A	Training Modules,	TECHNICAL (processes/procedures)
Volume 5B	Training Modules,	TECHNICAL (processes/procedures)
Volume 6A	Training Modules,	TECHNICAL (Withdrawal + Treatment)
Volume 6B	Training Modules,	TECHNICAL (Withdrawal + Treatment)
Volume 7	Training Modules,	TECHNICAL (Distribution + Consumption)
Volume 8	Training Modules,	TECHNICAL (equipment/materials)
Volume 9	Tape/slide programmes	

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TRAINING MODULES

CODE	TITLE
TPG 110	Water quality standards
TPG 120	Water quality control
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TPG 125	Clear water quality control
TPG 135	Water quality control information routing for water treatment processes
TPG 400	Water treatment
TPC 110	Setting out
TPC 120	Excavation, bedding, and backfilling

Module : WATER QUALITY STANDARDS	Code : TPG 110
	Edition : 14-03-1985
Section 1 : INFORMATION SHEET	Page : 01 of 01/08

Duration :	45 minutes.
Training objectives :	After the session the trainees will be able to: - identify several water quality guidelines, recommendations and standards; - identify the guidelines for each water quality parameter.
Trainee selection :	- Director of Water Enterprise; - Head of Technical Department; - Head of Section Production; - Head of Section Distribution; - Head of Sub-section Water Treatment; - Head of Sub-section Laboratory.
Training aids :	- Viewfoils : TPG 110/V 1; - Handout : TPG 110/H 1.
Special features :	-
Keywords :	Drinking water quality standards/WHO guidelines/ E-coli/coliforms/most probable number/MPN.

1. **Recommendations for drinking water**

   - The WHO recognizes a number of guidelines which can be met as:
     . acceptable;
     . preferable;
     . not to be exceeded;
     . maximum permissible.
   - One should aim for the "not to be exceeded" value.
   - The standards of the WHO are summarized in tables.

   Give H 1

2. **Expression of the results**

   Show V 2

   - Most results are expressed as mg/l.
   - The expression ppm (mg/kg) should be abandoned.
   - Chemical components should be expressed in ions.
   - Turbidity should be expressed in units of turbidity (FTU, NTU).
   - Colour should be expressed in units on a platinum-cobalt scale.
   - Volumes are expressed in ml.
   - Temperatures are expressed in degrees Celsius (°C).
   - Bacteriological examinations are given in colonies per millilitre of water, with the medium, time and temperature of incubation being stated.
   - Estimates of the number of Coliform organisms indicative of pollution should be given in terms of the "most probable number" per 100 ml (MPN/100 ml).
   - In reporting chemical analyses, the sensitivity, accuracy, and precision of the method should be indicated.

3. **Bacteriological quality**

   - Water treated (e.g. by chlorination):
     . effective treatment followed by chlorination will provide water free of coliforms;
     . no random sample of 100 ml will reveal the presence of coliforms;

   Use whiteboard

  . positive samples must always be subjected to an appropriate confirmation test. When this test proves possitive too one should immediately check the purification process.

- Untreated water: *(Use whiteboard)*
  . if E-coli are shown to be present in a 100 ml sample the water will be considered unsatisfactory;
  . if frequent sampling repeatedly shows that coliforms are present, steps must be taken to discover and eliminate the cause of pollution;
  . if E-coli exceeds the number of 3 per 100 ml, the water must be considered unusable without prior disinfection.

Module : **WATER QUALITY STANDARDS**	Code : TPG 110 Edition : 14-03-1985
Section 3 : **T R A I N I N G A I D S**	Page : 01 of 01

Expression of parameters — TPG 110/V 1 **EXPRESSION OF PARAMETERS** **CHEMICAL PARAMETERS :** - mg of ION **PHYSICAL PARAMETERS :** - TURBIDITY FTU NTU - COLOUR UNIT ON Pt / Co SCALE - TEMPERATURE °C **BACTERIOLOGICAL PARAMETERS :** - COLONIES / ml MEDIUM TIME OF INCUBATION TEMPERATURE OF INCUBATION - MPN / 100 ml	
	Drinking water quality standards — TPG 110/H 1

1. RECOMMENDATIONS FOR DRINKING WATER

Evaluating water quality requires standards. A number of different standards are available and in use, since they were developed in different societies under different circumstances.
Most commonly reference is made to the standards as issued by the World Health Organization. The WHO recognizes a number of guidelines that can be met, such as "acceptable", "preferable", "not to be exceeded", and "maximum permissible". It is obvious that, if feasible, the "not to be exceeded" guideline should be aimed at.
The drinking water standards as issued by WHO and Indonesia are shown in table 1.

The main recommendations may be summarized as follows:

- Expression of results

Results are expressed in mg/l. The expression "parts per million" (ppm) should be abandoned. Wherever possible, chemical components should be expressed in ions. Turbidity should be expressed in units of turbidity, and colour in units of colour based on the platinum-cobalt scale. Volumes should be expressed in millilitres (ml) and the temperature in degrees Celsius (°C). In bacteriological examinations, the total number of microorganisms developing on solid media should be expressed in significant figures as colonies per millilitre of water, the medium, time and temperature of incubation being stated. Estimates of the number of coliform organisms - Escherichia coli and other microorganisms indicative of pollution - should be given in terms of the "Most Probable Number" per 100 ml (MPN/100 ml).
In reporting chemical analyses, the sensitivity, accuracy, and precision of the method should be indicated. This includes the proper use of significant figures and the expression of reliability limits.

- Bacteriological quality

The following standards have been laid down for water distributed in pipe systems:

a. Water treated, for example, by chlorination:
Effective treatment followed by chlorination or another form of disinfection, will normally provide water free of coliforms, however polluted the initial raw water may have been. In practice, this means that no random sample of 100 ml of water will reveal the presence of coliforms. Any sample taken at the inlet to the network and not conforming to this standard should

call for an immediate inspection of the purification process and the sampling method. However, when examining chlorinated water, the samples assumed to be positive must always be subjected to an appropriate confirmation test.

b. Untreated water:
In this case the water entering the distribution network will be considered unsatisfactory if Escherichia coli are shown to be present in a sample of 100 ml taken periodically from an undisinfected network, provided that the intakes and reservoirs are considered to be satisfactory. If sampling repeatedly shows that coliforms are present, steps must be taken to discover, and if possible eliminate, the cause of the pollution. Where the number of coliforms exceeds 3 per 100 ml the water must be considered unusable without prior disinfection.

The following recommendations are made for samples taken from distribution networks:
1. In any one year, at least 95% of the 100 ml samples must be free of coliforms;
2. No single 100 ml sample must contain E-coli;
3. No single sample must contain more than 10 coliforms per 100 ml;
4. Coliforms must not be detected in 2 successive 100 ml samples.

If examination of samples reveals the presence of coliforms, at least one more sample must be taken. If 1 to 10 coliforms (or more in some samples) per 100 ml are regularly found, there is reason to believe that undesirable substances are entering the water, and urgent measures are necessary to discover and eliminate the cause of the pollution.

Table 1. Maximum acceptable contents of undesirable components in drinking water WHO standards (1970-1971) and Indonesian standards.

Component	Units	Maximum acceptable		Preferably not to be exceeded WHO
		Indonesia	WHO	
A. PHYSICAL CONDITION				
1. Colour	mg/l Pt/Co	-	50	5
2. pH	mg/l	6.9 - 9.2	6.9 - 9.2	7.0 - 8.5
3. Filtrable residue (TSS)	mg/l	-	-	5
4. Total dissolved solids	mg/l	1,500	1,500	500
5. Turbidity	mg/l	25	25	5
B. CHEMICAL CONDITION				
6. Organic matter	mg/l $KMnO_4$	10	-	10
7. Calcium	mg/l Ca	200	200	75
8. Iron (total)	mg/l Fe	1.0	1.0	0.1
9. Magnesium	mg/l Mg	150	150	-
10. Manganese	mg/l Mn	0.5	0.5	0.05
11. Ammonium	mg/l NH_4^+	0.0	-	0.05
12. Chloride	mg/l Cl^-	600	600	200
13. Bicarbonate	mg/l HCO_3^-	200	-	-
14. Nitrite	mg/l NO_2^-	0.0	0.1	-
15. Nitrate	mg/l NO_3^-	20	50	-
16. Sulphate	mg/l SO_4^{2-}	400	400	200
17. Dissolved oxygen	mg/l O_2	-	5	8
18. Hardness	°D	5-10	20	5
19. Aggressive CO_2	mg/l CO_2	0.0	-	-
20. Free chloride	mg/l Cl_2	0.2 - 1	0.2 - 1	0.5
C. BACTERIOLOGICAL CONDITION				
21. Total count	/100 ml		10	0
22. E-Coli	/100 ml		0	0
23. Faecal streptococci	/100 ml		0	0

2. SUMMARY

Various standards exist for judging the quality of drinking water. One of the most widely used sets of standards is that of the WHO, in which four types of ranges are indicated: "acceptable", "preferable", "not to be exceeded", and "maximum permissible".

Results of water quality analyses must be expressed according to a standardized format.

"Maximum acceptable" concentrations of undesirable water components are shown, according to the Indonesian and WHO standards.

* * *

Module : WATER QUALITY STANDARDS	Code : TPG 110
	Edition : 14-03-1985
Annex : V I E W F O I L S	Page : 01 of 02

TITLE :	CODE :
1. Expression of parameters	TPG 110/V 1

EXPRESSION OF PARAMETERS

CHEMICAL PARAMETERS :

- mg /ℓ ION

PHYSICAL PARAMETERS :

- TURBIDITY FTU NTU
- COLOUR UNIT ON pt / Co SCALE
- TEMPERATURE °C

BACTERIOLOGICAL PARAMETERS :

- COLONIES /mℓ
  MEDIUM
  TIME OF INCUBATION
  TEMPERATURE OF INCUBATION
- MPN / 100 mℓ

Module : WATER QUALITY CONTROL - INTRODUCTION	Code : TPG 120
	Edition : 14-03-1985
Section 1 : I N F O R M A T I O N S H E E T	Page : 01 of 01/14

Duration :	45 minutes.
Training objectives :	After the session the trainees will be able to identify : - subjects covered by water quality control; - activities to be carried out for water quality control; - types of information routing, for collecting of information and for trouble shooting.
Trainee selection :	- Director; - Head of Technical Department; - Head of Section Production; - Head of Sub Section Water Treatment; - Head of Section Distribution; - Head of Sub Section Distribution Connections; - Head of Section Planning & Supervision; - Head of Sub Section Laboratory.
Training aids :	- Viewfoils : TPG 120/V 1-5; - Handout : TPG 120/H 1.
Special features :	-
Keywords :	Water quality control/drinking water standards/treatment efficiency/source monitoring/process monitoring/clear water monitoring/information routing.

1. **Introduction**

- Water quality control can be executed on: (Show V 1)
  . water sources;
  . water treatment processes;
  . clear water.

- An important aspect is the handling of information. This can comprise:
  . actions to be taken;
  . advice to be given.

- Water quality control for water sources has to cover the following items:
  . which parameters are exceeding the drinking water standards;
  . which treatment processes are able to reduce these parameters to an acceptable value.

- Water quality control in water treatment processes focuses on:
  . monitoring process efficiency;
  . actions to be taken when efficiency drops.

- Clear water quality control has to be executed to check:
  . if water is bacteriologically safe;
  . if the chemical composition of the water will affect the water supply system.

- Information routing is a process which describes how information obtained is treated and transferred into understandable information for non-specialists.

- Information routing is differentiated into:
  . routine information routing, or collecting and storing data;
  . non-routine information routing, or problem identification and solving (trouble shooting).

2. Water quality control : source monitoring	
- Water quality monitoring can be applied to all kinds of water sources.	
- Source monitoring is executed as follows: . a sample is analyzed; . the result is reported; . the report is sent to the client (Directors of the Company, external people or Head of Technical Department); . one copy is saved for the water quality control files; . once every three months a period report is made and presented to the client.	Show V 2
3. Comments on water quality results for drinking water supply	
- In general, laboratory reports on water quality will be made.	
- A comment on water quality is reported as follows: . the data of the laboratory reports are compared with drinking water standards; . parameters which are exceeding the guidelines are reported; . additional information, comments, are added; . the report is sent to the client; . a copy is kept on file.	Show V 3
4. Treatment processes	
- Two sources of information are required when a certain water quality has to be improved to meet drinking water standards. . the drinking water standards; . the effect of separate treatment processes on water quality;	Use whiteboard

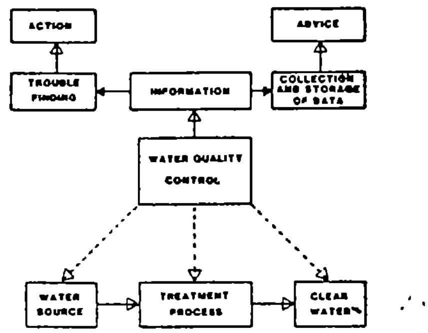
- To select the treatment processes necessary for the improvement of the water quality the following procedure must be followed: — Show V 4
  . compare the water quality data with drinking water standards;
  . trace all parameters exceeding the standards;
  . select the treatment units which are most suitable for the improvement of these parameters;
  . select the most condensed process out of these units.

5. **Treatment process control**

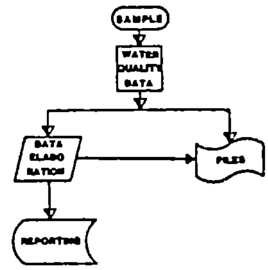
- To control the efficiency of the treatment process, the following steps must be taken — Show V 5
  . take samples of the effluent of each process unit;
  . analyze the samples;
  . present the obtained water quality data in laboratory reports;
  . compare the data with previous data obtained;
  . report any remarkable difference (c.q. efficiency drop);
  . take action if necessary;
  . all actions taken are reported and stored in the files;
  . all reports are stored in the files.

Module : **WATER QUALITY CONTROL - INTRODUCTION**	Code : TPG 120
	Edition : 14-03-1985
Section 3 : **T R A I N I N G A I D S**	Page : 01 of 01

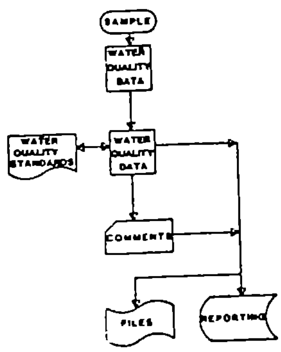
Water quality quality control — TPG 120/V 1



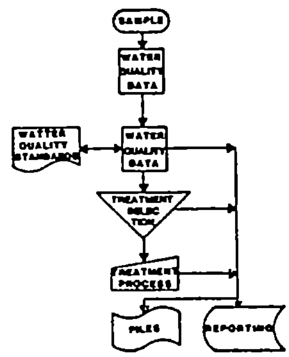
Water quality monitoring — TPG 120/V 2



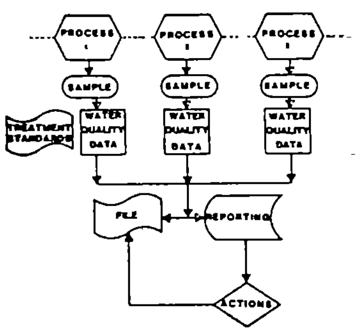
Comments on water quality — TPG 120/V 3



Advice on water treatment — TPG 120/V 4



Process monitoring — TPG 120/V 4



Water quality control - introduction — TPG 120/H 1

1. INTRODUCTION

Water quality control can be executed on sources of water , water treatment processes, and clear water. An important aspect is handling of information, i.e. the actions to be taken or the advice to be provided. The water sources to be discussed are groundwater and surface water, next to clear water for household use and drinking. Treatment processes can be divided in surface water and groundwater treatment processes.

To identify in which way data are handled and transferred to information that is understandable for the clients, information elaboration and routing is required.

The following types of groundwater can be distinguished:
- shallow groundwater;
- deep groundwater and
- artesian groundwater.

Water quality control of groundwater has to cover the following items:
- is water quality suitable for drinking water;
- if drinking water standards are exceeded, what kind of water treatment has to be recommended.

For water quality control, surface water, although present in several ways, can be treated as one group. Direct household use of surface water is unlikely, therefore water quality control has to focus on the type of water treatment required to obtain a water quality sufficient for household and drinking water purposes. The main question is which parameters are exceeding the standards, to determine the selection of water treatment processes.

Clear water quality control has to be carried out regularly, to identify those cases where transmission of diseases by water is likely, due to poor water quality, but also to obtain information whether the quality of water will give rise to damage of the water supply system. Clear water quality control comprises the monitoring of water produced at a treatment plant and of water distributed by a water transport system.

The process of water quality control for groundwater and surface water treatment processes is in fact similar. Water quality control focuses on monitoring of process efficiency and actions to be taken if efficiency drops.

Information routing is a process which describes how information, obtained during water quality control, is treated and transferred into information is that understandable for non-specialists.

Information routing for source monitoring is a rather static process, while information routing for clear water and "process" quality control differentiates into routine and non-routine routing.
Routine information routing is static and aims at data collection and storage, while non-routine information routing is dynamic:
a programme of problem identification and solving is required. For each type of water treatment and distribution system a specific plan of action has in fact to be available.

2. WATER QUALITY CONTROL: SOURCE MONITORING

Water quality monitoring can be applied to all kinds of water sources. The general flow sheet for data processing is shown in figure 1.

A sample is analysed and the sampling result is reported. In general the result of the chemical examination is sent directly to the client. However, one copy is saved in the water quality control files. Once every three months the data on the previous period are summarized in tables and graphs (time dependency) and presented to the client.
The client might be the Directors of the own company, external people, but also the Head of the Technical Department of the water enterprise.

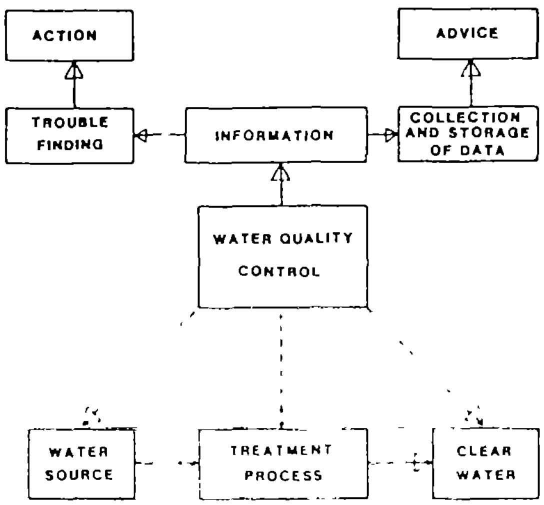


Fig. 1. Water quality control; flow chart.

3. COMMENTS ON WATER QUALITY RESULTS FOR DRINKING WATER SUPPLY

In general laboratory reports will be available with data to comment whether the water is fit for water supply purposes or not. If relevant parameters are missing, resampling and chemical/bacteriological examination is required.

The data of the laboratory reports are compared with the drinking water standards. If none of the chemical compounds is exceeding the guidelines, a qualification "fit for water supply" can be issued.
If some compounds do not meet the guidelines, the comment shall indicate "parameter ... is too high in concentration for drinking water". Additionally information can be provided on to what degree the standard is exceeded.

The laboratory report together with the comments is sent to the client. Besides one copy is kept in on files to build up an own data bank.
The flow chart is shown in figure 2.

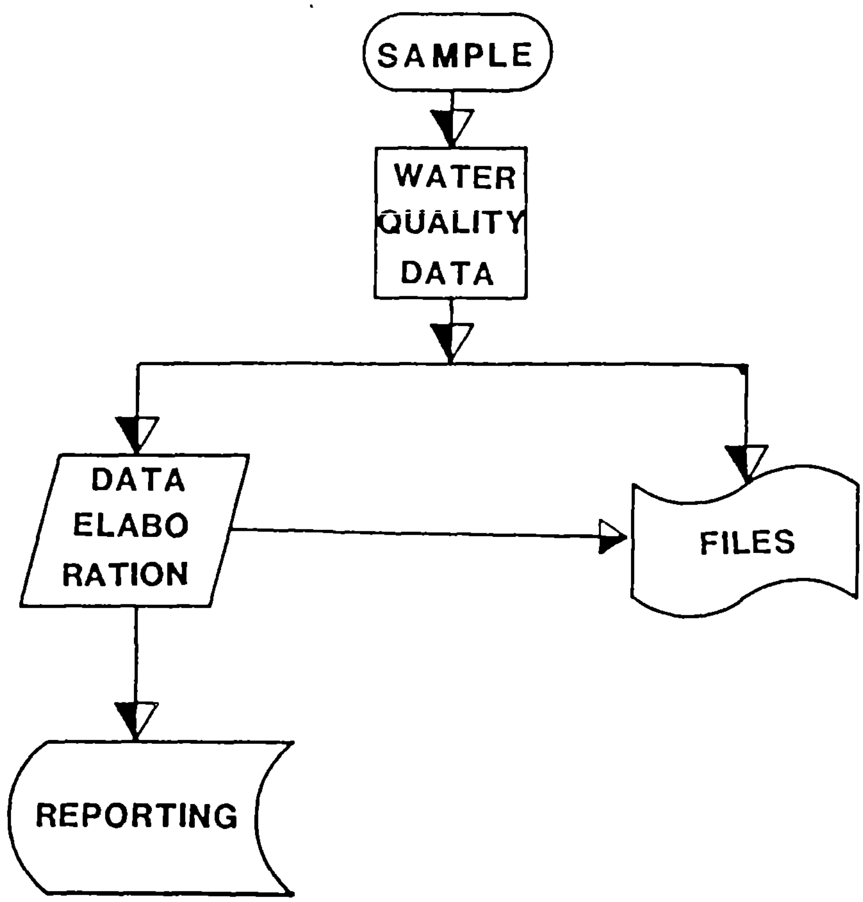


Fig. 2. Water quality monitoring; flow chart.

4. TREATMENT PROCESSES

If a sample is received for which an advice is requested regarding quality and ways to improve the quality up to drinking water standards, two types of information are required:

1. the set of drinking water standards.
2. the various water treatment processes and their effects on water quality.

The following procedure is recommended:

The results of the physio-chemical biological examination of the water sample are compared with the drinking water standards. All parameters exceeding the drinking water quality levels "acceptable" are traced and kept apart.
Subsequently for each parameter kept apart, the most common treatment process and alternative treatment processes are determined. In the following step the most condensed treatment process is selected.

The flow chart is shown in figure 3, while the review of treatment processes is shown in the following table.

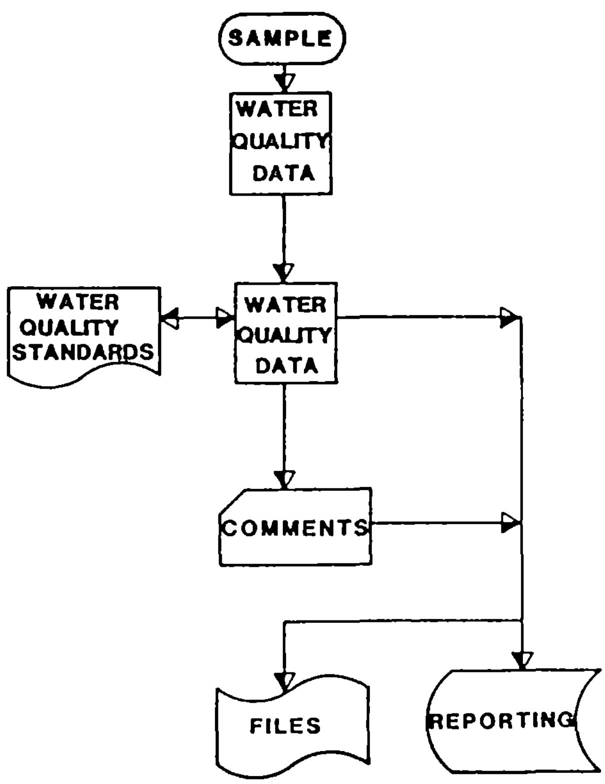


Fig. 3. Comments on water quality; flow chart.

SYSTEMATIC REVIEW OF TREATMENT PROCESSES (Continued)

PARAMETER	TREATMENT PROCESS TO BE SELECTED FOR	
	GROUNDWATER	SURFACE WATER
13. nitrite	trickling filter/ slow sand filter	slow sand filtration
14. nitrate	-	-
15. sulphate	-	-
16. dissolved oxygen	aeration	aeration
17. hardness	-	-
18. aggressive carbon dioxide	aeration/lime dosing marble filtration	lime dosing/ aeration marble filtration
19. free chlorine	chlorine dosing	chlorine dosing
20. bacteriological	disinfection	disinfection

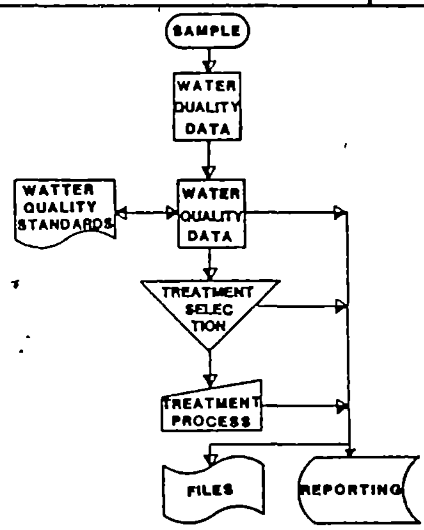


Fig. 4. Advice on water treatment; flow chart.

5. TREATMENT PROCESS CONTROL

To monitor the efficiency of water treatment processes samples are taken from specific places of the water treatment plant. After chemical, physical and bacteriological examination the water quality data are presented in laboratory reports.

The data of the sheets, i.e. the concentrations of the several parameters, are compared with special water treatment efficiency lists. If the removal rates are within the limits, the water quality control report issues a "no-comment, treatment according to specifications".
However, if the efficiency of one of the processes drops down to certain levels, action has to be taken and in the water quality control report a remark to that effect is incorporated.

Whether comments or no comments are issued, the water quality report is presented together with the laboratory results to the client and is also kept on file. The flow chart is shown in figures 4 and 5.

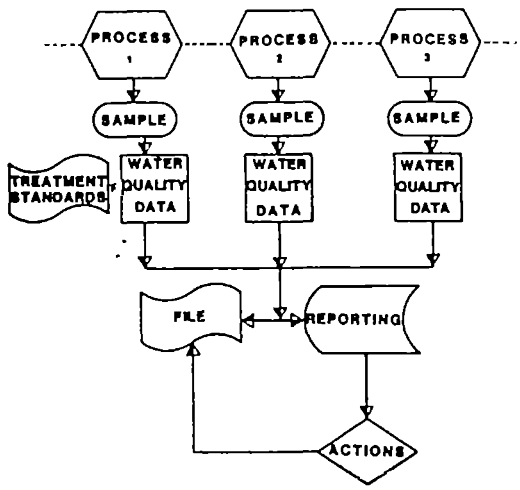


Fig. 5. Process monitoring; flow chart.

6. SUMMARY

Water quality control can be related to:

- Water sources.
- Water treatment processes.
- Clear water.

An important aspect is the handling of information, comprising: actions to be taken and advice to be provided.

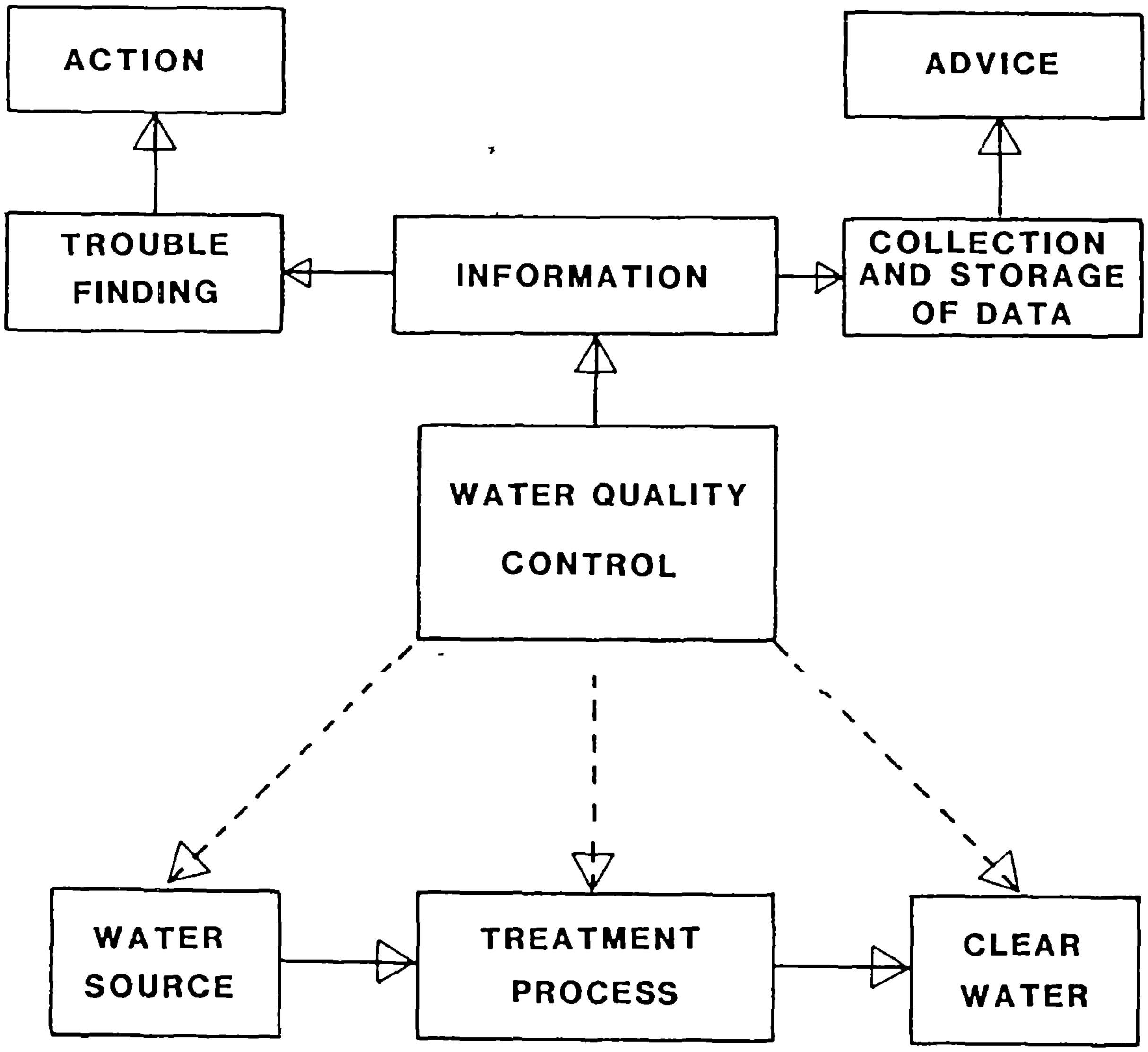
Flow charts are provided for:

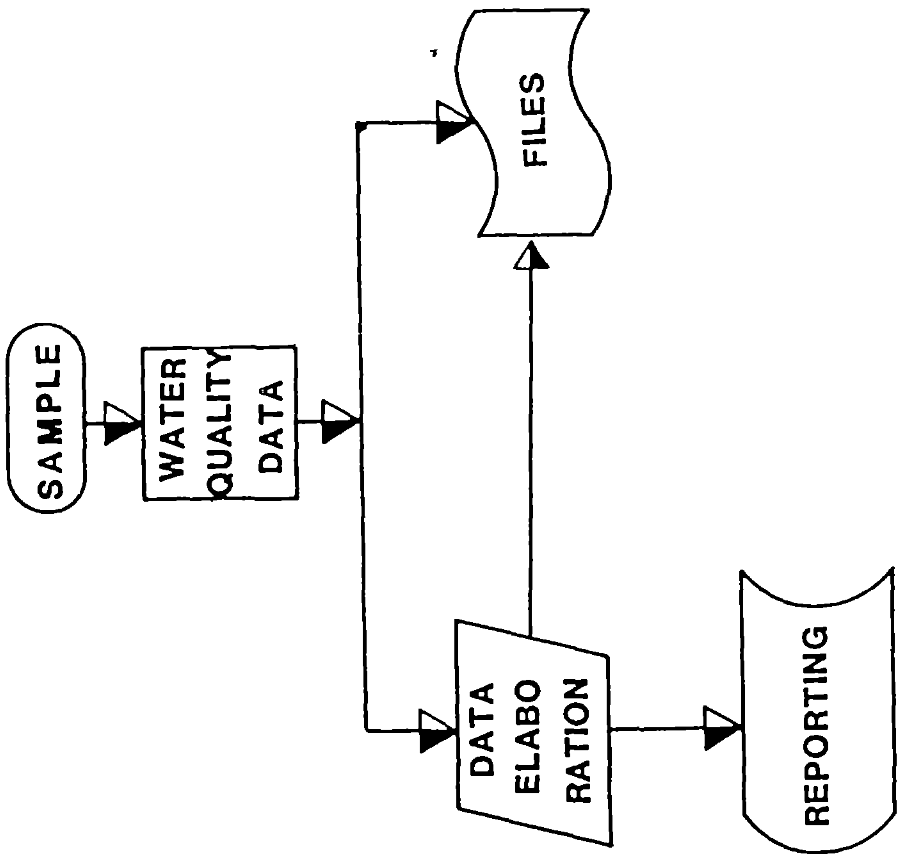
- Water quality control (general).
- Water quality monitoring.
- Comments on water quality.
- Advice on water treatment.
- Process monitoring.

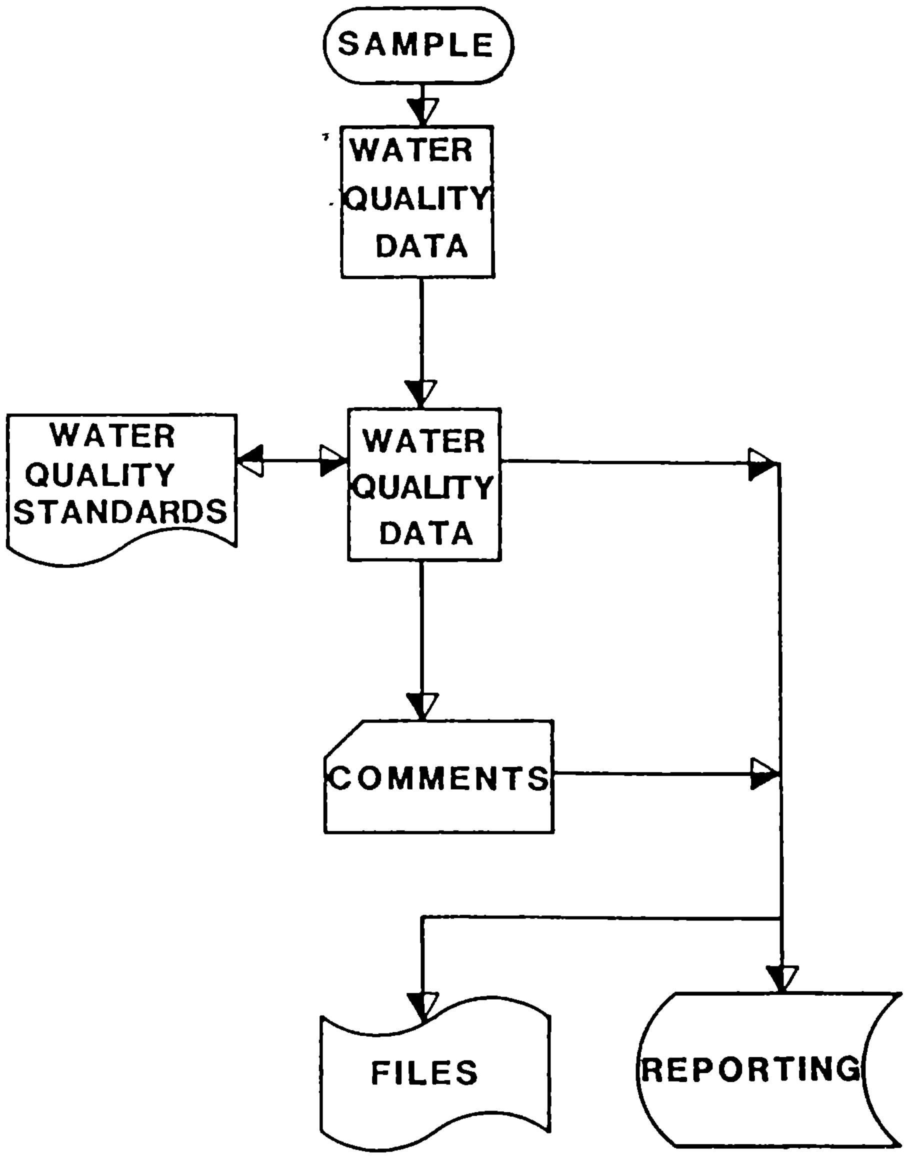
These show the routing of information, whether of a routine nature or not.

* * *

TITLE :	CODE :
1. Water quality control	TPG 120/V 1
2. Water quality monitoring	TPG 120/V 2
3. Comments on water quality	TPG 120/V 3
4. Advice on water treatment	TPG 120/V 4
5. Process monitoring	TPG 120/V 5


ACTION
ADVICE
TROUBLE FINDING
INFORMATION
COLLECTION AND STORAGE OF DATA
WATER QUALITY CONTROL
WATER SOURCE
TREATMENT PROCESS
CLEAR WATER


SAMPLE
WATER QUALITY DATA
FILES
DATA ELABO RATION
REPORTING


SAMPLE
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WATER QUALITY STANDARDS
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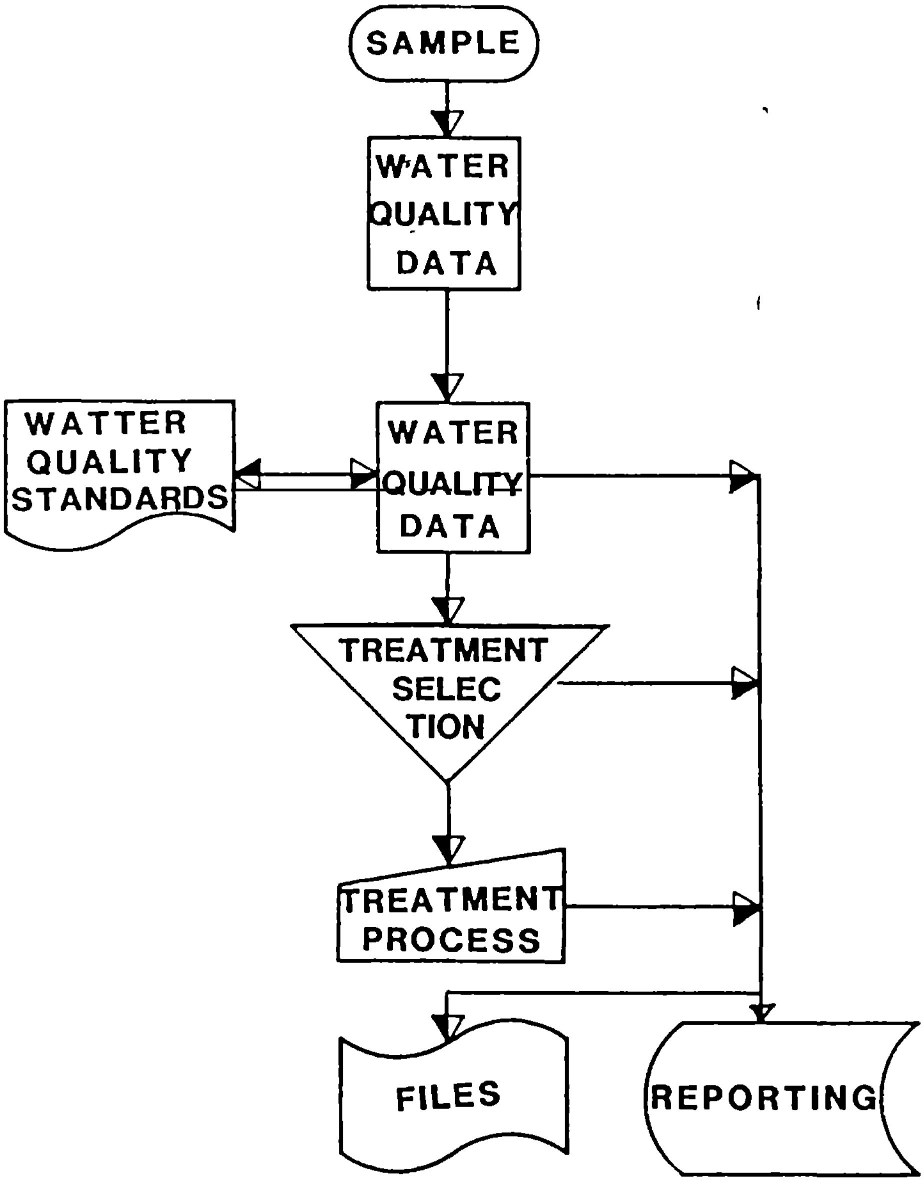
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TREATMENT PROCESS
FILES
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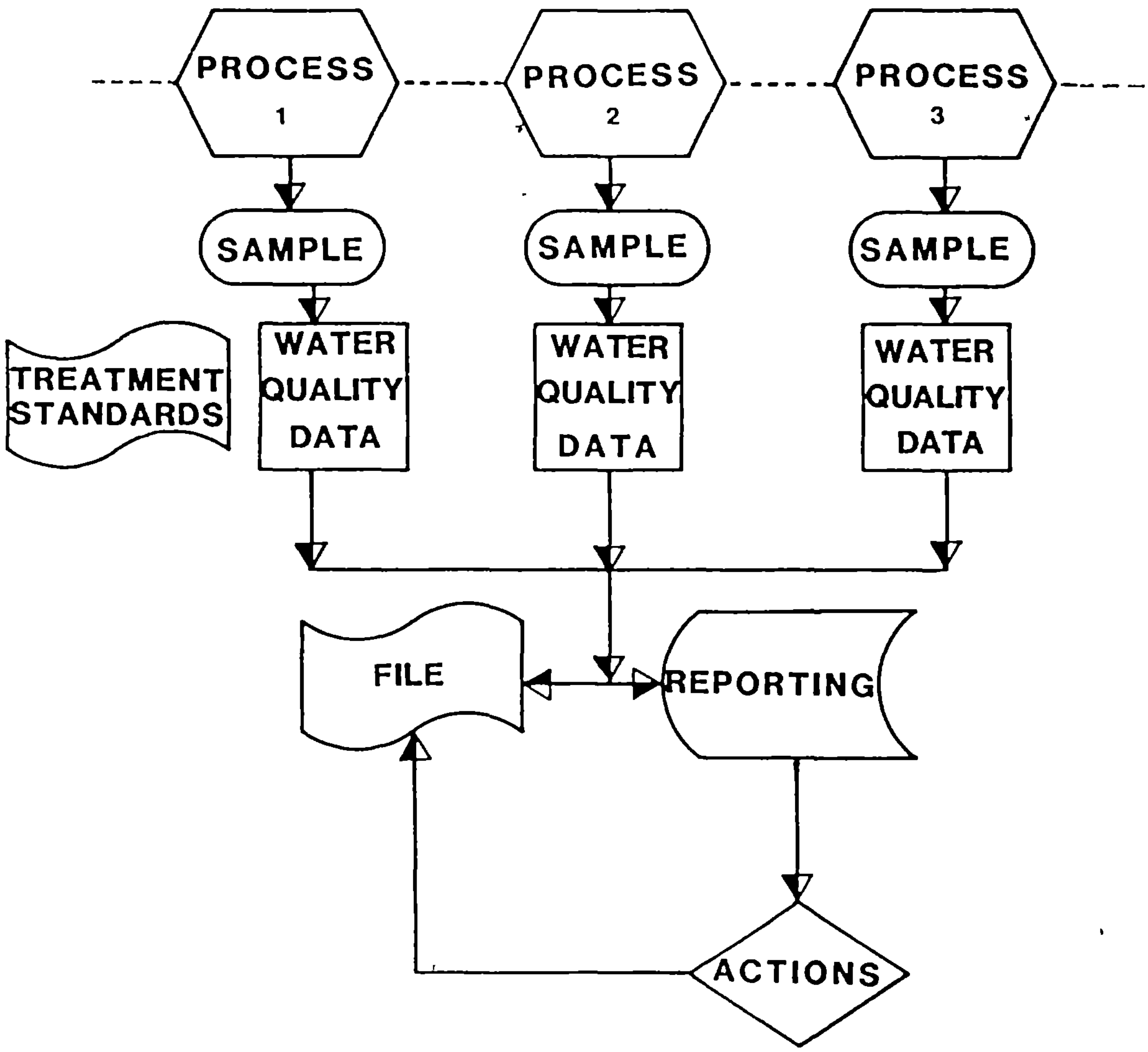

PROCESS
1
PROCESS
2
PROCESS
3
SAMPLE
SAMPLE
SAMPLE
TREATMENT
STANDARDS
WATER
QUALITY
DATA
WATER
QUALITY
DATA
WATER
QUALITY
DATA
FILE
REPORTING
ACTIONS

Module : WATER QUALITY CONTROL - QUALITY PARAMETERS	Code : TPG 121
	Edition : 14-03-1985
Section 1 : INFORMATION SHEET	Page : 01 of 01/10

Duration :	45 minutes.
Training objectives :	After the session the trainees will be able to: - identify the effects caused by water quality components; - recite the nature of each of the water quality parameters.
Trainee selection :	- Management of the Water Enterprise; - Head of Production and Distribution Section; - Chief (Head) of the Laboratory Section.
Training aids :	- Viewfoils : TPG 121/V 1-5; - Handout : TPG 121/H 1.
Special features :	-
Keywords :	Water quality control/water quality parameters/ physical parameters/bacteriological parameters/ colour / turbidity /pH/conductivity/temperature/ suspended solids/organic matter/free chlorine/ hardness/iron and manganese/chloride/sulphate/ nitrogen compounds/carbon dioxide/bicarbonate/ carbonate/aggressive CO_2.

1. **Introduction**

- Water quality control is important because:
  . it protects consumers against diseases caused by the consumption of water with a poor quality;
  . it prevents corrosion of pipes by aggressive water;
  . it prevents the people from being forced back to their traditional and often suspected sources because of poor quality of the water from the public water supply.

Write on whiteboard

2. **Review of water quality parameters**

Explain properties

Physical parameters

Show V 1

- Colour:
  . the origin of colour are organic compounds and/or some inorganic compounds like iron.

- Turbidity:
  . turbidity is caused by colloidal matter which consists of particles not visible to the naked eye.

- Conductivity:
  . the higher the conductivity, the higher the concentration of dissolved compounds in the water;
  . a high conductivity is mostly caused by the presence of chlorides, sulphates and nitrates.

- Temperature:
  . all biological and chemical reactions are dependent on the temperature.

- Suspended solids:
  . suspended solids are visually detectable;
  . suspended solids are settleable.

- pH: . definition: pH = - log $[H^+]$; . a pH of 7 indicates a neutral water; . a low pH (acidic water) in groundwater often indicates an aggressive CO_2 content; . a high pH (basic water) in surface water often indicates algae activity.	Show V 2
Chemical parameters - Organic matter: . organic matter can be oxidized by potassium permanganate; . water rich in organic matter must be suspected of bacteriological or chemical contamination. - Free chlorine: . chlorine is a strong oxidizing agent; . it inactivates pathogenic and non pathogenic organisms. - Hardness: . hardness is the presence of Mg and Ca ions; . hardness is measured in German degrees (°D); . 3-6 °D is called soft water, 15-25 °D is called hard water; . hard water forms insoluble precipitates with soap and leads to scale forming on pipes and boilers. - Iron and manganese: . if present above a certain concentration, they impart tastes and stain articles which are being washed. - Chloride: . chloride in a high concentration causes a salty taste (sea water); . chloride can be detrimental to agricultural crops.	Show V 3 Explain properties

- Sulphate: . sulphate as a salt of magnesium causes a salty bitter taste and has a laxative potential.	
- Nitrogen compounds: . nitrogen compounds are ammonia, nitrite and nitrate; . ammonia is formed anaerobically out of organic matter; . nitrite and nitrate are formed out of ammonia by aerobic biological processes; . oxidation of ammonia to nitrate can cause a deficiency of oxygen, finally resulting in anaerobic water of a poor quality.	Shov V 4
- Carbon dioxide/bicarbonate/carbonate/ aggressive CO_2: . in waters carbonic acid is present as CO_2, HCO_3 and CO_3, in amounts depending on the pH; . CO_3 is in equilibrium with Ca forming insoluble salts; . CO_2 is in equilibrium with atmospheric CO_2 gas; . an excess of dissolved CO_2 will dissolve $CaCO_3$ and is called aggressive CO_2; . an excess of carbonates will lead to insoluble $CaCO_3$ forming scale on structures in contact with the water.	Show V 5
<u>Bacteriological parameters</u>	Show V 6 Write on whiteboard
- The potability of water can only be determined by an additional bacteriological examination. - The presence of pollution by faeces is based on the search for Escherichia Coli. - Water that contains E-Coli can become dangerous in the event of an epidemic.	Give H 1

Module : WATER QUALITY CONTROL - QUALITY PARAMETERS	Code : TPG 121
	Edition : 14-03-1985
Section 3 : T R A I N I N G A I D S	Page : 01 of 01

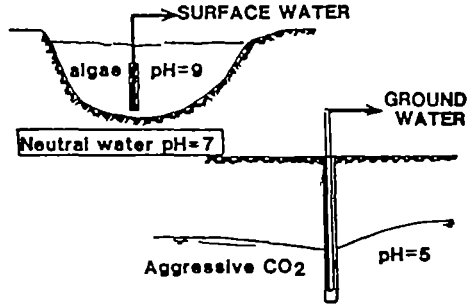
Physical parameters TPG 121/V 1

PHYSICAL PARAMETERS

- Colour
- Turbidity
- Conductivity
- Temperature
- Suspended solids
- pH

pH values of water sources TPG 121/V 2

pH Values of water sources



Chemical parameters TPG 121/V 3

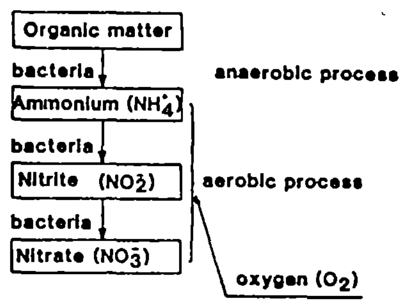
- CHEMICAL PARAMETERS -

- Organic matter
- Free chlorine
- Hardness
- Iron and Manganese
- Chloride
- Sulphate
- Nitrogen Compounds
- Carbon dioxide
- Bicarbonate
- Carbonate
- Aggressive CO_2

(Carbon dioxide, Bicarbonate, Carbonate, Aggressive CO_2: Carbonate system)

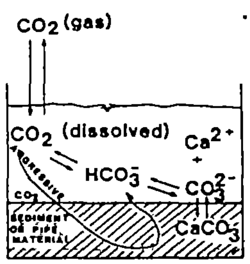
Nitrogen compounds TPG 121/V 4

NITROGEN COMPOUNDS



Carbonate system TPG 121/V 5

- Carbonate System -



Water quality control - quality parameters TPG 121/H 1

1. INTRODUCTION

Water quality control is important as it protects consumers against diseases caused by the consumption of water with a poor quality. But there are other reasons to practice water quality control. In special cases human health is threatened by indirect effects of water quality, such as aggressiveness of water causing corrosion to the pipes of the distribution system, which may result in leakage and thus contamination of drinking water. Some parameters like taste, smell and colour may adversely influence water use, and make the people go back to their traditional, and often suspected, sources of water supply.

In this section all parameters that are important for water quality control will be briefly reviewed, considering their physical, chemical and biological properties as far as relevant for water supply systems.

2. REVIEW OF WATER QUALITY PARAMETERS

1. Physical parameters

Colour

Colour of water is caused by the present of organic matter (brown, yellow, green) and/or certain inorganic compounds - such as iron (brown to reddish brown). Colour is expressed in units on the platinum-cobalt scale.

Turbidity

Turbidity is caused by the presence of colloids. Colloidal matter, mostly present in surface water, causes a turbid appearance. The colloidal matter consists of small particles that are not visible to the naked eye. Colloids behave like dissolved matter and remain in suspension even when the water is virtually at rest.
Turbidity is expressed in units NTU or FTU.

pH

Inorganic and organic matter dissolved in water, dissociates, forming positives ions (kations) and negative ions (anions). The same happens with the water molecule H_2O, which dissociates into one H^+ ion and one OH^- ion.
The pH of the water is defined as the negative logaritm of the hydrogen ion concentration: $pH = - \log [H^+]$.

A water with a pH lower than 7 is said to be acidic and a water with a pH higher than 7 basic. A low pH of groundwater often indicates an aggressive CO_2 content. A high pH value of surface water is often the result of algae activity.

Conductivity

The conductivity of water is a measure of the conductance of electricity by the water. Since the conductance is based upon the transport of electrically charged particles, measuring it gives a direct indication of the presence and quality of dissolved compounds in the water. The higher their concentration, the higher the measured conductivity.
A high conductivity is mostly caused by the presence of chlorides, sulphates and nitrates.

Temperature

For the examination of samples, whatever the source may be, temperature (°C) is important to know, since all biological and chemical processes are temperature dependent, mostly going faster as temperature increases.

Suspended solids

In water solids are present of which a part is suspended and, in contradiction to colloids, visually detectable. Since they will settle by gravity, their quantity (mg/l) can be determined easily.

2. **Chemical parameters**

Organic matter

This term includes all substances that can be oxidized by potassium permanganate at boiling point. The results are expressed either in mg/l O_2 or in mg/l $KMnO_4$; It is compulsory to state the reference (1 mg/l O_2 = 3.95 mg/l $KMnO_4$). The health significance of these substances is not clearly understood and it is not necessary dangerous to health to drink water which contains large quantities of organic matter (a cup of tea contains 2,000 mg/l of organic matter [sugar] expressed as oxygen).

Some forms of organic matter give rise to colour and bad taste, as they favour the development of such organisms as algae, fungi, and bacteria, which attach themselves to pipe walls and secrete essences having an unpleasant smell. They can also create malodorous compounds by reacting with the chlorine used for disinfection purposes. Water rich in organic matter must always be suspected of bacteriological or chemical contamination (reducing agents).

Free chlorine

Chlorine is a strong oxidizing agent, used for drinking water disinfection, i.e. to inactivate pathogenic and non-pathogenic micro-organisms. In drinking water free chlorine has to be present in a certain concentration to ensure the absence of pathogenic and non-pathogenic micro-organisms.

Carbon dioxide/bicarbonate/carbonate/aggressive carbon dioxide

In natural waters, carbonic acid is present in several forms (carbon dioxide, bicarbonate or carbonate) depending on the pH. Apart from this, salts of calcium and magnesium carbonates may be formed.
Carbon dioxide, a gas (CO_2), reacts with water forming carbonic acid (H_2CO_3). Through dissociation the bicarbonate form will be created.

In geneal the salts of carbonic acid are insoluble. One of them is calcium carbonate ($CaCO_3$). In water, calcium carbonate is in equilibrium with the soluble calcium bicarbinate and carbon dioxide according to the following equation:

$$CaCO_3 + H_2O + CO_2 \longrightarrow Ca(HCO_3)_2$$

$CaCO_3$	+	H_2O	+	CO_2	——>	$Ca(HCO_3)_2$
calcium carbonate		water		carbon dioxide		calcium bicarbonate

If some of the compounds are present in excess of the equilibrium concentration, reactions will take place. If the reaction is due to an excess of carbon dioxide, the calcium carbonate will dissolve and calcium bicarbonate is formed. The amount of carbon dioxide capable to dissolve calcium carbonate is called "aggressive carbon dioxide". Water containing aggressive carbon dioxide will affect concrete and asbestos cement, but also copper and lead pipes in a water supply system.
If calcium bicarbonate is present in excess of the equilibrium concentration (hard water) the reversed reaction will occur, calcium carbonate is formed and precipitates, forming scale on the surface of structures in contact with the water.

Hardness

Hardness of water is due to the presence of calcium and magnesium ions. The hardness can be expressed in American, French or German degrees, or as milli-equivalents. Commonly hardness is presented in German degrees (°D). 1°D complies with 10 mg/l CaO. To calculate water hardness in German degrees, the concentrations of calcium and magnesium are converted into the equivalent amount of CaO (by weight).

The classification of water hardness is as follows:

3°D	very soft
3 - 6°D	soft
6 - 10°D	rather soft
10 - 15°D	rather hard
15 - 25°D	hard
- 25°D	very hard

Hardness forms insoluble precipitates with soap, which leads to waste. It also leads to scale-forming on pipes and boilers.

Iron and manganese

Iron and manganese are natural components in water. Although not harmful to human health their presence in clear water will be avoided as much as possible. Iron may cause a yellow colour of water while both iron and manganese if present in any concentration above the very lowest, impart taste and stain articles which are being washed.

Chloride

Chloride is present in water as the soluble salt of sodium, potassium and calcium. Chloride as magnesium salt causes a bitter taste in water, while the sodium chloride at a concentration of 500 mg/l or more causes a salty taste (sea water). Too high salt levels (> 300 mg/l) can be detrimental to agricultural crops, depending on their salt tolerance.

Sulphate

Sulphate in water, mostly present as calcium sulphate (gypsum), is not harmful to human health. However, sulphate as a salt of magnesium, which also has a laxative potential, imparts a bitter taste.

Nitrogen compounds

The group of nitrogen compounds comprises ammonia (NH_4^+), nitrate (NO^{3-}) and nitrite (NO^{2-}) as inorganic compounds. Moreover, nitrogen can be present in a number of organic compounds. Since this group is rather complex, their presence is determined by chemical destruction with a suitable acid to release ammonia compounds which can be determined. The concentration obtained in this way is expressed as Kjeldahl nitrogen. The nitrogen compounds originate from a variety of sources, amongst which is faecal matter, either from animals or man. As organic matter, e.g. plant materials and solid waste, decomposes anaerobically, ammonia is also formed. Nitrate and nitrite are created in aerobic bacteriological processes, from ammonia.
Nitrate is not harmful for human beings as long as a concentration of 30.0 mg/l is not exceeded in water.
Nitrite is a compound causing infantile methaemo-globinaema and should not be present in drinking water.

Ammonia itself is not detrimental to human health. However, if present in water it can cause a deficiency in oxygen and a variety of anaerobic microbiological processes may occur, causing deterioration of water quality.

3. Bacteriological parameters

Chemical analysis as such is not sufficient for deciding whether a water is potable or not. Information regarding organic matter, nitrogen, etc. can only serve as a guide with respect to the possibility of pollution. The potability of water can only be determined by additional bacteriological analysis. Bacteriological analysis is essentially a laboratory matter and involves specialists or specially trained people.

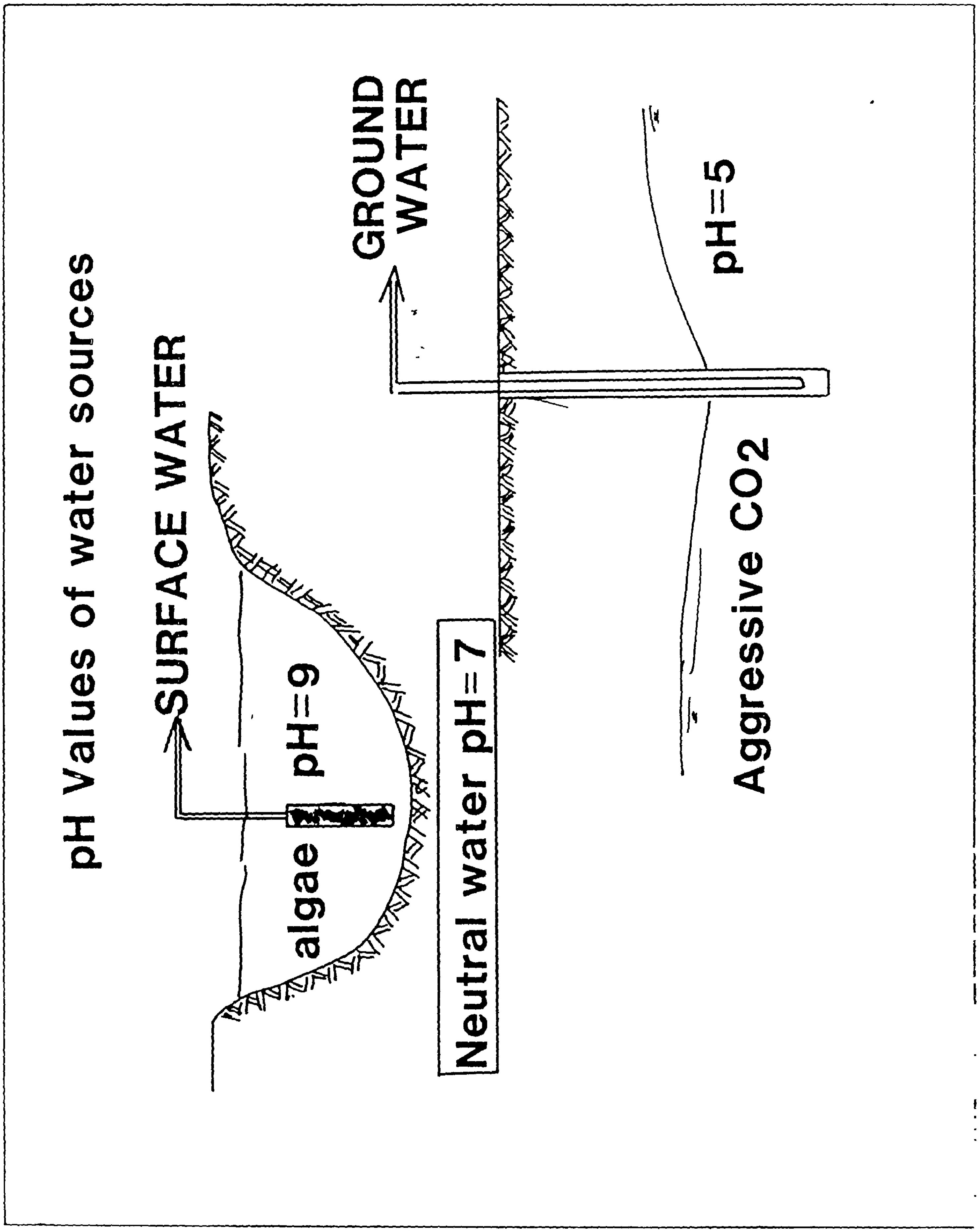
Water bacteriology is based on the search for germs of the bacterium coli type, and in particular Escherichia Coli. Although they are not dangerous in themselves they do indicate the possibility of faecal pollution. Water which contains these germs can thus become dangerous in the event of an epidemic.

* * *

TITLE :	CODE :
1. Physical parameters	TPG 121/V 1
2. pH valves of water sources	TPG 121/V 2
3. Chemical parameters	TPG 121/V 3
4. Nitrogen compound	TPG 121/V 4
5. Carbonate system	TPG 121/V 5

PHYSICAL PARAMETERS

- Colour
- Turbidity
- Conductivity
- Temperature
- Suspended solids
- pH


pH Values of water sources
SURFACE WATER
algae
pH=9
Neutral water pH=7
GROUND WATER
pH=5
Aggressive CO2

– CHEMICAL PARAMETERS –

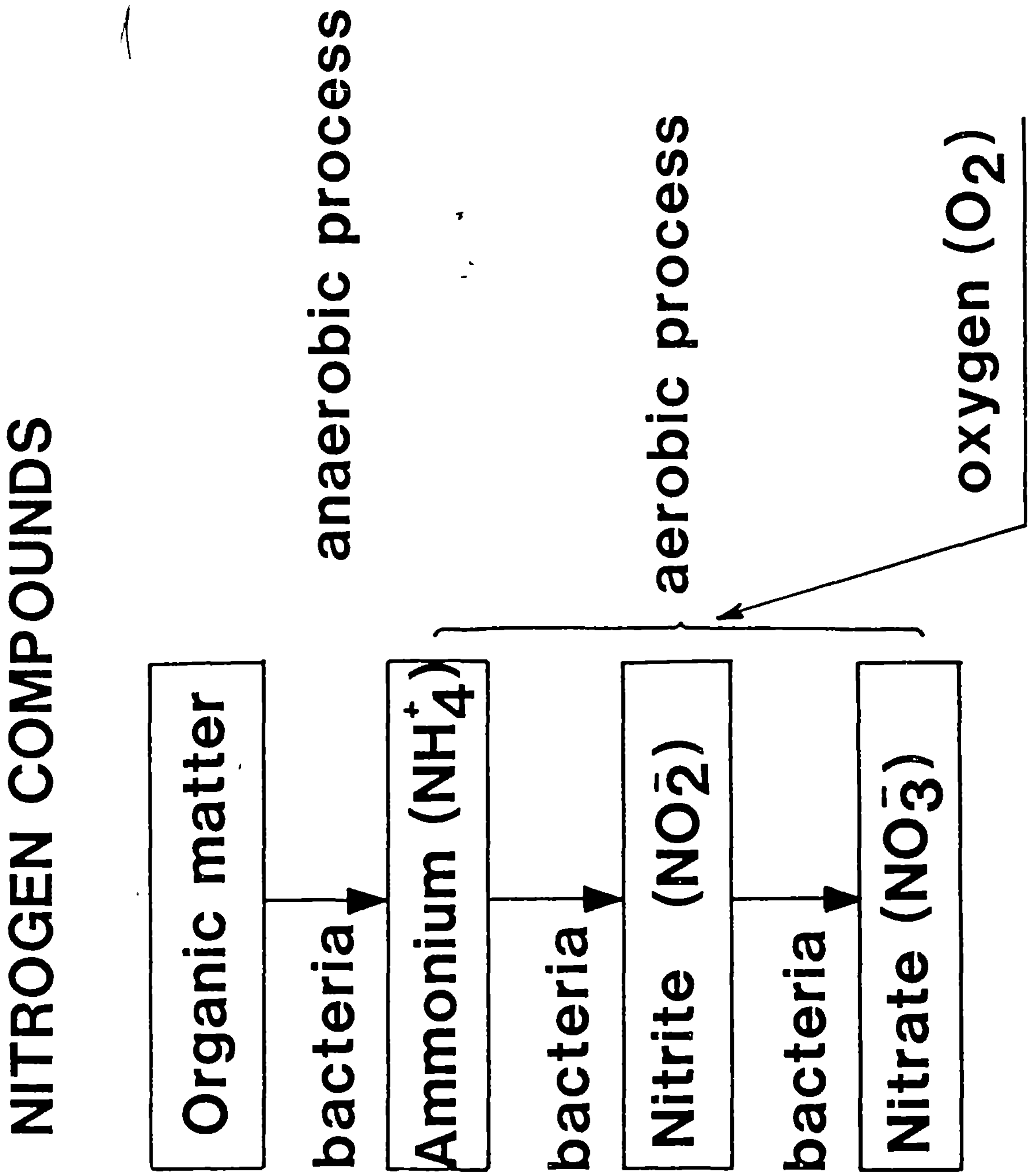
- Organic matter
- Free chlorine
- Hardness
- Iron and Manganese
- Chloride
- Sulphate
- Nitrogen Compounds
- Carbon dioxide

  Bicarbonate

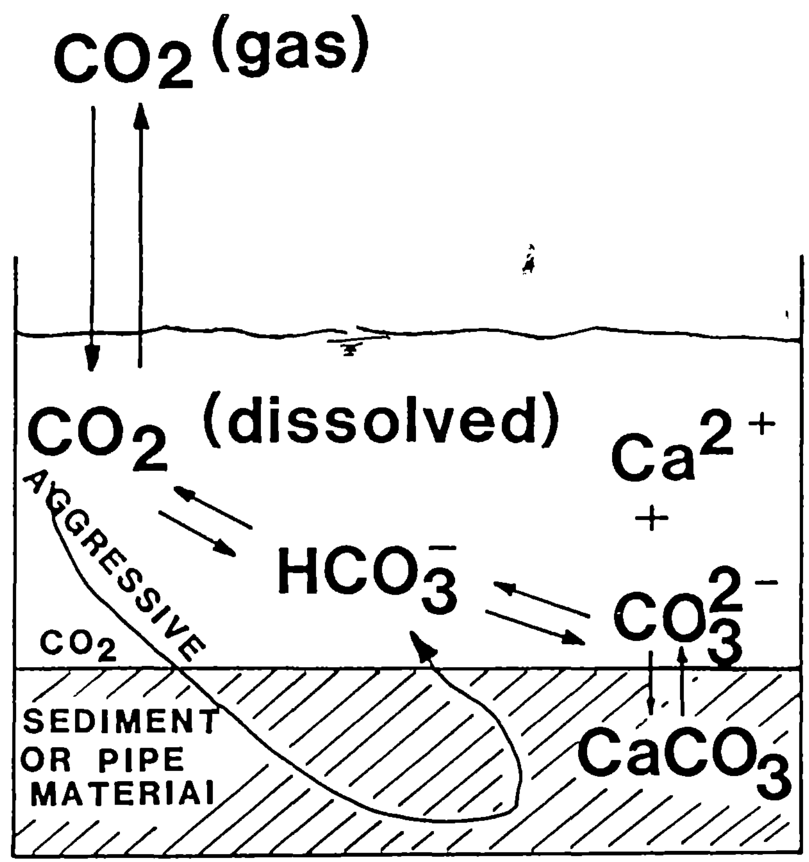
  Carbonate

  Aggressive CO_2

} Carbonate system


NITROGEN COMPOUNDS
anaerobic process
aerobic process
oxygen (O_2)
Organic matter
bacteria
Ammonium (NH_4^+)
bacteria
Nitrite (NO_2^-)
bacteria
Nitrate (NO_3^-)

- Carbonate System -



Module : CLEAR WATER QUALITY CONTROL	Code : TPG 125
	Edition : 14-03-1985
Section 1 : INFORMATION SHEET	Page : 01 of 01/10

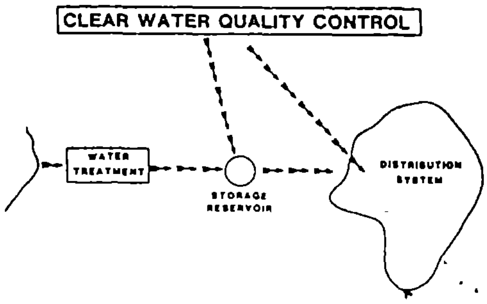
Duration :	45 minutes.
Training objectives :	After the session the trainees will be able to: - recite why clear water quality control has to be executed regularly; - recite how to execute water quality evaluation; - recite how to report results of water quality control; - identify how to react in case of water quality conditions that are detrimental to health.
Trainee selection :	- Head of Section Production; - Head of Sub-section Water Treatment; - Head of Sub-section Laboratory.
Training aids :	- Viewfoils : TPG 125/V 1-3; - Handout : TPG 125/H 1.
Special features :	-
Keywords :	Clear water quality monitoring/water deterioration/sampling frequency/free chlorine content/bacteriological condition.

1. Introduction	
- Clear water quality monitoring is required to: . prevent transmission of diseases to the consumer; . prevent detrimental effects to the supply system.	
- Clear water quality is checked: . prior to water distribution (at the storage reservoir); . after distribution (at the periphery of the system).	Show V 1
2. Water quality deterioration	
- Water quality deterioration can be caused by: . intrusion of shallow groundwater if water pressure in the distribution system drops; . intrusion of shallow groundwater at damaged places in the piping system; . dissolving of pipe materials due to aggressiveness of the water; . bacteriological processes due to absence of sufficient chlorine in the water.	Use whiteboard
- Bacteriological processes may occur even if the chlorine content in the reservoir is found to be sufficient, because free chlorine can be reduced by oxidizable matter that is: . present in the clear water; . entering the distribution system through leaks.	Show V 2

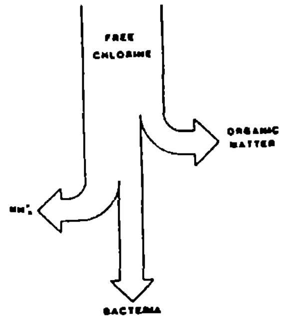
3. Examination and sampling frequency	
- Treated water entering the distribution system should undergo the following examinations: . bacteriological analysis once a day; . a check on each stage of the treatment, several times a day; . in situ inspection by experts, twice a year.	Use whiteboard
- Untreated water entering the distribution system should be examined with the following maximum intervals: . 1 month if the population served is lower than 20,000; . 2 weeks if the population served is between 20,000-50,000; . 4 days if the population served is between 50,000-100,000; . 1 day if the population served is more than 100,000.	Use whiteboard
- Samples must be taken at several points of the distribution system, with a minimum number of samples: . 1 sample per 5,000 people if the population is less than 50,000; . 1 sample per 10,000 people if the population is over 50,000.	Use whiteboard
4. Clear water quality evaluation	
- Water quality data are compared with drinking water standards with the result that: . the water is called "safe" if the concentration of all relevant parameters do not exceed the value "preferably not to be exceeded"; . the water is "fit for drinking water" concerning the measured parameters if not all relevant data are obtained; . the water is acceptable when the data are within the range "preferably not be exceeded" and "maximum accpetable";	Show V 3

. the water is unsuitable when some of the parameters exceed the maximum acceptable standards.	
- The water quality report shall indicate which parameters exceed the standard, and which impacts can be expected from this.	
- Reporting on two parameters needs special attention, namely: . residual chlorine content in the distribution system; . bacteriological condition in the distribution system.	Use whiteboard
- The chlorine dosing unit must be adjusted in such a way that the free chlorine content in the distribution system is: . high enough to prevent bacterial growth in the system (> 2 mg/l); . low enough to prevent taste and odour complaints (< 5 mg/l).	Use whiteboard
- If bacteriological contamination is confirmed by two successive samples, the Head of the Section Distribution has to implement corrective measures which must be checked by sampling.	Give H 1

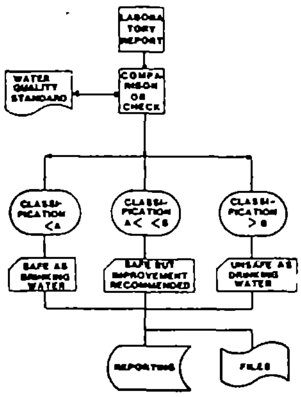
Clear water quality control — TPG 125/V 1



Reduction of free chlorine — TPG 125/V 2



Water quality monitoring — TPG 125/V 3



Clear water quality control — TPG 125/H 1

1. INTRODUCTION

Clear water quality monitoring is required to prevent transmission of diseases to the consumer and to prevent possible detrimental effects to the supply system.

Two places of clear water quality checking can be distinguished:
a. prior to water distribution, and
b. after distribution (at the periphery of the system).

The difference between them is that the first one is merely a production check, while the second one provides a check of water supplied to the customer. The latter is important to carry out, since during water transport and distribution water quality may change/deteriorate due to physio-chemical and bacteriological processes.

2. WATER QUALITY DETERIORATION

Water quality deterioration processes include:
- intrusion of shallow groundwater if water pressure in the distribution system drops;
- intrusion of shallow groundwater at damaged places in the piping system;
- dissolving of piping materials due to aggressiveness of the water;
- bacteriological processes due to the absence of sufficient chlorine in the water.

The latter possibility may occur, even if the chlorine content in the clear water is found sufficient. Free chlorine is reduced when oxidizable matter like organic matter, ammonia and iron (II) is present in the clear water or enters the distribution system through leaks. Clear water quality control must therefore be executed at the site of storage as well as after supply to the customer.

The chemical composition of water in both cases has to comply with the "preferably not to be exceeded (WHO) standard" and must not exceed the maximum acceptable standards.

3. EXAMINATION AND SAMPLING FREQUENCY

Treated water, on entering the distribution system should undergo the following examinations:
- bacteriological analysis preferably once a day (at least once a week);

- a check at each stage of the chemical treatment several times a day, the results being put on record;
- in situ inspection at least twice a year by engineering and sanitation experts acting on behalf of the responsible authorities.

For untreated water entering the distribution system, the following maximum intervals between routine examinations are proposed.

Population served	Maximum interval between successive samplings
up to 20,000	1 month
20,000 to 50,000	2 weeks
50,000 to 100,000	4 days
more than 100,000	1 day

For samples taken at several points of the distribution system the following sampling frequency is proposed, whether the water has previously been treated or not:

Population served	Maximum interval between successive samplings	Minimum number of samples to be taken from entire distribution system
up to 20,000	1 month	1 sample per 5,000 of population per month
20,000 to 50,000	2 weeks	
50,000 to 100,000	4 days	1 sample per 10,000 of population per month
more than 100,000	1 day	

4. CLEAR WATER QUALITY EVALUATION

The aim of monitoring the quality of clear water is to identify whether the water is fit for drinking or: that the water doesn't cause detrimental effects to the consumer.

The procedure to be followed is very simple: The water quality data are compared with the water quality standards. If the concentrations of all parameters mentioned do not exceed the values "preferably not to be exceeded", the water can be classified as safe. If data on only a part of the compounds are covered and do not exceed the above-mentioned values, the water is fit for drinking water.

After taking into account the raw water source, i.e. groundwater or surface water, it can be concluded whether additional data should be obtained for water quality evaluation or not.

If the water quality data are within the range between "preferably not to be exceeded" and "maximum acceptable" the water has to be considered as acceptable. However, notice shall be given that water quality is marginal and that measures to improve the drinking water quality with respect to the relevant parameter have to be taken on the long run.

If some of the water quality data exceed the maximum acceptable standards, usage of the water for drinking water should be rejected.

The water quality control report shall clearly indicate which parameters exceed the standard, and which impacts can be expected as a result of this.
The flow chart is shown in Fig. 1.

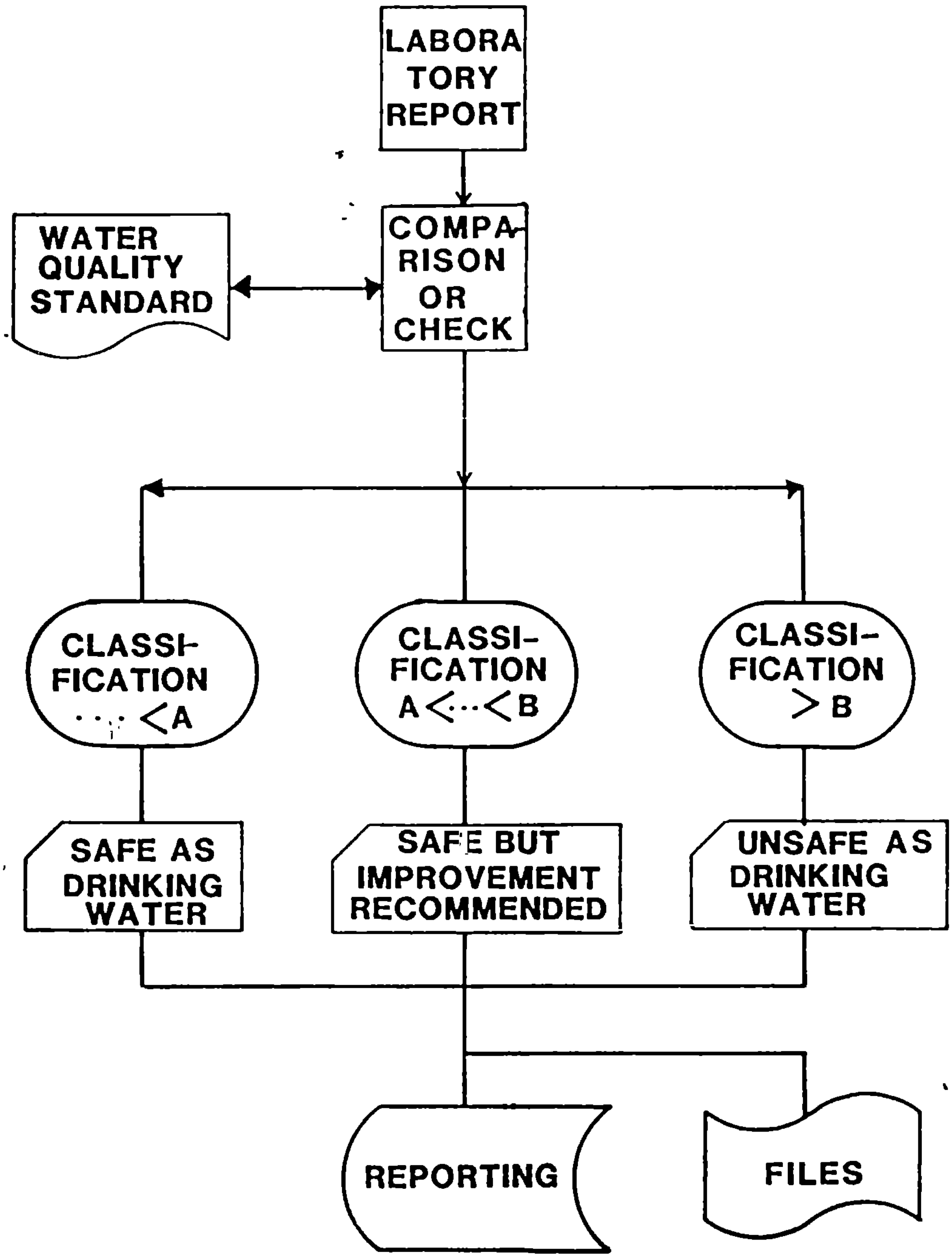


Fig. 1. Water quality monitoring; flow chart.

The water quality data on two important parameters for drinking water quality control need special attention. The free chlorine content and the bacteriological condition of water distributed through a piped system.

If the free chlorine content of the water at the periphery of the system is too low or too high, the responsible management of the water works enterprise shall be informed at once. In this way bacteriological growth in the distribution system and unhygienic and detrimental water conditions should be prevented.

If the quality of water, from a bacteriological point of view, is exceeding the standards, a check sample has to be taken immediately, to confirm the first one. At the same time people in charge should be notified of a "presumably dangerous" water condition. If the second sample also indicates a bacteriological contamination, the management of the distribution section has to be informed immediately about the results of the tests.

After the corrective activities have been taken by the distribution section, again a water sample has to be taken and analysed, following the same procedure of reporting, until the test results comply with the standards.

5. SUMMARY

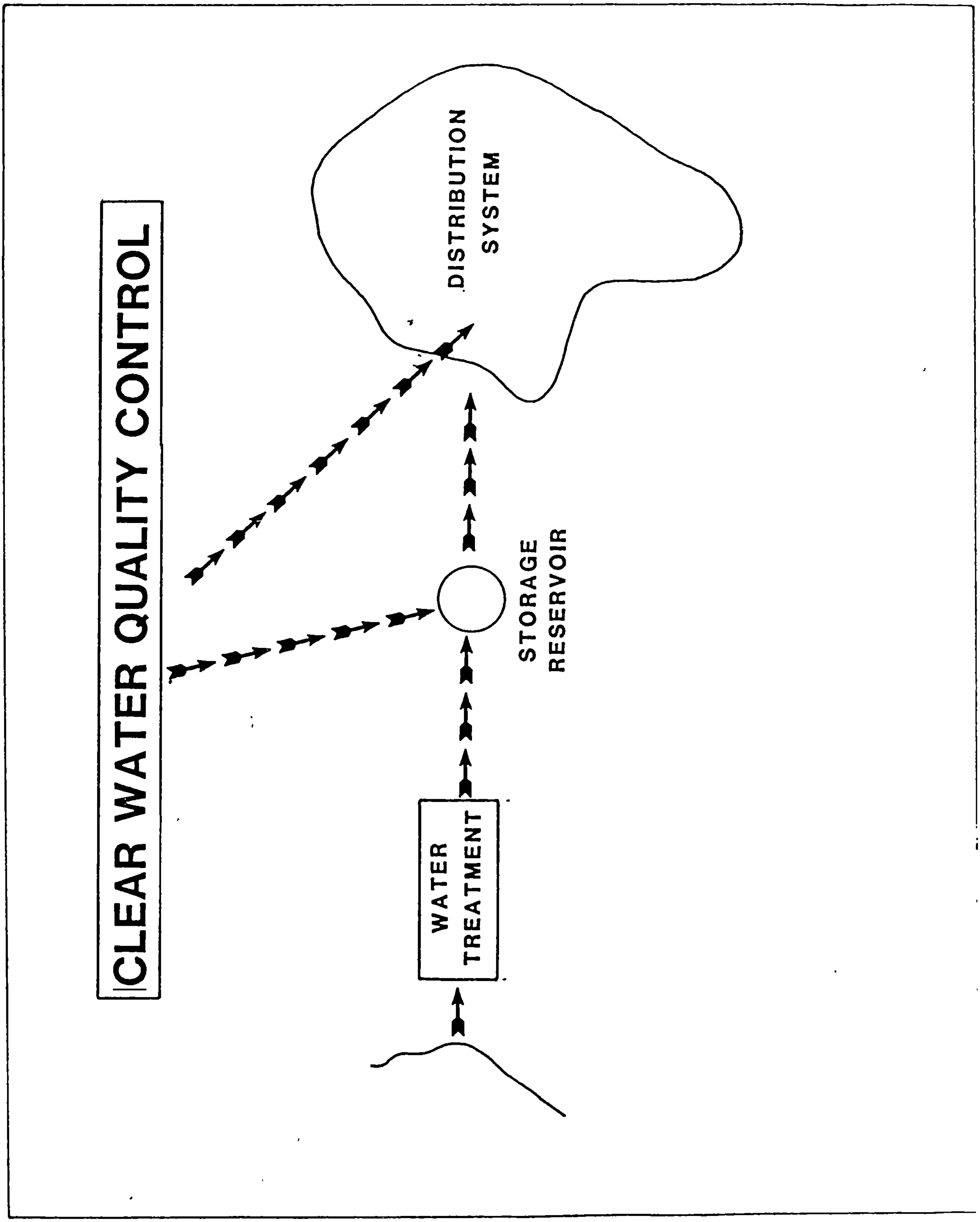
Monitoring the clear water quality is necessary to prevent that diseases are transmitted to the consumers and/or the water supply system is adversely affected. Because the water quality can deteriorate due to a number of factors, the quality of the water should be checked regularly, both prior to distribution and after distribution (at the periphery of the system).

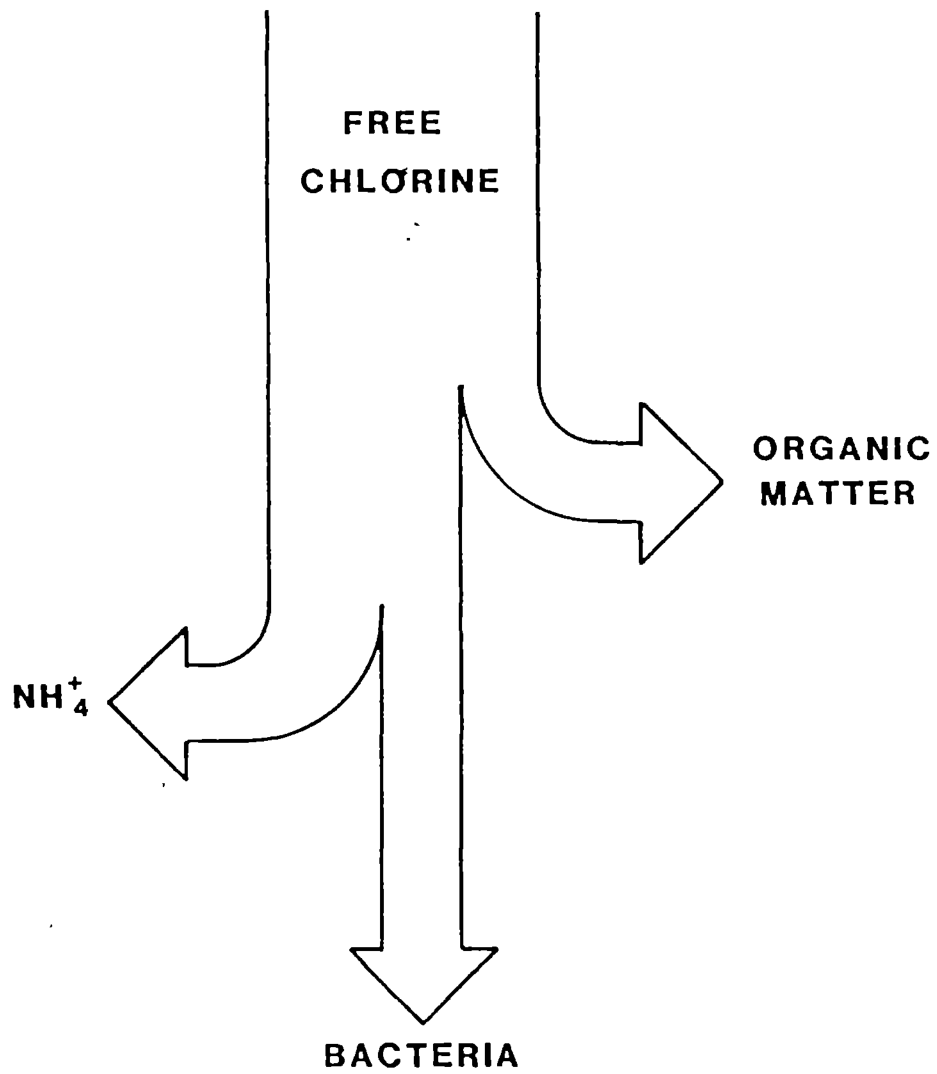
A number of water quality parameters must be checked, the most important of which are the bacteriological quality and residual chlorine content.
The number of samples to be taken and the sampling frequency are determined by the size of the water supply system.

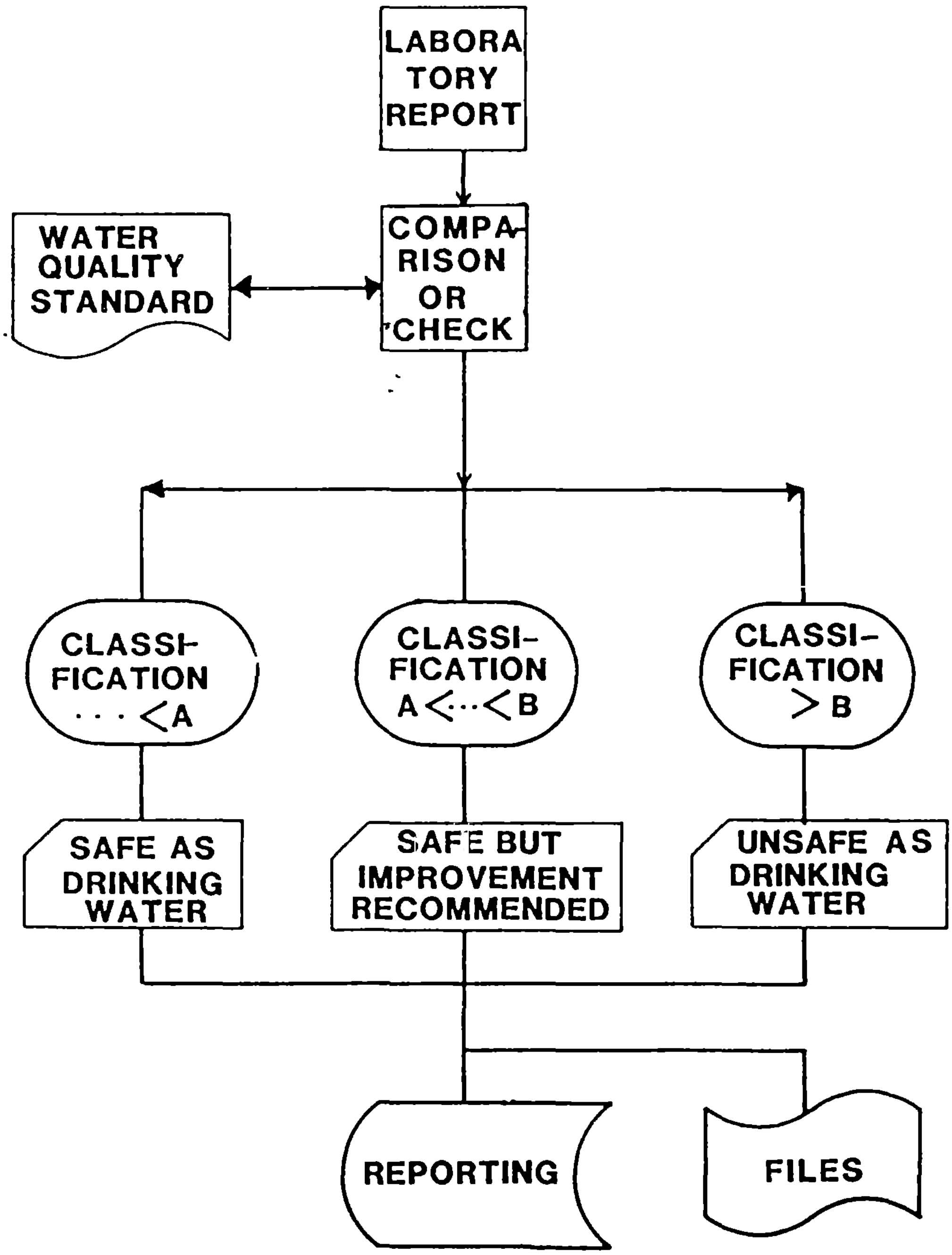
* * *

Module : CLEAR WATER QUALITY CONTROL	Code : TPG 125
	Edition : 17-04-1985
Annex : V I E W F O I L S	Page : 01 of 04

TITLE :	CODE :
1. Clear water quality control	TPG 125/V 1
2. Reduction of the free chlorine	TPG 125/V 2
3. Water quality monitoring	TPG 125/V 3


CLEAR WATER QUALITY CONTROL
DISTRIBUTION SYSTEM
STORAGE RESERVOIR
WATER TREATMENT


FREE
CHLORINE
ORGANIC
MATTER
NH$_4^+$
BACTERIA


LABORATORY REPORT
WATER QUALITY STANDARD
COMPARISON OR CHECK
CLASSIFICATION ... <A
CLASSIFICATION A<...<B
CLASSIFICATION >B
SAFE AS DRINKING WATER
SAFE BUT IMPROVEMENT RECOMMENDED
UNSAFE AS DRINKING WATER
REPORTING
FILES

Module : WATER QUALITY CONTROL INFORMATION ROUTING - TREATMENT PROCESSES	Code : TPG 135
	Edition : 14-03-1985
Section 1 : INFORMATION SHEET	Page : 01 of 01/11

Duration :	45 minutes.
Training objectives :	After the session the trainees will be able to: - identify the value of and the need for a water quality control script; - identify how to use a water quality script for process management; - identify how to anticipate deviation in clear water chlorine content and bacteriological count; - identify how the process of reporting is implemented.
Trainee selection :	- Director; - Head of Section Production; - Head of Sub-section Water Treatment; - Head of Section Distribution; - Head of Sub-section Distribution Connections; - Head of Section Planning & Supervisions; - Head of Sub-section Laboratory.
Training aids :	- Viewfoils : TPG 135/V 1-2; - Handout : TPG 135/H 1.
Special features :	-
Keywords :	Water quality monitoring/information routing/attention range/action range/data handling/laboratory journal/performance reports/residual chlorine/bacteriological tests.

1. Introduction	
- For implementing water quality control, an understanding of the treatment processes is required. One should know: . which parameters provide basic information; . which parameters influence the efficiency of the process.	
- For each treatment plant a script has to be available indicating how to act under certain circumstances to ensure a continuous and proper process operation.	
2. Methodology	
- First, one has to determine the acceptable values of the water quality parameters for the effluent of the separate units.	
- Three ranges of concentrations are possible: . the normal concentration range; . the concentration range whereby attention is necessary; . the concentration range whereby direct action is necessary.	Use whiteboard
- Explain the methodology for the parameters "turbidity": . for raw water; action if NTU > 150; attention if NTU > 50; . for clarified water; action if NTU > 9, attention if NTU > 6; . for filtered water; action if NTU > 2, attention if NTU > 1; . for clear water; action if NTU > 2, attention if NTU > 1.	Show V 1
- Direct action (when the parameters is in the action range) involves the following: . performing the jar test and adjusting the alum dosing rate; . checking of the process (dosing rate, mixing, stirring); . backwashing or filter bed inspection;	Explain using V 1

. inspection of the reservoir (on sediments, etc.)

3. **Data handling**

- The Head of Laboratory should enter all information related to water quality control in the laboratory journal.

- The regular reports on water quality and evaluation are summarized in monthly, quarterly and yearly performance reports and sent to:
  . the Management of the Waterworks;
  . the Head of the Section Production;
  . the Head of the Sub-section Water Treatment.

4. **Special procedures**

Chlorine

- The free chlorine content of clear water has to be 0.2 - 0.5 mg/l.

Show V 2

- If the chlorine content is outside the range of 0.2 - 0.5 mg/l the following must be checked:
  . dosing rate;
  . solution strength;
  . chlorine demand of the clear water.

- The results of all checking and control procedures are reported and sent to the Head of Sub-section Water Treatment; a copy is kept on file.

5. **Bacteriological water quality**

- Normally micro organisms should be absent from clear water.

- The results of the test will be either of the following:
  . the test complies with the standard and a report is sent to the Head of Sub-section Water Treatment;
  . the test exceeds the standard : another test must be performed to confirm the first one, whereafter the Heads of Sections Production and Distribution must be informed.

- If the test is positive, an action plan must be set up by the Heads of the Section Production and Distribution, comprising:
  . a check of free chlorine content;
  . sampling of water in the distribution network to identify whether water contamination has already spread to other areas;

- The following measures must be taken:
  . adjustment of the chlorine dosing if the residual chlorine content is too low;
  . flushing and disinfection of the distribution systems if the contamination has spread.

- The results of all checking, control and action procedures are reported and sent to the Heads of the Sections Production and Distribution; one copy is kept on file.

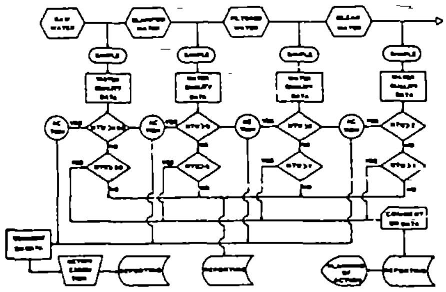
6. **Monthly, quarterly and annual performance reports**

- The reports on water quality control are regularly summarized and issued as:
  . monthly;
  . quarterly and;
  . annual performance reports.

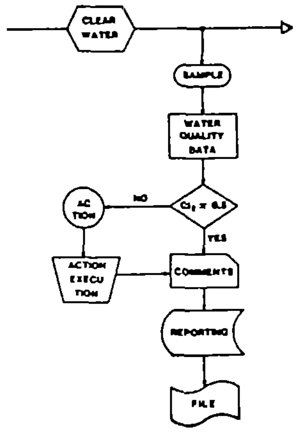
Use whiteboard

- These reports are sent to: . the Head of Section Production; . the Management of the Waterworks Enterprise. - The reports should cover: . volume of water treated; . volume of water distributed; . consumption of chemicals; . physical and chemical analyses, shown as averages, with maxima and minima indicated; . bacteriological analyses, shown as averages, with maxima and minima indicated; . comparison of the data, with comments; . special actions taken for operation or distribution. - The Head of the Sub-section Laboratory is responsible for all reports and the handling of information.	 Use whiteboard

Quality control flow chart — TPG 135/V 1



Chlorine control — TPG 135/V 2



Water quality control information routing - treatment processes — TPG 135/H 1

1. INTRODUCTION

Water quality control for water treatment processes means monitoring the performance of the processes. In this respect it must be kept in mind that in a sequence of processes the malfunctioning of one of the processes influences the other.
The procedure of water quality monitoring merely identifies where the real problems are.

To implement water quality monitoring, an understanding of the treatment processes is required. One should know which parameters provide the basic information and which parameters and circumstances influence the efficiency of processes.

In fact for each treatment a script has to be available, indicating how to act under certain circumstances to ensure a continuous and proper process operation.

A water quality monitoring script for a surface water treatment plant is demonstrated in this section. The treatment comprises coagulation, flocculation, sedimentation, filtration and disinfection. Special attention will be paid to three water quality parameters, namely: turbidity, residual chlorine and bacteriological quality.

2. METHODOLOGY

The first step is to determine for each of the parameters the acceptable concentrations in the effluent of the separate treatment units.

For each parameter three concentration ranges are given:

- The normal concentrations range;
- The concentration range whereby increased attention should be paid to process control;
- The concentration range whereby direct action has to be taken.

For turbidity the following script can be developed to demonstrate the methodology.

Raw water

The normal turbidity range is : 10 - 50 NTU.
The attention range is 50 - 150 NTU. If the raw water turbidity fluctuates in this range the alum dosing has to be adjusted regularly according to the results of the jar test.

The action range is reached when the turbidity is greater than 150 NTU. The jar test should be performed more times a day and the alum dosing should be adjusted. Because alum added to the water will lower the pH, the lime or soda ash dosing should be regulated in such a way that the optimum pH is reached.

Clarified water

The normal turbidity range is 2-6 NTU. The attention range is 6-9 NTU. In that case it can be expected that some minor process irregularities have occurred, such as a change in raw water conditions, or incorrect dosing of alum. It is possible that a more frequent sludge draining of the sedimentation tank is required.
Attention should be given to process operation and checks have to be carried out.
Action must be taken when the turbidity exceeds 9 NTU. Problems will now certainly arise at the subsequent step, the filtration. Filters will clog rapidly, and it is to be expected that the turbidity of the filter effluent will not meet the drinking water standards anymore.
Immediate action has to be taken, such as checking the dosing rate, determining new dosing rates with the jar test and checking the process itself.

Filtered water

The normal turbidity range is lower than 1 NTU. The attention range is 1-2 NTU.
An effluent quality up to 2 NTU is acceptable, but not preferable. If effluent turbidity is in this range, attention should be given to process operation. First the filter influent quality (clarified water) must be checked; if its turbidity is too high, the procedure as described for "clarified water" has to be followed. If the clarified water quality is not deviating from the normal values the reason for the increased turbidity of the filtered water is to be sought at the filters; inspection of operation procedures and filter condition is required.

The action range is reached when the turbidity exceeds 2 NTU.
The water produced does not comply with the standards. Immediate actions have to be taken. If the influent quality is according to the specifications and a backwashing process does not restore the effluent quality, a filter bed inspection is required.

The Heads of the Section Production and Sub-section Water Treatment should be informed that the filter that causes the high effluent turbidity has to be taken out of operation for direct repair or maintenance.

Clear water

The normal range of the turbidity is lower than 1 NTU; the attention range 1-2 NTU.
If the turbidity of the clear water is above 1 NTU, the effluent turbidity of the filters has to be checked. If these are according to the specifications, the reason for an increased turbidity level must be found at the reservoir.
The action range is reached when the turbidity exceeds 2 NTU.
In fact the same procedures as described above can be applied. However, the difference is that when the water quality is in the action range, action has to be taken at once.

3. DATA HANDLING

The Head of Sub-section Laboratory should enter all information obtained on water quality control in the laboratory journal.
The information is stored in the files, and a copy is sent to the responsible manager/operator/analyst of the water treatment plant according to the following scheme.

Normal process performance results and circumstances are reported to the Heads of the Section Production and of the Sub-section Water Treatment. Parameters classified in the "attention" range are also reported to them. On the basis of the report the Head of the Sub-section Water Treatment will prepare a plan for inspection, maintenance or repairs as well as a time schedule for these.
Circumstances classified in the "action" range have to be reported to the Head of the Sub-section Water Treatment, while at the same time services have to be provided to solve the trouble.

The regular reports on water quality and its evaluation are summarized into monthly or quarterly and annual performance reports and sent to the management of the water works and the Heads of the Section Production and of the Sub-section Water Treatment.

4. SPECIAL PROCEDURES

Chlorine

The procedure for residual chlorine monitoring is much simpler, since it only involves one treatment step. First the clear water is checked on the presence of chlorine, which has to amount to 0.2 - 0.5 mg/l.

If this value is found, the report comments "normal" and is put on file and sent to the Head of the Sub-section Water Treatment. The chlorine demand test is executed when the residual chlorine concentration is not in the range of 0.2 - 0.5 mg/l.
The water quality report serves as a reminder that the chlorine content must be adjusted. If the chlorine concentration is outside the range levels the dosing rate has to be checked, as well as the strength of the chlorine solution and the chlorine demand of the clear water. If the chlorine demand of the water is too high, the effluent turbidity as well as the organic matter content have to be checked. At the same time the clear water storage reservoir is checked upon accumulation with suspended and settled solids.
The results of the checking procedure are written down in the water quality control report and sent to the head of plant operation. A copy is kept in archive.

Bacteriological water quality control

The final procedure to be discussed is the monitoring of the bacteriological condition of the clear water. Under normal process operations, micro-organisms should be absent from the clear water. Their presence in water presents a potential health risk to the consumer.

If the results of the tests do comply with the standards, the results are only reported to the Head of the Sub-section Water Treatment, as was mentioned earlier for the physical parameters. If the standards are exceeded a resampling has to be carried out to confirm the first test.
If the tests again show that the standards are exceeded, the Heads of the Sections Production and Distribution are warned immediately, to discuss and implement a plan of action.

This plan comprises:
- Checking of the residual chlorine content.
- Sampling of water in the distribution network to identify whether water contamination has already spread.

Human health must be protected. If the chlorine content is too low, adjustment of the chlorine dosing has to be carried out immediately. If the contamination has already spread into the distribution system a programme of flushing and disinfection has to be considered.

The exceeding of the bacteriological standards, as well as the actions taken and their results are reported in the water quality control report and sent to the Heads of the Sections Production and Distribution, and of the Sub Section Water Treatment. A copy is filed.

5. MONTHLY, QUARTERLY AND ANNUAL PERFORMANCE REPORTS

The reports on water quality monitoring are reguarly summarized and issued as monthly, quarterly and annual performance reports. They are sent to the management of the waterworks enterprise and to the Heads of the Section Production and of the Sub-section Water Treatment. The reports should deal with :

- Volume of water treated per month, related to the full plant capacity.
- Volume of water distributed per month.
- Consumption of chemicals per month.
- Results of physical/chemical analyses, indicated as monthly averages, with minimum and maximum values.
- Results of bacteriological analyses, indicated as monthly averages with minimum and maximum values indicated, both for production water and for distributed water.
- Comparison with and comments on the compliance with the relevant water quality standards, of both the produced and distributed water.
- Special actions undertaken in order to adjust treatment operation and improve the quality of water in the distribution network.

The Head of the Sub-section Laboratory is responsible for the contents (lay-out) of all above mentioned reports as well as for the daily reports and the handling of information contained therein.

6. SUMMARY

For implementing a water quality control programme, an understanding of the treatment processe is required. For each of these processes a number of relevant water quality parameters must be monitored and reported upon.
The obtained information and any action taken on the basis thereof are laid down in (daily,) monthly, quarterly and annual performance reports.

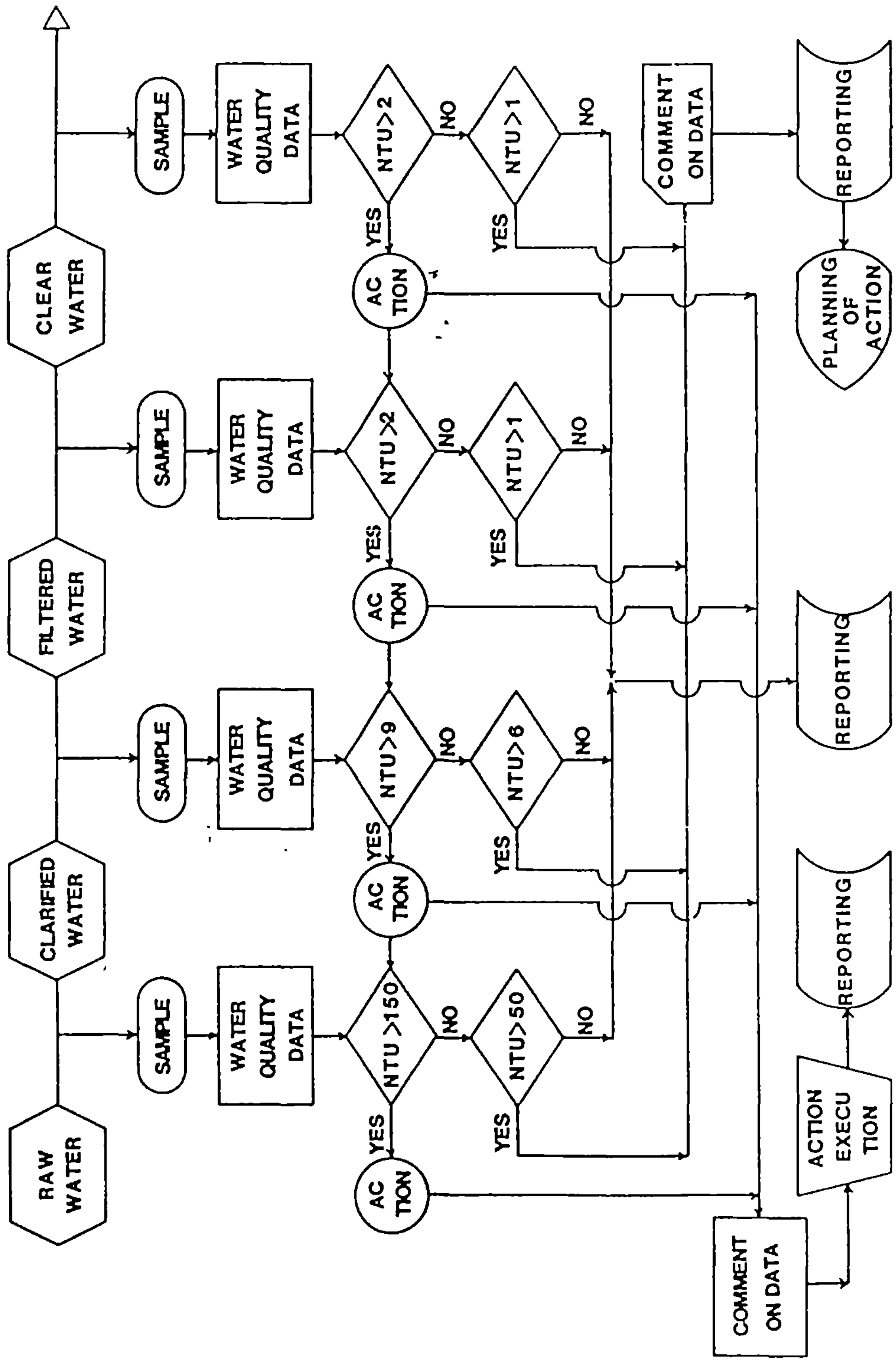
In addition to routine reporting, information on the water quality failing to meet the relevant standards must be given to the Heads of the Section Production and of the Sub-section Water Treatment. In case the bacteriological quality of the distributed water does not meet the standrads, also the Head of the Section Distribution must be informed.
The Head of the Sub-section Laboratory is reponsible for the compilation of the water quality data and the reporting thereon.

* * *

Module	: WATER QUALITY CONTROL INFORMATION ROUTING - TREATMENT PROCESSES	Code	: TPG 135
		Edition	: 14-03-1985
Annex	: V I E W F O I L S	Page	: 01 of 03

TITLE : **CODE :**

Title	Code
1. Quality control flow chart	TPG 135/V 1
2. Chlorine control	TPG 135/V 2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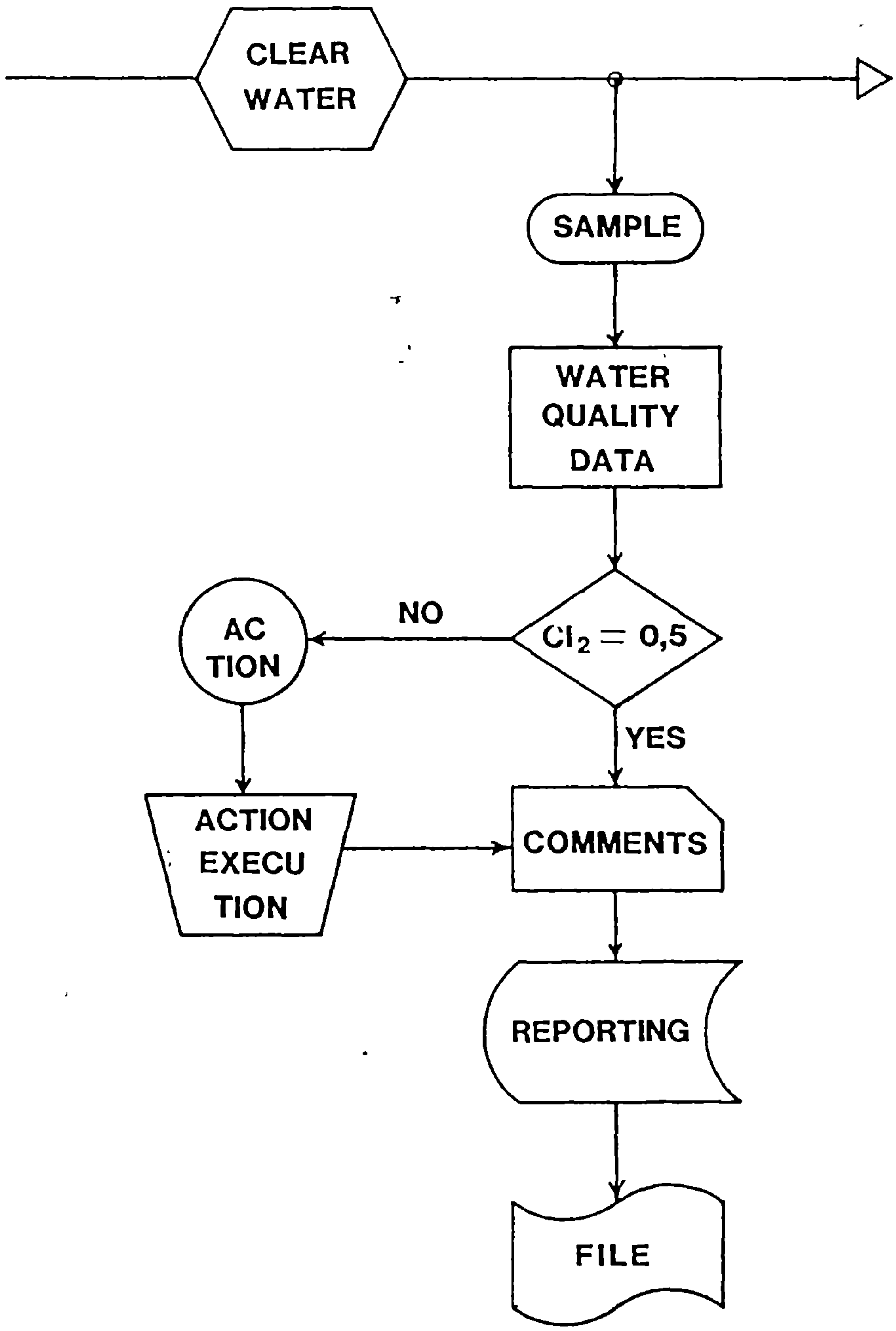
CLARIFIED WATER
FILTERED WATER
CLEAR WATER
SAMPLE
WATER QUALITY DATA
NTU >150
NTU>50
NTU>9
NTU>6
NTU>2
NTU>1
YES
NO
AC TION
COMMENT ON DATA
REPORTING
ACTION EXECU TION
PLANNING OF ACTION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COMMENTS
REPORTING
FILE

Module : WATER TREATMENT	Code : TPG 400
	Edition : 14-03-1985
Section 1 : I N F O R M A T I O N S H E E T	Page : 01 of 01/16

Duration :	90 minutes.
Training objectives :	After this session the trainees will be able to: - recite the basic principles of water treatment; - recite the usual unit operations in water treatment; - define a complete water treatment scheme for the purification of ground water and surface water.
Trainee selection :	- All employees of water enterprise.
Training aids :	- Viewfoils : TPG 400/V 1-8; - Handout : TPG 400/H 1.
Special features :	-
Keywords :	Ground water/surface water/unit treatment operations/water treatment schemes.

1. Principles

Introduction

- Water treatment is aimed at the conversion of raw water into clean water for human consumption or other purposes. The raw water may be rainwater, groundwater or surface water.

- Most important in water treatment is the removal of:
  . pathogenic organisms;
  . toxic substances.

- Other substances which need to be removed are :
  . suspended matter causing turbidity;
  . iron and manganese, for the bitter taste they give to water, and the stains they cause on laundry;
  . excessive CO_2 as it corrodes concrete and metal parts;
  . obnoxious gases, causing bad taste and odour.

Type of impurities

- Impurities occur in three, progressively finer, modifications: (Show V 1)
  . suspended;
  . colloidal;
  . dissolved.

  A major difference between the three modifications is the size of the suspended colloidal and dissolved particles, i.e. suspended > colloidal > dissolved.

- Suspended matter is :
  . normally settleable when water is at rest;
  . found in the water due to surface run-off (erosion) and sediment transport in waterways.

- Colloids have the following characteristics:
  . the particles are not visible by the naked eye;
  . colloids cause turbidity and colour;
  . they remain in suspension when the water is at rest.

- Dissolved solids may:
  . cause colour, but not turbidity;
  . be picked up by the water in the underground or during surface run-off;
  . cause hardness of water (e.g. calcium, magnesium);
  . give water an undesirable taste (e.g. iron, manganese).

- Dissolved gases may have the following effects:
  . excessive CO_2 corrodes concrete and metal parts;
  . a low oxygen content causes an unpleasant taste and/or smell.

Water sources

- Water sources can be divided into:
  . groundwater;
  . surface water.

- In general, groundwater has the following characteristics: — Show V 2
  . bacteriologically safe;
  . no turbidity;
  . a high CO_2 content;
  . a low oxygen content;
  . a high content of various dissolved solids.

- Surface water can be taken from:
  . rivers;
  . streams;
  . lakes;
  . irrigation canals.

- In general, surface water has the following characteristics: . bacteriologically polluted; . a high turbidity; . presence of organic matter; . a low content of various dissolved solids.	Show V 2
2. Water purification	
- Water treatment processes may be aimed at: . aeration/degasation; . coagulation/flocculation; . sedimentation; . slow sand filtration; . rapid sand filtration; . disinfection.	Use whiteboard
- The aeration/degasation process is aimed at increase of oxygen and/or reduction of dissolved gases (e.g. CO_2) and characterized by an intimate contact between water and air.	Show V 3
- The coagulation and flocculation process is aimed at the removal of colloids by agglomeration and characterized by: . addition of chemicals; . rapid mixing; . gentle stirring.	Show V 4
- The sedimentation process is aimed at: . removal of settleable suspended solids and characterized by; . low velocity of water; . sludge removal.	Show V 5
- The slow sand filtration process is aimed at removal of bacterioligical contamination and minor quantities of suspended/colloidal matter. It is characterized by: . schmutzdecke; . a bed of fine sand; . removal of suspended matter in top section of filter medium; . removal of micro-organisms in schmutzdecke and filter medium;	Show V 6

. filter cleaning by removal of the top layer of filter.	
- The rapid sand filtration process is aimed at the removal of suspended matter. It is characterized by: . a bed of coarser sand; . higher filtration rate (25 - 100 times) than in the slow sand filtration process; . retaining suspended matter deep in filter bed; . cleaning by backwashing;	Show V 6
- The disinfection process is aimed at the destruction of pathogenic micro-organisms and characterized by: . addition of chemicals; . contact period.	Use whiteboard
3. Water treatment schemes	
- Groundwater treatment - for spring: . normally clear water; . containing aggressive CO_2; . conditioning for the removal of CO_2 by aeration or neutralization; . disinfection to prevent bacterial growth in the distribution system;	Show V 7
- Groundwater treatment - for shallow well/ borehole: . high CO_2 content; . high iron and manganese content; . aeration to remove CO_2 and to oxidize Fe (II); . rapid filtration to retain insoluble Fe (III) precipitates; . disinfection to prevent bacterial growth in the distribution system.	Show V 7
- Surface water treatment: . high turbidity; . polluted with micro-organisms. . sedimentation followed by slow sand filtration when suspended matters are present and turbidity relatively low;	Show V 8

- coagulation/flocculation, sedimentation and rapid sand filtration when colloids are present and turbidity relatively high;
- disinfection for the inactivation of bacteria.

4. **Summary**

Give H 1

Types of impurities in water TPG 400/V 1

TYPES OF IMPURITIES IN WATER

- Suspended matter
- Colloidal matter
- Dissolved matter
  - solids
  - gases

Sizes of matter / particles :

SUSPENDED 〉 COLLOIDAL 〉 DISSOLVED

Water sources TPG 400/V 2

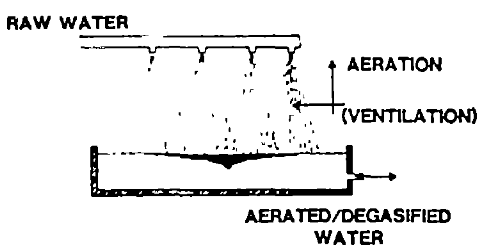
GROUNDWATER :

- Bacteriologically safe
- No turbidity
- High CO_2 content
- Low O_2 content
- High content of dissolved solids

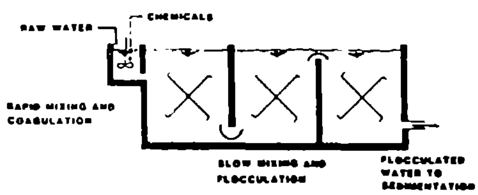
SURFACE WATER :

- Bacteriologically polluted
- High turbidity
- Organic matter (algae, faeces)
- Low content of dissolved solids

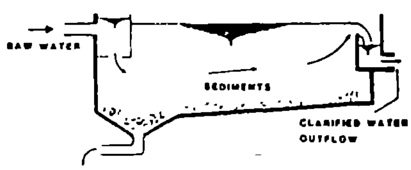
The aeration/degasation process TPG 400/V 3



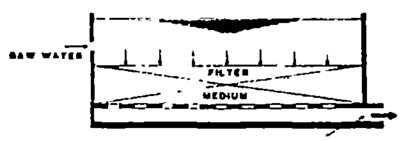
The coagulation and flocculation process TPG 400/V 4



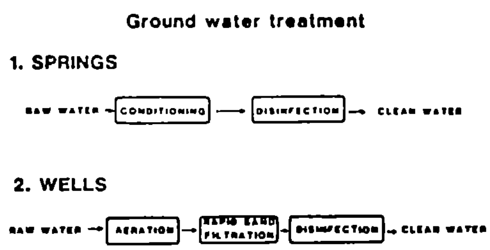
The sedimentation process TPG 400/V 5



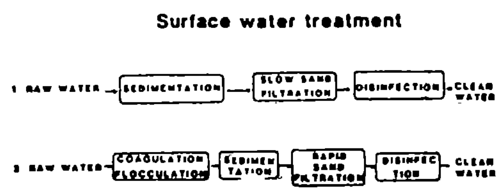
Sand filtration TPG 400/V 6



Ground water treatment — TPG 400/V 7



Surface water treatment — TPG 400/V 8



Water treatment — TPG 400/H 1

1. PRINCIPLES

Introduction

The purpose of water treatment is to convert "raw water", taken from a ground or surface source, into "product" water suitable for domestic use (drinking water) or other purposes. Most important is the removal of pathogenic organisms and toxic substances causing health hazards. Other substances may also need to be removed or at least considerably reduced. These include: suspended matter causing turbidity, iron and manganese compounds imparting a bitter taste or staining laundry, and excessive carbon dioxide corroding concrete and metal parts. For small community water supply, other water quality characteristics such as hardness, total dissolved solids and organic content would generally be less important. They should be reduced to acceptable levels but the extent to which the water is treated will usually be limited.

Type of impurities

Absolutely pure water is rarely found in nature. Impurities contained by water occur in three progressively finer states: suspended, colloidal and dissolved matter. Different methods of treatment are required for their removal or reduction to acceptable limits.

- <u>Suspended matter</u>

  Apart from the probability that a river might be carrying floating debris, running water has the capacity to pick up and transport solid particles of higher density than water : the higher the velocity, the bigger the particles picked up. Rivers in flood conditions (e.g. during banjirs) are therefore normally at their most turbid because of the increased velocity.

- <u>Colloids</u>

  The finer particles, called colloids, may not be visible to the naked eye, but in their finest forms they impart turbidity and colour to the the water. Colloids remain in suspension even when the water is virtually at rest.

- <u>Dissolved solids</u>

  In its passage over or through the ground, water also picks up such soluble substances as calcium, magnesium, sodium, potassium, iron and manganese. In their soluble forms, these are normally combined with bicarbonates, sulphates, chlorides, nitrates and other salts.

Bicarbonates, sulphates and chlorides of calcium and magnesium are commonly found in water and cause hardness. Hardness forms insoluble precipitates with soap. It also causes boiler scale.
Iron and manganese, if present in any concentration at all, impart taste, and stain laundry during washing.

- Dissolved gases

Gases may be also found adsorbed in water, particularly carbon dioxide, oxygen, nitrogen and ammonia.
A high CO_2 content causes corrosiveness towards metals and concrete structures. A low oxygen content will cause the water to taste and smell unpleasantly.

Water sources

Generally spoken water sources can be divided into groundwater and surface water.

- Groundwater

Groundwater will normally be free from turbidity and pathogenic organisms. When it originates from a clean sand aquifer, other hazardous or objectionable substances will also be absent. In these cases, a direct use of the water as drinking water may be permitted without any treatment. When the water comes from an aquifer containing organic matter, however, oxygen will have been consumed and the carbon dioxide content of the water is likely to be high. The water will then be corrosive. In cases where the amount of organic matter in the aquifer is high, the oxygen may be completely depleted. The water containing no oxygen (anaerobic water) will dissolve iron, manganese and heavy metals from the underground. Through treatment these substances can be removed.

- Surface water

Surface water can be taken from streams, rivers, lakes or irrigation canals. Water in such surface sources originates partly from groundwater outflows and partly from rainwater that has flowed over the ground to the receiving bodies of surface water. The groundwater outflows will bring dissolved solids into the surface water. The surface run-off is the main contributor of turbidity and organic matter, as well as pathogenic organisms present in surface water. In surface water, the dissolved mineral particles will remain unchanged but the organic impurities are degraded through chemical and microbiological processes. Sedimentation in impounded or slow-flowing surface water results in the removal of suspended solids. Pathogenic organisms will die off due to lack of suitable

nutrients. However, new contamination of the surface water is likely to take place as a result of waste influents and growth of algae, which may serve as nutrients for micro-organisms.

2. WATER PURIFICATION

A treatment plant may consist of several processes, such as aeration, coagulation, flocculation, sedimentation, filtration and disinfection. Each of these processes is intended to perform one main function although it may enhance other treatment processes. The impurities are removed in order of size : the bigger ones (suspended matter) are eliminated first. Not all water contains all the impurities and therefore not every type of water requires all the treatment processes.
The impurities are largely removed by the following processes.

Aeration

Aeration is the treatment process whereby water is brought into intimate contact with air for the purpose of:
a. increasing the oxygen content;
b. reducing the carbon dioxide content (removal of free and inparticular aggressive CO_2), and
c. removing hydrogen sulfide, methane and various volatile organic compounds responsible for taste and odour.

The treatment processes mentioned under (a) and (c) are always advisable in the production of good drinking water. Reducing the carbon dioxide content is of special importance for the protection of pipelines and appurtenances against corrosion if the water contains aggressive CO_2.
The oxygen transferred to the water during aeration may be used to oxidize dissolved material such as iron and manganase so as to enable their removal during subsequent filtration.

Coagulation and flocculation

Coagulation and flocculation are steps in a water treatment process whereby finely divided suspended and colloidal matter in the water is made to agglomerate and form flocs by the addition of chemicals, normally alum and soda ash. This enables their removal by sedimentation and/or filtration. Colloidal particles (colloids) are midway in size between dissolved solids and suspended matter.

The substances that frequently are to be removed by coagulation and flocculation are those that cause turbidity and colour. Surface waters in tropical countries are often turbid and contain colouring material.
Both turbidity and colour are mostly present as colloidal particles.

Sedimentation

Sedimentation is the settling and removal of suspended particles that takes place when water stands still in a basin, or flows slowly through it. Due to the low velocity of flow, turbulence will generally be absent or negligible, and particles having a mass density (specific weight) higher than water will be allowed to settle. These particles will ultimately be deposited on the bottom of the tank, forming a sludge layer. The water reaching the tank outlet will be in a clarified condition.

Slow sand filtration

Filtration is the process whereby water is purified by passing it through a porous material (or "medium"). In slow sand filtration a bed of fine sand with grain sizes of 0.15 - 0.35 mm is used, through which the water slowly percolates downwards. Due to the fine grain size, the pores of the filter bed are small. The suspended matter present in the raw water is largely retained in the upper 0.5-2 cm of the filter bed. This allows the filter to be cleaned by scraping away the top layer of sand. The top section of the filter bed of a slow sand filter contains the so-called "Schmutzdecke", which consists of a very broad range of micro-biological species. These micro-biological species are responsible for the remarkable improvement of the physical, chemical and bacteriological quality of water treated by slow sand filtration. As low rates of filtration are used (0.1-0.4 m/hour = 2-10 m/day), the interval between two successive filter cleanings will be fairly long, usually several months. The filter cleaning operation need not take more than one day, but after cleaning, one or two days more are required for the filter bed to become fully effective again (reripening of the Schmutzdecke).

Rapid sand filtration

As explained in the preceding paragraph on slow sand filters, filtration is the process whereby water is purified by passing it through a porous material (or "medium"). For rapid filtration, sand is commonly used as the filter medium, but the process is quite different from slow sand filtration. This is so because much coarser sand is used, with an effective grain size in the range of 0.6-1.2 mm, and the

filtration rate is much higher, generally between 5 and 15 m/hour (120-360 m/day). Due to the coarse sand used, the pores of the filter bed will be relatively large and the impurities contained in the raw water will penetrate deep into the filter bed. Thus the capacity of the filter bed to store deposited impurities is much more effectively utilized and even very turbid river water can be treated with rapid filtration. For cleaning a rapid filter bed, it is not sufficient to scrape off the top layer. Cleaning of rapid filters is effectuated by backwashing. This is directing a high-rate flow of water backwards through the filter bed whereby this expands and is scoured. The backwash water carries the deposited material out of the filter. The cleaning of a rapid filter can be carried out quickly; it need not take more than about half an hour. It shall be done as frequently as required, normally every 24-48 hours.

Disinfection

The single most important requirement of drinking water is that it should be free from any micro-organisms that could transmit diseases to the consumer. Processes such as storage, sedimentation, coagulation and flocculation, slow sand filtration and rapid filtration reduce the bacterial content of water to varying degrees. However, these processes cannot assure that the water they produce is bacteriologically safe. Final disinfection is needed. In cases where no other methods of treatment are available, disinfection may be resorted to as a single treatment against bacteriological contamination of drinking water.

Disinfection of water provides for destruction, or at least complete inactivation, of harmful micro-organisms present in the water. It is carried out by adding a suitable chemical, such as chlorine, to the water, usually in the form of kaporit.

SUMMARY OF WATER PURIFICATION PROCESSES

Summarizing, the treatment steps required in order to reduce the specified impurities are presented in the following table.

	Aeration/ Degasation	Coag./ flocculation	Sedimentation	Slow filtration	Rapid filtration	Disinfection
Turbidity						
low				x		
high		x	x		x	
Colour		x	x		x	
Taste/odour	x					
Iron/manganese	x				x	
Aggressive CO_2	x					
Low O_2	x					
Bacteria				o		x
Colloids		x	x		x	
Suspended solids		o	x	o	o	

x = essential; o = optional

3. WATER TREATMENT SCHEMES

For every kind of raw water specific purification processes are required to meet the quality standards for safe drinking water. They vary from mere disinfection to a very extensive treatment. To a certain extent the type of treatment can be related to the source, although the necessity or the sufficiency of a particular method must be studied carefully in each case separately.

Groundwater

- Spring

A spring is normally a source of clean water. It may, however, yield aggressive water. Therefore conditioning, by means of degasation of CO_2 (aeration) or addition of a base such as lime, soda ash or caustic soda, is executed before it is distributed.

Disinfection is excecuted to prevent bacterial growth in the distribution system, and as a safety precaution against recontamination.

RAW WATER ----> CONDITIONING ----> DISINFECTION ----> CLEAN WATER

- Shalow wells/deep boreholes

A typical layout of a treatment and purification process for groundwater is given below:

RAW WATER ---> AERATION ---> RAPID SAND FILTRATION ---> DISINFECTION ---> CLEAN WATER

This combination has the following aims. Gases such as CO_2/H_2 are removed by way of degasation/aeration and this brings oxygen into the water at the same time. The oxygen can be used for oxidation of iron, manganese and ammonia. After that the iron, manganese and ammonia can be removed in the sand filter. Disinfection is needed for killing contageous micro-organisms. If groundwater does not contain any iron or manganese ammonia the treatment would be simpler. The quality of groundwater at some places is so good, that treatment is not necessary at all (except for disinfection).

Surface water

Often surface water has an unacceptable turbidity and is polluted with pathogenic micro-organisms. Two examples are given here for surface water treatment.

1. RAW WATER --> SEDIMENTATION --> SLOW SAND FILTRATION --> DISINFECTION --> CLEAN WATER

2. RAW WATER --> COAGULATION FLOCCULATION --> SEDIMENTATION --> RAPID SAND FILTRATION --> ---> DISINFECTION ---> CLEAN WATER

The second example is a more advanced system, but, under current circumstances, in rural areas often difficult to realize. Then slow sand filtration preceded by presedimentation is a good alternative, if turbidity is not too high. Although disinfection is recommended,

often slow sand filtration is the last step under these circumstances producing an acceptable quality most of the time, because pathogenic micro-organisms as well as organic matter are biochemically removed.

4. SUMMARY

Water treatment is converting "raw water", from a ground or surface water source, into "product" water, e.g. drinking water. For both types of water sources normally typical treatment schemes can be designed since groundwater often contains aggressive CO_2 and a high iron and manganese content, while surface water is often bacteriologically polluted and has a high turbidity.

* * *

TITLE :	CODE :
1. Types of impurities in water	TPG 400/V 1
2. Water sources	TPG 400/V 2
3. Aeration/degasation process	TPG 400/V 3
4. Coagulation/flocculation process	TPG 400/V 4
5. Sedimentation process	TPG 400/V 5
6. Sand filtration	TPG 400/V 6
7. Ground water treatment	TPG 400/V 7
8. Surface water treatment	TPG 400/V 8

TYPES OF IMPURITIES IN WATER

- Suspended matter
- Colloidal matter
- Dissolved matter
  - solids
  - gases

Sizes of matter / particles :

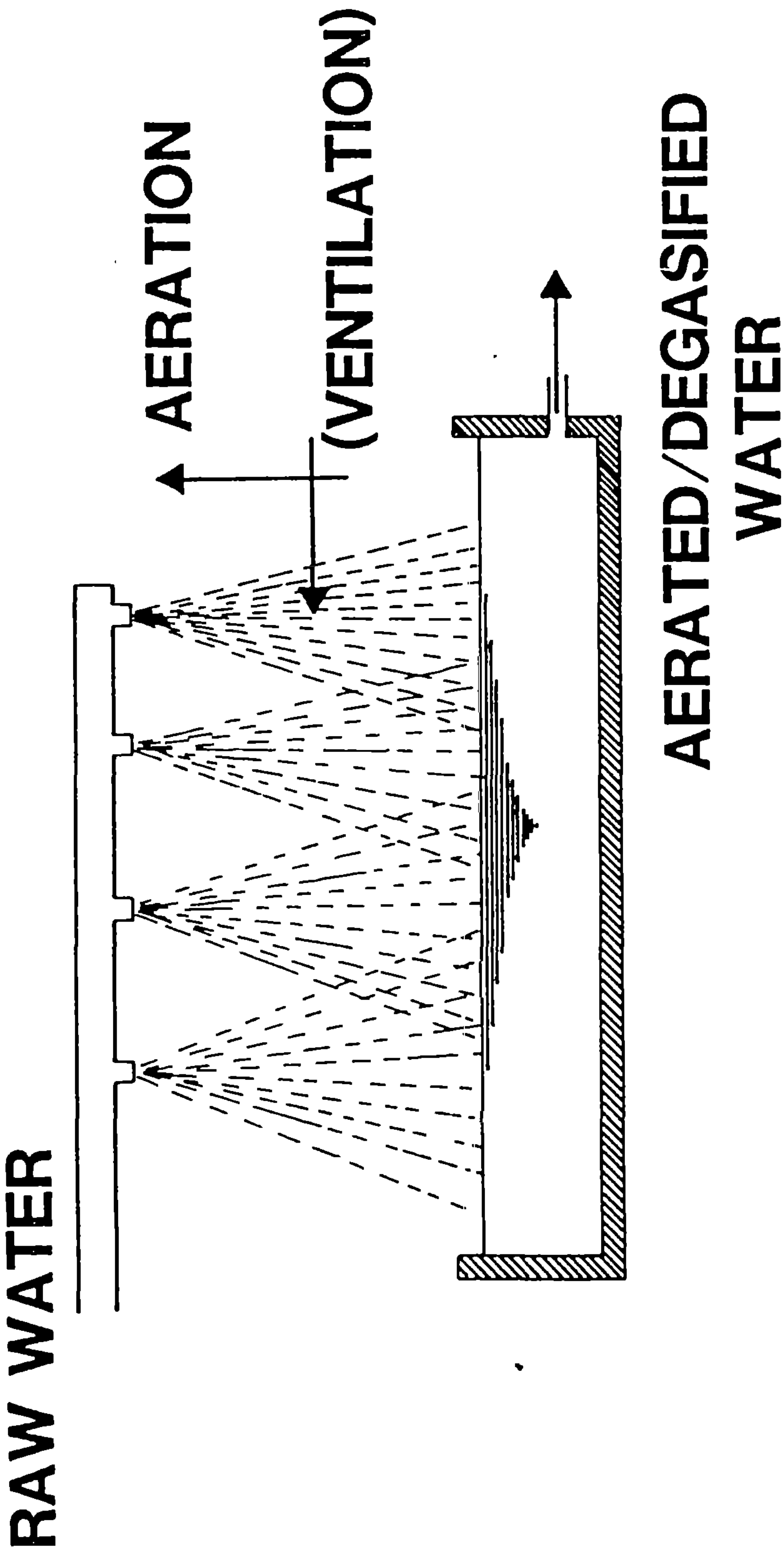
SUSPENDED > COLLOIDAL > DISSOLVED

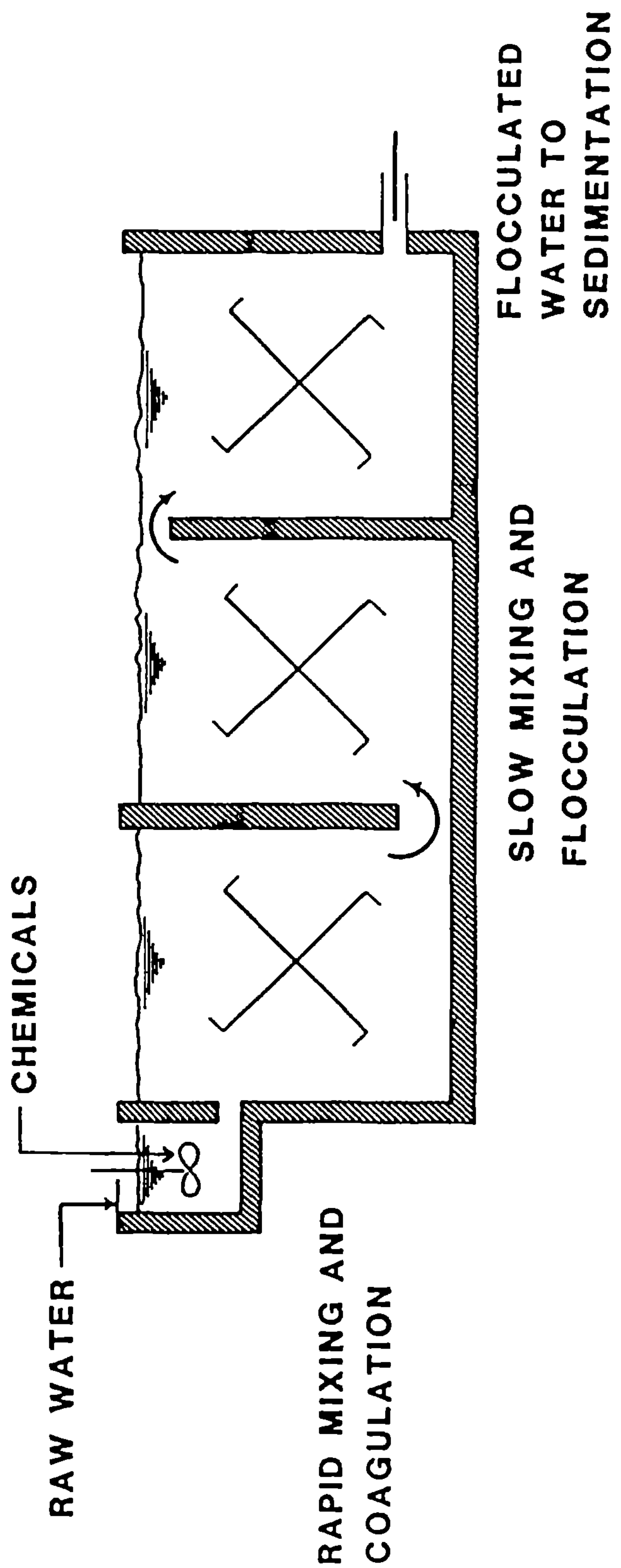
GROUNDWATER :

- Bacteriologically safe
- No turbidity
- High Co_2 content
- Low O_2 content
- High content of dissolved solids

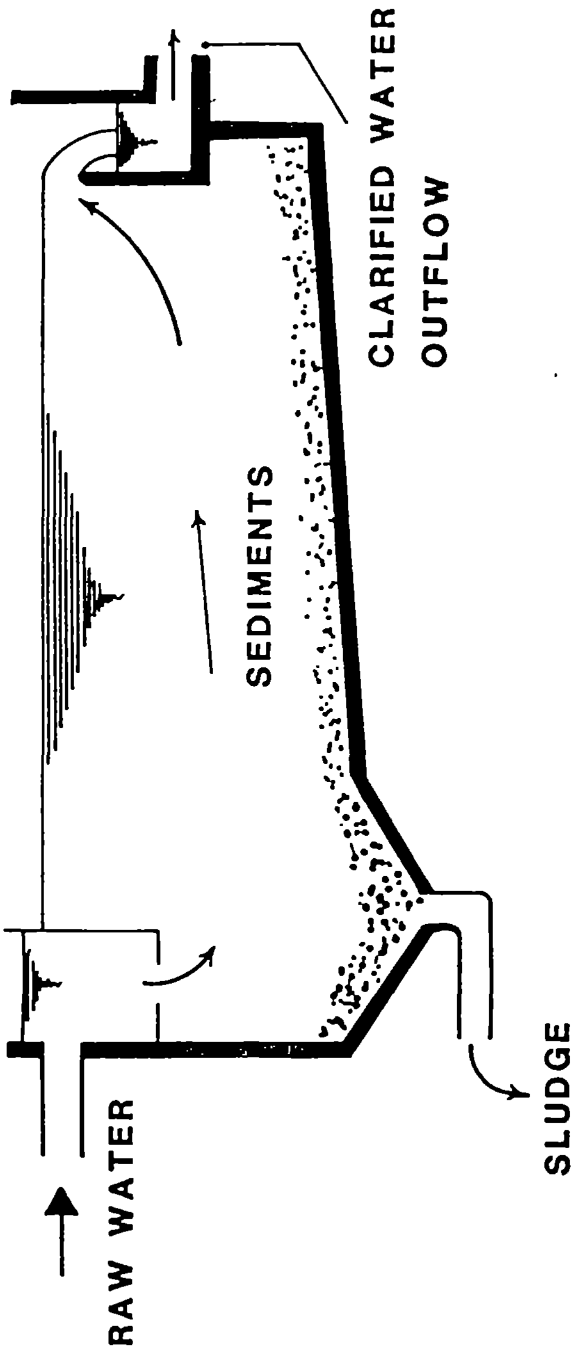
SURFACE WATER :

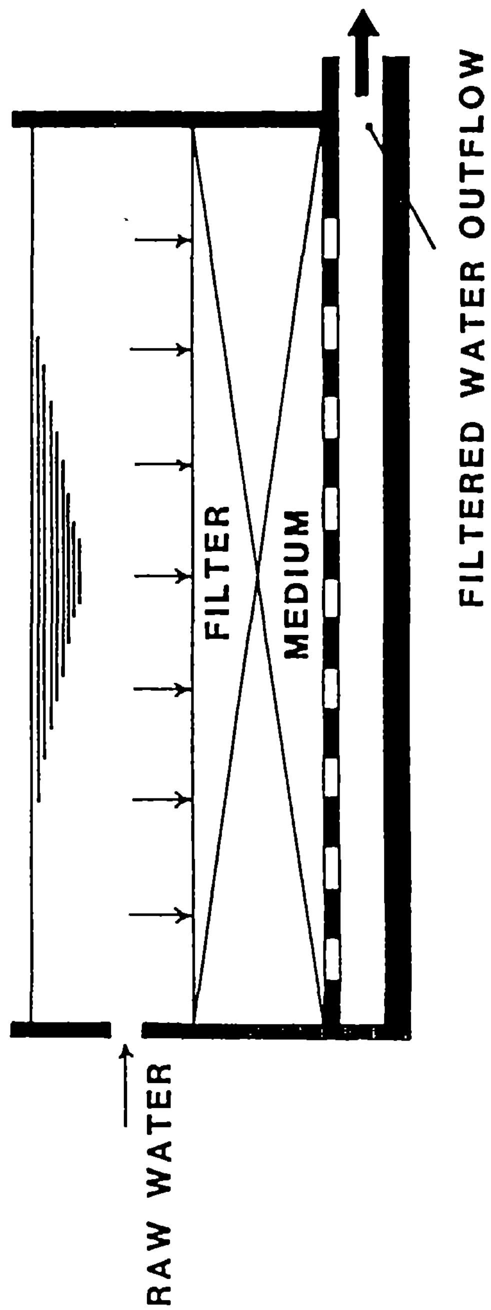
- Bacteriologically polluted
- High turbidity
- Organic matter (algae, faeces)
- Low content of dissolved solids

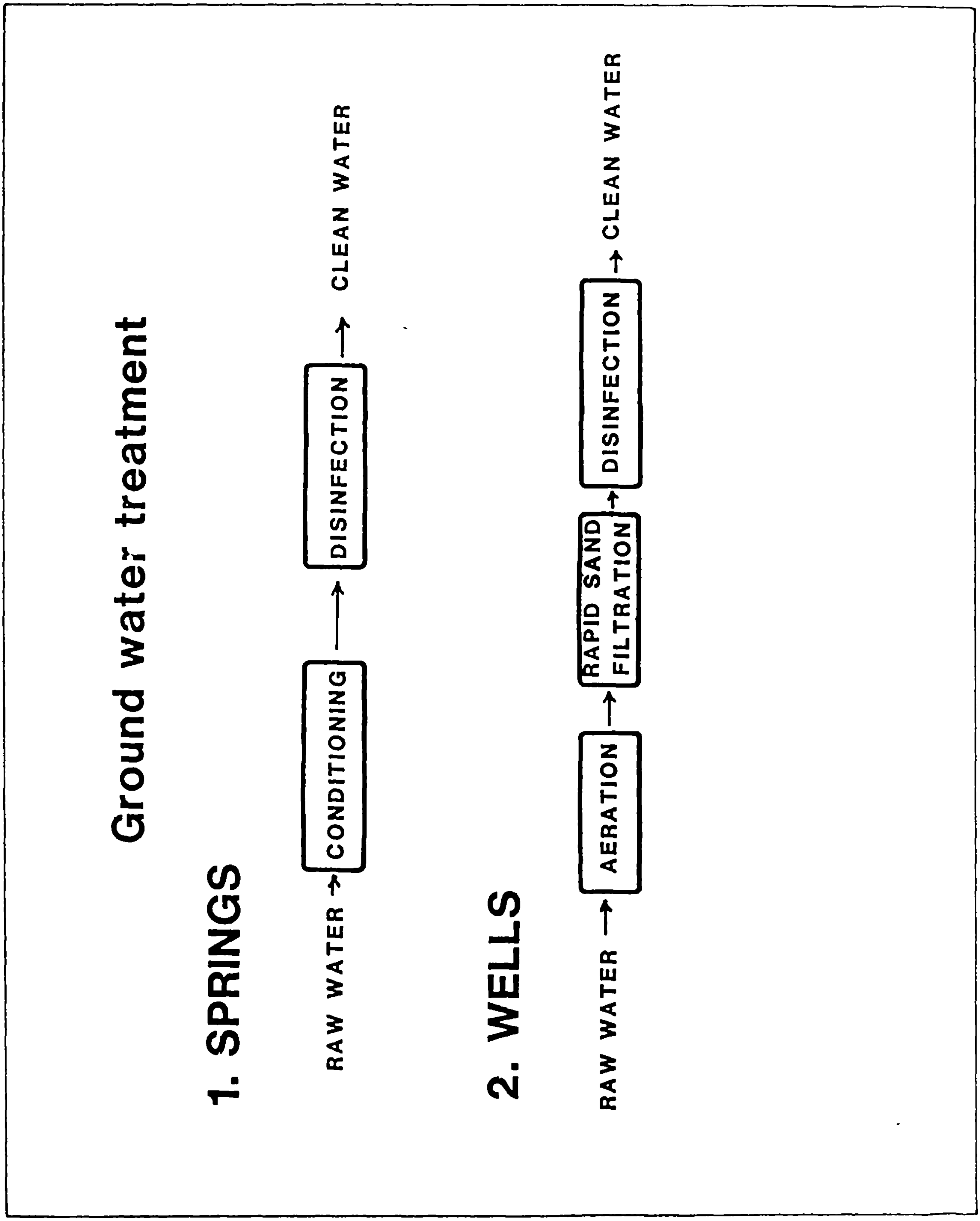

AERATION
(VENTILATION)
AERATED/DEGASIFIED
WATER
RAW WATER

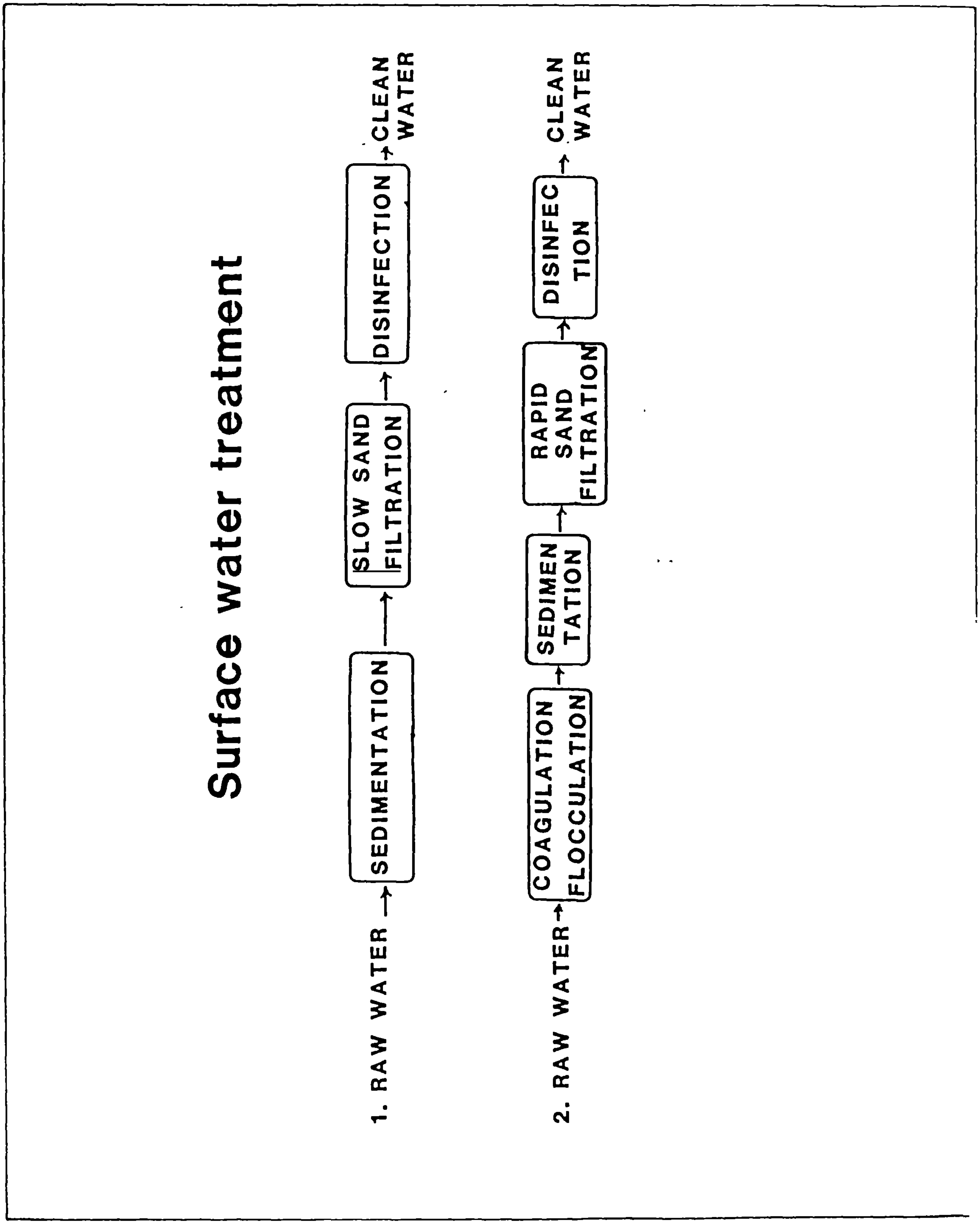


RAW WATER
CHEMICALS
RAPID MIXING AND
COAGULATION
SLOW MIXING AND
FLOCCULATION
FLOCCULATED
WATER TO
SEDIMENTATION


CLARIFIED WATER
OUTFLOW
SEDIMENTS
RAW WATER
SLUDGE


FILTERED WATER OUTFLOW
FILTER MEDIUM
RAW WATER


Ground water treatment
1. SPRINGS
RAW WATER → CONDITIONING → DISINFECTION → CLEAN WATER
2. WELLS
RAW WATER → AERATION → RAPID SAND FILTRATION → DISINFECTION → CLEAN WATER


Surface water treatment
1. RAW WATER
SEDIMENTATION
SLOW SAND FILTRATION
DISINFECTION
CLEAN WATER
2. RAW WATER
COAGULATION FLOCCULATION
SEDIMEN TATION
RAPID SAND FILTRATION
DISINFEC TION
CLEAN WATER

Module : SETTING OUT	Code : TPC 110
	Edition : 15-03-1985
Section 1 : INFORMATION SHEET	Page : 01 of 01/08

Duration :	90 minutes.
Training objectives :	After the session the trainees will be able to : - to set straight lines; - to set angles; - to level trenches.
Trainee selection :	- Head of Section Distribution; - Head of Subsection Distribution & House Connections; - Pipelayer; - Pipeline inspector; - Head of Subsection Construction Supervision; - Construction Supervisor.
Training aids :	- Angle boards; - Ranging rods; - Chalk; - Measuring tape (20 m); - Sighting boards; - Traveller; - Viewfoils : TPC 110/V 1-2; - Handout : TPC 110/H 1.
Special features :	-
Keywords :	Setting out.

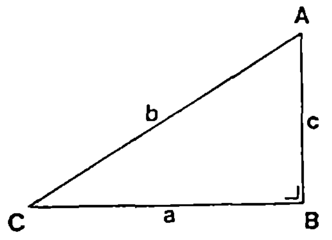
Module : SETTING OUT	Code : TPC 110
	Edition : 15-03-1985
Section 2 : S E S S I O N N O T E S	Page : 01 of 02

1. Introduction	
- It is important to lay water mains on the correct line. - Some joints are flexible while others are inflexible. - Mains are normally laid in : . straight lines; . with angles linking straight lines; . at right angles to straight lines; . at correct depth.	Use whiteboard
2. Setting straight lines	
- Fixed points are set at beginning and end of the line and lining-in by sight any point between. - Mark line with chalk, lime, etc.	- Demonstrate : use ranging rods as fixed points; - line-in another - ranging rod between the two fixed points and mark with chalks on ground; - Allow trainees to practice; - Check by using string to check points between the two fixed points.
3. Setting angles	
- Angles are set using prefabricated 30°, 45°, 60°, 90° angleboards (or adjustable angle boards). - For setting 45° the 3-4-5 ratio (Pythagoras Theorem) is used. - Also for setting right angles the 3-4-5 ratio is used.	- Demonstrate the use of angle boards (fixed and adjustable); - Show V 1 - Allow trainees to practice; - Demonstrate use of 3-4-5 method of setting right angle and 45'angles; - Allow trainees to practice.

4. Trench levelling	
- Explain basic theory of levels.	- Explain on white board the basic theory of levels - Show V 2 - Demonstrate use of sighting boards and allow trainees to practice.
- Explain use of sighting boards and traveller.	
5. Summary	Give H 1
- Correct setting out of trenches concerns : . straight lines; . angles; . correct depths.	

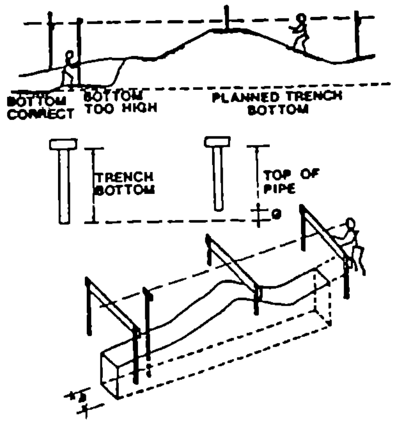
Module : SETTING OUT	Code : TPC 110
	Edition : 15-03-1985
Section 3 : T R A I N I N G A I D S	Page : 01 of 01

Pythageras theorem TPC 110/V 1



$$b^2 = a^2 + c^2$$

Trenching with profiles TPC 110/V 3 (a–c)



Setting out TPC 110/H 1

1. INTRODUCTION

Water pipes are made straight. Therefore it is essential to lay the pipe in a continuous straight line except where the design calls for bends, junctions ("Tees") or minor deviations.
Some joints are flexible allowing for a 5° angle of deviation at each joint. However, generally water mains are laid :

. in straight lines;
. with angles linking straight lines;
. at right angles to straight lines;

and, very important, at the correct depth.

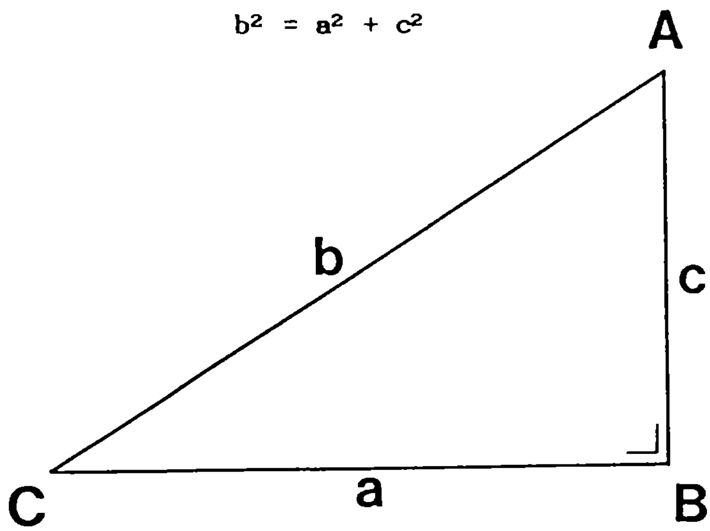
2. SETTING STRAIGHT LINES

Points should be fixed at the beginning and the end of the line.
Various methods can be implemented to line-in between these two points. This can be done with a long cord placed on the ground, pulled taut and the line marked or, more commonly, by fixing ranging rods at the beginning and end of the straight line and lining-in a third rod by eye at points in between. These points can then be marked on the ground using chalk, lime, etc.

3. SETTING ANGLES

Angles are easiest set out using prefabricated angle boards. These are normally triangles always with sides of approximately one metre lenght. Two are required, one with internal angles of 22.5°, 67.5°, and 90°, and the other with internal angles of 45°, 90° and 45°.
These can be set on the ground and the angles marked with chalk.
As an alternative to fixed angle boards, adjustable angle boards can be prefabricated.
Additionally, 90° angles can be constructed on site using Pythagoras' Theorem. This theorem states that the square of the lenght of the hypotenuse in any right-angled triangle is equal to the sum of the squares of the other two sides (See Fig. 1 on next page).

$b^2 = a^2 + c^2$



For most triangles the arithmetic, whilst simple, produces lines with dimensions that are difficult to construct accurately on site.
One triangle, however, is relatively straightforward :
a right-angled triangle can have a hypotenuse of 5 and the other two sides lengths of 3 and 4, respectively, which makes it very simple to construct on site a triangle with an internal angle of 90°.

CHECK : $b^2 = a^2 + c^2$

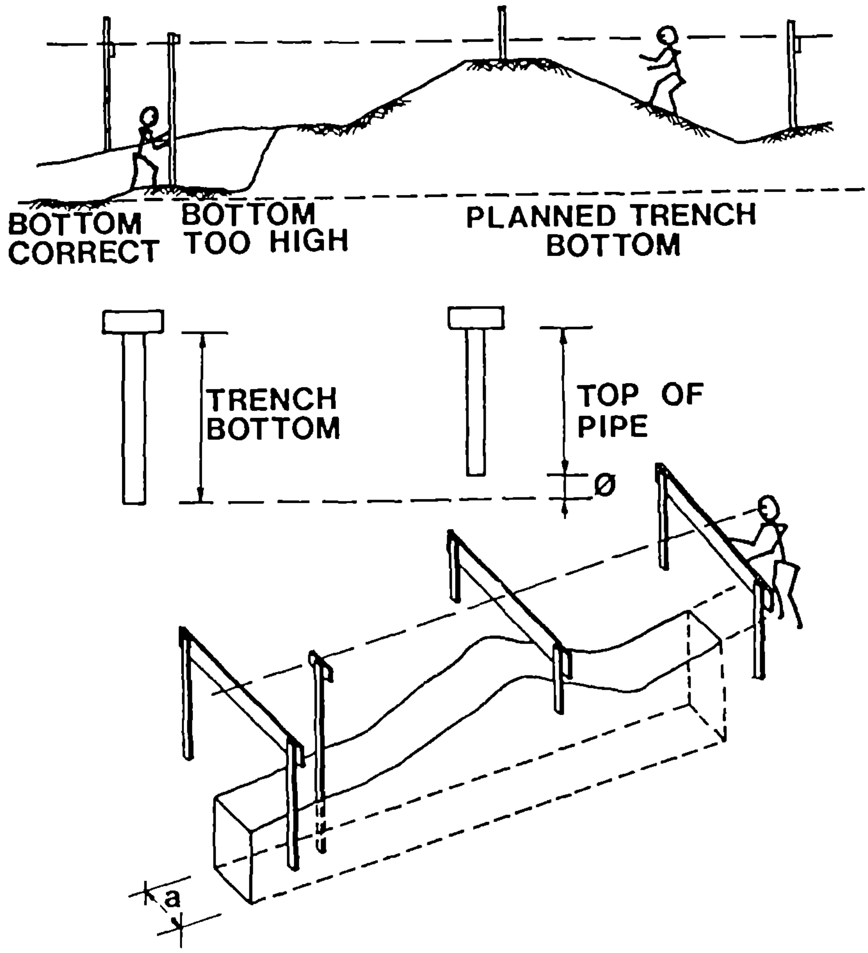
SUBSTITUTE : $5^2 = 3^2 + 4^2$

$25 = 9 + 16$

4. TRENCH LEVELLING

The sighting boards and traveller are normally used for setting trench bed levels when laying water mains.
Two sighting boards are placed across the trench at each end and a "Tee" shaped Traveller used to level in between (see fig. 2 on next page).

Figure 2


BOTTOM
CORRECT
BOTTOM
TOO HIGH
PLANNED TRENCH
BOTTOM
TRENCH
BOTTOM
TOP OF
PIPE
Ø
a

5. **SUMMARY**

It is important to set out the line of trenches in a correct manner, by setting out :

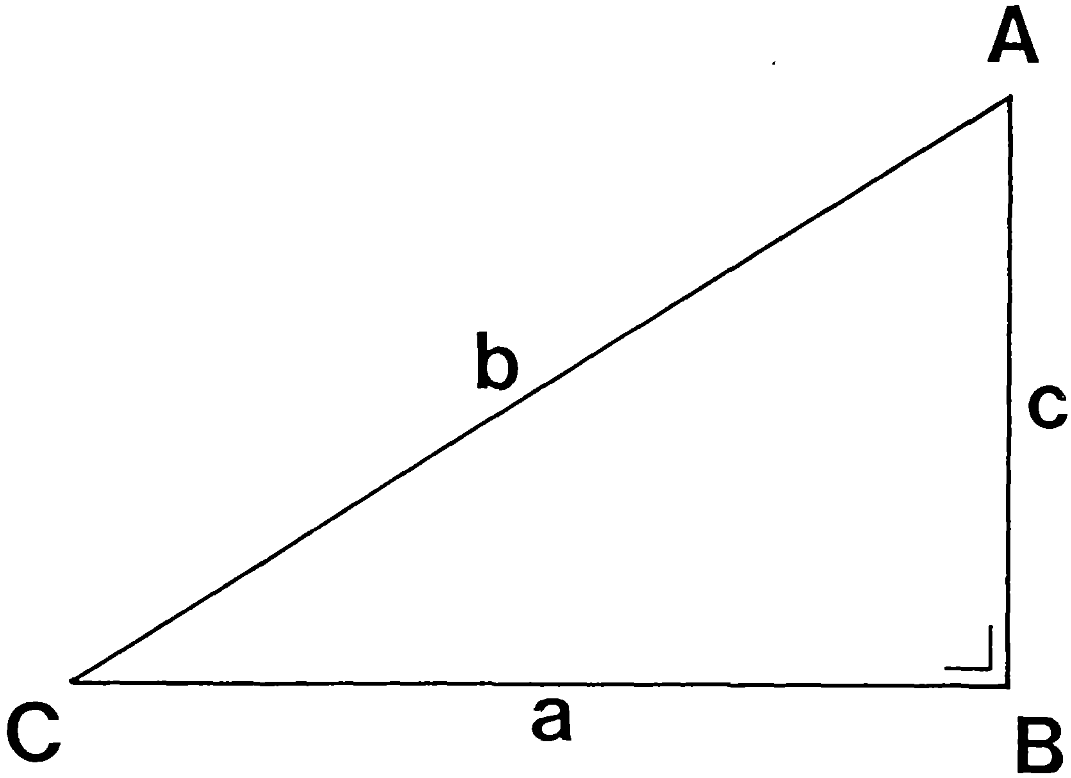
a. straight lines

b. angles,

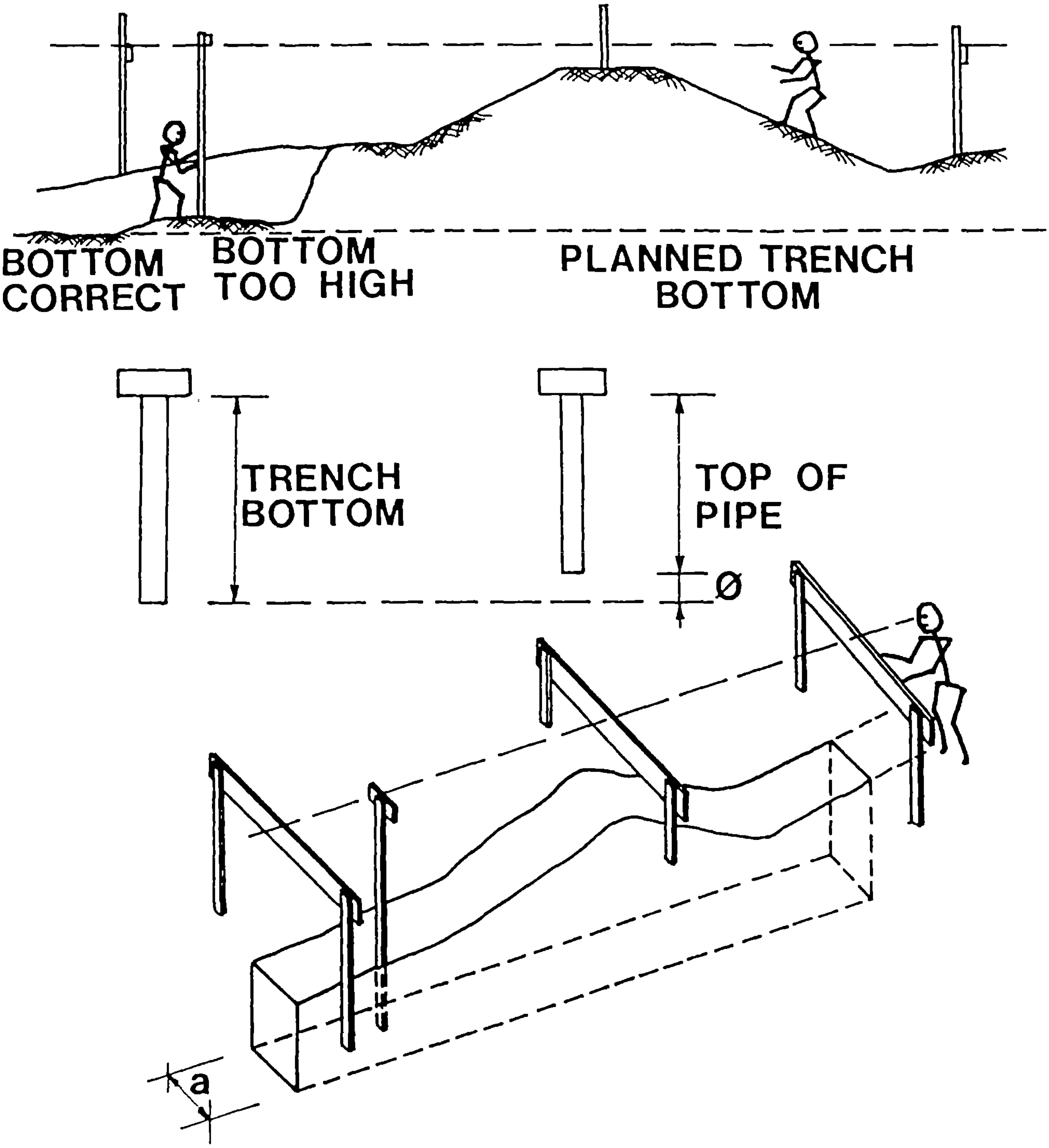
and also to maintain the correct depth.

* * *

TITLE :	CODE :
1. Pythagoras' theorem	TPC 110/V 1
2. Trenching with profiles	TPC 110/V 2



$$b^2 = a^2 + c^2$$


BOTTOM CORRECT
BOTTOM TOO HIGH
PLANNED TRENCH BOTTOM
TRENCH BOTTOM
TOP OF PIPE
Ø
a

Module : EXCAVATION, BEDDING AND BACKFILLING	Code : TPC 120
	Edition : 15-03-1985
Section 1 : INFORMATION SHEET	Page : 01 of 01/11

Duration : 45 minutes.

Training objectives : After the session the trainees will be able to:
- list the 3 important steps in laying underground pipes;
- identify the tools to be used in excavation, bedding and backfilling;
- state the safety practices required during excavation, bedding and backfilling.

Trainee selection :
- Head of Technical Department;
- Head of Section Distribution;
- Head of Sub-section Distribution & Connections;
- Pipelayer;
- Pipeline Inspector;
- Head of Sub-section Supervision;
- Construction Supervisor.

Training aids :
- Viewfoils : TPC 120/V 1-6;
- Handout : TPC 120/H 1.

Special features : -

Keywords : Excavation/bedding/backfilling.

Module : EXCAVATION, BEDDING AND BACKFILLING	Code : TPC 120
	Edition : 15-03-1985
Section 2 : S E S S I O N N O T E S	Page : 01 of 02

1. Introduction	
- To ensure good pipelaying underground three important steps must be undertaken to ensure that the pipe is undamaged and protected: a. excavation; b. bedding; c. backfilling.	Use whiteboard
2. Excavation	
- Important items for an excavation: . alignment set out correctly, including "Tees" etc.; . depth; . levels; . correct tools; . safety; . trench supports.	Show V 1-2
3. Bedding	
- Issues in bedding are: . depth of bedding; . bedding material; . provision for joints; . tools.	Show H 3-4
4. Backfilling	
- Explain issues bedding are: . type of backfill; . compaction by layers; . compactionn around pipe; . reinstatement.	Show V 5-6

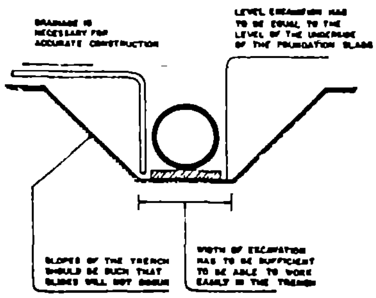
5. **Safety**

   - Safety measures should concern:
     . obstruction of traffic flow;
     . barriers;
     . pedestrians;
     . workers in trench;
     . tools.

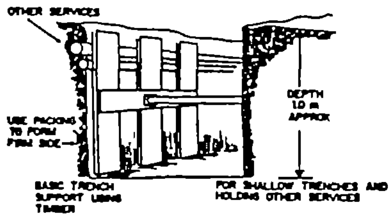
6. **Summary** — Give H 1.

Module :	**EXCAVATION, BEDDING AND BACKFILLING**	Code :	TPC 120
		Edition :	15-03-1985
Section 3 :	T R A I N I N G A I D S	Page :	01 of. 02

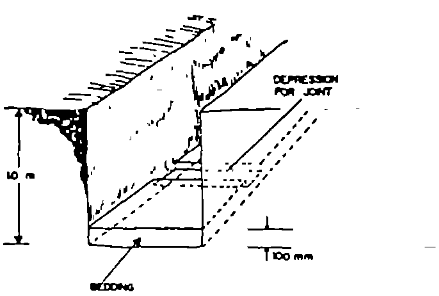
Excavation requirements TPC 120/V 1



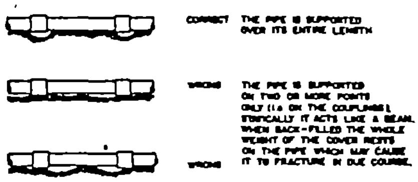
Timber trench support TPC 120/V 2



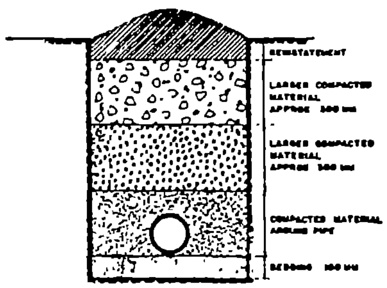
Depression in bedding TDC 200/V 3



Pipe bedding TPC 120/V 4 (a-c)

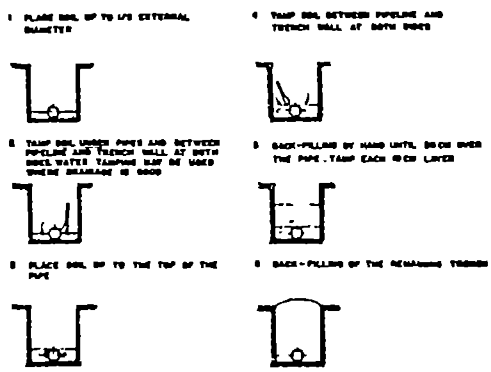


Backfilling by layers TPC 120/V 5



BACKFILLING BY LAYERS

Backfilling TPC 120/V 6



Excavation, bedding and backfilling   TPC 120/H 1

1. INTRODUCTION

When laying underground water mains there are three very important steps which must be undertaken to ensure that the pipe is laid in an undamaged and protected way. Badly laid pipes lead to many complicated maintenance problems in future years.
The three steps are :
a. excavation;
b. bedding;
c. backfilling.

2. EXCAVATION

Before starting excavations for main laying, the pipe alignment must be correctly set out according to the design drawings.
All bends, "Tees", valves or special fitments should be checked to make sure that their positioning does not conflict with any permanent feature already installed.

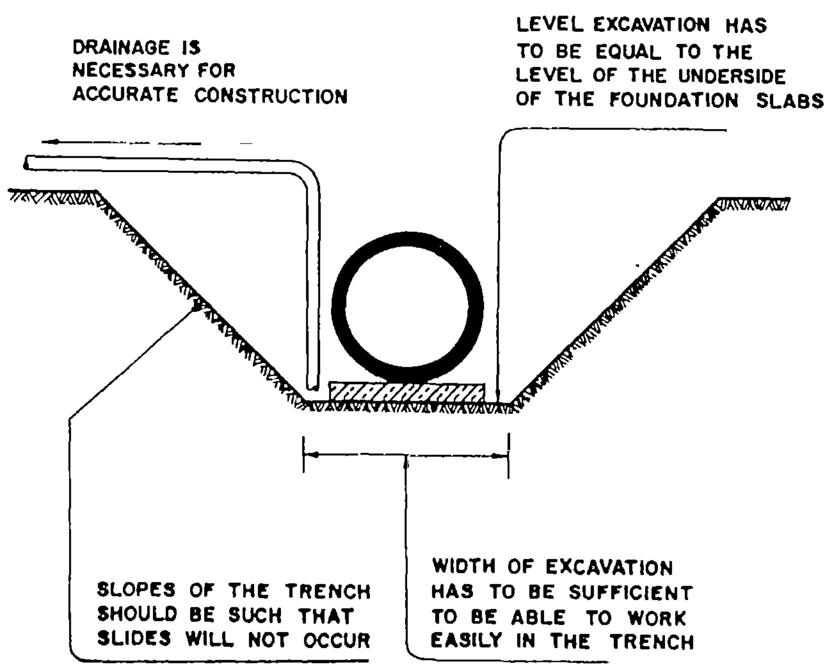


Fig. 1. Excavation requirements for the laying of pipes

When the excavation is made either with machine or by hand it is extremely important that the depth of the trench is planned beforehand. The sides of the trench should be clean and free of any dangerous obstructions like rocks protruding into the trench, which may become a safety hazard for people within the trench. If the sides of the trench or the spoil above the trench are unstable in any way then the trench sides should be supported properly using timber constructed in the correct manner and the spoil be preferably removed from near the trench edge to a safer position.

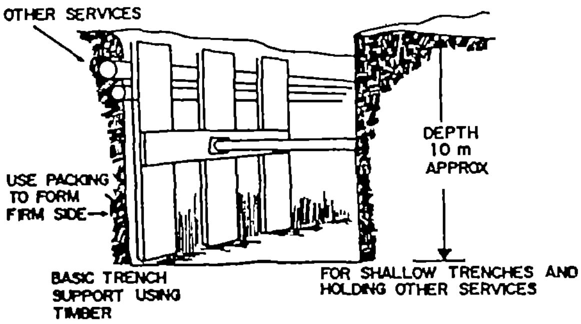


Fig. 2. Supporting trench sides

It is also essential that the correct tools are used in the excavation. This may seem a simple statement to make but pick axes are designed to break up rock only and shovels for moving earth to another place. We have all seen pick axes used as hammers.
The practice of using mechanical tools e.g. rammers, compressors etc. by workmen wearing no protective shoes but merely flip-flops appears rather dangerous. They should be encouraged to take all necessary safety precautions when working in trenches.

3. BEDDING

After excavation of the pipe trench, the pipe should be laid on a bedding of fine granular material. This can include sand, good quality top soil or pea gravel etc. The position of the joints should be marked in the bedding material and a small depression formed to allow the socket of the joint to rest in the depression leaving the remaining pipe evenly supported along its entire length (see figures on next page).

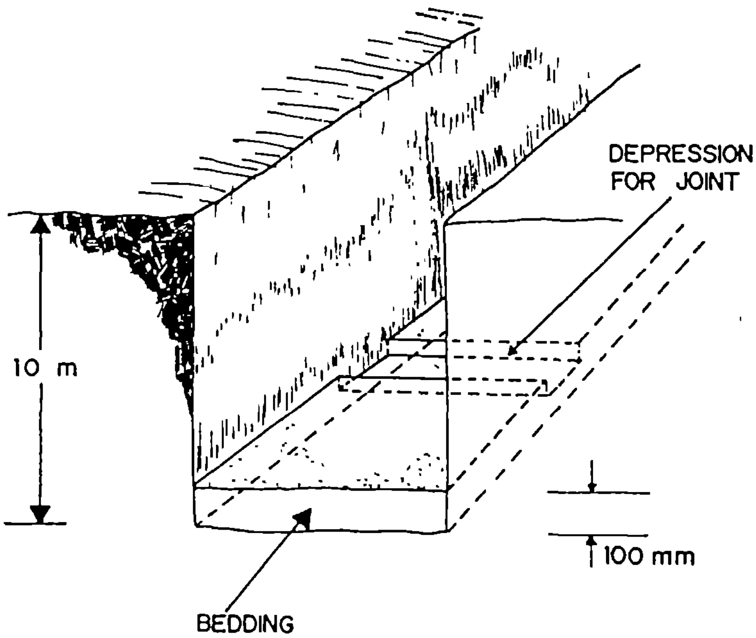
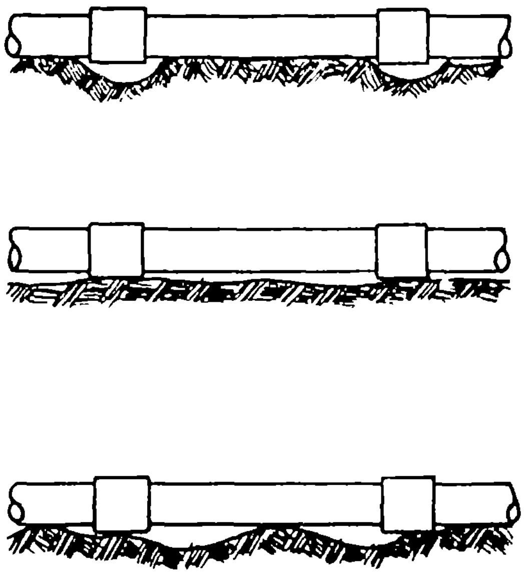


Fig. 3. Bedding requirements



correct — The pipe is supported over its entire lenght.

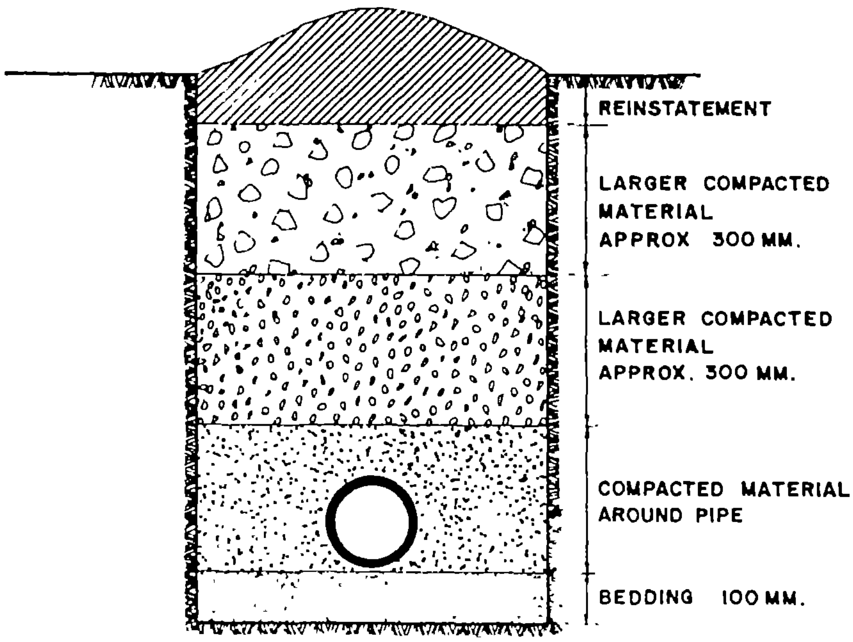
wrong — The pipe is supported on two or more points only (i.e. on the couplings). Statically it acts like a beam. When back-filled the whole weight of the cover rests on the pipe which may cause it to fracture in due course.

wrong

Fig. 4. Pipe bedding

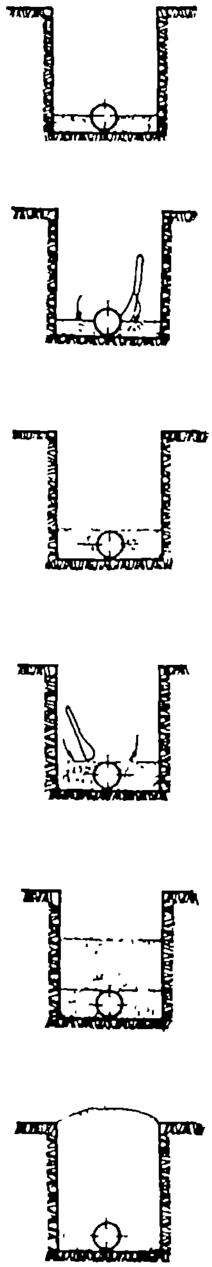
4. BACKFILLING

Much damage has been done to newly laid water pipes by ineffective methods of backfilling. A trench should be backfilled in layers of approximately 20 cm and rammed progressively (see figure below). Immediately around the pipe similar fine granular material as used for pipe bedding should be used. This must also be rammed and consolidated. As the trench is filled progressively, coarser backfilling material e.g. larger stones can be used towards the surface. Because of the excessive rain and heat experienced in Indonesia it is critical that the trench is reinstated as quickly as possible after backfilling, to prevent erosion by rain water. It should be reinstated in a material similar to the area e.g. tarmac on roads and grass on fields.



BACKFILLING BY LAYERS

Fig. 5. Cross-section through pipe trench



1. Place soil up to 1/2 external diameter.

2. Tamp soil under pipes and between pipeline and trench wall at both sides. Water tamping may be used where drainage is good.

3. Place soil up to the top of the pipe.

4. Tamp soil between pipeline and trench wall at both sides.

5. Backfilling by hand until 20 cm over the pipe. Tamp each 10 cm layer.

6. Backfilling of the remaining trenches.

Fig. 6. Backfilling sequence

5. SAFETY

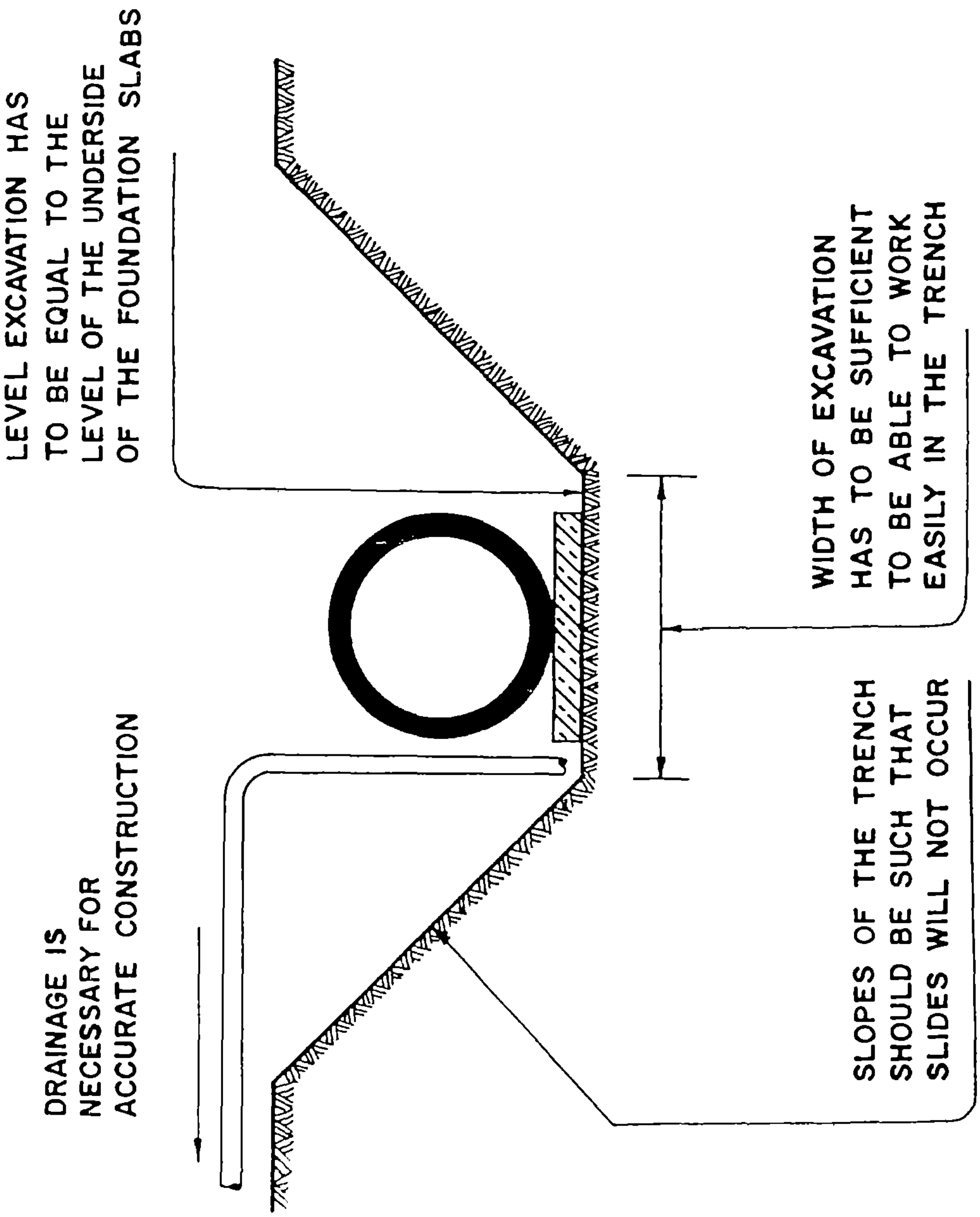
Safety standards in Indonesia, as in many other countries, are regrettably low. Care must be taken at all times to ensure that safety practices are observed not only by the workmen but also by their supervisors and anyone else who comes on site.

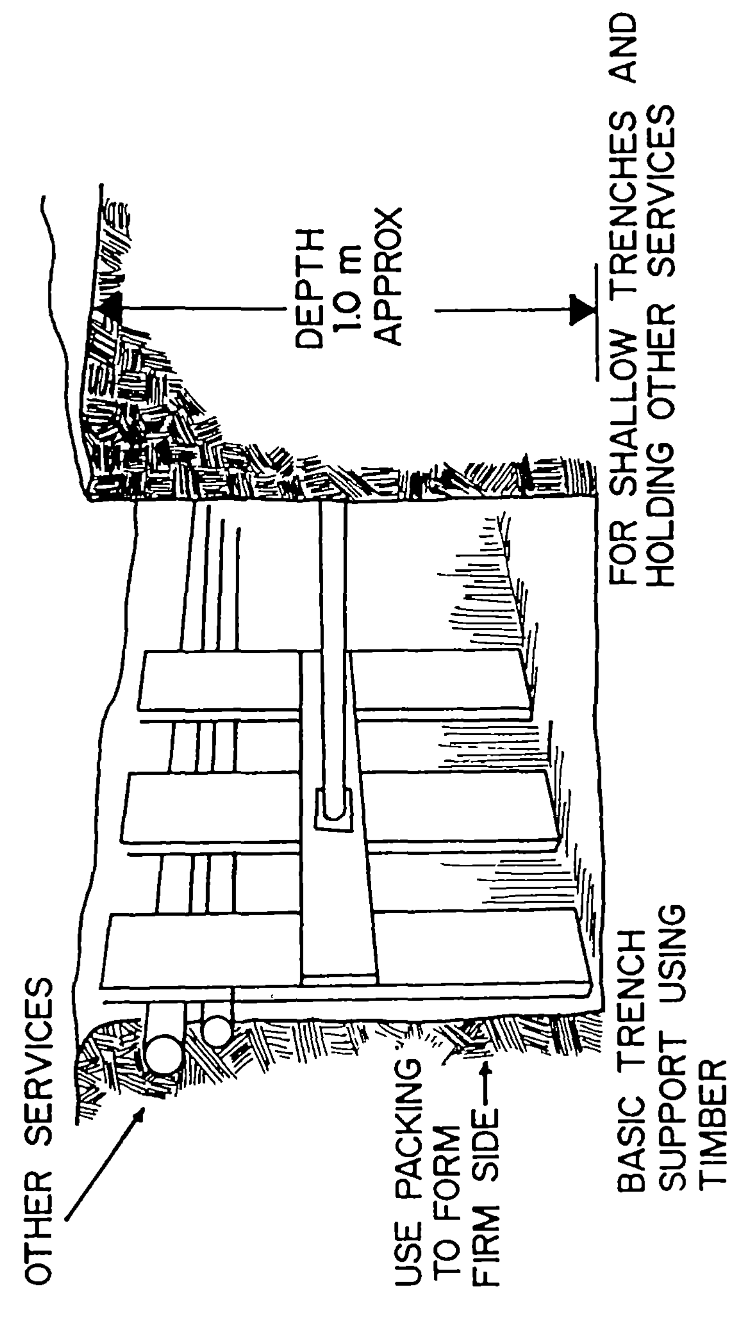
6. SUMMARY

There is no shortcut to good excavation, bedding and backfilling. It should be planned correctly and executed efficiently, using the right materials and tools, and always bearing safety in mind.

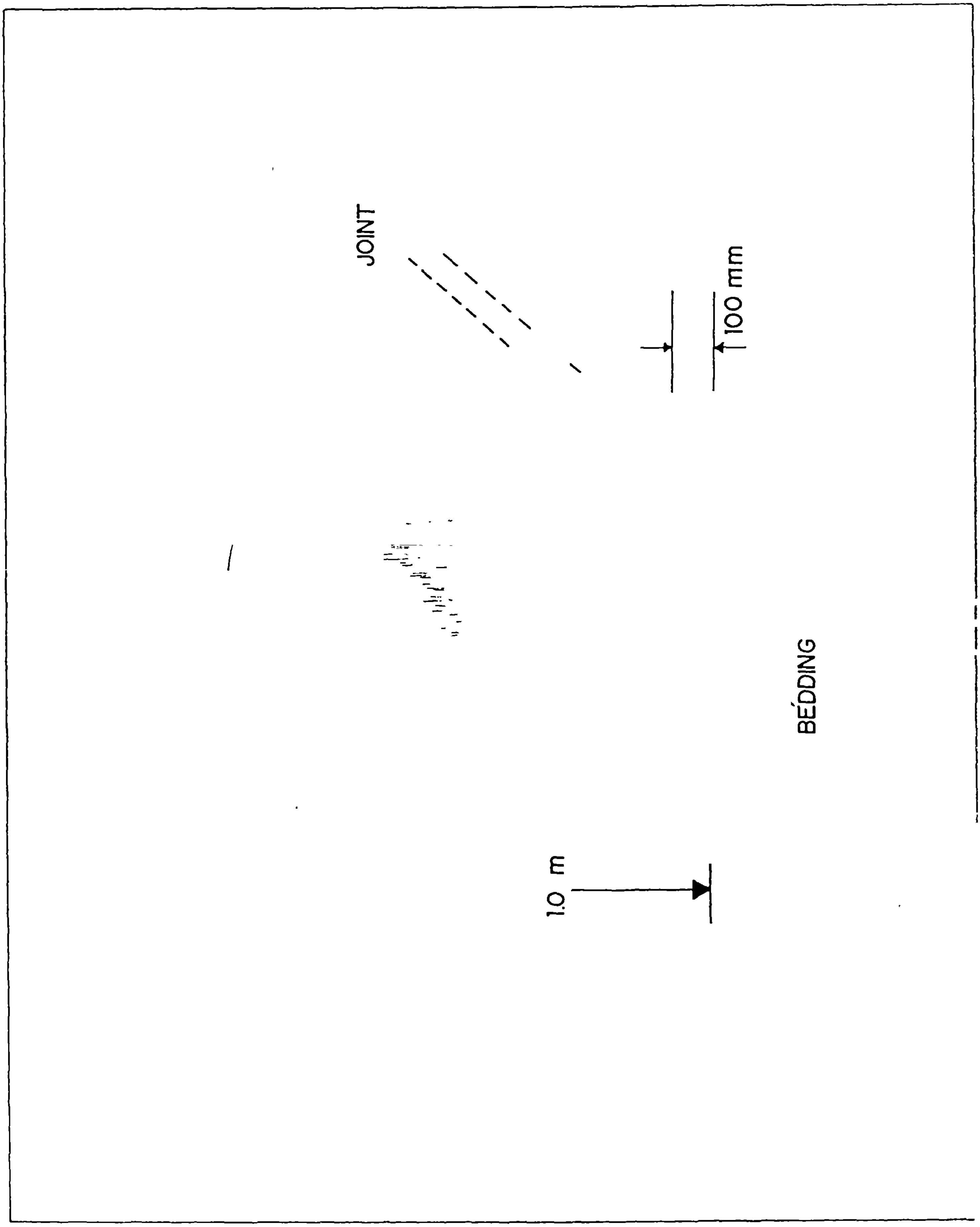
* * *

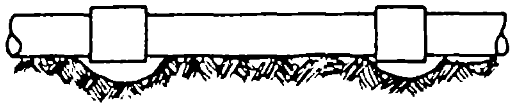
TITLE :	CODE :
1. Prefabricated pipes	TPC 120/V 1
2. Timber trench support	TPC 120/V 2
3. Depression in bedding	TPC 120/V 3
4. Pipe bedding	TPC 120/V 4
5. Backfilling by layers	TPC 120/V 5
6. Backfilling	TPC 120/V 6


LEVEL EXCAVATION HAS TO BE EQUAL TO THE LEVEL OF THE UNDERSIDE OF THE FOUNDATION SLABS
WIDTH OF EXCAVATION HAS TO BE SUFFICIENT TO BE ABLE TO WORK EASILY IN THE TRENCH
SLOPES OF THE TRENCH SHOULD BE SUCH THAT SLIDES WILL NOT OCCUR
DRAINAGE IS NECESSARY FOR ACCURATE CONSTRUCTION


DEPTH
1.0 m
APPROX
FOR SHALLOW TRENCHES AND
HOLDING OTHER SERVICES
OTHER SERVICES
USE PACKING
TO FORM
FIRM SIDE
BASIC TRENCH
SUPPORT USING
TIMBER

Depression in bedding

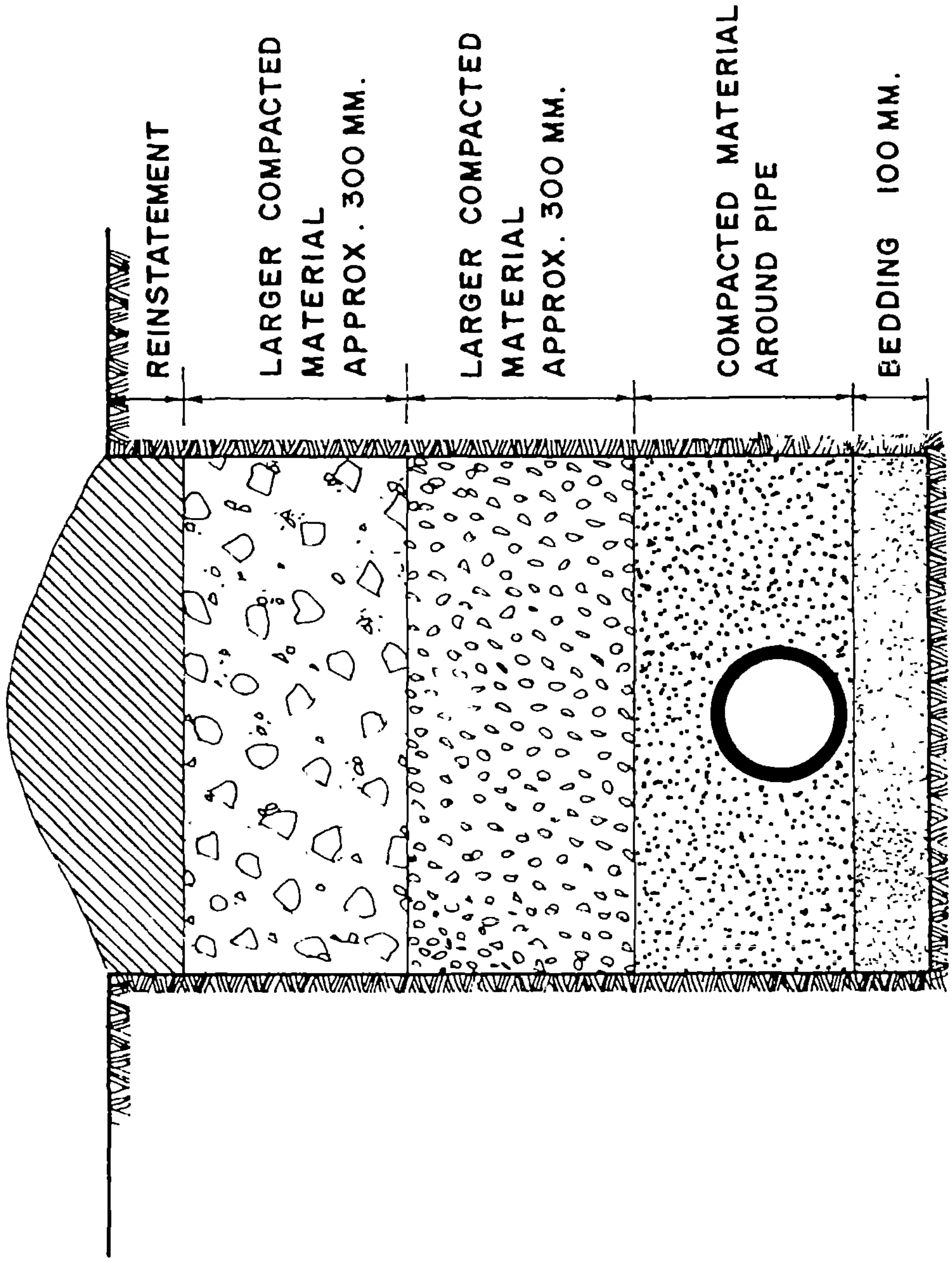




CORRECT THE PIPE IS SUPPORTED OVER ITS ENTIRE LENGTH.

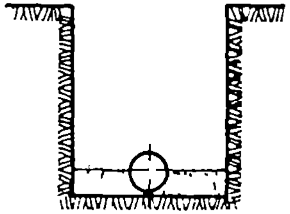
WRONG THE PIPE IS SUPPORTED ON TWO OR MORE POINTS ONLY (i.e. ON THE COUPLINGS). STATICALLY IT ACTS LIKE A BEAM. WHEN BACK-FILLED THE WHOLE WEIGHT OF THE COVER RESTS ON THE PIPE WHICH MAY CAUSE IT TO FRACTURE IN DUE COURSE.

WRONG

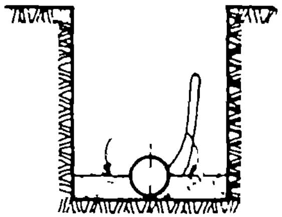


BACKFILLING BY LAYERS

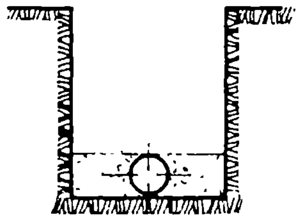
1. PLACE SOIL UP TO 1/2 EXTERNAL DIAMETER



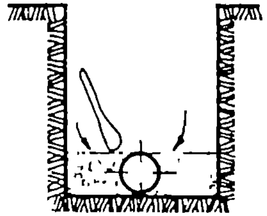
2. TAMP SOIL UNDER PIPES AND BETWEEN PIPELINE AND TRENCH WALL AT BOTH SIDES. WATER TAMPING MAY BE USED WHERE DRAINAGE IS GOOD.



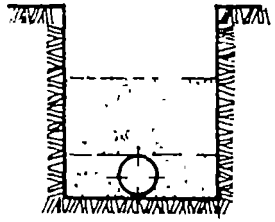
3. PLACE SOIL UP TO THE TOP OF THE PIPE



4. TAMP SOIL BETWEEN PIPELINE AND TRENCH WALL AT BOTH SIDES



5. BACK-FILLING BY HAND UNTIL 20 CM OVER THE PIPE. TAMP EACH 10 CM LAYER



6. BACK-FILLING OF THE REMAINING TRENCH